THE COOPER UNION

FOR THE ADVANCEMENT OF SCIENCE AND ART

COURSE CATALOG 2020 | 21

COOPER.EDU

ABOUT THE COOPER UNION

VISION

The Cooper Union for the Advancement of Science and Art is dedicated to Peter Cooper's radical commitment to diversity and his founding vision that fair access to an inspiring free education and forums for courageous public discourse foster a just and thriving world.

MISSION

Our mission is to sustain The Cooper Union as a free center of learning and civic discourse that inspires inventive, creative, and influential voices in architecture, art, and engineering to address the critical challenges and opportunities of our time.

ACADEMIC VISION

Through outstanding academic programs in architecture, art and engineering, and a Faculty of Humanities and Social Sciences, The Cooper Union for the Advancement of Science and Art prepares talented students to make enlightened contributions to society.

The Cooper Union for the Advancement of Science and Art, founded in 1859 by Peter Cooper, prepares talented students to make enlightened contributions to society through outstanding academic programs in architecture, art and engineering. The institution provides a challenging, interactive curriculum with distinguished, creative faculty and fosters rigorous, humanistic learning in a dynamic setting.

ACADEMIC CALENDAR

The Cooper Union for The Advancement of Science and Art operates within a two semester calendar (fall and spring). Most classes are scheduled Monday through Friday between the hours of 8:00 a.m. and 9:00 p.m. We offer a limited summer session with courses typically provided in Math, Physics, and Engineering..

2020–2021

Add the 2020–2021 academic calendar to your calendar app

Mon, Aug 3	Student bill due date
Tue, Aug 25–Sun, Aug 30	Orientation
Mon, Aug 31	Fall 2020 Semester Begins | Monday Classes Meet
Mon, Aug 31–Tue, Sep 8	Course Adjustment Period | Students can add/drop courses with advisor assistance
Mon, Sep 7	Labor Day | Offices and Classrooms are closed
Tue, Sep 8	Fall Festival
Tue, Sep 8	Course Add/Drop deadline | Last day to add/drop courses Last day to take leave of absence or fully withdraw from school and receive full tuition and fees refund.
Mon, Oct 12	Outstanding Student Bills Due and Account Hold Hold placed on student records preventing future course registration and/or release of transcript pending payment
Wed, Oct 28	Last Day to withdraw from classes
Tue, Nov 17–Mon, Nov 23	Registration for Spring 2021 classes All students must have advisor approval in order to register
Tue, Nov 24	MODIFIED SCHEDULE: THURSDAY classes meet
Wed, Nov 25	MODIFIED SCHEDULE: FRIDAY classes meet
Thu, Nov 26–Fri, Nov 27	Thanksgiving Holiday | Offices and Classrooms are closed
Mon, Nov 30	Classes Resume
Thu, Dec 10–Fri, Dec 11	Study Period | No Classes
Mon, Dec 1–Fri, Dec 18	Final Classes, crits and exams | Students meet in regularly assigned rooms at regular times
Fri, Dec 18	End of Fall term | Last day of the fall 2020 term
Mon, Dec 21–Sun, Jan 17	Winter Recess All schools closed
Wed, Dec 23–Sun, Jan 3	Staff Holiday

Mon, Jan 4	Administrative Offices Re-open | Fall grades due All grades due to the Office of the Registrar before noon [12PM]
Tue, Jan 5	Spring 2021 Bill Due Date
Mon, Jan 18	Martin Luther King Jr. Birthday Staff Holiday
Tue, Jan 19	Spring 2021 Semester begins Spring semester begins. MONDAY classes meet
Tue, Jan 19–Tue, Jan 26	Course Adjustment Period Students can add/drop courses with advisor assistance
Tue, Jan 26	Course Add/Drop Deadline Last day to add/drop courses. Last day to take leave of absence or fully withdraw from School and receive full tuition and fees refund. Advisors and School Offices are informed as to how to handle Tuesday evening courses.
Wed, Feb 10	MODIFIED SCHEDULE: FRIDAY classes meet
Fri, Feb 12	Founder's Day | Classrooms and office closed
Mon, Feb 15	President's Day | Classrooms and office closed
Fri, Mar 12	Outstanding Student Bills Due and Account Hold Hold placed on student records preventing future course registration and/or release of transcript pending payment
Sat, Mar 13–Sun, Mar 21	Spring Recess | No Classes Administrative offices remain open
Wed, Mar 31	Last Day to withdraw from classes
Tue, Apr 20–Fri, Apr 23	Course Registration for both Summer 2021 and Fall 2021 Registration into Summer and/or Fall semester courses. All students must have advisor approval in order to register
Thu, May 6–Fri, May 7	Study Period | No classes
Mon, May 10–Fri, May 14	Final classes, crits, and exams Students meet in regularly assigned rooms at regular times
Fri, May 14	End of Spring 2021 Term
Mon, May 17	Senior Grades due to Office of the Registrar before noon (12PM)
Wed, May 19	All non-senior grades due to Office of the Registrar before noon (12PM)
Tue, May 25	Commencement Rehearsal | Time TBD
Tue, May 25	End of Year Show Opening 5–9 pm
Wed, May 26	Commencement | 10:30am–12 pm
Mon, May 31	Memorial Day | Classrooms and offices closed
Sat, Jun 19	Juneteenth | Classrooms and offices closed
Mon, Jul 5	Independence Day Observed | Classrooms and offices closed

ACCREDITATION

The Cooper Union is accredited by the Middle States Commission on Higher Education; all of the degree programs are registered with the New York State Education Department. In addition, the program leading to the bachelor of architecture degree is accredited by the National Architectural Accrediting Board, the program leading to the bachelor of fine arts degree is accredited by the Association of Schools of Art and Design and the four programs (chemical, civil, electrical and mechanical engineering) leading to the bachelor of engineering degree are accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

Accredited & Post-Professional Programs

The following programs at The Cooper Union have been registered by the New York State Education Department.

Accredited

Program	Hegis Code	Degree
Architecture	0202	B.Arch.
Engineering	0901	B.S.
Chemical Engineering	0906	B.E.
Civil Engineering	0908	B.E.
Electrical Engineering	0909	B.E.
Mechanical Engineering	0910	B.E.
Fine Arts	1001	B.F.A.
Master of Engineering	0901	M.E.

Post-Professional

Program	Hegis Code	Degree
Architecture	0202	Master of Science in Architecture
Architecture	0202	Master of Architecture II (renamed in 2019)

STUDENT LIFE

Comprised of professionals who support and advocate for the students at The Cooper Union, The Office of Student Affairs encompasses many different services to help you along your personal journey at The Cooper Union and beyond. These services include: Career Development, Residence Life, Athletics, Campus Life, Health and Medical Records, Counseling Referrals, Student Support and Advocacy, Student Judiciary, Student Clubs and Organizations, Orientation Programs and Commencement.

First Year Profile Fall 2019 Data

The Cooper Union first-year students self-identify as follows:

- 31% Asian
- 13% Latino
- 7% Black
- 32% Caucasian, Non-Hispanic
- 2% Multi-Ethnic
- 5% did not self-report a race or ethnicity
- 10% nonresident aliens
- 49% women
- 51% male

The Cooper Union undergraduate admission process has instated a test optional pilot program for the Fall 2021 and 2022 entering classes. If submitted, test scores will be considered.

The average high school GPA for The Cooper Union degree-seeking, first-time, first-year students who submitted their GPA was 3.75.

16% acceptance rate

Services for Disabled Students

The Cooper Union is an equal opportunity institution that admits students without regard to their disabilities. The Cooper Union makes reasonable accommodations and modifications to policies, practices and procedures and provides auxiliary aids and services necessary to meet the needs of students with disabilities on campus. Students with disabilities seeking any accommodations, modifications or auxiliary aids or services regarding any aspect of the full Cooper Union experience—including anything pertaining uniquely to one of the Cooper Union's distinct schools—should contact the Dean of Students for assistance.

APPLYING TO COOPER UNION

APPLICATION INSTRUCTIONS AND DEADLINES

Undergraduate

The Cooper Union uses the Common Application as its first-year undergraduate application form. Transfer and Graduate applicants should submit their applications through the website.

Early Decision:

The Albert School of Engineering: Sunday, November 1, 2020

The School of Art and The Irwin S. Chanin School of Architecture: Tuesday, December 1, 2020

Regular Decision for all three schools: Tuesday, January 5, 2021

Graduate

Master of Science in Architecture:

To apply for the program starting in Spring 2021, the deadline is Tuesday, September 15, 2020.

To apply for the program starting in Fall 2021, the deadline is Tuesday, January 5, 2021.

Master of Engineering: Monday, February 15, 2021

Non-Matriculating Student Programs

The Irwin S. Chanin School of Architecture: Non-Matriculating (Visiting) Student

The School of Art: Exchange

ADMISSION PROCESS
THE IRWIN S. CHANIN SCHOOL OF ARCHITECTURE

Undergraduate/First-Year

EARLY DECISION

If The Cooper Union is your first choice, you may consider applying early decision. If admitted via early decision you must accept our offer and withdraw your other college applications.

STEP 1 Submit the first part of your application online by Tuesday, December 1, 2020.

STEP 2 You will receive a confirmation email.

STEP 3 You will have to prepare and submit by Tuesday, December 1, 2020:
- Your official high school transcript or GED certificate (required for all applicants)
- Any official college transcripts (sent directly from the college or university)
- Recommendation letter (1 strongly encouraged)
- Official TOEFL, IELTS, or DET scores, if applicable*

STEP 4 You will receive the Studio Test via email on Tuesday, December 8, 2020. You will have approximately one month to complete the test. The Office of Admissions must receive the Studio Test and all application materials no later than Tuesday, January 5, 2021. Extensions are not permitted unless in the case of extenuating circumstances. We highly recommend adding admissions@cooper.edu to your email address book in order to prevent important emails (like your Studio Test and admission decision) from going to spam!

Please follow all instructions carefully. For First Year applicants, no additional portfolio material should be sent.

STEP 5 You will receive an admission decision by Monday, February 1, 2021.

REGULAR DECISION

STEP 1 Submit the first part of your application online by Tuesday, January 5, 2021.

STEP 2 You will receive a confirmation email.

STEP 3 You will have to prepare and submit by Tuesday, January 5, 2021:
- Your official high school transcript or GED certificate (required for applicants)
- Any official college transcripts (sent directly from the college or university)
- Recommendation letter (1 strongly encouraged)
- Official TOEFL, IELTS, or DET scores, if applicable*

STEP 4 You will receive the Studio Test via email on Tuesday, January 12, 2021. You will have approximately one month to complete the test. The Office of Admissions must receive the Studio Test and all application materials no later than Tuesday, February 9, 2021. Extensions are not permitted unless in the case of extenuating circumstances. We highly recommend adding admissions@cooper.edu to your email address book in order to prevent important emails (like your Studio Test and admission decision) from going to spam!

Please follow all instructions carefully. For First Year applicants, no additional portfolio material should be sent.

STEP 5 You will receive an admission decision by Thursday, April 1, 2021.

Calculus is a required first-year course for all architecture students. Entering first-year students must have completed Mathematics (including Trigonometry, Algebra II and Pre-Calculus). Any student who has not completed Pre-Calculus in high school must do so during the summer before enrollment, and must submit an official transcript documenting successful completion of the course.

**Undergraduate applicants whose native language is not English and who have not graduated from a secondary school in a country with English as the official medium of instruction are required to take one the below exams.*

TOEFL (Test of English as a Foreign Language), IELTS (International English Language Testing System), or DET (Duolingo English Testing) Scores per the below requirements. Scores must be submitted directly by the testing service to admissions@cooper.edu.

Deferral of an Offer of Admission in the School of Architecture: Due to the small size of the programs, the deferral of an offer of admission to the Bachelor of Architecture (undergraduate) and/or Master of Science in Architecture (graduate) program is not permitted.

Admission After Three Years of High School: Candidates of exceptional merit may be considered for admission after completion of three years of high school. Engineering applicants must have excellent high school averages and test scores. Art and architecture applicants must have excellent high school records and exceptional ability. A recommendation from the high school principal, at least one recommendation from a teacher and an interview will be required. In accordance with the regulations of individual states, a student may or may not be eligible to receive an Equivalency Diploma after completion of a specific number of credits in appropriate subject areas at The Cooper Union. It is the responsibility of the applicant to investigate his or her state regulations in this regard.

Transfer/The Irwin S. Chanin School of Architecture

You may apply for transfer to The Irwin S. Chanin School of Architecture if:

You have completed at least one year of an accredited architecture program elsewhere by June of the year for which you are applying.

OR by June you hold a bachelor's degree or the equivalent in a discipline other than architecture.

OR
you can submit a portfolio of your creative work and you have begun studies in a discipline related to architecture.

EARLY DECISION

If The Cooper Union is your first choice, you may consider applying early decision. If admitted via early decision you must accept our offer and withdraw your other college applications.

STEP 1 Submit the first part of your application online by Tuesday, December 1, 2020.

STEP 2 You will receive a confirmation email.

STEP 3 You will have to prepare and submit by Tuesday, December 1, 2020:

- Your official high school transcript or GED certificate (required for all applicants)
- Any official college transcripts (sent directly from the college or university)
- Recommendation letter (1 strongly encouraged)
- Official TOEFL, IELTS, or DET scores, if applicable*

STEP 4 You will receive the Studio Test via email on Tuesday, December 8, 2020. You will have approximately one month to complete the test. The Office of Admissions must receive the Studio Test and all application materials no later than Tuesday, January 5, 2021. Extensions are not permitted unless in the case of extenuating circumstances. We highly recommend adding admissions@cooper.edu to your email address book in order to prevent important emails (like your Studio Test and admission decision) from going to spam!

The Studio Test will include portfolio requirements for transfers. All portfolio work should be sent with the studio test.

Please follow all instructions carefully.

STEP 5 You will receive an admission decision by Monday, February 1, 2021.

REGULAR DECISION

STEP 1 Submit the first part of your application online by Tuesday, January 5, 2021.

STEP 2 You will receive a confirmation email.

STEP 3 You will have to prepare and submit by Tuesday, January 5, 2021:

- Your official high school transcript or GED certificate (required for applicants)
- Any official college transcripts (sent directly from the college or university)
- Recommendation letter (1 strongly encouraged)
- Official TOEFL, IELTS, or DET scores, if applicable*

STEP 4 You will receive the Studio Test via email on Tuesday, January 12, 2021. You will have approximately one month to complete the test. The Office of Admissions must receive the Studio Test and all application materials no later than Tuesday, February 9, 2021. Extensions are not permitted unless in the case of extenuating circumstances. We highly recommend adding admissions@cooper.edu to your email address book in order to prevent important emails (like your Studio Test and admission decision) from going to spam!

The Studio Test will include portfolio requirements for transfers.

Please follow all instructions carefully.

STEP 5 You will receive an admission decision by Thursday, April 1, 2021.

If admitted, transfer students are offered admission into a specific year of the five-year design sequence. Placement in the design sequence is a condition of the offer of admission and not subject to further review or appeal. By accepting the offer of admission, the transfer student agrees to this placement and acknowledges his/her anticipated graduation date.**

**Undergraduate applicants whose native language is not English and who have not graduated from a secondary school in a country with English as the official medium of instruction are required to take one the below exams.TOEFL (Test of English as a Foreign Language), IELTS (International English Language Testing System), or DET (Duolingo English Testing) Scores per the below requirements. Scores must be submitted directly by the testing service to admissions@cooper.edu.*

***It will be necessary for the matriculating transfer student to successfully complete the design studio to which he/she is admitted, as well as all subsequent studios, as part of his or her degree requirements. There is no opportunity for transfer students to accelerate through the required design sequence. Transfer applicants from programs other than accredited architecture programs will likely be placed in the first-year design studio (Architectonics). The official academic transcript of a transfer student will be reviewed prior to the student's first registration. This review will determine what, if any, additional coursework may be eligible for transfer credit.*

Deferral of an Offer of Admission: Due to the small size of the programs, the deferral of an offer of admission to the Bachelor of Architecture (undergraduate) is not permitted.

Master of Science in Architecture

The Master of Science in Architecture program (formerly Master of Architecture II*) will serve professionals who wish to continue in practice with higher research and design skills in those areas in which the program offers specialization. It will additionally prepare those who wish to develop parallel careers in teaching and/or continue to engage in research toward an appropriate Ph.D. degree at another institution.

Exciting Update

The Master of Science in Architecture program is now designated as a STEM program, making international M.S. Arch graduates eligible to extend their F-1 visas for up to three years in order to work in the United States.

The Master of Science in Architecture is open to applicants who:

- Hold the degree of Bachelor of Architecture (B.Arch), the Master of Architecture I (M.Arch I) or an equivalent degree from an international institution.
- Have completed a minimum of one year of work experience after obtaining their first professional degree.

Application Deadlines and other application requirements:

To apply for the program starting in Fall 2021, the deadline is Tuesday, January 5, 2021.

Complete the Master of Science in Architecture Application. It must include:

- A nonrefundable application fee of $75
- Official academic records (transcripts) from all colleges and universities from which you have received credit
- TOEFL, IELTS, or DET score is required if you have less than three years of study in English.
- Recommendation letters (three are required)
- Resumé/CV
- Written Essay: The essay should succinctly explain your interest in the Master of Science in Architecture program as well as the specified area of concentration
- Portfolio: Applicants must submit a portfolio via regular mail that includes the most important and representative design and written work. The portfolio should consist of professional, academic and/or scholarly work.

Potential candidates may be required to be available and make necessary arrangements for a personal interview.

While we make every attempt to conduct interviews remotely, any interview expenses will be the responsibility of the candidate.

All application materials can sent to: admissions@cooper.edu (In the subject line of your email, please reference Master of Science in Architecture Application.)

Deferral of an Offer of Admission from the School of Architecture: Due to the small size of the programs, the deferral of an offer of admission to the Bachelor of Architecture (undergraduate) and/or Master of Science in Architecture (graduate) program is not permitted.

*On September 23, 2019, the New York State Education Department approved the name change of the Master of Architecture II program to Master of Science in Architecture.

SCHOOL OF ART

First Year

EARLY DECISION

If The Cooper Union is your first choice, you may consider applying early decision. If admitted via early decision you must accept our offer and withdraw your other college applications.

STEP 1 Submit the first part of your application online by Tuesday, December 1, 2020.

STEP 2 You will receive a confirmation email.

STEP 3 You will have to prepare and submit by Tuesday, December 1, 2020:
- Your official high school transcript or GED certificate (required for all applicants)
- Any official college transcripts (sent directly from the college or university)
- Recommendation letter (1)
- Official TOEFL, IELTS, or DET scores, if applicable*

STEP 4 You will receive the Hometest via email on Tuesday, December 8, 2020. You will have approximately one month to complete the test. The Office of Admissions must receive the Hometest and all application materials no later than Tuesday, January 5, 2021. Extensions are not permitted unless in the case of extenuating circumstances.We highly recommend adding admissions@cooper.edu to your email address book in order to prevent important emails (like your Hometest and admission decision) from going to spam.

The Hometest will include portfolio requirements. All portfolio work should be sent with the Hometest.

Please follow all instructions carefully!

STEP 5 You will receive an admission decision by Monday, February 1, 2021.

REGULAR DECISION

STEP 1 Submit the first part of your application online by Tuesday, January 5, 2021.

STEP 2 You will receive a confirmation email.

STEP 3 You will have to prepare and submit by Tuesday, January 5, 2021:

- Your official high school transcript or GED certificate (required for applicants)
- Any official college transcripts (sent directly from the college or university)
- Recommendation letter (1)
- Official TOEFL, IELTS, or DET scores, if applicable*

STEP 4 You will receive the Hometest on Tuesday, January 12, 2021. You will have approximately one month to complete the test. The Office of Admissions must receive the Hometest and all application materials no later than Tuesday, February 9, 2021. Extensions are not permitted unless in the case of extenuating circumstances. We highly recommend adding admissions@cooper.edu to your email address book in order to prevent important emails (like your Hometest and admission decision) from going to spam!

The Hometest will include portfolio requirements. All portfolio work should be submitted with the Hometest.

Please follow all instructions carefully!

STEP 5 You will receive an admission decision by Thursday April 1, 2021.

**Undergraduate applicants whose native language is not English and who have not graduated from a secondary school in a country with English as the official medium of instruction are required to take one the below exams.*

TOEFL (Test of English as a Foreign Language), IELTS (International English Language Testing System), or DET (Duolingo English Testing) Scores per the below requirements. Scores must be submitted directly by the testing service to admissions@cooper.edu.

Potential School of Art students who have received a preliminary review at National Portfolio Days, which occur after The Cooper Union's regular admission deadline may be invited to apply after the regular admission deadline. All reasonable effort is made by the School of Art Admissions Committee to review these applications in a fair and timely fashion.

Admission After Three Years of High School Candidates of exceptional merit may be considered for admission after completion of three years of high school. Engineering applicants must have excellent high school averages and test scores. Art and architecture applicants must have excellent high school records and exceptional ability. A recommendation from the high school principal, at least one recommendation from a teacher and an interview will be required. In accordance with the regulations of individual states, a student may or may not be eligible to receive an Equivalency Diploma after completion of a specific number of credits in appropriate subject areas at The Cooper Union. It is the responsibility of the applicant to investigate his or her state regulations in this regard.

Transfer/School of Art

You may apply for transfer to The School of Art if:

You have completed 18-60 credits of studio art courses

OR you have previously earned a baccalaureate degree in a discipline other than art

FALL 2021 EARLY DECISION

STEP 1 Submit the first part of your application online by Tuesday, December 1, 2020.

STEP 2 You will receive a confirmation email.

STEP 3 You will have to prepare and submit by Tuesday, December 1, 2020:
- Your official high school transcript or GED certificate (required for all applicants)
- Your official college transcripts (sent directly from the college or university)
- Recommendation letters (2)
- Official TOEFL, IELTS, or DET scores, if applicable*

STEP 4 You will receive a Hometest on Tuesday, December 8, 2020, which you must complete and submit by Tuesday, January 5, 2021.

We highly recommend adding admissions@cooper.edu to your email address book in order to prevent important emails (like your Hometest and admission decision!) from going to spam.

The Hometest will include portfolio requirements. All portfolio work should be sent with the Hometest.

Please follow all instructions carefully.

STEP 5 You will receive an admission decision by Monday, February 1, 2021.

FALL 2021 REGULAR DECISION

STEP 1 Submit the first part of your application online by Tuesday, January 5, 2021.

STEP 2 You will receive a confirmation email.

STEP 3 You will have to prepare and submit by Tuesday, January 5, 2021:
- Your official high school transcript or GED certificate (required for all applicants)
- Your official college transcripts (sent directly from the college or university)
- Recommendation letters (2)
- Official TOEFL, IELTS, or DET scores, if applicable*

STEP 4 You will receive a Hometest on Tuesday, January 12, 2021, which you must complete and submit by Tuesday, February 9, 2021.

We highly recommend adding admissions@cooper.edu to your email address book in order to prevent important emails (like your Hometest and admission decision!) from going to spam.

The Hometest will include portfolio requirements. All portfolio work should be submitted with the Hometest.

Please follow all instructions carefully.

STEP 5 You will receive an admission decision by Thursday, April 1, 2021.

**Undergraduate applicants whose native language is not English and who have not graduated from a secondary school in a country with English as the official medium of instruction are required to take one the below exams. TOEFL (Test of English as a Foreign Language), IELTS (International English Language Testing System), or DET (Duolingo English Testing) Scores per the below requirements. Scores must be submitted directly by the testing service to admissions@cooper.edu.*

***Transfer applicants typically have fewer than 60 credits at another institution.*
An accepted applicant who has previously earned a baccalaureate degree in a discipline other than art will be treated as a transfer student for purposes of evaluating completion of degree requirements and length of time allotted at The Cooper Union to complete the B.F.A.

ALBERT NERKEN SCHOOL OF ENGINEERING

Undergraduate/First Year

EARLY DECISION

If The Cooper Union is your first choice, you may consider applying early decision. If admitted via early decision you must accept our offer and withdraw your other college applications. See below for instructions on regular decision.

STEP 1 Submit your application online by Saturday, November 1, 2020.

Please Note: Applicants are required to have studied chemistry, physics and calculus.

STEP 2 You will receive a confirmation email.

STEP 3 You will have to prepare and submit by Saturday, November 1, 2020:

- Your official high school transcript or GED certificate (required for all applicants)
- Any official college transcripts (sent directly from the college or university)
- 2–3 Letters of Recommendation, with at least one from a STEM course instructor
- Official TOEFL, IELTS, or DETscores, if applicable*

Please respond to all questions in the writing section of The Common Application. We read these thoroughly and ask that you be thoughtful in your responses.

Submit all application materials through the Common Application. If necessary, you may email materials to us at admissions@cooper.edu, though this is not the preferred method.

STEP 4 You will receive an admission decision by December 15, 2020.

STEP 5 Candidate reply date is January 15, 2021.

REGULAR DECISION

STEP 1 Submit your application online by Tuesday, January 5, 2021.

Please Note: Applicants are required to have studied chemistry, physics and calculus.

STEP 2 You will receive a confirmation email from the Office of Admissions.

STEP 3 You will have to prepare and submit the following by Tuesday, January 5, 2021:

- Your official high school transcript or GED certificate (required for all applicants)
- Any official college transcripts (sent directly from the college or university)
- 2–3 Letters of Recommendation, with at least one from a STEM course instructor
- Official TOEFL, IELTS, or DETscores, if applicable*

Please respond to all questions in the writing section of The Common Application. We read these thoroughly and ask that you be thoughtful in your responses.

Submit all application materials through the Common Application. If necessary, you may email materials to admissions@cooper.edu, though this is not the preferred method.

STEP 4 You will receive an admission decision by March 25, 2021.

**Undergraduate applicants whose native language is not English and who have not graduated from a secondary school in a country with English as the official medium of instruction are required to take one the below exams. (Test of English as a Foreign Language), IELTS (International English Language Testing System), or DET (Duolingo English Testing) Scores per the below requirements. Scores must be submitted directly by the testing service to admissions@cooper.edu.*

Admission After Three Years of High School Candidates of exceptional merit may be considered for admission after completion of three years of high school. Engineering applicants must have excellent high school averages and test scores. Art and architecture applicants must have excellent high school records and exceptional ability. A recommendation from the high school principal, at least one recommendation from a teacher and an interview will be required. In accordance with the regulations of individual states, a student may or may not be eligible to receive an Equivalency Diploma after completion of a specific number of credits in appropriate subject areas at The Cooper Union. It is the responsibility of the applicant to investigate his or her state regulations in this regard.

Transfer/Albert Nerken School of Engineering

Preference for transfer is given to those applicants that have completed coursework similar to all of Cooper Union's first year program at another accredited college. The Transfer application can be found on The Cooper Union website.

STEP 1 Submit your application online by Tuesday, January 5, 2021.

STEP 2 You will receive a confirmation email from the Office of Admissions.

STEP 3 You will have to prepare and submit the following by Tuesday, January 5, 2021:

- Your official high school transcript or GED certificate (required for all applicants)
- Your official college transcripts (sent directly from the college or university)
- 2–3 Letters of Recommendation, with at least one from a STEM instructor
- Official TOEFL, IELTS, or DET scores, if applicable*

Submit all application materials through the application on The Cooper Union website. If necessary, you may email them to admissions@cooper.edu, though this is not the preferred method.

STEP 4 You will receive an admission decision by the end of April.

** Undergraduate applicants whose native language is not English and who have not graduated from a secondary school in a country with English as the official medium of instruction are required to take one the below exams. (Test of English as a Foreign Language), IELTS (International English Language Testing System), or DET (Duolingo English Testing)*

HIGH SCHOOL GRADUATION REQUIREMENTS

At The Cooper Union, each school has its own high school graduation requirements for applicants.

The Irwin S. Chanin School of Architecture

High school records must show graduation with a minimum of 19 units* before July 15th of the year for which admission is sought, with required and elective subjects as follows:

Subject	Units Required for Architecture
English	4
History and Social Studies	3
Mathematics (including Trigonometry, Algebra II and Pre-Calculus)	3
Science	3
Other Electives	6
Total Units Required	**19**

Calculus is a required first-year course for all architecture students. Entering first-year students must have completed Mathematics (including Trigonometry, Algebra II, and Pre-Calculus). Any student who has not completed Pre-Calculus in high school must do so during the summer before enrollment and must submit an official transcript documenting successful completion of the course.

School of Art

High school records must show graduation with a minimum of 16 units* before July 15th of the year for which admissions is sought, with required and elective subjects as follows:

Subject	Units Required for Art
English	4
History and Social Studies	2
Mathematics	1
Science	1
Other Electives	8
Total Units Required	**16**

Students who apply while attending high school will be expected to supply transcripts of subjects studied during the first three years of high school (Grades 9, 10, and 11). High school graduates must supply the full four-year record. High school transcripts should be sent during the fall and winter months, but not later than January 18th if supporting a first-year application. Each candidate should make certain that the high school subjects required for his or her major are completed prior to graduation since The Cooper Union will not be able to verify his or her senior program until final transcripts arrive in June or July. This is too late to make up a missing required subject or to make plans for admission to another college. Students who have not fulfilled their application requirements may have their offer of admission rescinded.

Albert Nerken School of Engineering

High school records must show the following:

Subject	Units Required for Engineering
English	4
History and Social Studies	2
Mathematics (including Calculus)	4
Physics	1
Chemistry	1
Other Electives	5-7
Total Units Required	**17 minimum, 19 recommended**

Students in high school will be expected to supply transcripts covering subjects taken during the first three years of high school (Grades 9, 10, and 11). High school graduates must supply the full four-year record. High school transcripts should be sent during the fall and winter months, but not later than January 18th if supporting a first-year application.

Each candidate should make certain that the high school subjects required for his or her major are completed prior to graduation since The Cooper Union will not be able to verify his or her senior program until final transcripts arrive in June or July. This is too late to make up a missing required subject or to make plans for admission to another college. Students who have not fulfilled their application requirements may have their offer of admission rescinded.

In the area of Mathematics, candidates may offer somewhat different patterns of preparation provided they will be ready for the intensive study of Calculus at college. Preparation beyond the listed minimum in Mathematics is highly recommended. College Board Advanced Placement (AP) Mathematics are suitable courses for such further preparation.

**A unit represents a year's study in a subject, with classes meeting at least four times a week in a secondary school.*

INTERNATIONAL APPLICANTS

International students are those who do not hold U.S. citizenship or permanent residency.

The Cooper Union is proud to have a robust international community, comprising approximately 19% of our student body and representing more than 35 countries. Each year The Cooper Union welcomes international students from around the world to study in our undergraduate and graduate programs.

The mission of the International Student Services Office (ISSO) is to provide services and programs for the international community at The Cooper Union. This support includes advisement on immigration, visa matters, work permission, orientation, cultural adjustment, and general resources. ISSO supports the University's overall internationalization and helps facilitate the integration and assimilation of international students into the Cooper Union community.

Financial Aid: International students are not eligible for Federal or State Financial Aid. However, they are eligible for the half-tuition scholarship and additional merit aid.

English Language Proficiency Requirement: Cooper Union does not require TOEFL, IELTS, or DET scores for applicants:

- Whose native language is English
- Who have attended 3 years of high school or more where English is the primary language of instruction
- Who have earned a four-year degree from a U.S. college/university or from a university where English is the primary language of instruction (minimum of three years attendance)

Everyone else is required to submit TOEFL (Test of English as a Foreign Language), IELTS (International English Language Testing System), or DET (Duolingo English Testing) Scores per the below requirements. Your scores must be submitted directly by the testing service to admissions@cooper.edu.

TOEFL (Test of English as a Foreign Language): A minimum score of 600 (paper-based test) or 100 (Internet-based test) is necessary for admission to The Cooper Union. Cooper Union accepts only TOEFL IBT® scores by test administration date (e.g. full test administration results for one sitting) and does not accept MyBest® scores. You may send multiple results for consideration.

IELTS (International English Language Testing System): A minimum score of 7.0 is necessary for admission to The Cooper Union.

DET (Duolingo English Test): A minimum score of 120 on the current DET (or 75 on the DET prior to July 2019) is necessary for admission to Cooper Union.

Make sure the name on your passport matches your name on the application, and on your language scores.

Required Documentation: All high school and college transcripts must be translated into English, notarized and sent to The Cooper Union.

Students planning to attend Cooper Union as an F-1 international student will need a Form I-20. To obtain a Form I-20 from Cooper Union, you will be required to submit an I-20 Request Form with supporting documents to International Student Services Office (ISSO). Please review next steps here.

Additional fees: International students are assessed a fee of $1,005 per semester.

In addition to the international student fee, please click here to review all costs of attendance.

TUITION AND FEES

Undergraduate Tuition

The cost of tuition at The Cooper Union for the 2020-2021 academic year is $44,550. The part time tuition per credit is $1,310 for 2020-2021 academic year. Part-time students will not receive any institutional aid including half-merit scholarship, tuition assistance, innovator, institutional grants, and scholarships.

Starting in the Fall of 2014, all students enrolling for the first time at Cooper Union receive a half-tuition scholarship currently worth $22,275.00 per year ($11,137.50 per semester). Additional financial aid is provided to eligible students to help cover tuition, housing, food, books, supplies etc. The amount of additional aid is based upon a student's demonstrated financial need. Students must file a FAFSA to be considered for additional financial aid. Please note that Cooper Union offers merit scholarships to exceptional students. Also, Cooper Union uses a need-blind admissions process, meaning that a student's ability to pay does not impact the admissions decisions.

Undergraduate students first enrolling at Cooper Union prior to the Fall of 2014, receive a full tuition scholarship valued at $44,550 ($22,275.00 per semester) for the 2020-2021 school year.

Graduate Tuition

School of Architecture 2020-2021: The Master of Architecture II program is a three-semester program. All admitted students will be assessed tuition at the rate of $23,635.00 per semester.

School of Engineering 2020-2021: Students in the Master of Engineering program are charged $1,390.00 per credit; 30 credits total.

Fees and Refunds

PLEASE BE ADVISED THAT ALL FEES ARE SUBJECT TO CHANGE ANNUALLY WITHOUT PRIOR NOTICE.
A nonrefundable application fee of $75.00 is paid by all candidates for admission. Each student enrolled in a degree program pays a mandatory student fee of $960.00 and Lab & Studios Materials fee of $175.00 per semester (Total Fees:$1,135 per semester) for 2020-2021 academic year. For new students, this fee is payable on acceptance of admission and is non-refundable (refundable for Fall 2020 until August 1, 2020). For continuing students, the $1,135.00 fee per semester is mandatory and non-refundable (refundable for Fall 2020 until August 1, 2020).

Continuing students must pay each semester's student fee in accordance with the bill's due date. All fees are subject to annual revision. Students who do not pay the required fee will have their registration cancelled.

Summer 2020 (2019-20 academic year We wish to provide clarity with respect to fees and the Summer Semester. There will be no lab or studio fees this summer and the mandatory student fee of $900 will be reduced by 50% to $450. This amount will be charged for all students regardless of the number of credits in their enrollment.

Refund Process During the first month of the semester financial aid refunds are processed twice a week in order to meet the needs of our students.
After the first month of the semester regular financial aid refunds are processed once a week in accordance to the Finance Department Institutional policy and procedure.

Direct Deposit All student financial aid or student account refund can only be processed through direct deposit. Click here for detailed direct deposit sign up instructions.

Withdrawal Fees Should a student choose to withdraw, tuition can be refunded. It is 100 percent refundable up to the 7th day of class, 50 percent refundable up to the 14th day of class and 25 percent refundable up to the 28th day of class. Thereafter, it is not refundable.

General Lab and Studio Materials Fee A general lab and studio materials fee of $175.00 per semester will be charged to each student's account. This fee covers normal usage, "wear and tear," and basic supplies for laboratory and studio projects. For new and continuing students, this fee is payable on acceptance of admission or semester and is non-refundable.

Student Residence Fees Students electing to live in Student Residence will be responsible for paying the regular housing fees. The fees for the 2020-2021 academic year are $13,410.00 for a double (two students per bedroom) and $14,610.00 for a single (one student per bedroom). The fees cover residence for the fall and spring semesters and may be paid in two parts.

Refund Policy for Student Residence A refund of housing charges resulting from an approved request to cancel the housing agreement will be made in accordance with the following schedule: 100 percent of the total housing charges for the semester if the cancellation request is made prior to August 1 for the subsequent fall semester and December 1 for the subsequent spring semester; 65 percent if made by September 30 for the fall semester and January 31 for the spring; and 35 percent if made by October 31 for the fall and February 29 for the spring. No refunds will be made after these dates.

Students who are evicted from the Student Residence or whose Housing Agreements are terminated for violations of the terms of the Housing Agreement are not eligible for refunds.

Cooper Union Health Insurance It is a requirement that all matriculated students have health insurance coverage. The Cooper Union provides health insurance for all students through The Cooper Union Accident and Sickness plan. The cost of insurance will appear on every student's billing statement. Students who are covered under their own or their parent's insurance policy may choose to waive The Cooper Union Accident and Sickness plan. Please be advised that if you wish to waive the insurance, he insurance you provide must be currently active and will be subject to verification.To enroll or waiver in the health insurance plan, you must access The Cooper Union Accident and Sickness plan online at http://www.wellfleetstudent.com using their Cooper Union ID number.

If you do not complete health insurance waive process with the above insurance company by October 15th, 2019, you will be responsible to all assigned health insurance charges. There will be no exceptions to this policy.

International Student Fee International Students (those who are non-citizens or who are not permanent residents) are responsible for an additional non-refundable fee of $1,005 per semester.

Graduation Fee A graduation fee of $250 is required of all students entering their first semester of their undergraduate/graduate senior year at The Cooper Union. This fee is payable upon registration for the senior year and is refundable if a student fails to meet graduation requirements that year.

Special Fees

A charge of $100 will be made for late payment of the student fee.
A charge of $25 will be made per occasion involving change of section or registration program.
A fee of $100 shall be incurred for late registration.
A bill payment plan fee of $50 per semester will be charged to your account at the time of payment plan enrollment.
The Cooper Union reserves the right to change its fees at any time.

Graduate Student Maintenance of Matriculation Fee The requirements for the Master of Engineering program must be completed within two years of admission to graduate status, except with the expressed consent of the Dean of Engineering. Requests for extension must be presented in writing to the Dean in the final semester of the second year. In addition, approval must be granted from the student's thesis adviser. Master's students who receive approval to extend their studies beyond two years will be assessed a maintenance of matriculation fee of $3,000 per semester.

Tuition/Housing Payment Plan Instructions Payment plans are available for students or tuition and housing fees. The tuition and housing fees can be paid in 4 installments. A $50 payment plan enrollment fee (per plan) will be added to your total bill. A $100 late payment fee will be assessed for each late payment. A $25 returned payment fee will be charged to your account.

Financial Aid Recipients You may elect to apply expected sources of financial aid and/or loans towards the tuition and housing fees. You are responsible for completing and submitting the required paperwork to the Financial Aid Office. Please contact the Financial Aid Office for more information. Students expecting outside scholarships may apply these amounts to the installment plan when the scholarship is received. International payments (any payments made from foreign accounts) may be made by: https://www.flywire.com/pay/cooper.

THE IRWIN S. CHANIN SCHOOL OF ARCHITECTURE

About

The mission of The Irwin S. Chanin School of Architecture is to provide for its students the finest professional education available within an intellectual environment that fosters and expands their creative capacities and sensibilities and establishes the foundation for a creative professional life. The school is committed to the belief that one of society's prime responsibilities is toward learning and education in the deepest sense: that the exercise of individual creativity within a willing community is a profoundly social act. Fundamental to the mission of the school is the maintenance of an atmosphere in which freedom of thought and exploration can flourish, where students can explore and utilize their strengths and individual talents, interests and modes of working, to their highest potential.

BACHELOR OF ARCHITECTURE

The Bachelor of Architecture curriculum of the School of Architecture is designed to provide the student with a comprehensive educational experience, gaining knowledge and skills in preparation for the successful and ethical practice of architecture. Design studios and courses build cumulatively over the five years in order to establish a broad and deep foundation of knowledge in architecture and urban design in relation to developments in the sciences, arts, and technology. The curriculum stresses the importance of architecture as a humanistic discipline concerned with the design and construction of habitats in diverse social and ecological conditions, and their corresponding requirements for sustainability and ethical responsibility.

The traditional and essential skills of drawing, model-making and design development are complemented by a full investigation of the analytical and critical uses of digital technologies. The study of world architecture and urbanism is deepened by the understanding of individual cultures, environmental, and technological issues at every scale. The theory of the discipline, past and present, is investigated through the close analysis of critical texts and related to the theory and practice of other arts, such as public art, film and video. The position of the School of Architecture, together with the Schools of Art and Engineering and the Faculty of Humanities and Social Sciences, offers a unique opportunity for interaction and interdisciplinary research and experience.

In recent years the school has developed the studio curriculum in ways that have reinforced its strong traditions of design and craft while investigating problems that reflect the changing conditions of contemporary practice, the urgent issues resulting from rapid urbanization and the need for environmental and cultural conservation. In these studio experiments students and faculty together explore the potential contributions of architecture to our changing world, redoubling their efforts to imagine a positive future for an architecture that is, after all, a discipline of design. This task does not involve a wholesale rejection of the past—our traditions and historical experience—for what has changed are not the principles, but rather the determinants and the materials of design. We are in the process of re-learning the poetics of a space of life: of air and water, of geology and geography, of culture and society, of poetics that lie deeply within these elemental forces. On this re-framing—programmatically, technologically, and above all formally—rests not simply the future of architecture, but of our life in the world. Gradually, out of this process, architecture, once more, may become a force through which life is transcribed into art in order to enhance life.

The five year professional program is framed within the context of a rigorous liberal arts education that includes a wide range of required and elective courses in the Humanities and Social Sciences, together with elective opportunities in the Schools of Art and Engineering, emphasizing the nature of architecture as a cultural, social, and technological practice intimately tied to the increasingly urgent questions raised by the man-made and natural environment.

First Year

The First Year is conceived as a broad introduction to society, culture, environment, and the nature, place and role of architecture in this context. The student is introduced to the principles and experience of drawing and representation in a broad range of media and formats: freehand drawing is taught side by side with projective geometry (hand constructed and computer generated), and other means of architectural representation. The Architectonics Studios encourage the investigation of space, structure, and form, as inflected by the occupation and movement of the human body, and situated in the context of environments from natural to urban. The first two semesters of the History of Architecture sequence take the student through the global developments in architecture from Antiquity to the end of the Medieval Period, with special attention to non-western and traditional architectures. The First year of the Humanities and Social Sciences Core emphasize the student's reading, writing, and analytical skills through the study of literary, historical, and sociological texts.

Second Year

The Second Year advances the student's knowledge of architecture historically, culturally, and professionally. The Second Year Design Studios are dedicated to the examination, through analysis and design exercises, of the "elements" of architecture and their assemblage, including sites and its ecological conditions, program, spatial accommodation and organization structure and environment. The first segment of the structures sequence introduced students to the principles of architectural structure. The second two semesters of the History of Architecture sequence examine the history of global architecture from the Renaissance to the present, with special emphasis on the complex environmental relations between increasingly industrialized and developing societies. The second year of the Humanities and Social Sciences core advances the students' knowledge of writing and analytic skills with in-depth courses in literature, history, and philosophy.

Third Year

The Third Year is envisaged as a comprehensive experience of the discipline in design and professional knowledge, supplemented by a range of required and elective courses in environmental, technological, and humanistic subjects, forming an integrated introduction to the environmental, social, and programmatic understanding of design. The Third Year Design Studios build from analysis to synthesis, from analyses of total building assemblages and smaller-scale design exercises, to the development of a comprehensive design for a complex programmatic institution. To this end, the faculty responsible for the teaching of environmental technology, building technology, and structures join the design faculty as teachers in the design studio, with students bringing appropriate aspects of their design proposals for elaboration within the specialized courses.

Fourth Year

The Fourth Year broadens the study of architecture, placing it within its diverse urban and rural contexts, with students gaining advanced knowledge of technological, structural, and professional concerns, the planning, zoning, social and cultural implications of architectural interventions. The Fourth Year Design Studios study the relation of institutional architecture to urban networks and infrastructures, public space, and typologies, from the investigation of rebuilding strategies following disasters, the role and nature of tall buildings, the nature of public and private institutions. The study of landscape is emphasized, both as large-scale natural environments and smaller scale site developments. A broad spectrum of specialized elective courses, including Modern Architectural Concepts, Analysis of Architectural Texts, Landscape, Advanced Topics in Environmental Studies, History, Theory and Criticism, Advanced Concepts in the related arts and professional ethics, deepens the understanding of the profession, and its relationship to different cultures and environmental context.

Fifth Year

The Fifth Year is constructed around the student's development of their individual thesis project, and the in-depth study of professional practice in all its aspects. The year-long Thesis is divided into two stages over two semesters, with intensive research followed by a comprehensive design. The subjects of the thesis vary in scale and context, with the proviso that the student investigates a problem of fundamental importance to contemporary life and architecture, identified as a site for the intervention of design as an ameliorative construct. Overall the design thesis emphasizes the profound relationship of architecture to the broader problems of the environment and ecological sustainability, whether at the scale of desertification and rising sea-waters brought on by global warming, the provision of unpolluted water to developing communities, to the smaller scales of urban signification, mobility, and programmatic re-use. The course in professional practice surveys the questions of licensing, internship and IDP participation, and introduces students through site visits to a range of practices and public hearings.

MASTER OF SCIENCE IN ARCHITECTURE

The Master of Science in Architecture, formerly known as Master of Architecture II, is a post-professional degree program launched in 2009 to extend the vision and intellectual rigor of the undergraduate program and allow a further development of the school's preeminent position in the education of architects. It is open to applicants with a first professional degree in architecture (Bachelor of Architecture or Master of Architecture I) from a program accredited by the NAAB or equivalent accrediting agency in another country.

Applicants are required to complete a minimum of one year of work experience after obtaining their first professional degree before applying to the program. The design studio serves as a major component of the program. Seminars address issues particular to the interdisciplinary environment of the graduate program, making use of the varied resources offered by The Cooper Union.
While the Master of Science in Architecture program is studio based, concentrations in one or a combination of three areas are offered: theory, history and criticism of architecture, urban studies and technologies. Prospective students will declare their area(s) of concentration during the application process.

In addition to the existing curriculum of Advanced Design Studio work that culminates in a , advanced level seminars and workshops offer an intensive one-year immersion in the criticism, history and theory of architecture. Emphasis is placed on approaches to architectural analysis and history, the role and contemporary relevance of theory, and the relations between theory and design. Seminars will offer students preparation for careers in journalism, teaching, and eventual doctoral studies, with a broad understanding of the cultural conditions of architectural production and a concentration on excellence in writing. Analysis studios provide a deep insight into the formal and programmatic diversity of historical and contemporary architecture, the process of design, and potential avenues for new approaches towards theory and practice. A required emphasis in Urbanism or Technologies of Representation allows for deeper investigation into specific areas of historical or contemporary architectural theory.

Faculty directly engaged with the Master of Architecture II program in studios and seminars for the current year include Diana Agrest, Hayley Eber, Pablo Lorenzo-Eiroa, Will Shapiro, Anthony Vidler, Michael Young, Tamar Zinguer and Guido Zuliani.

Recent guest lecturers and visiting critics have included Aaron Sprecher (McGill University), Mary McLeod (Columbia University), Timothy M. Rohan (University of Massachusetts), Spyridon Papapetros (Princeton University), Alessandra Ponte (Université de Montréal), Dietrich Naumann (Brown University), Caroline A Jones (MIT), Brandon Clifford (MIT), Mariana Ibanez (MIT), Peter Laurence (Clemson University), Jean-Louis Cohen (Princeton University), Mario Carpo (Yale University), Andrew Saunders (University of Pennsylvania) and Anthony Richard Acciavatti (Columbia University), among others.

Theory, History and Criticism of Architecture
Considers questions concerning the theory and criticism of modernism and contemporary architecture, the philosophy and aesthetics of architecture, the mediatization of architecture and broader cultural and historical issues through the critical readings of texts, the development of critical projects and a written thesis.

Urban Studies
Addresses issues central to the design, planning and development of cities and regions, including study of the morphological, social and cultural effects of globalization; the survival of local urban cultures; redevelopment of central cities, suburbs and exurbs; and issues specific to New York and comparative cities.

Technologies

Focuses on technological issues of architectural design, representation, planning and production, such as the impact of new information technologies, new materials and manufacturing processes; hardware and software development; mapping and modeling techniques; and the technologies of fabrication as they influence new design strategies. This area focuses as well on the economic, ethical and technological dimensions and design potentialities of sustainability and developments in new structural systems, materials and building assemblies.

Eligibility

All applicants to the Master of Science in Architecture program must 1) hold the professional degree of Bachelor of Architecture (B.Arch.), the professional degree of Master of Architecture (M.Arch. I) or an equivalent accredited professional degree in architecture from a foreign institution; and 2) have completed a minimum of one year of work experience after obtaining their first professional architectural degree. The program is structured to be completed in two full-time consecutive semesters with a final thesis semester during the subsequent summer session. See the Academic Calendar on pages 2-3 for information on the Fall and Spring semesters. The Summer semester runs from June-early September (after Memorial Day until the date of the Master of Architecture II final Thesis review and exhibition opening during the second week of September). Final thesis presentations will take place during the second week of September at the end of the student's year of study. Graduate students must complete all 30 credits of the Master of Architecture II degree requirements in full-time contiguous resident study at The Cooper Union.

CURRICULUM

Bachelor of Architecture Professional Degree

The School of Architecture offers a five-year program leading to the Bachelor of Architecture, a first professional degree which is accredited by the National Architectural Accrediting Board (NAAB). The architecture curriculum is designed to prepare students for a breadth of opportunities in the profession, offering a broad cultural and intellectual foundation in the liberal arts as they relate to the design of the environment at all scales. The discipline of architecture interpreted as a cultural practice is seen as a basis for a fully-rounded education at the undergraduate level. Students develop their knowledge and design skills within a framework of studios and courses that stimulate research and debate into the nature and role of architecture as a cultural practice with profound social and environmental implications.

The content of the curriculum, based on a wide cultural view of architecture, reflects broad ethical values. Faculty-student interaction is conducted on an intensive basis in the design studio and other classes. Within this framework faculty members encourage students to develop their individual interests and strengths, with a constant stress on fundamentals and a basic commitment. This is intended to equip the graduate with a lasting ability to produce an architectural design that is a meaningful synthesis of the social, aesthetic and technological. The relationship between architecture and other creative disciplines is stressed through the five years. Students are encouraged to express themselves both verbally and visually.

In a moment where the nature, role and scope of the architect is rapidly assuming new directions and dimensions in both the social and technological domains, the school emphasizes the principles of design and their underlying human values, while preparing students to respond positively to change. The program seeks to engender a strong sense of the responsibilities of service and leadership, team-work and individual creativity essential to the development of principled professionals dedicated to interpreting and constructing the spatial needs of the community. The five-year design sequence is carefully structured to introduce the student to the principles of architectonics, the investigation of program and site, structures and environmental and building technologies, in a comprehensive and integrated curriculum. The studios comprise an introduction to the basic elements of form, space and structure; complex institutional design problems in their urban context; and a year-long thesis that demonstrates the student's ability to synthesize a comprehensive understanding of architecture in society. The essential skills of drawing, model-making and design development are complemented by a full investigation of the analytical and critical uses of digital technologies. The study of world architecture and urbanism is deepened by the understanding of individual cultures, environmental and technological issues at every scale. The theory of the discipline, past and present, is investigated through the close analysis of critical texts and related to the theory and practice of other arts, such as public art, film and video. The position of the School of Architecture, together with the Schools of Art and Engineering and the Faculty of Humanities and Social Sciences, offers a unique opportunity for interaction and interdisciplinary research and experience.

The Cooper Union's location in New York City in the heart of downtown Manhattan provides a stimulating professional, social and cultural context for the education of an architect and an urban laboratory for the study of design in society. The numerous cultural institutions of the city provide an inexhaustible resource for research and experience outside the studio and classroom.

The school's faculty includes nationally and internationally recognized architects; the school's diverse student body consists of highly talented and motivated individuals and its distinguished alumni are leaders in architecture and related fields.

Master of Science in Architecture Post-Professional Degree

The Master of Science in Architecture, formerly known as the Master of Architecture II, is a post-professional degree program launched in 2009 to extend the vision and intellectual rigor of the undergraduate program and allow a further development of the school's preeminent position in the education of architects. It is open to applicants with a first professional degree in architecture (Bachelor of Architecture or Master of Architecture I) from a program accredited by the NAAB or equivalent accrediting agency in another country.

The program serves professionals who wish to continue in practice with higher research and design skills in those areas in which the program offers specialization. It additionally prepares those with first professional degrees who wish to develop parallel careers in teaching and/or continue to engage in research toward an appropriate Ph.D. degree at another institution.

Applicants are required to complete a minimum of one year of work experience after obtaining their first professional degree before applying to the program. The design studio serves as a major component of the program. Seminars address issues particular to the concentrations as well as other topics making use of the interdisciplinary resources offered by The Cooper Union.

Concentrations in one or a combination of three areas are offered: theory, history and criticism of architecture, urban studies and technologies. Prospective students will declare their area(s) of concentration during the application process.

DEGREE REQUIREMENTS

Bachelor of Architecture

The Irwin S. Chanin School of Architecture offers a five-year program leading to the Bachelor of Architecture degree. The degree requirements are intended to provide students with a rigorous training in and exposure to the creative and technical aspects of architecture. The professional courses in the curriculum are supplemented and enhanced by required courses both within and outside the discipline of architecture. The requirements are:

First Year		Sem 1	Sem 2
ARCH 103	Calculus and Analytic Geometry	3	-
ARCH 111	Architectonics	4	4
ARCH 115	History of Architecture I	3	3
ARCH 117	Representation I, II	3	3
ARCH 106	Concepts of Physics	-	3
FA 100RA	Shop Tech	1	1
HSS 1	The Freshman Seminar	3	-
HSS 2	Texts and Contexts: Old Worlds and New	-	3
Total Credits		17	17

Second Year		Sem 1	Sem 2
ARCH 121	Design II	5	5
ARCH 122	Structures I	2	2
ARCH 124	Environments	2	2
ARCH 125	History of Architecture II	3	3
ARCH 127	Representation III, IV	3	3
HSS3	The Making of Modern Society	3	-
HSS4	The Modern Context: Figures and Topics	-	3
Total Credits		18	18

Third Year		Sem 1	Sem 2
ARCH 131	Design III	5	5
ARCH 132	Structures II	2	2
ARCH 133	Introduction to Urban History and Theories	-	2
ARCH 134	Environmental Technologies	3	3
ARCH 135	Building Technology	2	2
	Electives*	3	3
Total Credits		15	17

Fourth Year		Sem 1	Sem 2
ARCH 141	Design IV	5	5
ARCH 142	Structures III	2	2
ARCH 143	Construction Management	1	1
	Electives*	5	5
Total Credits		13	13

Fifth Year		Sem 1	Sem 2
ARCH 151	Thesis	6	6
ARCH 152	Structures IV	2	-
ARCH 154	Professional Practice	2	2
ARCH 205/225	Advanced Concepts/Topics	2	2
	Electives*	5	5
Total Credits		17	15

Total Credit Requirements for B.Arch Degree 160

**The bachelor of architecture curriculum includes 27 credits of REQUIRED coursework in general studies (non-professional coursework outside the discipline of architecture). In addition to general studies, students also complete 26 ELECTIVE credits. The elective component can be fulfilled by elective courses in subject areas such as architecture, humanities and social sciences, visual arts, mathematics, engineering, science and languages. Among the elective credits, at least six elective credits must be completed in humanities and social sciences. Additionally, a minimum of seven elective credits must be completed outside the discipline of architecture for a total of thirteen elective credits in general studies.*

Minor Architecture students in good academic standing with advance permission who complete a minimum of 15 upper-division credits in a specific field of liberal arts may qualify for a minor in that field of humanities and social sciences. Minors are offered and will be designated on student transcripts in the following fields: Art History; Economics and Public Policy; History and Society; Literature; and Science, Technology, and Society. Students must apply in advance of completing their course-work to be considered for the minor. Approval of the dean of the school of architecture is required for the minor. Additional information is available from the office of the dean of humanities and social sciences.

Master of Science in Architecture

All applicants to the Master of Science in Architecture program must 1) hold the professional degree of Bachelor of Architecture (B.Arch.), the professional degree of Master of Architecture (M.Arch. I) or an equivalent accredited professional degree in architecture from a foreign institution; and 2) have completed a minimum of one year of work experience after obtaining their first professional architectural degree. The program is structured to be completed in two full-time consecutive semesters with a final thesis semester during the subsequent summer session. See the Academic Calendar for information on the Fall and Spring semesters. The Summer semester runs from June-early September (after Memorial Day until the date of the Master of Architecture II final Thesis review and exhibition opening during the second week of September). Final thesis presentations will take place during the second week of September at the end of the student's year of study. Graduate students must complete all 30 credits of the Master of Science in Architecture degree requirements in full-time contiguous resident study at The Cooper Union.

Courses		Credits
Semester 1 (Fall)		
ARCH 411	Graduate Research Design Studio I	6
ARCH 401	Proseminar	2
FA 100R	Introduction to Techniques	0
	Seminar in concentration	2
	Seminar out of concentration	2
Total Credits First Semester		**12**
Semester 2 (Spring)		
ARCH 412	Graduate Research Design Studio II	6
ARCH 402	Thesis Research Tutorial	2
FA 100R	Introduction to Techniques	0
	Seminar in concentration	2
	Seminar out of concentration	2
Total Credits Second Semester		**12**
Semester 3 (Summer)		
ARCH 413	Graduate Thesis (written or studio)	6
Total Credit Requirement for M.Arch II Degree		**30**

Thesis In April of the spring semester prior to advancing to Arch 413 Thesis, each student will be required to present an elaboration of his or her thesis topic and program for review and acceptance by the faculty. Final thesis presentations will be made during the first week of fall semester following the student's year of study.

Seminars Out of Concentration It is recommended that students register for courses originating in the graduate program (Arch 482, Arch 483 and Arch 485) to satisfy their out-of-concentration seminar requirements.

Graduate courses in the Albert Nerken School of Engineering as well as select upper level undergraduate elective courses could be made available to Master of Architecture II students with prior permission from the student's academic adviser and the individual course instructor. Undergraduate courses may be used to satisfy requirements for out-of-concentration coursework only.

ACADEMIC STANDARDS AND REGULATIONS

Credits

Only those students who are officially registered in a course (i.e., by approval of the dean of the School of Architecture or a faculty adviser and notification of the Office of Admissions and Records) will have grades and credits entered on their records.

Satisfactory Progress Toward Degree

The bachelor of architecture degree program is a rigorous course of study that seeks to prepare students intellectually and professionally for the investigation and making of architecture. The privilege of studying at The Cooper Union, with the benefit of a 50% tuition scholarship for all admitted undergraduate students, brings with it important responsibilities. For students in the School of Architecture, these responsibilities include meeting the requirements of a demanding professional curriculum.

All students who accept our offer of admission are expected to fully commit themselves to completing the degree requirements in accordance with the curriculum, which has been designed with great attention to sequence, prerequisites and the relationships between course work and the goals of each design studio. All classes that comprise the curriculum are essential to the education of an architect, and must be successfully completed by each student in the year and sequence intended. Students admitted as freshmen will complete the program in five years; transfer students will complete the program in accordance with their placement in the design sequence.

Students who do not successfully complete required courses as outlined in the curriculum will not be permitted to advance to the next year of study until the missing requirement(s) is/are completed. Since make-up classes are not offered at The Cooper Union, missing requirements may need to be fulfilled through coursework taken outside The Cooper Union. The intention to complete requirements outside The Cooper Union requires a meeting with the appropriate academic adviser or faculty member in order to obtain advance approval of the potential substitute course, and to confirm the minimum grade required in order for transfer credit to be awarded. It is the responsibility of the student to locate an eligible course at a college/university that allows part-time/summer study; the approved course will be taken at the student's expense. Students making up courses in this manner will be permitted to register for Cooper Union classes in September only after the Office of Admissions and Records receives a transcript showing the successful completion of these courses. It is in the best interest of each student to complete their coursework here at Cooper Union in conformance with the approved curriculum.

A student must pass a sufficient number of credits each semester to complete his or her degree requirements within five years of study. When dropping or adding courses, a student must follow all degree requirements for their particular year of study. The normal course load is 15–19 credits per semester. Stu-dents are required to be registered for a minimum of 12 credits per semester. Failure to maintain satisfactory progress toward the degree may be grounds for dismissal.

Students are eligible to register for more than 18 credits per semester, but not more than 20, if they have received at least a 3.0 rating for the previous semester.

Transfer Students

When admitted, transfer students are offered admission into a specific year of the five-year Design sequence. Placement in the Design sequence is a condition of the offer of admission and not subject to further review or appeal. By accepting the offer of admission, the transfer student agrees to this placement and acknowledges his/her anticipated graduation date. There is no opportunity for transfer students to accelerate through the required Design sequence.

Placement in the Design studio sequence is the only transfer credit evaluation made at the time of the offer of admission. Independently of Design studio placement, transfer students must fulfill all of their B.Arch. degree requirements either through transfer credit or by completing required and elective coursework here. Transfer credit evaluation for required and/or elective coursework in the B.Arch. curriculum,

other than the Design studio, is the responsibility of the individual transfer student. Transfer students are required to have all other previous courses individually evaluated for transfer credit. It may not be possible for transfer students to complete all academic coursework simultaneously with their Design studio requirements. It will be necessary for the matriculating transfer student to successfully complete the design studio to which he or she is admitted, as well as all subsequent studios, as part of his or her degree requirements. The official academic transcript of a transfer student will be reviewed prior to the student's first registration. This review will determine what, if any, additional coursework may be eligible for transfer credit.

Transfer Credit Incoming students who have completed college-level academic work outside The Cooper Union may be eligible to receive transfer credit. Approval of transfer credit will be made by the appropriate dean or faculty based on transcripts from other schools and additional materials, including a course description, a course syllabus with topics and course requirements, a reading list and any quizzes, examinations, papers or projects, etc., that demonstrate the level, content and requirements of the course, as well as the student's proficiency with the course topics. If necessary, a proficiency/placement exam may be administered in certain subject areas. Transfer students must be prepared to present these and other requested materials for each course for which transfer credit is sought. Transfer credit evaluation must be completed by the end of the first semester of study.

Currently enrolled students who find it necessary to complete degree requirements at another institution for transfer credit to The Cooper Union must have appropriate advance approval.
Credit may be granted for work done at another institution by any student upon examination by the dean. This credit is to be recorded after satisfactory completion of one semester's work at The Cooper Union.

Grades

Grades used, with their numerical equivalents, are: A (4.0), A- (3.7), B+ (3.3), B (3.0), B- (2.7), C+ (2.3), C (2.0), C- (1.7), D+ (1.3), D (1.0), D- (.7), F (0).

The assigned numerical equivalents are used in computing semester and annual ratings by multiplying the numerical equivalent of the grade for each subject by the credits assigned to the subject. The sum of such multiplications for all the subjects carried by a student is divided by the total credits carried by him/her for that period to determine the average rating.

The official meanings for letter grades are as follows:

A Outstanding performance
B Above average performance
C Requirements satisfactorily completed
D Minimum requirements met; passing but unsatisfactory
F Failure to meet the minimum requirements of a subject
I The designation I indicates that the work of the course has not been completed and that assignment of a grade and credit has been postponed.

An **I** designation is permitted only in cases of illness (confirmed by a physician's letter) or documentation of other extraordinary circumstances beyond the student's control.

The deadline for removal of an I designation will be determined by the instructor and recorded at the time the designation is given, but will not be later than two weeks after the start of the next semester. If the I is not removed within the set time limit, either by completing the work in the subject or by passing a reexamination, the I will automatically become an F unless the dean of the School of Architecture extends the time or the student withdraws from school. The designation of I will be granted only with the approval of the dean.

W The student has received permission from the instructor and the dean of the School of Architecture and has withdrawn from a course while passing the course requirements at the time of withdrawal. This permission must be obtained before the end of the sixth week of the semester. The grade is not included in the calculation of the student's semester rating (grade point average) but remains on the student's transcript. (See Change of Program: Withdrawing from a Course) Students are not permitted to withdraw from required classes.

WF The student has received permission from the dean of the School of Architecture and the instructor and has withdrawn from a course while failing the course requirements at the time of withdrawal. This permission must be obtained before the end of the sixth week of the semester. This grade is included in the calculation of the student's semester rating, its numerical equivalent is 0, and it remains on the student's transcript. (See Change of Program: Withdrawing from a Course).

When appropriate, certain courses may be designated as Pass/Fail courses.

Pass Requirements completed. This designation is not included in the calculation of the student's semester rating.
Fail Failure to meet the minimum requirements of a course. This grade is included in the calculation of the student's semester rating; its numerical equivalent is 0.

Automatic Probation/Final Probation

The Academic Standards Committee meets following the end of the Fall and Spring semesters to review the academic records/status of students on automatic probation and, as necessary, final probation. These students will be informed of the meeting in order to have the opportunity to appear before the Committee.

Studio Grades, Grade Point Average and Probation A student who receives a semester grade point average below 2.0 will be placed on automatic probation and may be the basis for final probation or dismissal, as determined by the Academic Standards Committee.

A student who receives a grade less than C in Architectonics, Design or Thesis will be placed on automatic probation and may be the basis for final probation or dismissal, as determined by the Academic Standards Committee.

A student who receives a grade of C- in Architectonics, Design or Thesis may be required by the Academic Standards Committee to repeat the studio.

A student who receives a grade of D+, D or D- in Architectonics, Design or Thesis will be placed on automatic probation and will be required to repeat the studio. If, in addition, the student has a semester rating below 2.0 the Academic Standards Committee may place the student on final probation. The Academic Standards Committee may also set further academic and/or grade requirements for the student.

A student who receives an F in Architectonics OR Design II, if Design II is the student's first design studio at The Cooper Union will be placed on probation and will be required to repeat the studio. The student will be required to receive a grade of C+ or better in the repeated class.

General Probation Rules A student placed on automatic probation may be subject to academic requirements as determined by the Academic Standards Committee.

A second probation may result in final probation or the dismissal of the student as determined by the Committee. The Academic Standards Committee may place a student on final probation.

A student on probation may not be registered for more than 18 credits a semester.

Final Probation A student may not be placed on final probation before the end of his/her third semester, regardless of whether the student is in Architectonics or Design II.

A student who receives an F in Design or Thesis will be placed on final probation and will be required to repeat the studio. The student will be required to receive a grade of C+ or better in the repeated class. A student who fails to meet this condition may be dismissed by the Academic Standards Committee.

A student on Final Probation who receives a semester rating below 2.0 and/or a grade less than C in Design or Thesis at any point in the remainder of his or her academic career in the School of Architecture will be automatically and permanently dismissed from The Cooper Union with a forfeit of the right of appeal.

At the Academic Standards Committee meeting immediately following automatic dismissal, the Academic Standards Committee may decide to reconsider cases of automatic dismissal and may rescind the dismissal of a student allowing the student to continue the course of study in the School of Architecture. In the case of automatic dismissal being rescinded, the Academic Standards Committee may establish performance requirements for the remainder of their education at the School of Architecture.

Automatic dismissal on final probation (not rescinded by the Academic Standards Committee) unconditionally and irrevocably terminates a student's academic career in the School of Architecture. A student dismissed on final probation (or permitted to withdraw on final probation) cannot apply or petition for readmission to the School of Architecture.

Failing and/or Repeating Design Studio Each student is responsible for his or her total accomplishment and for being continuously aware of the standards defined in the preceding paragraphs. Students whose work by mid semester indicates possible failure to meet the minimum standards of a course, including excessive absences, may be so informed and should arrange to meet with their respective faculty to address the matter in detail.

A student may not repeat any Design studio (or Architectonics and Thesis) more than once. Any student who fails Arch 151 (Thesis) twice will be dropped automatically from the program.

A student may not fail Architectonics, Design or Thesis throughout the five years more than two times in total. A third grade of F in any of these courses will result in automatic dismissal.

Additional credits for any repeated Design studio (including Architectonics or Thesis) remain on a student's transcript, but do not count towards the 160 credits required for the B.Arch. degree

Change of Grade

A change in an official grade of record cannot be made by the dean of admissions and records without the express consent of the dean of the School of Architecture except as defined here. The dean of admissions and records will automatically convert an I designation to an F if an official change of grade is not submitted within the two-week deadline after the start of the following semester. A grade change is not permitted after the end of the subsequent semester.

Change of Program

Adding a Course A student is permitted to add a course only during the first week of a semester, during the drop/add period, and only with the dean's approval.
Adding a course after the drop/add period is not permitted even if the student has been attending the class.

Dropping a Course A student may drop a course during the first week of the semester, during the drop/add period, with the dean's approval. A student who wishes to drop a course may be required to add equivalent credits in an-other course as needed to maintain satisfactory progress towards the degree.
A course dropped during the first week of the semester will be deleted from the transcript.

Withdrawing from a Course After the drop/add period a student may withdraw from a course through the sixth week of the semester, with the dean's approval. It is the student's responsibility to obtain the necessary permission from the School of Architecture and to notify the instructor in order to withdraw from a course. If the student is passing the course at the time of withdrawal, a grade of W will appear on the transcript. If the student is failing the course at the time of withdrawal, a grade of WF will be recorded.

Failure to attend a class does not constitute withdrawal; a student who fails to attend a class without formally withdrawing will earn a grade of F in the course. A student may not withdraw from a course to avoid receiving a failing grade.

A student is not permitted to drop or withdraw from a course necessary to maintain satisfactory progress towards the degree.

Attendance

Classes and studios are scheduled Monday through Friday between 9 am and 10 pm. Studio facilities usually are available to students on Saturdays and Sundays throughout the academic year. Each student is required to be punctual and to attend each scheduled class. In the case of unavoidable absence, the student should, on his or her return, report to the instructor to explain the absence and inquire about making up the lost work.

All architecture students are provided with studio space and are expected to work in the studio during regular business hours.

Leave of Absence

A leave of absence is generally granted between the second and third years or the fourth and fifth years of study. A meeting with and permission from the dean of the School of Architecture is necessary.

Students in good academic standing and making satisfactory progress toward the degree only may request a leave of absence.

Students who have completed at least one year of study and need to interrupt their studies may be granted a leave of absence for up to one year by permission of the dean.

Mandatory Leave of Absence If it is not possible for the student to make significant progress towards the degree requirements in the semester prior to repeating the studio course (as determined by the Academic Standards Committee and/or the dean), the student will be placed on a mandatory leave of absence for one semester and will resume his or her studies in the following semester by repeating the required studio and enrolling in other classes for a total registration of at least 12 credits. If a student is permitted to continue in lieu of repeat-ing and/or a mandatory leave of absence, the student will do so as per the instructions of the Academic Standards Committee. In both cases, the student's registration must be approved by the dean.

Readmission Students who have withdrawn from the School of Architecture after having completed at least one year of study at The Cooper Union must reapply to the School of Architecture to be considered for readmission as a transfer applicant. Students who have withdrawn from the School of Architecture before they have completed one year of study at The Cooper Union must reapply through the freshman admission procedure.

Students who have been dismissed by the Academic Standards Committee or to whom the Academic Standards Committee has given permission to withdraw in lieu of dismissal and are eligible for readmission must apply within two years to the chair of the Academic Standards Committee before May 15 for admission in September and before November 15 for admission in January. Applicants must be prepared to demonstrate a change from the circumstances that warranted their dismissal.

Former students who have been dismissed by the Academic Standards Committee or to whom the Academic Standards Committee has given permission to withdraw in lieu of dismissal and who have been out of The Cooper Union for more than two years (four semesters) must apply through the regular admission procedure at the time of anticipated return. If offered admission, previous Cooper Union credits earned may be evaluated for transfer credit.

Residence

A student must spend a minimum of four semesters in full-time resident study at The Cooper Union to be eligible for graduation with a Bachelor of Architecture Degree. A candidate for a degree must be enrolled and in residence during the entire academic year immediately preceding the granting of the degree.

A student must complete all curriculum requirements for the Master of Architecture II degree program while in residence during three contiguous and consecutive semesters of study (Fall, Spring, Summer) to be eligible for graduation with the Master of Architecture II.

A student must have a cumulative grade point average of 2.0 or better in order to graduate from the School of Architecture.

Graduation

Students are responsible for their total accomplishment and for being continuously aware of the standards for graduation. A student must complete all curriculum requirements for the Bachelor of Architecture degree program.

ACADEMIC INTEGRITY

Built upon Peter Cooper's vision of education, The Cooper Union for the Advancement of Science andArt from its inception has been dedicated to the highest ethical standards. The School of Architecture, founded on principles of independent and exploratory thought, maintains that individual creativity within a willing community is a profoundly social act. In fostering a context of intellectual rigor, the program gives emphasis to a broad spectrum of cultural and ethical concerns which are of significance in the preparation of students for a professional degree and their role in society as practicing professionals of intelligence, creativity and integrity.

Authorship

Acts of academic dishonesty are extremely serious violations of both the spirit and the substance of this community. The Academic Standards Committee of The Irwin S. Chanin School of Architecture will review acts of academic dishonesty including cheating, plagiarizing or the submission of work that has not been prepared by the person claiming authorship. Such acts are viewed as an extremely serious violation,punishable by probation, suspension or dismissal. The action of the Academic Standards Committee in such cases will become part of the student's permanent academic record.

The Studios/Studio Culture

Central to maintaining a creative environment for intellectual investigation and intuitive exploration are the shared design and computer studio spaces on the third and seventh floors of the Foundation Building.

In the studios, students work together as a community of individuals. Here, students and faculty from all years engage in a process of rigorous inquiry, discussion and critique, freely sharing knowledge, ideas and methodologies. Students study the principles and works of architecture that have contributed to the betterment of the human condition in the development of their own projects. Students of the upper years serve as mentors for the lower years. Diversity and balance are critical values in generating an academic ambiance where humanistic ideals and ethical views serve as a constant reference for individual growth and development. The social and intellectual environment thus created is considered a vital part of the students' experience at The Cooper Union.Students are required to be present in studio for all hours that their design studio meets and to develop their work in the studio.

Students should be aware of and observe all policies and conditions for the use of the studios, including hours of access. Studio use policies and responsibilities are distributed at the beginning of each academic year.

Annual Exhibition of Student Work

The End of Year Show is a major event of the School ofArchitecture,exhibiting the work developed during the previous academic year to the academic and professional communities and the public at large. It is an opportunity to present the pedagogical framework of the school and faculty and to celebrate the rigor and diversity of the student work.

The exhibition occupies the lobbies, halls and classrooms of the third and seventh floors, and the Houghton Gallery. Preparation of these spaces and hanging the work is a tremendous task that must be accomplished in the very short period of time between the end of classes and commencement. Students of all years are required to make requested projects available for the exhibition and are expected to fully participate in the installation.

In addition to making their work available for the Annual Exhibition, individual student work may be requested for other purposes (other exhibitions, accreditations, etc.). Students are required to provide requested projects or other materials, which will be returned to them in a timely manner. While student work is to be available for these purposes,work produced by students as part of their coursework remains their property.

Students are required to sign a release form at the start of their studies granting the school permission to use, copy, publish or distribute, perform or publicly display, create derivative works, and incorporate into compilations or collective works the works of authorship created during their enrollment as a student at Cooper Union in any form, format or media now known or later developed or created in the future, for educational purposes and for promoting, marketing and advertising Cooper Union and its educational services worldwide, without compensation. The student retains the copyright to the work.

COURSES

UNDERGRADUATE REQUIRED

Arch 103 **Calculus and Analytic Geometry**
Emphasis on topics that involve the mathematical approach to geometrical and physical relationships and on basic concepts and applications of calculus of functions of one and two variables. *3 credits.*

Arch 106 **Concepts of Physics**
An introduction to physics with an emphasis on statics and dynamics. Additional topics include optics, waves and an introduction to structural analysis. *3 credits.*

Arch 111 A-B **Architectonics**
Introduction to the study of architecture; investigation of the interrelationships of space, structure and visual composition. Exploration of the syntax of architecture. Models and orthographic drawing. *4 credits per semester.*

Arch 115 A-B **History of Architecture I**
Semester I A broad introduction to the study of the concepts, designs and built examples of architecture from antiquity to the present. Selected projects from around the world will be analyzed in terms of planning, design, structure, technique, function, social context and meaning.
Semester II An introduction to the study of the concepts, designs and built examples of architecture from approximately the 12th through the 17th century. Selected projects from around the world will be analyzed in terms of planning, design, structure, technique, function, social context and meaning. *3 credits per semester.*

Arch 117A **Representation I: Geometry**
Introduction to various geometric logics; methods of graphic description, as well as an introduction to concepts and systems of projection and the two-dimensional representation of three-dimensional form and space. Emphasis on the control, precision, and rigor of the geometric description of form. *3 credits per semester.*

Arch 117B **Representation II: Observation**
This course is an exploration of the visual and conceptual aspects of drawing from direct observation. Focusing on drawing in a variety of media; questions of figuration and abstraction, space and form, perception, and composition will be investigated. *3 credits per semester.*

Arch 121 A-B **Design II**
Projects comprise elemental architectural programs wherein the student is required to sustain the formal investigations of first year while integrating the complexities of program, context and site. Spatial, structural, material, environmental and visual design are integrated. Emphasis is placed on communicating concepts through drawings and models. *5 credits per semester.*

Arch 122 A-B **Structures I**
A qualitative examination of the behavior of structures. Characteristics and development of the stresses generated from the simple to the complex. A study of the materials of construction used in structures. *2 credits per semester.*

Arch 124 **Environments**
Introduction of critical issues of the "natural" environment and the recognition of contemporary interior space as a complex environment both mechanical and passive. This class will provide students with a conceptual grounding in environmental issues at the urban and building scales in the second-year curriculum, when complexities of program, context and site are introduced in the studio. The class will be directly aligned with the Design II spring semester studio, through common faculty and shared projects. *2 credits per semester.*

Arch 125 A-B **History of Architecture II**
Semester I An introduction to the study of the concepts, designs and built examples of architecture from approximately the 18th to the mid 20th century. Selected projects from around the world will be analyzed in terms of planning, design, structure, technique, function, social context and meaning.
Semester II An introduction to the study of the concepts, designs and built examples of architecture from approximately the mid to the end of the 20th century. Selected projects from around the world will be analyzed in terms of planning, design, structure, technique, function, social context and meaning. *3 credits per semester.*

Arch 127A **Representation III: Analysis**
Introduction to the representational conventions of architectural analysis. Drawing modes to include plans, sections, elevations and axonometrics. Analytical readings of form, structure, space, program, and site will be explored. Students to achieve the ability to critically interpret architectural precedents through analytical representation. *3 credits per semester.*

Arch 127B **Representation IV: Imaging**
This course will focus on the various techniques and methods of producing architectural images including photography, rendering, animation, and pixel manipulation. In addition to exposing students to advanced imaging methods, questions of aesthetics, composition, color theory and optical mechanics will be explored in relation to architectural representation. *3 credits per semester.*

Arch 131 A-B **Design III**
Study and analysis of historical precedents followed by a sequence of design problems of increasing complexity. Emphasis on the planning of buildings and the interrelationships among form, structure, detail and technologies. *5 credits per semester.*

Arch 132 A-B **Structures II**
The study of strength of materials is applied to the quantitative design procedures for wood and steel structures. Students complete individual projects in wood and lowrise steel structures. *2 credits per semester. Prerequisites: Arch 103/104, Ph 165/166, Arch 122 A-B Structures I.*

Arch 133 **Introduction to Urban History & Theories**
An introduction to Urban History and to the principles, concepts, and Theories of Urbanism, from antiquity to the present, with an emphasis on the 20th Century urbanism. *2 credits.*

Arch 134 A-B **Environmental Technologies**
Environmental and life safety systems as they affect program and building form, including mechanical (heating, cooling, ventilating), water supply and disposal, electrical, lighting, acoustics, vertical transportation, communication, security and fire protection. Principles of sustainability. Passive and active systems. *3 credits per semester.*

Arch 135 A-B **Building Technology**
Materials and methods of architectural construction, lectures, examination and discussion of classic as well as current building techniques. Students assemble full-size "mock-ups" of details for class study germane to their design classes. In general, this course does not separate "construction" from "design" but attempts to supplement, by a means of a more detailed study of design assignments. Field trips may be made to buildings under construction. *2 credits per semester.*

Arch 141 A-B **Design IV**
Investigation of urban programs and sites requiring the integration of form, structure and space. Examination of the complexities implicit in the resolution of urban problems. Analytic studies and explorations generate specific programs for development of each project. Emphasis given to large-scale integrations and the impact of urban transformations upon existing fabric. *5 credits per semester.*

Arch 142 A-B **Structures III**
The design of reinforced concrete using stress methods and plastic design is combined with individual projects in low-rise concrete structures. Elements of soil mechanics and soil investigations are included (Fall only) in foundations design.
2 credits per semester. Prerequisite: Arch 132 A-B Structures II.

Arch 143 A-B **Construction Management**
Introduction to construction management principles, techniques and methods including scheduling, cost-estimating, planning and controlling construction process.
1 credit per semester.

Arch 151 A-B **Thesis**
A synthesis of four years' educational experience. The choice of the area of study is the responsibility of the student. The scope of the problem is defined by each student, who also decides on his or her method of exposition. Problems are analyzed and studied with the aid of faculty from each discipline and by visiting critics. *6 credits per semester.*

Arch 152 **Structures IV**
Intensive seminars are completed on prestressed concrete, wind and earthquake design for tall structures and special structures, while the student becomes the structural consultant for individual assignments for the structural solution of real architectural projects covering prestressed, high-rise steel and concrete buildings and shells.
2 credits. Prerequisite: Arch 142 A-B Structures III.

Arch 154 A-B **Professional Practice**
The role of the architect in relation to the community, client, builder, worker and engineer. Societal, ethical, legal and personal obligations. Office organization and administration. *1 credit per semester.*

Arch 205 **Advanced Concepts**
This course is intended to be an advanced course dealing with the relationship between architectural space and some other discipline in the humanities. The course deals with an interdisciplinary approach toward a new poetic and the phenomenology, psychology and metaphysics of space. *2 credits. Prerequisite: permission of instructor*
After fulfilling the Arch 205 Advanced Concepts degree requirement, a student may enroll in other additional Arch 205 Advanced Concepts classese for elective credit.

Arch 225 **Advanced Topics in History, Theory, Criticism**
Advanced study in history, theory, criticism of architecture, urbanism and technology.
2 credits. Prerequisites: Arch 115 A-B, Arch 125 A-B and Arch 175 or permission of the instructor.
After fulfilling the Arch 225 Advanced Topics degree requirement, a student may enroll in other additional Arch 225 Advanced Topics classes for elective credit.

FA 100RA–FA 100RB **Shop Tech**
An introduction to the physical aspects of working with wood, metal and plaster (mold making). *1 credit per semester.*

UNDERGRADUATE ELECTIVES

Arch 153 **Town Planning**
A modernist response to the problems of large metropolitan cities. Taking a historical perspective, the course will analyze town planning responses of specific architects and groups for cities such as Paris, London, New York, Vienna and Chicago, questioning the cultural determinants that made town planning a modernist stance.
2 credits per semester.

Arch 165 **Analysis of Architectural Texts**
Introduction to analytical methods and techniques and their relationship to synthetic activity in the design process. *2 credits. Prerequisite: permission of instructor*

Arch 175 **Modern Architectural Concepts**
The concepts and generators of form and space relative to architecture of the 20th century are explored and investigated. *2 credits. Prerequisites: Arch 115 A-B and Arch 125 A-B or permission of instructor*

Arch 176 **Theory of Landscape Architecture**
Lecture/studio course explores the interrelationships of nature, site design and built form. Focus on basic elements of nature addressed ideologically, poetically, culturally and practically through an interdisciplinary study of works by selected artists, writers, landscape architects and architects. Work with landscape fundamentals, continue on to more complex issues of natural processes and aesthetics, such as atmosphere, ephemerality and time, and of site planning, such as site selection, topography, drainage, ecology and climate, especially as related to architecture and art in the land. *2 credits.*

Arch 177 **Computer Graphics, Image Processing and Vision**
Introduction to basic concepts of spatial description and manipulation by computer enables student to use these techniques as an aide in problems of formal spatial drawing with a computer. Examination of the issues of "hand-eye axis" in computer-based drawing and "paint" systems as well as more abstract algorithmic methods of drawing. Image acquisition and transformation by computer, its relation to computer vision and control of robots and machines which build will be another area of emphasis. Survey of a wide variety of applications including typeface design, page layout and make-up, animation and interactive control of video systems. *2 credits.*

Arch 178 **Advanced Drawing Seminar**
The course will focus on the dialogue between figuration and abstraction. Students will be expected to plan and elaborate an ongoing series of drawings. The class will meet on a seminar basis to critique work in progress and to discuss issues relevant to the language of drawing. There may be an open studio available for those students who wish to pursue drawing from the model. However, students will be encouraged to investigate a broad spectrum of imagery and materials. *2 credits. Prerequisite: permission of instructor*

Arch 185 **Crossings, The Feltman Seminar**
This seminar will investigate the principles, aesthetics and methodologies of lighting perception and design. The Feltman Fund, a gift to the school, makes this seminar possible and supports its chairs. *2 credits.*

Arch 185.12 **Crossings**
This project-oriented studio course will explore and investigate developments in architecture, art, literature and engineering that reinforce or reintroduce the interrelationships of these diverse disciplines including the implications of recent scientific developments that cross and disrupt established boundaries and foundations of compartmentalized disciplines, giving us new insights into the natural processes within the rich diversity of nature. A revitalized and stimulating field of inquiry is now offered to architects, artists and engineers, with technological and cultural implications.
2 credits. Prerequisite: permission of instructor

Arch 190 **Structures Elective**
The reason for the unique structural solutions for existing building structures is presented in depth. These studies will include structures of all sizes subject to gravity, wind and/or seismic forces. The path followed to arrive at the best solution is analyzed in open discussion. The correlation between the architectural, structural and mechanical needs, as well as considerations related to the actual erection of these structures, is presented. *2 credits. Prerequisites: Arch 122 A-B, Arch 132 A-B, Arch 142 A-B, Arch 152 or permission of the instructor*

Arch 193 **Experience in Practice**
Supervised experience in the practice of architecture or a related discipline in the built environment during the summer break from classes that will enhance the student's knowledge and design skills. A minimum of 8 weeks/300 hours work is required for credit. The work experience must be approved a minimum of 4 weeks prior to the beginning of work. It is expected that the student will be compensated for work as required by law. May be repeated for credit up to a maximum of 3 credits.
1 credit. Pass/Fail. Prerequisites: Successful completion of all second year requirements.

Arch 194 **Environmental Technologies Elective**
Advanced study in environmental issues to include such topics as cultural and environmental sustainability, resource allocation, new materials and methods, global networks, urban growth, etc., as they relate to architecture on many scales.
2 credits. Prerequisite: Arch 134 A-B or permission of the instructor

Arch 300 **Computer-Aided Design and Descriptive Geometry**
Architecture-specific exploration into perception, methods and conventions of the geometric representation of space through the new perspective of computer applications. Introduction to concepts of projections, hinge and projector lines as well as absolute and relative coordinate systems through local deduction by considering parallel, axial, radiant and stereoscopic projections as variations of the same system. Introduction of CAD specificmethods such as Solid, NURBS and Parametric Modeling, hierarchical- and command-based programs. Critical comparison of computer capabilities and architectural tangible scale modeling methods to understand possibilities and limitations of computer-aided design in architecture. Critical exploration of methods and media for representation and design of specific works of architecture. *2 credits.*

GRADUATE REQUIRED

Arch 401 **Proseminar**
An introduction to research in architecture and urbanism: theory, research (methods and techniques) and writing, for M.Arch. II degree students only. Selected readings in historiography, theory, criticism and design and methods. Includes lectures and seminars by faculty and visiting specialists in the fields of history and criticism, architecture and urban design methods, research in representational techniques, digital technology, etc. Presentations by each student in the program will encourage interdisciplinary comparison and shared knowledge. *2 credits.*

Arch 402 **Thesis Research Tutorial**
Individual thesis research conducted under the supervision of an adviser or advisers leading to the preparation of a Thesis Prospectus required for advancement to the third semester of the program. *2 credits.*

Arch 411 **Graduate Design Research Studio I**
The Design Research Studio 1 will establish a general problem incorporating aspects of architectural, urban and technological design research to be undertaken by the class, with each student contributing to his or her specific area of expertise. The studio will include seminars by invited guests on topics relevant to the program's principal areas of study. *6 credits.*

Arch 412 **Graduate Design Research Studio II**
Individual design projects within general guidelines established by the faculty, each emphasizing the special area(s) of research of the student. *6 credits.*

Arch 413 **Graduate Thesis**
The choice of the area of study is the responsibility of the student. The scope of the project and method of exposition is defined by each student in consultation with their thesis adviser and must be approved prior to the beginning of the summer term on the basis of a thesis prospectus presented to the group of faculty. Students will develop a mutually agreed upon schedule for meetings with their adviser and for regular project reviews. *6 credits.*

Arch 482 **Graduate Seminar in Technologies**
Selected topics in the advanced study of technological issues in architectural design, representation, materials, planning, production and construction. *2 credits.*

Arch 483 **Graduate Seminar in Urban Studies**
Selected topics in the advanced study of urban form including readings and case studies in urban analysis, global development, historic preservation and typological transformation. Open to undergraduate fourth- and fifth-year architecture students as an elective with permission of the instructor and the dean. *2 credits.*

Arch 485 **Graduate Seminar in Theory, History and Criticism of Architecture**
Selected topics in the advanced study of the theory and criticism of modernism and contemporary architecture, the philosophy and aesthetics of architecture, the mediatization of architecture and broader cultural and historical issues, through the critical readings of texts as well as case studies. Open to undergraduate fourth- and fifth-year architecture students as an elective with permission of the instructor and the dean. *2 credits.*

ADMINISTRATION, FACULTY AND STAFF

Administration

Nader Tehrani
Dean; Professor
Hayley Eber
Associate Dean

Steven Hillyer
Director, The Irwin S. Chanin School of Architecture Archive
Monica Shapiro
Academic Administrator

Full-Time Faculty

Diana Agrest
Professor
Nora Akawi
Assistant Professor
Lorena del Rio
Assistant Professor
Lydia Kallipoliti
Assistant Professor
Anthony Vidler
Professor
Michael Young
Assistant Professor

Proportional-Time Faculty

Benjamin Aranda
Assistant Professor
Elizabeth O'Donnell
Professor
Mersiha Veledar
Assistant Professor
Tamar Zinguer
Associate Professor

Adjunct and Visiting Faculty

Samuel Anderson
Professor Adjunct
Tulay Atak
Associate Professor Adjunct
Erieta Attali
Assistant Professor Adjunct
Ted Baab
Assistant Professor Adjunct
Anna Bokov
Assistant Professor Adjunct
Gerri Davis
Assistant Professor Adjunct
Powell Draper
Associate Professor Adjunct
Peter Eisenman
Professor Emeritus
Glenn Forley
Associate Professor Adjunct
David Gersten
Distinguished Professor Adjunct
Sue Ferguson Gussow
Professor Emerita
Elisa Iturbe
Assistant Professor Adjunct
Nima Javidi
Visiting Professor II
Michael Jefferson
Assistant Professor Adjunct
Lauren Kogod
Associate Professor Adjunct
Steven Kreis
Associate Professor Adjunct
Stephanie Lin
Assistant Professor Adjunct
Farzin Lotfi-Jam
Assistant Professor Adjunct
James Lowder
Assistant Professor Adjunct
Jon Maass
Assistant Professor Adjunct
Mokena Makeka
Associate Professor Adjunct
Timothy McDonough
Assistant Professor Adjunct
Kayla Montes de Oca
Instructor Adjunct
Joan Ockman
Professor Adjunct
Nat Oppenheimer
Associate Professor Adjunct
Julian Palacio
Assistant Professor Adjunct
Linda Pollak
Professor Adjunct
Ashok Raiji
Professor Adjunct
Jonah Rowen
Assistant Professor Adjunct
Stephen Rustow
Distinguished Professor Adjunct
Michael Samuelian
Assistant Professor Adjunct
Sheng Shi
Assistant Professor Adjunct
Austin Wade Smith
Instructor Adjunct
Richard Sommer
Associate Professor Adjunct
Ruslan Trusewych
Visiting Instructor Adjunct
Ife Vanable
Visiting Professor II
Bryan Young
Assistant Professor Adjunct
Guido Zuliani
Distinguished Professor Adjunct

Instructors

Thorsten Helbig
Associate Professor
Florian Meier
Instructor

Staff

Caitlin Biggers
Project Manager—Student Work Collection
Chris Dierks
Collections Manager and Grants Liaison
Robyn Fitzsimmons
Administrative Assistant
Mauricio Higuera
Administrative Assistant for Public Programs and New Projects

PROFESSIONAL ACCREDITATION

In the United States, most registration boards require a degree from an accredited professional degree program as a prerequisite for licensure. The National Architectural Accrediting Board (NAAB), which is the sole agency authorized to accredit professional degree programs in architecture offered by institutions with U.S. regional accreditation, recognizes three types of degrees: the Bachelor of Architecture, the Master of Architecture, and the Doctor of Architecture. A program may be granted an eight-year, three-year, or two-year term of accreditation, depending on the extent of its conformance with established educational standards.

Doctor of Architecture and Master of Architecture degree programs may require a preprofessional undergraduate degree in architecture for admission. However, the preprofessional degree is not, by itself, recognized as an accredited degree.

The Irwin S. Chanin School of Architecture of The Cooper Union offers the following NAAB-accredited degree program:
Bachelor of Architecture (160 undergraduate credits)
The next accreditation visit for this program will be in 2024.

The NAAB expects programs to be transparent and accountable in the information provided to students, faculty, and the public. As a result, the following seven conditions require all NAAB-accredited programs to make certain information publicly available online.

II.4.1 Statement on NAAB-Accredited Degrees
All institutions offering a NAAB-accredited degree program or any candidacy program must include the exact language found in the NAAB 2014 Conditions for Accreditation, Appendix 1, in catalogs and promotional media. See above.

II.4.2 Access to NAAB Conditions and Procedures
The program must make the following documents electronically available to all students, faculty, and the public:
The 2014 Conditions for Accreditation
The 2009 Conditions for Accreditation(in effect at the time of the last visit)
The Procedures for Accreditation(edition currently in effect)

II.4.3 Access to Career Development Information
The program must demonstrate that students and graduates have access to career development and placement services that help them develop, evaluate, and implement career, education, and employment plans. See

II.4.4 Public Access to APRs and VTRs
To promote transparency in the process of accreditation in architecture education, the program is required to make the following documents electronically available to the public:

II.4.5 ARE Pass Rates
NCARB publishes pass rates for each section of the by institution. This information is considered useful to prospective students as part of their planning for higher/post-secondary education in architecture. Therefore, programs are required to make this information available to current and prospective students and the public by linking their web sites to the results.

II.4.6. Admissions and Advising
The program must publicly document all policies and procedures that govern how applicants to the accredited program are evaluated for admission. These procedures must include first-time, first-year students as well as transfers within and from outside the institution. This documentation must include the following:

Admissions requirements, admissions decisions procedures, including policies and processes for evaluation of transcripts and portfolios (where required), and decisions regarding remediation and advanced standing. See School of Architecture Academic Standards and Regulations

Student Diversity Initiatives

See below, excerpted from President Sparks' communication Opportunities for Involvement in Cooper's Future, dated April 6, 2017

New Diversity & Inclusion Task Force Late last year, the Faculty Student Senate passed a resolution recommending we take a closer look at gender diversity issues in engineering admissions. I support the resolution and am eager to better understand this issue. I am also expanding the exploration of diversity issues college wide and establishing a new Diversity & Inclusion Task Force to help us do so. Diversity is a central feature of Cooper Union's legacy and historic mission. It's also an area where, I believe, we must lead. The structure and approach for this Task Force is being developed now and will launch shortly. The goal is to engage faculty, students and staff in a process that examines diversity and inclusion in our community in order to

develop an actionable plan that drives us toward excellence by promoting inclusive practices across all facets of Cooper Union operations, pedagogy, and student support. Look for more information to come on this initiative in the coming weeks, including how you can get involved.

II.4.7 Student Financial Information

The program must demonstrate that students have access to information and advice for making decisions regarding financial aid. The program must demonstrate that students have access to an initial estimate for all tuition, fees, books, general supplies, and specialized materials that may be required during the full course of study for completing the NAAB-accredited degree program.

SCHOOL OF ART

MISSION

The mission of the School of Art is to educate artists in the broadest sense, both as creative practitioners engaged with a wide range of disciplines in the visual arts and as enlightened citizens of the world who are prepared to question and transform society. The program is structured around an integrated curriculum that fosters connections between disciplines, as well as between traditional and new media. The studio experience affords the opportunity for the development of individual artistic vision in dialogue with collective debates and experiments within an intimate community of artists. The study of history, theory and criticism in the visual arts and general studies in the humanities and social sciences are considered essential in intellectually grounding studio practice. Central to the school's philosophy is the advancement of the artist's role in relation to the prevailing forms and institutions of cultural production. Students are challenged to expand their research and experimentation across The Cooper Union, as well as in the surrounding urban environment and in the wider public sphere.

CURRICULUM

The goal of the B.F.A. program is to educate students in the skills, knowledge and understanding necessary for professional practice in art- and design-related fields. An integrated program not only teaches students in specific disciplines, but also in the complex interrelation of all visual vocabularies.

The Foundation Program consists of a series of prerequisite courses taken during the first year—designed as a basis for the educational program of the School of Art and is intended to prepare students for studies in all of the disciplines offered within the curriculum. Through exposure to a variety of two- and three-dimensional projects, students are given a general introduction to the specifics of visual and spatial phenomena, and to concepts, principles and techniques of the visual arts.

Following the completion of the Foundation Program, the disciplines offered are drawing, film and video, graphic design, painting, photography, printmaking and sculpture. Elective studio classes and seminars are also offered on a rotating basis. Students may choose to focus their work in one or more areas of specialization and are encouraged to follow an integrated approach by selecting from various areas while observing a prerequisite system designed to allow in-depth study in specific disciplines.

Students may enroll in advanced studio classes with the same course number multiple times. Instructors and syllabi in these courses will vary. In addition, the content of advanced studio classes changes with the mix of students in each class. Consequently, the development of individual students' work varies with the interchange of ideas among these students and their instructor. The School of Art believes that the ability to work with the same instructor in the same discipline multiple times (even as the course content changes) can foster a valuable mentoring relationship between an instructor and an advanced student.

ACADEMIC STANDARDS AND REGULATIONS

Credits

A credit is an academic unit of measure used for recording progress in the program of study and in meeting the academic requirements of the degree. In studio and lecture courses, one (1) credit represents a minimum of three (3) hours of work during each week of a 15-week semester dedicated solely to that course. These criteria apply to each course in which the student is enrolled.

Example in studio courses Drawing, 3 credits, equals 9 hours of work per week (i.e., 4 hours in class and 5 hours outside work [studio or home] or 3 hours in class and 6 hours outside work).

Example in techniques courses Casting Techniques, 2 credits, equals 6 hours of work per week (i.e. 4 hours in class and 2 hours outside work).

Example in a lecture course English Literature, 3 credits, equals 9 hours of work per week (i.e., 3 hours in class and 6 hours of outside work).

The number of credits awarded in each course represents the fulfillment of an agreement by the student to satisfy the course requirements as defined by each instructor, on time, and in accordance with the definition of credit.

Additional Credits in an Advanced Studio Course Permission to add credits to individual course commitments may be granted only under special conditions and must receive the written approval of the instructor and the dean of the School of Art (or the academic adviser) during the registration process.

Juniors and seniors in good academic standing (defined as having earned a minimum 3.0 G.P.A. in School of Art studio courses for the previous semester) may add credits to their individual course commitment under the following conditions: no more that two (2) additional credits in one course and no more that a total of three (3) additional credits in any one semester.

Additional Credits in a Semester Normal progress towards a degree is 16 credits per semester. Students may register for up to 19 credits only if they earned a minimum 3.0 G.P.A. overall for the previous semester. Under special conditions, students may register for more than 19 credits only with the permission of the dean of the School of Art (or the academic adviser). Students who wish to register for less than 16 credits must do so in consultation with the Office of Academic Advisement of the School of Art.

Independent Study Independent study is an alternative to classroom study and may be taken only with a member of the resident faculty (defined as full-time or proportional-time faculty members or adjunct faculty members who have taught at the School of Art for at least seven semesters). Only juniors and seniors in good academic standing (defined as having earned a minimum 3.0 G.P.A. overall for the previous semester are eligible for independent study. Independent study may be taken only once during a semester in an advanced subject for one (1), two (2) or three (3) credits. One (1) credit of independent study represents a minimum of three (3) hours of work during each week of a 15-week semester.

The major consideration in approving proposals for independent study is the educational value of the study project within the structure of the degree requirements. Permission to undertake study off-campus can be given only when it is required by the nature of the specific project and when the experience has been evaluated to be valid by the instructor and approved by the dean of the School of Art.

Transfer Credits All incoming students (freshmen with advanced standing and transfer) may apply for transfer credits to be counted toward the B.F.A. degree requirements. These credits must be approved by the dean of the School of Art, after the evaluation by faculty based on official transcripts from other schools. The transfer credits will be officially recorded only after one semester of satisfactory work is completed at The Cooper Union.

Transfer credits may be granted specifically in lieu of the School of Art's foundation, prerequisite or elective courses. A maximum of 60 credits may be transferred toward the B.F.A. degree, at the time of admission only. An accepted applicant who has previously earned a baccalaureate degree in a discipline other than art will be treated as a transfer student for purposes of evaluating completion of degree requirements and length of time allotted at The Cooper Union to complete the B.F.A.

The required 10 credits of free electives, however, must be completed during the student's stay at The Cooper Union. No previously earned credits may be transferred into this category. Exceptions to this rule may be granted by the Admissions Committee, with the approval of the dean of the School of Art, at the time of admission only. (See School of Art Transfer Requirements)

Attendance

Attendance at classes is mandatory. Unexcused absences and excessive lateness will be cause for probation or dismissal.

Registration

Only those students who are officially registered in a course (i.e., by approval of the dean of the School of Art) will have the grades and credits entered on their records. Students are required to register for each semester through the online registration system, during the announced registration period.
A student who receives a grade of F, W or WU in the first semester of a one-year course will not be allowed to register for the second semester of that course. In such a situation the student will be called before the Academic Standards Committee for individual review and/or counseling in order to determine a future program of study. Students whose records by mid-semester indicate a possible failure to meet required standards may be so informed.

Grades

Grades used, with their numerical equivalents, are: A (4.0), A- (3.7), B+ (3.3), B (3.0), B- (2.7), C+ (2.3), C (2.0), C- (1.7), D+ (1.3), D (1.0), D- (.7), F (0).

The numbers in parentheses give the assigned numerical equivalents of the letter grade for each course. These are used in computing semester index and cumulative index ratings by multiplying the numerical equivalent of the grade for each course by the credits assigned to that subject. The sum of such multiplications for all the subjects carried by a student is divided by the total credits carried by him or her for that period to determine the index or grade point average.

The official meanings for letter grades are as follows:

A Outstanding performance
B Above average performance
C Requirements satisfactorily completed
D Minimum requirements met; passing but unsatisfactory
F Failure to meet the minimum requirements of a subject
I Incomplete (see below).

An **I** designation indicates that the work of the course has not been completed and that assignment of a grade and credit has been postponed. An I will be given only in cases of illness (confirmed by a physician's letter) or documentation of other extraordinary circumstances beyond the student's control. The designation of I will be granted only with the approval of the dean of the School of Art.

The deadline for removal of an I designation will be determined by the instructor and recorded at the time the designation is given, but will not be later than two weeks after the start of the next semester. If the I is not removed within the set time limit, either by completing the work in the subject or by passing a reexamination, the I will automatically become an F unless the dean of the School of Art extends the time or the student withdraws from school before the deadline date.

W Indicates that the student has received permission from the dean of the School of Art and the instructor to withdraw from a course while passing the course requirements at the time of withdrawal. This permission must be obtained no later than the end of the eighth week of the semester. The grade is not included in the calculation of the student's semester rating.

WU Indicates that the student has dropped a course without permission of the dean of the School of Art and the instructor after the end of the eighth week of the semester. This grade is not included in the calculation of the student's semester rating.

When appropriate, certain courses may be designated as Pass/Fail courses.

Pass Requirements completed. This designation is not included in the calculation of the student's semester rating.
Fail Failure to meet the minimum requirements of a course. This grade is included in the calculation of the student's semester rating; its numerical equivalent is 0.

A change in an official grade of record, other than the I designation, cannot be made by the dean of Admissions and Records without the express written consent of the instructor and the dean of the School of Art. Grade changes will not be accepted after one year has elapsed from the completion of the course.

Change of Program

Adding a Course A student is permitted to add a course only during the first week of a semester, during the drop/add period, and only with the adviser's approval..

Dropping a Course A student may drop a course during the first week of the semester, during the drop/add period, with the adviser's approval. A student who wishes to drop a course may be required to add equivalent credits in another course as needed to maintain satisfactory progress towards the degree. A course dropped during the first week of the semester will be deleted from the transcript..

Withdrawing from a Course After the drop/add period a student may withdraw from a course through the eighth week of the semester, with the dean's and instructor's approval. If the student is passing the course at the time of withdrawal, a grade of **W** will appear on the transcript. A student who stops attending a course without permission of the instructor and the dean of the School of Art will receive a grade of **WU**; however, the instructor is free to record a grade of F in such a case.

If, in the opinion of the instructor, a student's presence is hindering the educational progress of the class, the student may be dropped from the class at the request of the instructor. A grade of **W** will be recorded for the course.

Academic Probation and/or Dismissal

A semester rating of all courses, (i.e., School of Art and Faculty of Humanities and Social Sciences) below 2.5 places students on probation and makes them subject to dismissal by the Academic Standards Committee. Students with unexcused absences and those excessively late to class are also subject to probation or dismissal. Students must maintain normal progress toward the degree. Failure to observe this standard is grounds for probation or dismissal.

Appeal Students may appeal to the Academic Standards Committee of the School of Art in person and/or in writing when notified of their unsatisfactory academic performance. Students have on-line access to their grades. Please contact the Registrar's Office for more information.

When students are called to the Academic Standards Committee meeting, they are strongly advised to take this opportunity to communicate/explain/defend their unsatisfactory academic performance. The student should appear in person. If this is not possible the student may address the committee in writing.

After the hearing and deliberation the Academic Standards Committee shall either determine a probationary period or vote for dismissal. The decision of the committee is final.

Students on academic probation who do not improve their academic standing during the probationary semester or who fail to meet minimal academic standards during any subsequent semester may be called to the committee and are subject to probation or dismissal from The Cooper Union.

Leave of Absence

In the School of Art, discretionary leave is available only upon completion of the first-year Foundation Program. Before taking such a leave, all financial obligations to The Cooper Union must be satisfied.

All requests for leaves of absence should be made through the Office of Academic Advisement. Note that this office is closed between June 10 and August 15 each year.

Students must request all leaves of absence in writing. A written request for reinstatement is also required. A student on leave is inactive and does not have access to the facilities of The Cooper Union.

Withdrawal from School Written requests for withdrawal from school should be addressed to the dean of the School of Art.

Readmission Students who have been dismissed or who have withdrawn from the school and wish to be considered for readmission must reapply through the normal admissions procedures.

Such applicants may be asked to appear for an interview with a representative of the Admissions Committee as part of this process.

Graduation

To be eligible for graduation students must complete the minimum number of credits required for the B.F.A. degree and must have been enrolled for a minimum of four semesters at The Cooper Union as a full-time student for the B.F.A.

All candidates for the B.F.A. degree must satisfactorily complete the requirement for a senior presentation.

Students must have a cumulative grade point average of 2.0 or better in order to graduate from The Cooper Union School of Art.

Students eligible to graduate and participate in commencement exercises must be approved by the Faculty of the School of Art.

Students who have not fulfilled the requirements for graduation will normally not be permitted to participate in commencement exercises.

Graduation requirements as outlined here are guidelines that are subject to change.

Students are responsible for their total accomplishment and for being continuously aware of the standards defined in the preceding paragraphs.

Residence

A candidate for a degree must have been enrolled during two academic semesters preceding the granting of the degree and in residence during the last semester.

DEGREE REQUIREMENTS

Candidates for the Bachelor of Fine Arts degree are expected to complete 130 credits within eight semesters of study and within the following disciplinary credit distribution.

Courses	*Credits*
Required Foundation Courses	
Basic Drawing (Analytical and Descriptive)	6[1]
2-Dimensional Design	6[1]
3-Dimensional Design	6[1]
4-Dimensional Design	3[1]
Color	21
Introduction to Techniques	1[1]
Foundation Project	1[1]
Required Art History Courses	
Modern to Contemporary: An Introduction to Art History	4[1]
Art History Electives	10*
Required General Academic Studies	
Freshman Seminar	3[1]
Texts and Contexts: Old Worlds and New	3[1]
The Making of Modern Society	3[2]
The Modern Context: Figures and Topics	3[2]
Science	3
General Academic Studies Electives	
To be elected from Art History[3], Foreign Language[4], History of Architecture, Humanities, Social Sciences, and Sciences	12
Prerequisite and Advanced Studio Courses	
To be elected from any studio discipline	54
Required Senior Presentation	0
Free Electives	
To be elected from courses in any discipline at Cooper Union or at other institutions approved by the dean of the School of Art	10
Total Credit Requirements for the B.F.A. Degree	**130**

** Including 2 credits in prehistory through 17th century art and 2 credits in global perspectives on art*

[1] First-year requirement for all students

[2] Second-year requirement for all students

[3] Maximum of three credits

[4] With permission of the dean of the School of Art

Studio Courses

The student's choice of studio courses is based on individual interest in various disciplines, on prerequisite courses for advanced areas of study and on the student's interest in working with particular instructors.
There are limitations on the number of credits a student may take each semester in any one area of study, depending upon the student's progress in the program (number of credits completed toward the degree). The number of credits allowed is determined as listed below:

Credits Completed	Maximum Credits per Semester per Area of Study*
32 (Sophomore)	6
64 (Junior)	9
96 (Senior)	no limit

* Includes related techniques courses

General Academic Studies Requirements and Electives

During the first two years, B.F.A. candidates must take four core courses in the humanities and social sciences (12 credits), as well as one course each semester in art history (two required courses and two elective courses, eight credits total). At any time after the firstyear they must take a three-credit science course.

Throughout the last two years, they must complete a minimum of 18 elective credits, 6 of which are required to be in art history; the remaining 12 may be taken in humanities, foreign languages (with permission of the dean of the School of Art), social sciences, art history (maximum three credits), history of architecture and the sciences.

Foreign language credit for intermediate and advanced courses, taught by language instructors with appropriate academic credentials, will be granted two general studies credits per semester with a limit of four credits accepted in the category of general academic studies electives with permission of the dean of the School of Art. Intermediate or advanced foreign language studies beyond four credits counted toward general academic studies will be acceptable for free elective credit, limited to two credits in language studies per semester.

Free Electives During the last three years, students have a choice of electives in the School of Art in addition to the required curriculum. Courses designated with the prefix TE or SE receive free elective credit, as do studio courses taken beyond the 54 credit requirement. Only one TE course per semester may be taken. Students may also enroll in engineering or architecture courses at The Cooper Union or courses at

other accredited institutions with the permission of the dean of the School of Art (or the academic adviser). Free elective credits are approved and granted by the dean of the School of Art (or the academic adviser).

Outside Electives These electives may be used only to meet free elective and/or general academic studies credit requirements; they cannot substitute for prerequisite or advanced studio electives. Students may take up to three credits per semester at a college other than The Cooper Union. For credit to be counted toward the B.F.A. degree, permission of the dean of the School of Art (or the academic adviser) is required before registration at another institution for the semester concerned. No such credit will be awarded retroactively.

Senior Presentation Requirement A public presentation of each senior student's work, normally in the student's final semester, is a requirement for graduation. Each student may satisfy this requirement with an exhibition or, where appropriate, a screening, performance or publication. No student will be permitted to receive a degree unless this requirement is completed to the satisfaction of the faculty and the dean of the School of Art at a mutually agreed upon time and venue. Completion of the requirement will be reflected on the student's transcript. The 41 Cooper Gallery will be reserved for senior student exhibitions during much of the spring semester; other appropriate exhibition spaces will also be made available.

Progress Toward the Degree

Students are expected to maintain normal progress toward their degrees.
Normal progress In the Foundation year Is defined as completing all courses In the Foundation curriculum. Normal progress in any semester after the Foundation year, and for transfer students, is defined as completing an appropriate balance of fine arts, general academic studies, and free elective courses such that the student can finish all degree requirements In the number s of semesters allotted.

Students should consult with the Office of Academic Advisement in order to assess their progress towards the degree.

Requirements for Nonresident Study

Eligibility for non-resident study, i.e., the exchange programs, is as follows: Students who have completed at least 64 credits toward the Bachelor of Fine Arts degree, have a cumulative G.P.A. of 3.0 overall, and have no outstanding first- and second-year requirements, may apply for one semester of non-resident study. The student must maintain good academic standing in the semester prior to departure, otherwise permission to participate may be revoked.

Transfer students must have completed at least 32 credits in residence at The Cooper Union before applying for non-resident study and must have an additional 32 credits to complete in residence upon their return. Transfer students must also have met all first- and second-year requirements and be in good academic standing, defined as having a cumulative G.P.A. of 3.0 overall.

Students applying for non-resident study must be in residence during the semester when they are completing the application process.

Students may earn a maximum of 12 credits in studio courses for one semester of study on exchange. A maximum of 6 credits may be awarded by any one faculty member for work done while on exchange.

Since foreign schools may have academic calendars at variance with that of The Cooper Union, students studying on exchange who cannot return in time for the start of the next semester at the School of Art must request a discretionary leave of absence for that semester.

Students may participate in non-resident study only once during their stay at The Cooper Union.

Students should consult the Office of Off-Campus Programs for information about these exchange opportunities.

Students from other institutions who are enrolled at the School of Art as exchange students may not apply to transfer to The Cooper Union School of Art while in residence at The Cooper Union.

Exchange Programs The School of Art offers a number of exchange programs with schools abroad. They currently include opportunities to study in the Czech Republic, England, France, Germany, Israel, Japan, the Netherlands, Spain, Sweden and Switzerland.

COURSES

Foundation

Foundation courses are required of all first year students.

FA 100.1, FA 100.2 **Introduction to Techniques**
An introduction to the physical aspects of working with wood, metal, plaster - and plastics, as well as an introduction to on-campus computer facilities and resources. A basic introduction to the Adobe interface, specifically Photoshop and Illustrator will be provided. *½ credit per semester. Required for first year students. One-year course. Pass/Fail. Staff*

FA 101 **Color**
A study of the physical, perceptual, art historical and cultural aspects of color. The phenomenon of color and principles of light are explored in various media towards an understanding of color application in all of the fine art disciplines and architecture.
2 credits. Required for first year students. Fall only. Backström/Raven/Jones/Hewitt

FA 102.1 FA 102.2 **Two-Dimensional Design**
Exploration of the visual and intellectual aspects of form on the two-dimensional surface, in a variety of media. Investigations into the relationships of perception, process and presentation. *3 credits per semester. Required for first year students. One-year course. Harris/I. Raad/Rub/Waters*

FA 104.1, FA 104.2 **Basic Drawing (Analytical and Descriptive)**
A course in freehand drawing designed to emphasize perceptual and inventive skills in all drawing media. *3 credits per semester. Required for first year students. One-year course. Brown/Hoffman/Masnyj/Robinson*

FA 105 **Four-Dimensional Design**
This course investigates the properties of time and movement and the fundamentals of four-dimensional design. Students explore duration, condensation, expansion, interruption, simultaneity, stillness, action and situation through a wide range of materials. *3 credits. Spring only. Required for first year students. Backström/Laris Cohen/Lehyt/Raven*

FA 109.1, FA 109.2 **Three-Dimensional Design**
Students work on projects that explore the fundamentals of forms and space and investigate the properties of materials, structure, mass, scale, light and motion.
3 credits per semester. One-year course. Required for first year students. Adams/Ashford/Cetera/Imber/Schrader

SE 150 **Foundation Project**
A course that brings together all Foundation year students around a series of presentations that introduce various artistic practices, critical languages, and criticism. The course intends to present contrasting historical and contemporary models of creating, seeing, speaking and thinking about art. *1 credit. Required for first year students.*

Calligraphy

FA 419 **Independent Study in Calligraphy**
1-3 credits. Requires approval of instructor and the Dean of the School of Art.

TE 216 **Calligraphy**
Geometry, optical balance and the stroke of the broad-edge pen are primary influences that shape the Roman alphabet. Students learn the fundamentals of "beautiful writing" through the study of historical models and the principles that are the basis of classical and modern letterforms. Exercises in ink train the hand kinaesthetically to write letters with graceful movement. Exercises in pencil train the eye to see and analyze the subtle geometry and skeletal "ideal" form of letters. Precise rhythm in letterspacing and careful line-spacing create the color and texture of the page. The class will have an emphasis on page design involving hand written compositions. Roman and Italic capitals and small letters will be the focus of first semester students. Those who repeat may be introduced to other historical hands.
2 credits. One-semester course. May be repeated once. Free elective credit. DiEdwardo

Computer Techniques

TE 303 **Techniques in Photoshop: Digital Workflow**
This course explores techniques and projects in Photoshop. Students will complete projects that develop their skills and understanding of digital image creation. Students will both apply and experiment with the software relative to projects that they are engaged in or planning. A structured series of workshops will be presented to help students experience various tools, methods and models relative to image construction, manipulation and rendering. *2 credits, 4 contact hours. One-semester course. Cannot be repeated. Free elective credit.*

TE 304 **Techniques in After Effects**
This course explores techniques and projects in Adobe After Effects. Students will complete projects that demonstrate their skill and understanding of visual effects and motion graphics. Projects will be faculty and student generated.
2 credits. One-semester course. Cannot be repeated. Free elective credit. Garrett

TE 305 **Techniques in HTML and Programming**
This course explores programming techniques using HTML, CSS, Javascript and other data formats. Students will complete projects that demonstrate their skill and understanding of building web sites and basic programming. The purpose of this course is for the student to develop the skills necessary to utilize the many and varied web technologies for their artistic and professional practices.
2 credits. One-semester course. Cannot be repeated. Free elective credit. Sparling/Bailey

Audiovisual

FA 272 AV **Film Workshop**
Independent projects workshop in Super 8 and 16mm film. As well as working in depth with film, students are encouraged to explore all possibilities of the moving image from expanded projection techniques to kinetic constructions. *3 credits. One-semester course. prerequisite: audiovisual I. Perlin*

FA 275 **Audiovisual I**
An introduction to concepts, production techniques, and histories of artists moving image work. Over two semesters, students will investigate the origins and evolution of animation, film, video, and sound recording for cinema, with classroom instruction and experimentation in the techniques and production of each. Alongside a historical and theoretical framework, a wide range of practical tools will be introduced, including precinematic image capture, 16mm film and digital cinema production, stop action animation, sound recording, and lighting. *3 credits. One-semester course. May not be repeated. Hedditch/Liu/McWreath*

FA 276 **Audiovisual II**
Semester two of the yearlong AV sequence, this course continues with greater depth and more individualized student projects, the introduction to concepts, production techniques, and histories of artists' moving image work. Students will investigate the origins and evolution of animation, film, video, and sound recording for cinema, with classroom instruction and experimentation in the techniques and production of each. Alongside a historical and theoretical framework, a wide range of practical tools will be introduced, including pre-cinematic image capture, 16mm film and digital cinema production, stop action animation, sound recording, and lighting. *3 credits. Prerequisite: Audiovisual I. Hedditch/Liu/McWreath.*

FA 376 **Animation Workshop**
An advanced course in frame by frame film making. An examination of existing work in the field will accompany the development of independent projects, ranging from traditional cartoon animation to fine art-based experimentation. Films begun in Animation I can be carried to completion in this course. Techniques can vary from simple index card animation to elaborate combinations of cel and rotoscope. The relationship of sound to image will be explored and sound tracks produced. Individual projects will be completed on 16mm film with the option to transfer final work to video. *3 credits. One-semester course. Prerequisite: AV I. Reeves*

FA 380A/B, FA 385A/B, FA 386A/B, FA 387A/B, FA 389A **AV Projects**
For Fall 2020 (Topics change each semester): X the Unknown Borrowing its title from a 1956 horror sci-fi film of the same name, this course will examine questions around unknowable, ambivalent threat made material in the form of monsters, natural disasters, and unexpected turns of event. Focusing on subjects in cult sci-fi and horror films, artist videos, mainstream and "reality" TV, and the news, we will examine larger collective fears and anxieties—both contemporary and historic—given form by these figures. With a particular focus on those "monsters" that resist easy description in language, or are otherwise unknowable, we will explore the powerful, uneasy potential of animate form devoid of rational motivation. Readings, screenings, and class discussion will take off from this shared line of inquiry, but student may work on individually chosen project. *Raven*

Can I Have Your Attention, Please?—Attention, Distraction, Boredom, and the Moving Image From social media to smartphones, multiplexes to museums, our attention is in constant demand. Under advanced capitalism, attention has become a kind of currency: limited, exchangeable, unable to be subdivided too minutely or given out too freely. For many, limited attention is coupled with a nearly constant sense of anxiety and loss. Our attention is always deferred from things we feel are important: loved ones, family, work, reading, or simply doing nothing. Some, meanwhile, embrace the pleasures of distraction and consciously volunteer for a lifestyle of highspeed multitasking. We all, however, operate under a single economic and cultural regime, one that keeps consumers active, entertained, engaged, and all the time free from capitalism's longtime bugbear: unproductive boredom. This course argues that artists working in the moving image have always been concerned with the problems of attention, distraction, and boredom. The so-called "slow cinema" movement, seemingly uninterested in entertaining its audiences, has turned to a movie-making made up of long takes and a lack of spectacular action. Video artists and film essayists have deconstructed how capital uses sexuality, women's bodies, violence, and fear as techniques to capture and commercialize our gaze. Some composers

have attempted to deflect audience attention entirely, releasing music that happily exists as background accompaniment in airports and other liminal spaces. Accelerationist practices have conversely worked to mimic the rapid-fire commercial imagery that saturate our media landscape. Through screenings, discussions, and readings, we will consider as many approaches to the problems of attention. Screenings will include works by Michael Snow, Marguerite Duras, João César Monteiro, Gretchen Bender, Otolith Group, Lawrence Abu Hamdan, Adam Curtis, Józef Robakowski, Chantal Akerman, Mika Rottenberg, and others.
Visiting Artist John Menick. Please note that students are not required to make work on the subject of attention and may work on any projects they please.

Talk Show, Visiting Artist Thomas Beard The primary task at hand for this advanced audiovisual studio course is straightforward: to produce a talk show, collectively, as a class. Our work on such a project will then lead us down numerous paths of historical and theoretical inquiry as we examine every aspect of the talk show—its functions as a social environment as well as a cultural idiom. These efforts will occasion us to study linguistics and nonverbal communication in granular detail, to better understand the mechanics of speech and the expressive vocabulary of the body. We will also consider the shifting conceptions of conversation across eras, with readings ranging from Cicero's On Duties to Jonathan Swift's "Hints towards an Essay on Conversation" to Sherry Turkle on "the power of talk in the digital age." Finally, we will approach the talk show as a televisual genre, tracing its evolution, with special attention to both its stylistic character and its role in shaping the public sphere.
3 credits. One-semester course

FA 381 **Digital Sound Design Workshop**
People don't usually notice the soundtrack, but it makes a big difference in how they see a movie. A movie with a sketchy track simply does not look good. This is a course about how sound, music, and noise work in art and life, how they affect our emotions and what we see, and how they stimulate and dull our imaginations. We will explore how various kinds of sound, music and noise can be used to strengthen and illustrate relationships and add dimension to visual images (and vice versa), and how they can be used to provide clues to what is occurring visually, create a sense of space (depth) and place (location), focus attention on objects and actions, and create psychological (emotional) ambience. We will learn to listen analytically, by looking at diverse movies and listening to their soundtracks, as well as the world around us. The course is also a workshop in using digital and analog tools and techniques to design sounds and soundtracks, using Pro Tools and other softwares. *3 credits. Offered Fall and Spring. Pre- or corequisite: AVI or Motion Graphics. May not be repeated. Burckhardt*

FA 382A, FA 382B **The Question of the Document**
This class is open to students working in all forms. Students are expected to initiate and work on independent projects—individually or in groups and must be willing to show work in class while in the process of making it. The focus of the class will be on the question of the document in media art and related themes of history, facticity, testimony, witnessing and evidence. Students are expected to attend all screenings and exhibitions, keep up with the assigned readings and write short papers.
3 credits. Pre- or corequisite: One advanced studio course. May be repeated with a different instructor Raad

FA 385A AV **Projects**
Section I: Dynamic Range This course is organized around individual student-driven works in relation to three invited guest artists/ filmmakers, each of whom will be with us for three weeks. Dynamic range in cinema is used to refer to the difference between the darkest and lightest tones in an image—ostensibly pure black to pure white. These two absolute values are fugitive in most moving images, and the range between them can be affected by many factors— technological, phenomenological, historical, any many still to be explored. Throughout the semester, our readings, guest visits, discussions, and screenings will examine, break down, and at times, reform the ideologies underpinning those values that define dynamic range.
Section II: Guest Artist Series: Bill Morrison. Discovered Footage If all recordings in some way embody human thought, the moving image, accompanied by sound, is the perhaps best approximation of our consciousness. By extension, the storage of the moving image is a model of human memory taken to a societal level—a collective memory. Students will be encouraged to find existing media that in some way is in dialogue with their experience as sentient beings in the real world today. This can take many forms. They can source physical, analog films, or download digital imagery via the internet. They can access their family's archives. They can seek out lost or "forgotten" moving images, and try to discover how it came to be marginalized, and what their role is in uncovering it anew. Each student is encouraged to evaluate their own history—personal, familial, cultural, political, or other—and to arrive as a way of reconciling that history with the world that they live in today.
Section IV: Visiting Artist Paul Pfeiffer Advanced projects class in audio-video post-production and the everyday. This class will explore the digital post-production studio as a space defining the limits of contemporary society and individual experience, technologically and ontologically. How are the handheld devices and apps we use daily like personal post-production studios? We will explore this. question through readings, screenings, discussions, field trips, and guest lectures, setting the stage for individual or group projects to be presented at semester's end. Projects will be limited to whatever you can do on your smartphones, social media platforms, and other everyday-level apps and hardware. No advanced post-production skills required. *3 credits. One-semester course. Prerequisites: Video II or Film II or Animation II.*

FA 385B AV: **Advanced Projects/Installation**
This advanced course investigates video installation as an evolving contemporary art form that extends the conversation of video art beyond the frame and into hybrid media, site-specific, and multiple channel environments. Presentations, screenings, and readings augment critical thinking about temporal and spatial relationships, narrative structure, viewer perception and the challenges of presenting time-based work in a gallery or museum setting. Students will develop research interests and apply their unique skills sets to short turnaround exercises and more expanded self-directed projects for gallery and non-theatrical contexts. *3 credits. One-semester course. Prerequisites: Video II or Film II or Animation II. Visiting Artist Glen Fogel.*

FA 479A, FA 479B **Independent Study in Film**
1-3 credits. Requires approval of instructor and the Dean of the School of Art

FA 489A, FA 489B **Independent Study in Video**
1-3 credits. Requires approval of instructor and the Dean of the School of Art

Drawing

FA 240A, FA 240B **Drawing I**
The course is designed to explore the phenomena of drawing as basic to the visual language of all disciplines. The fundamental notion of observation and analysis in drawing is investigated. As preparation for work in an advanced level, the course involves further development of drawing skills and techniques, as well as an emphasis on individual aesthetic development. Assignments and group critiques are central to the course. *3 credits per semester. One-semester course. May be repeated once. Prerequisite to all Advanced Drawing. Degen/Hoffman/Merz/Mooses*

FA 341A, FA 341B **Advanced Drawing**
Advanced studies in drawing emphasizing the student's conceptual independence from traditional draftsmanship. This course is for students who have an established direction in drawing. *3 credits. One-semester course. Barth*

FA 342A, FA 342B **Advanced Drawing**
Offered to students working independently in any medium. Must be self-motivated. There will be group and individual critiques. *3 credits. One-semester course. Lehyt*

FA 343A, FA 343B **Advanced Drawing**
Offered to students working independently in any medium. Must be self-motivated. There will be group and individual critiques.
3 credits. One-semester course. Masnyj

FA 345A, FA 345B **Advanced Drawing**
Offered to students working independently in any medium. Must be self-motivated. There will be group and individual critiques.
3 credits. One-semester course. Mooses

FA 499 **Independent Study in Drawing**
1-3 credits. Requires approval of instructor and the Dean of the School of Art

Contemporary Art Issues

SE 401A **Contemporary Art Issues Seminar** (Topic varies)
Theories of the Subject Critical Theory is a school of thought that emerged in the 1930s that interprets society and culture through the lens of philosophy, sociology, psychology and linguistics. It does not offer a theory of art or aesthetics, but its proponents do engage in critique of cultural texts and focus frequently on the workings of visual culture. In this seminar, we will review some of the foundational texts of critical theory and consider multiple theories of the subject. We will read texts by Sigmund Freud, Walter Benjamin, Roland Barthes, Michel Foucault, Stuart Hall and Judith Butler, among others. We will concentrate on the relationship between Critical Theory, aesthetic experience and artistic production. We will also study foundational texts for theoretical analysis of images. The goal of these discussions is to arrive at a more nuanced understanding of who we are and how we see when we imagine, when we create and when we interact with art.
2 credits. May be repeated once for Art History credit. Fusco

ELECTIVES

SE 403A, SE 403B **IntraDisciplinary Seminar**
This course is a hybrid between a lecture series and discussion seminar. It is intended to provide a stimulating and rigorous forum between students' artistic concerns and those of twelve visiting speakers in a public lecture series of the School of Art. Class discussions will center on diverse presentations by artists, theorists, activists, designers, writers, curators, gallerists and other practitioners involved in the arts from positions that embody an interdisciplinary approach or that imply new uses for disciplinary traditions. Accordingly, the course is designed to introduce students to some of the debates currently driving contemporary art and the larger social context it embodies. Members of the class are expected to be active participants and will therefore be asked to respond with some intellectual invention to a variety of topics with weekly discussions, readings, and written or oral presentations.
2 credits. Free elective credit. Berrada/Hewitt

TE 353 **Papermaking Techniques**
This course includes the making of traditional Western paper from rags to a finished sheet and the making of traditional Oriental paper from tree bark to a finished sheet. Students learn to use a pulp beater, dyes, sizings and a small vacuum table for molding the pulp. Simple binding and box-building techniques as well as marbling are demonstrated. *2 credits. One-semester course. Free elective credit. Martin*

Graphic Design

FA 211 **Graphic Design I**
An introduction to the techniques and visual language of graphic design. Weekly projects explore fundamental concepts in form, composition, and typography. Presentations and readings in graphic design history will complement weekly assignments. Explore basic imagemaking processes as well as be instructed in digital production techniques.
3 credits. Fall only. Key/Gasparska/Joel

FA 212 **Graphic Design II**
The complex relationship between word and image is explored. The study of semiotics, emphasizing the philosophy of communication, provides a rich historical and intellectual base for experimental projects combining verbal and pictorial information. Weekly projects reflect a broad range of disciplines within the field of design. Computer instruction will be provided as it relates to specific projects.
3 credits. Spring only. Prerequisite: Graphic Design I. Gasparska/Joel/Key

FA 215 **Typography**
Empirical explorations of typographic messages through placement, massing, weight, size and color are analyzed to develop an understanding of aesthetic composition of typographic form and meaning. Legibility, unpredictability and sequencing, as well as the use of grid structures, are investigated. The development of critical judgment about typography is emphasized. *3 credits. Prerequisite: Graphic Design I. Pre- or corequisite: Graphic Design II. Tochilovsky*

FA 310 **Information Design**
The visual communication of complex information is introduced through presentations and studio projects that explore organizational structures such as charts, diagrams, maps, illustrations, photographs and typography. Computer instruction will be provided as it relates to specific projects. *3 credits. Prerequisites: Graphic Design I and II. Pre- or co-requisite: Typography. Cheng/Glauber*

FA 311 **Publication Design**
The complex issues unique to editorial and publication design are explored through studio projects and presentations that emphasize the grid, effective sequencing and typographic form. Computer instruction will be provided as it relates to specific projects. *3 credits. Spring only. Prerequisites: Graphic Design I and II. Pre- or corequisite: Typography.*

FA 312 **Experimental Typography**
This course will emphasize innovation, imagination and creativity in the realm of typography, manipulating it freely as a means of expression. Computer techniques as well as hand drawing, collages and pictures will be used to compose layouts, including posters, limited art books and animated typography for the web. Students will choose a theme and develop it with abstract type expression. *3 credits. Prerequisite: Graphic Design I and II. Pre- or corequisite:Typography. Famira/Glauber*

FA 313 **Art of the Book**
In this course the book will be explored as an interdisciplinary medium, placing emphasis on integrating and experimenting with form, content, structure and ideas. During the first half of the semester, students will make a number of books, examining sequence, series and text/image relationships, using various book structures. These "sketches" will prepare students for an extended book project during the second half of the term. *3 credits.*

FA 315A **Advanced Design**
Section I: Type Design
Section II: Web Design
Section III: Guest Artist Series
This course is for students who have a strong commitment to graphic design. Students will create three projects, each presented by a visiting graphic designer. Presentations, readings, and trips to local design studios will support group critiques.
3 credits. Prerequisites: Graphic Design II, Typography I

FA 315A, FA 315B **Advanced Design**
Fall 2020
Archives Can your work be recognized as 'your work' instantly? Is that a good thing? This class will explore how to make use of and come to terms with the intersection of your personal esthetic and the realities of professional problem-solving. *Tochilovsky*
Type Design In this hands-on class, students will go from the fundamentals of writing and hand-drawn type to contemporary digital type design. By the end of this class every student will have created their own, original digital font. *Famira*
3 credits. Prerequisites: Graphic Design II. Pre- or corequisite: Typography.

FA 317A, FA 317B **Advanced Design: Open Studio**
Students will develop a series of personal and unconventional narratives through writing prompts and mix-media studio exercises. The goal is to expand methods and visual techniques when designing or expressing an idea/story. Emphasis will be placed on contemporary graphic design/art practices and developing a personal voice and aesthetic. Visiting lecturers, readings, and individual meetings with the instructor will complement group critiques. *3 credits. Prerequisites: Graphic Design I and II. Pre- or corequisite: Typography. For Fall 2020: Frank Stanton Chair Helene Silverman*

FA 326 **Interactive Design Concepts**
An exploration of the nature of interactive design and how it informs and transforms experience. Information structures, navigational issues, design strategies and social implications of interactive experiences using traditional as well as electronic media will be examined. *3 credits. One-semester course. May not be repeated. Prerequisite: Techniques in HTML and Programming or permission of the instructor. Sparling*

FA 327 **Advanced Interactive Design Concepts: Computational Media**
An advanced design course in interactive computational media. The course will explore advanced interactive design concepts utilizing software which that includes Processing and Macromedia Flash as well as XHTML coding. Students will complete two fully realized independent projects. Analysis of relevant work and readings support group critiques. *3 credits. One-semester course. Prerequisite: Interactive Design Concepts.*

FA 328 **Motion Graphics**
Students will explore the conceptual and technical challenges of design for the television screen. All aspects of industry video/ broadcast production are introduced and integrated into a design core focused on strong communication. Projects include identity design, combining kinetic typography, animation, sound and video. The course includes workshops in After Effects, Final Cut Pro and Protools. *3 credits. One-semester course. Prerequisites: Graphic Design I and II. Pre- or corequisite: Typography. Vondracek*

FA 429A, FA 429B **Independent Study in Graphic Design**
1-3 credits. Requires approval of instructor and the Dean of the School of Art

Painting

FA 130A, FA 130B **Painting**
A studio experience with the physical, compositional and conceptual components of pictorial invention and image-making. Readings, assignments and critiques will enhance the development and articulation of an inventive individual approach to the painting discipline in preparation for advanced level work. *3 credits per semester. One-year course. Prerequisite to all Advanced Painting courses. Asper/Bluestone/Evans*

FA 331A, FA 331B **Advanced Painting**
A seminar course for self-motivated students who are working independently in their studios with a primary focus in drawing and/or painting. In addition to individual studio growth, the course will encourage the development of a critical practice of looking at one's own work and that of others. Though the emphasis is on individual meetings and working on one's own, we will meet together at the beginning of each class for discussion of students' work, current exhibitions, readings, or for slide/video presentations relevant to students' current projects. *3 credits. One-semester course. Villalongo*

FA 334A, FA 334B **Advanced Painting**
A seminar course for students who have the ability to work independently in their studios with a primary focus in drawing or painting. Students will be expected to develop their ideas and work independently, but the class will meet together every week or two for discussion of each other's work, as well as various museum and gallery shows, readings or slide presentations of current work. The course will emphasize experimentation and expansion of one's visual language and process, and the ability to articulate these ideas in discussion. *3 credits. One-semester course.*

FA 335A **Advanced Painting**
In this course, students develop their individual studio work through experimentation, risk taking and rigorous evaluation of how to explore questions of content in their work. Students are encouraged to work through their ideas and relationship to painting to find their own distinct voice and ways of working. The course is centered around individual meetings, with scheduled group critiques for group evaluation and discussion. Supplemental readings, image presentations, discussions, and gallery/museum visits expand the knowledge of the open field of painting today and it's potential for invention and the production of meaning. *3 credits. One-semester course. Jessica Dickinson*

FA 336A, FA 336B **Advanced Painting**
How does an artist find their voice and sustain it over a lifetime? One answer is to understand art as a process that arises from both the heart and the brain, a kind of machine where these two areas work dynamically together. The aim of this class is to help advanced students achieve a more nimble and trusting artmaking process and a greater degree of critical intelligence. We will try to align production and conversation, bringing language to what you already do instinctually, and meanwhile developing the guts and rigor to investigate other work and ideas that you are not already aligned with, or that may seem outside your area. The goal is the expanded field: to widen, question, cross-fertilize, and push your work individually and collectively. The class will include individual studio visits, class critiques, visiting exhibitions, reading and discussing texts by artists writing about their processes.
3 credits. One-semester course. Fall 2020 Alex Katz Chair Amy Sillman

FA 337A, FA 337B **Advanced Painting**
Students will explore the inner reservoirs of the imagination and investigate, as well, specific external resources for imagery. The course will seek to develop a range of expressive vocabulary including representation and abstraction. Group and individual critiques will be augmented through discussions of museum and gallery exhibitions and slide presentations. Emphasis will be upon developing a personal visual direction. *3 credits. One-semester course. TBA*

FA 338A, FA 338B **Advanced Painting/Water Media**
Students will focus on water media—acrylic, transparent watercolor and gouache—through work on canvas and paper. The class will explore the specific technical challenges and characteristics inherent in these media including the range from transparency to opacity. Individual approaches will be encouraged in developing the aesthetics of the evolving image from spontaneity to studied expression, from figuration to abstraction. Exposure to selected examples of historical and contemporary imagery will be accomplished through slides, exhibitions and gallery or studio visits. *3 credits. One-semester course. TBA*

FA 339A, FA 339B **Advanced Painting/Katz Guest Artist Series**
This course is for students who have made a strong commitment to painting. Students are expected to work independently in their studios on a series of paintings that will develop during the semester in response to a dialogue with the different guest artists. *3 credits. One-semester course. Villalongo/Asper*

FA 439A, FA 339B **Independent Study in Painting**
1-3 credits. Requires approval of instructor and the Dean of the School of Art

Performance

FA 290 **Elements of Performance**
This course examines the elements that unify the diverse set of practices gathered as "performance art." Engaging concepts of time, movement, voice, text and body in performance based work, the course addresses both the historical development of performance practices within the field of contemporary art, as well as their current manifestations. Lectures, screenings, readings and discussions support the development of individual and collaborative studio work. *3 credits. One-semester course. May not be repeated*

FA 395 **Performance**
Performance or the live event has been a continuous element of art practice throughout most of the 20th century. The changing technologies of sound and digital recording devices and their increasing availability have enhanced the possibilities of documentation and allowed artists to consider the mediation and documentation of a live event as an integral part of the work itself. In this course, students will examine the interaction between performance and its documentation through practical, historical and theoretical interrogation. The class proposes to address documentation, not as an inadequate representation nor as a nostalgic marker but as something that operates within a distinct system that can become a vital site of art production. This class takes an interdisciplinary approach to making performance work. The medium of performance and its utilization of photography, video and sound will be explored. Students will read and discuss texts, looking at the work of other artists and making their own work. *3 credits. One semester course. Cohen/Fusco*

Photography

FA 206 **Lens/Screen/Print I**
The first section of a two-semester trajectory. This is an immersive foundation course in the practice of photography focusing on a critical engagement with lens technology, color theory/management and combined analog/digital workflows. Topics include: exploratory and technical knowledge of 35mm and medium-format analog cameras, DSLR cameras, lenses and lighting conditions, fluid movement through digital black-and-white and color processes, such as digital imaging editing software, scanning analog color, and digital printing in black-and-white and color. Exposure to critical theory and major philosophical arguments central to lens, screen and print based practices will be explored. This is an assignment driven class. *3 credits. 4 contact hours. Deschenes/ Westpfahl*

FA 207 **Lens/Screen/Print II**
The second half of a two-semester trajectory. This course builds upon the foundations of LSP I with an emphasis on post-production and a critical engagement with lens technology, color theory/management and combined analog/digital workflows. Technical knowledge of the tensions and possibilities found between "digital" and "analog" spaces in relation to critical theory and major philosophical arguments central to lens, screen and print based practices will contribute to student development. Topics include advanced digital editing and printing techniques, analog black-and-white production methods, such as shooting with black-and-white film and darkroom printing, advanced medium-format cameras and scanners, as well as introduction to new technologies and modes of display. A distinction in LSP II is a

focus on experimentation, articulation and acumen. Students are encouraged to begin to develop semi-autonomous ways of working over the course of the semester, this includes supervised independent or collaborative projects. This course will afford students the opportunity to build a coherent body of work in preparation for advanced study. *3 credits. Prerequisite: Photo I or Lens/Screen/Print I*

FA 360 **Photography: Printing Images**
This course will focus on the materiality of the photographic print, both analog and digital. Options in silver-gelatin printing including toning, bleaching and plating, as well as advanced options in digital printing will broaden students' understanding of the photographic image. Issues involving photographic representation will be addressed through discussions, group and individual critiques, hands-on demonstrations and field trips. Students will produce a finished set of printed images by the end of the semester. *3 credits. Prerequisite: Photo I.*

FA 361 **Photography: Topics**
Topic varies. For Fall 2020
The Constructed Image This studio art course will explore the physical construction of images, relying upon the language and material qualities of photography as their base. The history of collage, montage, composited, staged forms, multiples, and book-as-artform will be discussed. Contemporary artists using these methods will be introduced. Hands-on analog and digital processes, both pre- and post-capture, will be discussed and demonstrated. Individual and group critiques will be supplemented by discussions, readings, presentations, and technical instruction. The final project will focus on the creation of an individual or group book, realized through an online printing service or constructed by hand. *Henry Wolf Chair Jennifer Williams*

Art and Ecology This studio class will approach questions around making art with respect to ecological thinking. Ecology will be interpreted as interdependent systems operating on different scales such as the micro, the social, and the cosmic scale, including mental states, human and non-human exchanges, material histories, and global information flows. Through critiques and discussion, the class will explore aesthetics and language to be developed for catastrophic times. *Backström.3 credits. Prerequisite: Photo I. Visiting Artist: Fia Backstrom (Fall 2020)*

FA 361A **Advanced Photography: Large Format**
This course focuses on the expanded photographic potentials afforded through the use of large format materials, both analog and digital. Students will explore the ways in which photographs alter and create both architectural and psychological space, become fluent in the techniques of large format analog camerawork, learn advanced printing techniques in the darkroom, and explore the wide range of large format digital printing options. The format of the class will combine lectures, discussions, hands-on demonstrations, and field trips. Students will discuss work in group and individual critiques and the class will culminate with the presentation of a final project.
3 credits. Prerequisite: Photo I; Ward

FA 362A, FA 362B **Photography: Lighting**
This critique-based studio course explores the use of light on location in photography. Topics explored by this course will include the use and modification of available light as well as the use of portable light sources such as flash (both single and multiple), portable battery powered strobes, remote light triggers and other tools.

The emphasis of this course will be on using lighting techniques outside the studio in order to gain an understanding of how light effects the way we interpret our world.
3 credits. Prerequisite: Photo I. Stroh

FA 363A, FA 363B **Digital Photography**
This studio course focuses on issues related to digital imaging. Students will explore ideas related to digital work as well as techniques such as color management, various corrective measures, and options in digital cameras and printers. Issues central to photography in the digital era will be explored. Students will pursue individual projects that will be discussed in group and individual critiques. *3 credits. Prerequisite: Photo I.*

FA 364A/B **Photography**
This is a project-based seminar which focuses on photography as a discursive practice. We will examine specific questions relevant to photography now (regarding the relation between politics and aesthetics, mediums and mobility, how images can function to both approximate and deny a sense of 'reality'...) and discuss these issues in relation to each students' studio objectives. The format of the class will integrate slide presentations, readings, group discussion and critique. Towards the end of semester, students will develop individual proposals and complete a final project. Although there will be an emphasis on strategies and critical theory related to lens-based media, these ideas can be mined to inspire a wide range of practice. Students with different priorities can thrive in this class— from artists who focus on photography to artists who work across different media. *3 credits. Prerequisite: Photo I*

FA 365A/B **Photography**
This studio based class will explore conceptual topics surrounding current issues such as social justice; the image in the public sphere, and the socio-political landscape. Frequent critiques and discussions will include information on artists relevant to the students' work as well as provide space to develop technically to support a lens based practice. We will consider how a studio practice in photography develops, this includes considering how traditional wet lab and digital lab processes actually complement and support each other. *3 credits. Prerequisite: Photo I. Spring only. Hewitt*

FA 366 **Advanced Photography: Alternate Processes**
A course for students who wish to explore the possibilities of hand-applied photographic emulsions and alternative methods of printing. Processes will include liquid light, cyanotype, palladium, color copier and digital printing options. Student work will be discussed in relation to contemporary art issues. *3 credits.*
Prerequisite: Photo I. Williams

FA 368A, FA 368B **Photography: Guest Artist Series**
This course is intended to help students clarify and further the growth of their own work through group and individual critiques, classroom presentations and discussions with contemporary guest artists and the instructor. *3 credits.*
Prerequisite: Photo I. Osinski

FA 369A **Photography**
Students will produce work using photographic material(s), camera or any photographic device of their choice. Work will be discussed in group critiques as well as individual conferences with the instructor. Photographic issues and representation will be the subject of reading and class discussions. *3 credits. Prerequisite: Photo I. Fall only. Raad*

FA 469A, FA 469B **Independent Study in Photography**
1-3 credits. Requires approval of instructor and the Dean of the School of Art

Printmaking

FA 250 **Silkscreen I**
This course explores screen printing as a means of communication with emphasis on the execution of these images. Students visit museums to learn to appreciate posters from various historical periods. The actual screen printing will be taught with the use of images, type and color. The goal of the course is to combine the components of art, printing and communication. *3 credits. One-semester course. May not be repeated. LaRocca*

FA 251 **Lithography I**
An introduction to traditional and contemporary image-making on lithographic stones and commercial aluminum plates, with emphasis on the technical aspect of the medium. The various areas to be examined include stone graining, crayon and tusche drawing, processing, proofing and edition printing procedures, etc. *3 credits. One-semester course. May not be repeated. Nobles*

FA 252 **Etching I**
An introduction to etching images on metal plates, through the use of hardground, aquatint softground. The emphasis is on the technical understanding of the medium. Other image-making processes to be covered are drypoint and engraving.
3 credits. One-semester course. May not be repeated. Ancona

FA 253 **Paper: Materiality and Sustainability**
This studio course explores making paper from traditional to contemporary approaches. The course incorporates specified instruction and experimentation driven by student independent projects. The exploration of the structural and historical uses of Western and Eastern methods including contemporary issues of recycled and alternative fibers will frame an understanding of the potential uses and appearances of handmade paper. From a basis in sheet forming, pigmenting, sizing, and the use of additives, the class will move into an emphasis on paper as a visual and sculptural object, covering paper casting and other three-dimensional approaches.
3 credits. 4 contact hours. One-semester course. May not be repeated. Martin

FA 350A, FA 350B **Silkscreen Workshop**
An advanced workshop in which the students are free to explore screen printing, graphic arts and photography. There will be formal teaching of advanced photographic processes such as halftone and color separation. *3 credits. One-semester course. Prerequisite: Silkscreen I. Nobles*

FA 352A, FA 352B **Etching Workshop**
This course will involve individual directions in etching as well as the development of projects combining print technique and aesthetic goals. The understanding and use of the contemporary professional print shop will be discussed. *3 credits. One-semester course. Prerequisite: Etching I.*

FA 354A, FA 354B **Experimental Printmaking**
The course will supplement the traditional printmaking techniques of etching, lithography and silk screen with an introduction to linoleum woodcut techniques and monoprint/monotype combination of methods appropriate to developing an aesthetic understanding of the vocabulary of the print. Color, multiple printing, work in series or book formats will be discussed in developing student projects. *3 credits. One-semester course. Prerequisites: 2 of the following 4 courses: Silkscreen I, Lithography I, Etching I or Papermaking Techniques. Cornejo/Nobles*

FA 355A, FA 355B **Relief**
Students will be instructed in various relief printing techniques, including traditional Japanese water-based woodblock and Western techniques with oil-based inks on wood and linoleum. Use of the hydraulic press will allow large format works to be produced. Hand-printing techniques will be taught as well. Small edition printing in multiple colors will be emphasized. *3 credits. One-semester course. Ancona/Nobles/Shibata*

FA 459A, FA 459B **Independent Study in Printmaking**
1-3 credits. Requires approval of instructor and the Dean of the School of Art

Projects

FA 384A **Projects**
This course is open to all third and fourth year students who intend to initiate or pursue a longer term (longer than a semester) art project. Students are expected to present their work-inprogress weekly, to research the works of other artists, writers, and thinkers, and to participate actively in class discussions.
Open to all 3rd and 4th year students. May be repeated with instructor's permission. Raad

Science

RS 201 **Science**
Topics vary.

RS 201a **Earth Science** The course will cover a broad range of Earth Science topics including understanding rocks and the stories they tell, the vast scale of geological time, dynamic plate tectonic processes, climate change, and what makes the planet habitable for life. It will inspire wonder and a deep appreciation for the Earth. The course will present to students a different way of looking at the Earth: not as something that is constant and static but rather dynamic and constantly changing, a place with a broad and exciting history of which we are only a small part.
RS 201f **Introduction to Biomaterials** From the time of cave paintings, artists have been depicting living organisms. But what happens when the art consists of the organism itself or its products? Living material is dynamic by nature, and so the artwork changes with time, perhaps in unpredictable ways. In this class we will explore various biomaterials, including organisms such as bioluminescent plankton and plants that respond to touch, fermentations that create color pigments or cellulose mats, and the DNA that controls it all. The class will be part lecture, part hands-on experience.

RS 201g **Astronomy** This course begins with an historical overview and then introduces the contemporary understanding of the universe. Students learn about the key elements of the universe, including motion, energy, gravity and light. Topics include; the solar system and its origins; the sun; stellar evolution including white dwarfs, neutron stars, and black holes; galaxies beginning with the structure of the Milky Way; dark matter, dark energy and the Big Bang theory. Labs and field trips to an observatory augment class discussion. *Grcevich*

RS 201h **Science: Physics for Artists** The course provides an overview of discoveries in physics over the past two millenia, focusing on the development of modern theories. Topics include nature of light and matter, relativity, quantum mechanics, evolution of the universe and the nature of science. Knowledge of basic algebra is assumed. Field trips and computer lab assignments are included in the syllabus. *Kreis*

RS 201i **Science, Technology and Societal Impact**
This course explores the ramifications of the latest scientific discoveries and technological breakthroughs. How will they affect our lives and the planet? What social, moral, and ethical questions have inspired artists to use them in their work? Each class will focus on a different scientific discipline such as genetic engineering, cognitive neuroscience, tissue engineering, synthetic biology, and personal genomics. An explanation of the science will be followed by a discussion examining the utopic/dystopic myths surrounding these technologies, fact vs. hype, and what questions should be raised as we implement them. Guest artists and their work will be featured along with scientists and ethicists.

RS 201j **The Climate System** The Earth's climate system is complex and dynamic, and a solid understanding of this system is crucial in order to address concerns about human influences on climate. In this course we examine the basic physical and chemical processes that control the modern climate system, including the role of incoming solar radiation, the greenhouse effect, ocean and atmospheric circulation, and El Niño. We also look at the methods and archives used to reconstruct climate in the past. We explore the possible effects of greenhouse gas emissions caused by humans on modern and future climate by examining the models used in climate prediction, and discuss the challenges of modeling such a complex system. Although this course is taught from a primarily scientific perspective, it includes discussions of the roles policy and economics play in the current dialogue on global climate change. Finally, we look at some of the local impacts of climate change and preparedness planning for New York City.

RS 201m **Ecology** Ecology is the study how organisms interact with other organisms and their environments. The field tackles a broad set of questions. How do prey populations respond to predators? How do aquatic systems differ from those on land? What happens when additional nutrients are introduced to a habitat? Understanding the fundamentals of ecology is ever more important: ecosystems are regularly degraded and many species are at risk of extinction due to climate change, legal rollbacks of environmental law, and consumptive human practices. However, individuals, conservation organizations, and politicians can better solve these problems by understanding ecological principles. In this course, we will jointly explore the science of ecology with biological conservation, considering current and local ecologies and issues. To gain deeper knowledge in these subject areas, we will become familiar with both scientific background and current events. To enrich our perspectives, we will have regular discussions on ecology, conservation, and how it all relates to us. To gain local context, we will take field trips within the NYC to learn about city ecology and conservation.

RS01n **Evolution** Evolution is one of the most fundamental concepts for understanding life on Earth. The field of evolution allows us to ask important questions like: How are humans related to fish or bacteria? Why are some animals brightly colored while others are drab? How can something complex like flight evolve separately in birds, bats, and insects? In this class we will learn to answer questions like these, and many others. We will examine tools used to understand evolution in deep time and take field trips to see the organisms that live around us, while learning about evolution in the city. *Tessler*

3 general studies credits. Required science course. To be taken during the sophomore, junior or senior year.

Sculpture

FA 391A, FA 391B **Sculpture**

This course helps students develop projects related to their own vision and ideas. Class discussions address the full range of conceptual and material processes that generate production. Research and development will be given equal weight to finished work. Intention, form, materiality and context will be analyzed against larger questions of culture in relation to artistic practice. Student work will be reviewed by the entire class and by the instructor on an individual basis. Lectures, readings and field trips will complement studio critiques. *3 credits. One-semester course. Adams*

FA 392A, FA 392B **Sculpture**
Fall 2020: Art and Ecology This studio class will approach questions around making art with respect to ecological thinking. Ecology will be interpreted as interdependent systems operating on different scales such as the micro, the social, and the cosmic scale, including mental states, human and non-human exchanges, material histories, and global information flows. Through critiques and discussion, the class will explore aesthetics and language to be developed for catastrophic times. *3 credits. One-semester course. Backström*

FA 393A, FA 393B **Sculpture**
This course helps students explore and develop their personal process of making art, with an emphasis on sculpture. Formal and material choices will be discussed in relation to intention, meaning, context, and contemporary culture. Research and development are given equal weight to finished work. Students will discuss their process individually with the instructor, and present work for review to the entire class. In-class slide presentations, readings, and field trips will complement class discussions. *3 credits. One-semester course. Lehyt/Mooses*

FA 394A, FA 394B **Sculpture**
This course takes a concrete approach to the development of critical discourse about works of art. It exercises the student's ability to analyze the activity of making sculpture in particular and advances the student's understanding of how to proceed in the studio. Problems of structure, materials, meaning, intention and context are the subject of class discussion. *3 credits. One-semester course. Farmiga*

FA 397A, FA 397B **Sculpture**
This course takes a concrete approach to the development of critical discourse about works of art. It exercises the student's ability to analyze the activity of making sculpture in particular and advances the student's understanding of how to proceed in the studio. Problems of structure, materials, meaning, intention and context are the subject of class discussion. *3 credits. One-semester. Ashford*

FA 398A, FA 398B **Sculpture**
This course helps students develop projects related to their own vision and ideas. Class discussions address the full range of conceptual and material processes that generate production. Research and development will be given equal weight to finished work. Intention, form, materiality and context will be analyzed against larger questions of culture in relation to artistic practice. Student work will be reviewed by the entire class and by the instructor on an individual basis. Lectures, readings and field trips will complement studio critiques. *3 credits. One-semester. Magid/Raven*

FA 499A, FA 499B **Independent Study in Sculpture**

1-3 credits. Requires approval of instructor and the Dean of the School of Art

TE 390 **Casting Techniques**

Casting Techniques is a process intensive course covering the methods of translating a wax positive into bronze or other non-ferrous metals. All associated techniques from beginning a plaster or rubber mold to casting, chasing, finishing and patination of metal sculptures will be covered. Students will explore a variety of approaches to casting, as well as engage in discussions involving the history of bronze casting, and its place in contemporary art.

2 credits. One-semester course. May not be repeated. Free elective credit. Wilhelm

Sound Art

FA 281 **Project in Sound Art**

This class will introduce strategies for understanding and participating in the aural world. The course is divided into specific weekly topics, including acoustic ecology, circuit-bending, radio transmission, synaesthesia and others. Screenings, readings and discussion are supported by hands-on workshops in capturing, manipulating and reproducing sound in unconventional ways. Grading is based on three student projects and participation in class discussions. *3 credits. One-semester course. May not be repeated. Poff*

Practicum

FA 301 **Teaching as Collaborative Social Practice**

As a practicum, this course invites students to actively explore the evolving role of the artist engaged in teaching as an art practice. The aim is to help the undergraduate who is currently teaching or who has interest in teaching in The Saturday Program. Through the course students will begin to frame pointed questions, such as: What is art? What is architecture? What constitutes community? What kind of societal questions can art/architecture raise while still being art/architecture? How can human interaction be seen and understood as a work of art or as architecture? Introductions to artists, art collectives and institutions that hold varied approaches to the notion of community, education, social discourse and positionality will also be essential to the learning environment. *3 credits. Olivera*

ALBERT NERKEN SCHOOL OF ENGINEERING

Overview

With an average enrollment of about 450 undergraduate students, engineering is the largest of The Cooper Union's schools. The school maintains small class sizes in courses and laboratories in order to provide for personal attention. It offers bachelor of engineering (B.E.) degree programs in chemical, civil, mechanical and electrical engineering, accredited by the EAC commission of ABET*.

In addition, the school offers a general engineering program (B.S.E.). This program empowers students to create their own curricula (within carefully set parameters) in those areas of engineering that cross traditional boundaries—for example, computer science, entrepreneurship, biomedical, energy, sustainability, infrastructure, environmental, mechatronics, robotics, etc.

The B.S.E. program provides an excellent preparation for graduate work in law, medicine, business, finance, etc.

The integrated master's program offers the opportunity to earn both a bachelor's and a master's degree in an engineering discipline at The Cooper Union within four, five or six years.

Degree programs are designed to prepare students to enter the workplace immediately after graduation or to pursue graduate study. An extraordinary number of Cooper Union engineering graduates go on to earn Ph.D. degrees at the nation's most prestigious graduate schools. Others go on to study in fields such as medicine, law or business. Many graduates rise to leadership positions in industry, education and government.

The early curricula in engineering are based on intensive study in the sciences, mathematics, computer science and engineering sciences, which serve as preparation for deeper immersion within the engineering fields. Building on this strong base of mathematics and sciences, and emphasizing the integration of knowledge, these curricula promote an understanding of nature, the limitations of our present knowledge and the potential for advancing that knowledge.

Strong mathematical and computer skills are developed in all engineering students. This includes the ability to mathematically model and solve problems algorithmically, in a suitable language, and to use existing commercial packages for analysis and

design. Students are expected to be highly computer literate and gain proficiency in specialized packages that are used both in elective and in required courses. The faculty expect assignments to be carried out using computers in appropriate ways, both as a design tool using packages and also as a platform for creating original software.

Defining characteristics of the School of Engineering's programs are the emphasis on project-based learning and opportunities for undergraduate research. Students and their peers regularly join the faculty in solving real-life problems that exist in contemporary society. Multi-disciplinary teams, frequently cooperate with outside professionals, who act as mentors. Superior analytical abilities and thorough grounding in engineering fundamentals and design enable students to collaborate on these projects. Results may be published, presented at conferences or even patented.

A strong background in engineering design threads throughout the curriculum, starting with the first year. These design experiences take into consideration factors such as environmental issues, sustainability, economics, teamwork, societal impact, safety and political climate—showing students that a "design" is much more than a purely technological solution.

Some design problems are offered in collaboration with foreign universities to increase awareness of the global nature of the engineering profession (e.g., The Cooper Union's study abroad and international exchange programs). Others may involve collaboration with industry, hospitals and/or other US universities.

Diverse electives are offered so that students can add a background in business and finance, additional mathematics and sciences or a "concentration" in an additional engineering area.

Like The Cooper Union's other schools, the Albert Nerken School of Engineering is intimately involved with the New York metropolitan area. Sometimes, the city and its infrastructure are used as a laboratory. The school also draws on the region's abundant talent and resources, including an outstanding array of engineers and scientists employed at major corporations, governmental agencies and consulting firms in the New York region. The school calls on physicians, lawyers and other specialists to collaborate on research and mentoring and to give unique insights into contemporary problems and social issues confronting modern engineers. Many of these professionals are alumni and may serve as adjunct faculty members lending a dynamism to the classroom.

Students benefit from an uncommonly close interaction with dedicated faculty, some of whom are alumni, in a conservatory style environment. Our faculty bring their diverse experiences to the classroom and laboratory setting and serve as role models to our students. Our students are encouraged to participate in The Cooper Union's rich seminar and cultural programs as well as to attend talks by guest speakers. They join various professional societies, many of which have chapters at The Cooper Union. Students are inspired to qualify for membership in national engineering honor societies. They also participate in student government and sports, and take advantage of the vast cultural environment offered by New York City and the neighborhood.

The School of Engineering strongly encourages undergraduate research activities and permits juniors and seniors to register for graduate level courses, when deemed appropriate. This enrollment does not guarantee admission to the master's program however. A Cooper Union undergraduate may declare the intent to complete an integrated degree in the second semester of the junior year or apply to the graduate program (Master of Engineering) in one of the degree-granting departments during the second semester of the senior year

Graduates of The Cooper Union are recruited by major national and international corporations, consulting companies, new ventures and graduate schools nationwide. Alumni are found in the top management and research leadership of many American corporations; hold key positions in federal, state and city agencies; and distinguish themselves on university faculties and administrations nationwide. Through their many and varied professional accomplishments, alumni have earned for the school its reputation for excellence.

CURRICULUM

Bachelor of Engineering

The requirements for the bachelor's degree programs must be completed within four years of first registration, except with the explicit consent of the dean/associate dean. Requests for extension must be presented in writing to the dean's office prior to the sixth semester of registration (or the end of junior year). It is the responsibility of the student to maintain normal and reasonable progress toward the degree.

Courses may be taken at other institutions for credit with prior advisor(s) approval only. If the course is to substitute for a Cooper Union course, prior approval must be given by the chair of the appropriate department in the engineering school or by the appropriate school or faculty for courses outside engineering. The student is responsible for all costs incurred. As a general matter, many courses simply may not be taken elsewhere (e.g., Physics I). In order to get a course pre-approved, bring as much course documentation as possible to the Chair of the appropriate department to have the course assessed. These materials must include at least the syllabus and textbook. The course must be judged to be equivalent to one taught at Cooper or an appropriate high academic standard. Note that only grades "B" or better can be transferred (not B-) and the grade will not be factored into your G.P.A.

Additionally, ABET accreditation requires:

- One year of a combination of mathematics and sciences (some with experimental experience) appropriate to the discipline,
- One and a half years of engineering topics consisting of engineering sciences and engineering design appropriate to the student's field of study and
- A general educational component that complements the technical content of the curriculum and is consistent with the program and institutional objectives.

In order to graduate, all students must meet the following conditions:

- A minimum of 135 credits are required
- Satisfaction of all program curricula
- Satisfaction of the residence study requirements
- A minimum grade point average (G.P.A.) of 2.0
- A minimum grade point average (G.P.A.) of 2.0 for the junior and senior years combined

Faculty Advisors

All first-year students have the same faculty advisor. For subsequent years, students will be assigned one, two or more advisors each, appropriate to their field of study. Each student's program is established in consultation with his or her advisor(s); changes can only be made with approval of the advisor(s).

Humanities and Social Sciences

The requirements in this area are satisfied by courses offered by The Cooper Union Faculty of Humanities and Social Sciences or by transfer credit for liberal arts courses taken at other institutions. The courses in this area are intended to provide both breadth and depth and should not be limited to a selection of unrelated introductory courses. The Cooper Union liberal arts courses, shown elsewhere in the Faculty of Humanities and Social Sciences catalog section, have prefixes H, S and HTA.The basic courses HSS1–HSS2 and HSS3–HSS4 are prerequisites for all higher level courses in the same prefix family. H and S courses carry three credits each; HTA courses carry two credits. Engineering students should consult with the dean of Humanities and Social Sciences about choice of courses to satisfy particular interests.

Transfer credits for liberal arts courses must be approved by the dean of Humanities and Social Sciences. Courses that cannot be used to satisfy the Humanities and Social Sciences requirement are:

- Language skills courses such as introductory foreign language, public speaking, report writing
- Craft and performance courses unless accompanied by theory or history
- Subjects such as accounting, finance, engineering economy, industrial management, personnel administration

Some programs require "free electives or non-technical electives." For transfer credit for particular courses, the School of Art or the School of Architecture may be a more appropriate authority to sanction the transfer. Students who are uncertain should approach the Office of the Dean of Engineering in the first instance and be directed to the correct group of faculty.

Free Electives/Non-Technical Electives

Some programs require "free electives or non-technical electives." For transfer credit for particular courses, the School of Art or the School of Architecture may be a more appropriate authority to sanction the transfer. Students who are uncertain should approach the Office of the Dean of Engineering in the first instance and be directed to the correct group of faculty.

Program Requirements

The specific programs for entering students are shown in detail in the curriculum tables. From time to time, changes are made to these programs following curricular developments authorized by the faculty. Advances in technology and new technologies are closely monitored and are reflected by adjustments in all the engineering programs.

Course Substitutions and Credits

A student may request to substitute for a required course or courses given in the School of Engineering provided that:

- The substitution is limited to 12 credits maximum toward the total number of credits required for graduation,
- The substitution is approved by the dean/associate dean and program advisor(s) and
- ABET accreditation requirements are not violated.

The Chemical Engineering Department does not permit the substitution of any courses.

The number of academic credits for each course generally is based on the following relationship:

- 1 credit per contact hour in class
- 0.5 credit per contact hour of laboratory

This relationship was established on the basis that generally two hours of preparation are expected of the student for every contact hour in class or project activities and generally one hour of preparation is expected for every contact hour of laboratory.

Residence Study Requirement

A candidate for a bachelor's degree must be enrolled during the entire academic year immediately preceding the granting of the degree and must carry at least 12 credits per semester during that period. Also, the candidate must have been enrolled for a minimum of four semesters at The Cooper Union as a full-time student for the bachelor's degree.

ACADEMIC STANDARDS AND REGULATIONS

Academic Integrity

Faculty at Cooper Union are committed to preserving an environment that challenges every student to realize his or her potential. You are expected to provide your best effort and will be supported to produce original work of the highest caliber. Plagiarism is the presentation of another person's "work product" (ideas, words, equations, computer code, graphics, lab data, etc.) as one's own. Whether done intentionally or unintentionally, plagiarism is not tolerated in the School of Engineering.

There are many types of plagiarism, some of which are listed below. (The list is not exhaustive. Speak with the appropriate faculty member or dean or associate dean of engineering if you are uncertain as to what constitutes ethical conduct in a particular situation.)

You are plagiarizing if:

- You present as your own work product a homework assignment, a take-home exam or a class project that includes the efforts of other individuals. The contributions of other individuals (if permitted by your instructor) must be acknowledged in writing on the submitted assignment, exam or project.
- You copy the work of other students on an in-class examination or communicate with other individuals in any fashion during an exam.
- You submit as part of a homework assignment, take-home exam or class project material that has been copied from any source (including, but not limited to, a reference book, periodical, the Internet) without properly citing the source, and/or without using quotation marks. It is also prohibited to submit such materials in a minimally altered form without proper attribution. Improperly copied material might include text, graphics (computer or otherwise), computer source code, etc.

Other prohibited acts of academic dishonesty include (but are not limited to):

- Attempting to obtain a copy of an examination before it is administered.
- Dishonesty in dealing with a faculty member or a dean, such as misrepresenting the statements of another faculty member.
- Bringing notes into an examination when forbidden to do so.

- Bringing any device into an examination (computer/ smartphone/ calculator), which permits the retrieval of examination-related materials unless expressly permitted by the instructor.
- Bringing any device into an examination that allows communication with other individuals or computers or computer databases unless expressly permitted by the instructor.

Faculty members may not unilaterally resolve incidents of academic dishonesty. Each faculty member is required to report all cases of plagiarism or academic dishonesty to the engineering dean's office in a memorandum. If documentary evidence of the incident exists, it should be attached. The dean's office, in consultation with the faculty member and the student, will select from the following sanctions: a grade of F for the assignment, a grade of F for the course or dismissal of the student from the school. A record of all incidents will be kept in the dean's office and considered for second-time offenders. Students who are dismissed because of academic dishonesty should be aware that incident reports and any responsive actions by the dean's office or Academic Standards Committee become part of their permanent record.

Sexual or Racial Harassment

Such behavior will not be tolerated. Incidents should be reported immediately. Students should see the dean or associate dean, and also the dean of students as soon as possible.

Code of Conduct

Students are required to read and abide by The Code of Conduct.

Transfer Credit

Students, at their own expense, desiring to register for courses at another institution for transfer credit to The Cooper Union must have appropriate approval in advance. For courses in mathematics, sciences or engineering, this approval is to be obtained from:

- the department responsible for the course at The Cooper Union and
- the dean or associate dean of engineering.

For liberal arts courses, approval is to be obtained from the dean of Humanities and Social Sciences. In order that transfer credits from another school be accepted, a grade of B or better is required. (A grade of B- or worse cannot be transferred). An exception may be granted in special circumstances only upon formal appeal to the Academic Standards Committee. Transfer credit is never granted for paid summer internships or work experience or paid or unpaid research.

Grades of Record

The definitions below deal with the student's attainment in the formal work of the subject. Nevertheless, it should be understood that such essential qualities as integrity, adherence to class regulations, enthusiasm, motivation, clarity in presentation of work and sense of obligation, together with ability to use the English language correctly and intelligibly, are reflected in the grade. The course grade is assigned by the instructor in conformity with definitions indicated in this section.

The grade **A** indicates a superior and comprehensive grasp of the principles of the subject. It denotes an ability to think quickly and with originality toward the solution of difficult problems.

The grade **B** indicates evidence of a good degree of familiarity with the principles involved in the subject. It implies less originality and a tendency to hold to patterns of thought presented in the formal subject matter.

The grade **C** indicates an average knowledge of the principles involved in the subject and a fair performance in solving problems involving these principles. This grade implies average ability to apply the principles to original problems.

The grade **D** indicates a minimum workable knowledge of the principles involved in the subject. This grade denotes low achievement and therefore the number of such grades permitted any student is limited in a manner prescribed by the section on Scholastic Standards.

The grade **F** indicates an unsatisfactory understanding of the subject matter involved. A grade of F may be made up only by repeating the subject in class; both the new grade and the new credits and the original grade and credits are included in the permanent record and in the grade point average. A student who receives an F grade in a repeated course is a candidate for dismissal by the school's Academic Standards Committee.

The Incomplete **(I)** Grade The designation of I indicates that the work of the course has not been completed and that assignment of a grade and credit has been postponed. This designation will be given only in cases of illness (confirmed by authorized physician's letter) or of other documented extraordinary circumstances beyond the student's control. The I designation will be given only with the approval of the dean or associate dean of engineering. At the time of submission of an I designation, the instructor will indicate whether the student's progress to that point has been satisfactory or unsatisfactory, offering an estimation of grades whenever possible as a means of assisting the Academic Standards Committee in their deliberations.

The deadline for removal of an I designation will be determined by the instructor, but will not be later than six weeks after the start of the spring semester for students who receive such a designation in the fall semester and not later than one week after the start of the fall semester for students who receive such a designation in the spring semester. If the I is not removed within the set time limit, either by completing the work in the subject or by passing a re-examination, the I will automatically and irrevocably become an **F** unless the dean or associate dean of engineering, in consultation with the instructor, extends the time or the student withdraws from the school.

Grade Point Average or Ratings To determine academic ratings, numerical equivalents are assigned to grades as follows: A is represented by 4, B by 3, C by 2, D by 1 and F by 0. The sum of the products of credits attempted and grade equivalents earned in a period at The Cooper Union, divided by the sum of credits for that period, is the rating for that period.

Only Cooper Union grades of A, B, C, D and F will be used in determining ratings. Grades from other colleges and other designations such as I and W are not used in Cooper Union ratings.

Grade Changes A change in an official grade of record, other than the designation I, cannot be made by the dean of Admissions and Records without the express consent of the dean or associate dean of engineering. Grade changes will not be accepted after one year has elapsed from the completion of the course.

Final Examinations Final examinations are held in most subjects, except in cases when content does not lend itself to formal examination, such as laboratory or project work. In certain other subjects, the class record may be ample for determining student standing. The decision on giving a final examination in a given subject is made by the instructor.

Academic Probation, Withdrawal and Dismissal

Probation is the consequence of unsatisfactory scholarship. It is a warning that may involve a compulsory reduction of academic load, interviews with an assigned advisor and additional academic counseling. A student on academic probation must fulfill conditions as prescribed by the Academic Standards Committee.

- The records of all students may be reviewed by the office of the dean of engineering for recommendations to the Academic Standards Committee for appropriate action at any point in the student's career.

- Students may be required to withdraw or resign from The Cooper Union based on a single semester's academic performance, a cumulative GPA lower than 2.0, and/or infractions of the academic integrity policies.
- The Academic Standards Committee reserves the right to determine probation and/or dismissal at any point in the student's career for appropriate academic issues.
- A student whose semester grade point average is below 2.0 is on automatic probation and is a candidate for dismissal by the committee.
- Estimates of grades in subjects with I designations may be included in all committee deliberations.
- Students who fail to register will have their records annotated: "Dropped: Failure to Register"

Students seeking readmission to the School of Engineering with a separation from Cooper Union of less than two years must apply through the Academic Standards Committee. The student must first contact the Dean of Admissions and Chair of Academic Standards to discuss the measures required to meet before the Academic Standards Committee. Students seeking readmission for the fall term must contact the Dean of Admissions and Chair of Academic Standards no later than April 1 to schedule an appointment for the June Academic Standards meeting.

Students seeking readmission to the School of Engineering with a separation from Cooper Union of more than two years must apply through the Office of Admissions and adhere to the transfer application requirements. Students who believe that a modification of their status should be made because of extenuating circumstances may petition, in writing, the Academic Standards Committee.

Change of Program

Adding a Course A student is permitted to add a course only during the first week of a semester, during the drop/add period, and only with the advisor's approval.

Adding a course after the drop/add period is not permitted even if the student has been attending the class.

Dropping a Course A student may drop a course during the first week of the semester, during the drop/add period, with the advisor's approval.

A course dropped during the first week of the semester will be deleted from the transcript.

Withdrawing from a Course A student anticipating inability to continue an assigned program should immediately see his or her advisor. A student's program may be adjusted at the discretion of and after conferring with the advisor and the dean or associate dean of engineering, but only in cases where scholastic performance is impaired by conditions beyond the control of the student, such as health or home conditions. After the drop/add period a student may withdraw from a course through the eighth week of the semester. A grade of W will appear on the transcript. A student who stops attending a course without permission of the instructor and the dean or associate dean will receive a grade of WU; however, the instructor is free to record a grade of F in such a case.

A student may lighten his or her academic load and receive a W grade after the eighth week of classes only with the approval of the course instructor, the advisor, and the dean or associate dean. It is the policy of the faculty and the Office of the Dean not to approve any withdrawal after the eighth week of classes except under extreme, extenuating circumstances.

A student is not permitted to drop or withdraw from a course if doing so would impede satisfactory progress towards the degree.

Repeating a Course A course may be repeated if a student has failed the course or, with appropriate approval been allowed to withdraw from the course. When a course is repeated, the grade earned when the course was repeated is calculated into the G.P.A.

Course Designation

Course	*Prefix*
Biology	Bio
Chemical Engineering	ChE
Chemistry	Ch
Civil Engineering	CE
Computer Science	CS
Electrical Engineering	ECE
Engineering Sciences	ESC
Interdisciplinary Engineering	EID
Mathematics	Ma
Mechanical Engineering	ME
Physics	Ph

Students should consult official class schedules for courses offered in a given semester.

Be advised that each school at The Cooper Union offers certain electives that are open to all students; consult each school's course listing.

Unless otherwise indicated, credit listings are for single semesters. Courses are not generally offered in the summer.

Definitions

- A free elective is any course (for which a student is qualified) given within The Cooper Union. Foreign language courses do not count as free electives.
- The status advanced engineering elective is to be determined by the advisor(s) and the Office of the Dean. Normally, such courses will require prerequisites and are usually taken by juniors and seniors.
- A minimum of 12 credits of engineering electives must be at an advanced level.

Honors and Special Programs

Dean's List The Office of Admissions and Records determines a Dean's List twice a year, at the end of each semester, on the basis of the record of the completed grade in every subject at the official end of the grading period. To qualify, a student must have a 3.5 or better semester grade point average for a study program of at least 12 credits during that semester with no grade lower than C and no grades of Incomplete (I). Note: Students may petition the dean/associate for reconsideration in the Dean's List after the Incomplete (I) has been made up.

Course Overload An overload in the first year consists of a credit total greater than the standard load for that semester in a student's respective program. A student having a grade point average of 3.0 or better may take an overload of one course in any given semester with the approval of the freshman academic advisor and the written approval of the dean or associate dean. In all other cases, overload is any credit load over the designated load for that semester in the student's program curriculum and requires approval of the student's academic advisor(s). Overload beyond 21.0 credits also requires the written permission of the dean/associate dean and no overload is permitted for students with a prior semester G.P.A. of less than 3.0 or a cumulative G.P.A. of less than 3.0. Requests for overloads must be submitted to the dean/associate dean during the add period of that semester together with written advisor's approval, and only after all grades from the previous semester(s) have been entered.

Graduation with Honors Each graduating senior in the School of Engineering who has achieved an overall cumulative rating of 3.8 or higher is awarded the degree with the notation summa cum laude. Magna cum laude requires a G.P.A. of 3.7 or higher and cum laude requires at least a 3.5 G.P.A.

Curricular Transfers A student wishing to change his or her major should first discuss the plan with his or her current advisor(s) in the current major and the chair of the new major. Transfer is at the discretion of the dean's office and the receiving department. It may be affected by the student's grades and availability of program resources. Students who request a change in major must consult with the policies of the department they wish to transfer into. It becomes effective when the required petition form, approved by the dean or associate dean of engineering, has been delivered to the Office of Admissions and Records. First-year students may not change their area of study until the end of the year when two semesters' grades are available. A G.P.A. of 3.0 or better is required for approval to transfer curriculum.

Pre-Medical, Pre-Law or Pre-Business Studies Upon completion of the engineering degree, some graduates may decide to attend medical, dental, business or law school. Most of the prerequisites for such a course of action are offered at The Cooper Union. For medical school or dentistry, students are advised to take one year of organic chemistry and one year of biology. For law or business, additional economics, political science and professional ethics courses are useful. Students should consult their advisor(s).

Study Abroad The Cooper Union offers suitably qualified, approved students the opportunity to participate in research programs at various foreign universities during the summer. For example, students have attended universities in England, Ireland, Scotland, Australia, Hong Kong, Germany, China, Japan, Italy, Spain, Ghana and France. Cooper Union credit (up to six credits at the 300 level) is granted upon successful completion of the research work, presentation of a written report and its approval by the Office of the Dean. Three credits are considered for technical credit and may count towards the elective science/engineering requirements for the student, the remaining three credits are non-technical credits that do not satisfy the HSS elective requirements of the degree. Applications are available in the dean's office in mid-January. (Students on probation are ineligible for this program). Credit is only allowable for exchange programs authorized by The Cooper Union School of Engineering.

Professional Development Mastering the technical aspects of an engineering field is only part of being a successful engineer. There are many other areas that go toward building and continuing a professional career.

MASTER'S DEGREE REQUIREMENTS

Cooper Union offers master's degrees in chemical engineering, civil engineering, electrical engineering and mechanical engineering. The integrated bachelor/master of engineering program is intended to integrate work at the undergraduate and graduate levels and prepare graduates for entry into the engineering profession at an advanced level or for further graduate study.

See the application guidelines for the admissions procedure.

Cooper Union students applying for the 4 year undergraduate/graduate dual degree see instructions for application below.

See the course list for graduate level courses.

General Application Requirements

Applicants who are not Cooper Union graduates are expected to have a superior undergraduate record and to have given evidence of ability for independent work. Students are accepted on an academically competitive basis subject to the availability of an advisor and of suitable available facilities. Students have up to five years to complete their degree. They must declare whether they plan to pursue the thesis or non-thesis option by the end of their third year or when they complete 24 credits, whichever comes first. Once students declare the thesis option, they have four semesters to finish the program. Students may complete the degree requirements as part-time or full-time students in consultation with their advisor. Students receiving more than 50% scholarship or are in receipt of a Fellowship may be required to complete their degree on a different timeline.

Cooper Union Undergraduates A Cooper undergraduate degree does not guarantee admission to the graduate program. To be considered for admission to the master's program, one must be a currently enrolled Cooper Union undergraduate, with a minimum 3.0 grade point average according to the major.

Integrated Degree:All Cooper undergraduates looking to earn their Master's degree at Cooper fall within the integrated degree program. In an integrated program,there is only one transcript for the Bachelor of Engineering and Master of Engineering coursework, with one cumulative GPA. There are two types of integrated degrees:

1. The Dual degree: The Cooper Union Dual Degree Master's Program is one in which the bachelor's and master's degree are awarded simultaneously after four years of study. Only the thesis option is available for the Dual degree. With the approval of their advisor, students apply credits from courses taken beyond those required for the Bachelor of Engineering towards the requirements for the Master's degree. In the dual degree program, a student's status remains as an "undergraduate" throughout the program, until award of the bachelor's and master's degree. To maintain undergraduate status, students are required to enroll in a minimum of 12 credits that are applied to the undergraduate degree each term.

Cooper Union undergraduates may declare the intent to complete a dual degree in the second semester of the junior year.

Students interested in the dual degree program should NOT submit an application to the graduate program via the admissions site. They should complete this form, obtain the appropriate signatures and submit it to the Deans office in the second semester of their Junior year. Please note: If a Cooper Union student interested in the dual degree program fails to follow this instruction, the submitted application will be rejected and the application fee will not be refunded.

2. 4+ degree: The Cooper Union 4+ Master's Program is one in which a Cooper Union undergraduate student completes the undergraduate degree, receives the diploma and then begins the graduate degree program. Students interested in the 4+ degree should apply to the Master of Engineering program via the admissions site in one of the degree-granting departments during their senior year.

Graduates of Other Colleges The School of Engineering may admit outstanding students or qualified practicing professionals, on a tuition basis, into the master's degree programs. To be considered for admission, a student should have completed an engineering baccalaureate program that is accredited by the Accreditation Board for Engineering and Technology (ABET). In addition, an essay is required of all applicants who were not Cooper Union graduates. Applicants must submit official transcripts. Graduates of foreign institutions whose native language is not English are required to submit scores of the Test of English as a Foreign Language (TOEFL). Admitted students may be required to register for advanced engineering courses to make up for any deficiencies.

Thesis and Non-Thesis Requirements

The Albert Nerken School of Engineering offers both thesis and non-thesis Master of Engineering degrees. A minimum of 30 graduate level credits beyond the baccalaureate degree must be completed at The Cooper Union (in addition to resolving possible undergraduate deficiencies) for both the thesis requiring M.E. Program and the non-thesis M.E. Program. All graduate level credits, including possibly cross-listed upper level undergraduate credits, must be approved by a student's academic advisor(s). A complete program of study is designed by the student with the assistance and approval of the academic advisor(s) and filed in the Office of the Dean of Engineering.

Each student is required to submit a thesis or project in their area of study, equivalent to a maximum of six credits (graduate level), for partial fulfillment of the master of engineering requirements. This project must be discussed with and approved by an advisor prior to being started. The thesis or project must be successfully presented orally by the student and submitted in written form.

Each of the engineering departments may have additional specific guidelines for the requirements for the M.E. degree. See links for Masters Program found under each department.

Thesis Requirements

The 30 credits offered for the thesis program degree must satisfy the following distribution:

- Major: Complete a minimum of 12 credits of graduate level courses in a chosen field
- Complete a minimum of 12 further credits of graduate level courses.
- Thesis Project: 6 credits

All four departments offer the thesis option.

Non-Thesis Requirements

The 30 credits offered for the non-thesis program degree must satisfy the following distribution along with a special project requirement:

- Major: Complete a minimum of 18 credits of graduate level courses in a chosen field
- Complete a minimum of 12 further credits of graduate level courses

Special Projects requirement can be fulfilled in one of two ways:

- Complete a graduate level independent study course (up to 3 credits)
- Submit a report to the Dean's office of other course work that satisfies requirements for a graduate level course in which a grade of "B" or higher was received. If your home department has specific guidelines for the Special Projects requirement report, you should follow those guidelines. If there are no guidelines from your department, the Deans office suggests these basic structure and formatting requirements.

When the special projects requirement is completed this form should be filled out and submitted, along with any report, to the Dean's office.

The Department of Chemical Engineering does not offer the non-thesis option at this time.

Other General Requirements

Grade Requirement A minimum overall grade point average of 3.0 is needed in all courses used to satisfy the 30 credit master's degree requirement.

Appropriate Excess Credits Taken as an Undergraduate For Cooper Union baccalaureate holders, any credits of graduate level, taken as undergraduates in excess of their bachelor's degree requirement, may be applied to the master's degree, subject to the above cross-listing requirements and advisor approval.

Time Limitation Once students have declared they are following the thesis or non-thesis track, they must complete the program within four semesters. Students receiving less than 50% scholarship must declare no later than the end of their sixth semester of enrollment. Students who receive more than 50% scholarship are required to be full-time students, and must complete the program in either four or five semesters, dependent on their department's requirements. Students who request and are granted an extension beyond the four, five or ten semesters of expected enrollment will be assessed a maintenance of matriculation fee of $3,000 per semester.

Fellowships One source of funding available to students wishing to pursue graduate study in engineering is the Enders Fund, governed by the will of Henry C. Enders and administered by the New York Community Trust. This fellowship is available to engineering graduates of The Cooper Union who have satisfactorily completed all required chemistry courses in the ChE curriculum and plan to do graduate work in chemistry, chemical engineering, chemistry-based environmental engineering, or chemistry-based bioengineering. Recipients are selected by the joint faculties of chemistry and chemical engineering.

Guidelines for Master's Thesis

1. Graduate students conduct their thesis work under the close supervision and guidance of a full-time faculty member of the School of Engineering. The thesis advisor and Dean approve all copies of the thesis report after it has been successfully defended.

2. The master's thesis is defended through an oral presentation during the fall or spring semesters only. This defense summarizes the content of the thesis and is open to all interested persons. School-wide distribution of an invitation should go to all engineering faculty, graduate students, and seniors within your major at least two weeks before the defense. An invitation should be submitted to the Dean's Office for posting. If needed, the Dean's Office will guide you through the preparation.

3. One digital copy of the thesis for faculty review must be made available in the Dean's office a minimum of two weeks before the thesis defense.

4. After a thesis is successfully defended and the thesis report is finalized with the student's advisor:
   a. Make sure your thesis follows the format outlined within this document: https://media2.proquest.com/documents/Preparing+Your+Manuscript+for+Submission+Revised+31jul2015.pdf
   b. The advisor should sign the thesis and you should email a searchable pdf file of your approved thesis to Beth Slack (beth.slack@cooper.edu). Alternatively, you can also email a dropbox link where the file can be downloaded.
   c. Your thesis should be digitally archived at https://www.etdadmin.com/cgi-bin/school?siteId=967 choosing the ProQuest Open Access Publishing Plus option. Please make sure to include the scanned copy of the signature page prior to submitting.
   d. Purchase any copies of the thesis through the ProQuest website.

5. The Office of Admissions & Records submits the list of engineering Master's Degree candidates to the School of Engineering Committee on Academic Standards. The Committee in turn presents the recommended list of candidates to the engineering faculty at the semester-end faculty meeting, and to the Board of Trustees' December/May meeting for approval of conferment of the Master of Engineering degree.

Engineering Minors

The Albert Nerken School of Engineering offers two minors to undergraduate students: Computer Science Minor and Mathematics Minor. Students can also obtain a Humanities and Social Science (HSS) Minor from our HSS Program.

COMPUTER SCIENCE MINOR The department of Electrical Engineering offers a minor in Computer Science. Students seeking a minor in Computer Science must complete Data Structures & Algorithms I (ECE 264), Data Structures & Algorithms II (ECE 365), or a course selected from a list of alternative courses (see details), and 12 additional credits at the 300 or 400 level from a list of approved courses. At most six credits of 300 level courses that are required in the major can be applied toward the requirements for the Computer Science Minor.

MATHEMATICS MINOR The department of Mathematics offers a minor in mathematics. Students seeking a minor in mathematics must complete at least 15 credits of mathematics coursework in addition to the 17 credits required by every engineering department. These additional credits must include Mathematical Analysis I and II (Ma 350, 351), Linear Algebra (Ma 326), Modern Algebra (Ma 347) and an elective course in mathematics at or above the 300 level. An overall G.P.A., at graduation, of at least 3.0 among the mathematics portion (32 credits) of the program is required to obtain a minor in mathematics.

HUMANITIES AND SOCIAL SCIENCE MINOR Students who complete a minimum of 12 upper-division credits in a specific field of liberal arts may qualify for a minor in that field of Humanities and Social Sciences. Minors are offered and may be designated on student transcripts in the following five fields. Please contact HSS Academic Advisor, Professor Sohnya Sayres.

- Art History
- Economics and Public Policy
- History and Society
- Literature
- Science, Technology, and Society

CHEMICAL ENGINEERING

Mission Statement

The Cooper Union's Department of Chemical Engineering is committed to the development and graduation of engineering professionals. The department will promote student learning and understanding of science and engineering fundamentals and guide and encourage the application of this knowledge to the ethical, professional practice of chemical engineering. This will be undertaken in an environment that is responsive to new technologies and that encourages lifelong learning and research
.

Program Educational Objectives

- Our graduates will attain professional careers where they apply their abilities to solve problems and meet challenges in engineering and non-engineering fields.¨
- Our graduates will join professional societies and/or attain professional licensure.
- Our graduates will grasp the concept of lifelong learning and appreciate the continuing development of new technologies and issues in the professional field.
- Our graduates will transition easily into their professional careers and demonstrate success in that role.
- Those graduates who pursue graduate studies and research at The Cooper Union and/or other institutions will have the necessary technical background, support and preparation to succeed.

Student Outcomes

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- An ability to communicate effectively with a range of audiences
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

2020-21 Enrollment and Graduation
Freshman: 23
Sophomore: 24
Junior: 29
Senior: 19
Total: 95

In May 2020 the Department of Chemical Engineering graduated 21 students with a Bachelors of Engineering–Chemical Engineering degree.

Program Description

The education of the chemical engineer requires a strong foundation in chemistry and physics, which must be applied through the medium of mathematics to the solution of design, modeling, scale-up and control problems. A thorough knowledge is required of chemical structures, together with the energetic and kinetic relationships predicted in chemical reactions and molecular transport. The chemical engineer deals with the application of these principles to processes carried out on a variety of scales from micro-reactors to an industrial scale, in which matter undergoes changes in physical state, chemical composition or energy content. Emphasis is placed on developing creative ability; facts and theories are presented primarily to stimulate further thought and study in all fields of chemical engineering. âĐ¨Formal instruction is supplemented by visits to several plants and companies where the contribution of engineers can be observed and understood with respect to equipment, utilities, safety, costs, environmental impact, labor and supervision. The students get first-hand experience in the chemical engineering laboratory in applying engineering analysis to equipment performance, and in learning limitations of theoretical concepts. In the senior year, the student learns how to design chemical plants from fundamental data on new processes and to recognize areas of limited knowledge from the results of the design, and thus recommend pilot plant studies, if necessary.

Chemical engineering graduates find employment in a wide variety of areas. In addition to the chemical and petroleum industries, chemical engineers are involved heavily in the biomedical, materials and environmental fields. A chemical engineering education can also be easily applied to other interdisciplinary areas such as biochemical and biomedical engineering, energy resources, environmental engineering and materials science. As a result, chemical engineers are also finding employment in non-industrial institutions such as government, research think- tanks, policy study groups and even publishing companies.

The Chemical Engineering Program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

If you have any questions or need additional information about the department, please contact our faculty directly using our faculty and staff pages or contact our department administrator.
Liz Leon, Chemistry & Chemical Engineering Departments
The Cooper Union School of Engineering
41 Cooper Square, New York, NY 10003
(212) 353-4370

Chemical Engineering Curriculum

Freshman Year Credits

Fall Semester:	Credits
ESC000.1 Professional Development Seminar	0
Ma 110 Introduction to Linear Algebra	2
Ma 111 Calculus I	4
Ch 110 General Chemistry	3
EID 101 Engineering Design and Problem Solving	3
EID 102 Engineering Graphics	1
CS 102 Computer Programming for Engineers	2
HSS 1 Literary Forms and Expressions	3
Total Credits Fall Semester	18

Spring Semester:	Credits
ESC000.2 Professional Development Seminar	0
Ma 113 Calculus II	4
Ph 112 Physics I: Mechanics	4
Ch 111 General Chemistry Laboratory	1.5
Ch 160 Physical Principles of Chemistry	3
HSS 2 Texts and Contexts: Old Worlds and New	3
Total Credits Spring Semester	15.5

Sophomore Year Credits

Fall Semester:	Credits
ESC000.3 Professional Development Seminar	0
ChE 221 Material and Energy Balances	3
Ma 223 Vector Calculus	2
Ph 213 Physics II: Electromagnetic Phenomena	4
ChE 211 Materials Science for Chemical Engineers	3
Ph 291 Introductory Physics Laboratory	1.5
Ch 231 Organic Chemistry I	3
HSS 3 The Making of Modern Society	3
Total Credits Fall Semester	19.5

Spring Semester:	Credits
ESC000.4 Professional Development Seminar	0
Ma 240 Ordinary and Partial Differential Equations	3
Ph 214 Physics III: Optics and Modern Physics	3
Ch 232.1 Organic Chemistry II	2
Ch 233 Organic Chemistry Laboratory	2
ChE 232 Chemical Engineering Thermodynamics	3
HSS 4 The Modern Context: Figures and Topics	3
Total Credits Spring Semester	16

Junior Year Credits

Fall Semester:	Credits
Ma 224 Probability	2
Ch 351 Instrumental Analysis Laboratory	2
Ch 361 Physical Chemistry I	3
ChE 331 Chemical Engineering Thermodynamics II	3
ChE 341 Fluid Mechanics and Flow Systems	3
Engineering Elective	3
Total Credits Fall Semester	16

Spring Semester:	Credits
Ch 362 Physical Chemistry II	2
ChE 332 Chemical Reaction Engineering	3
ChE 342 Heat and Mass Transfer	4
ChE 352 Process Simulation and Mathematical Techniques for Chemical Engineers	3
Engineering or Science elective	3
Free Elective	3
Total Credits Spring Semester	18

Senior Year Credits

Fall Semester:	Credits
ChE 371 Chemical Engineering Laboratory I	2
ChE 381 Process Evaluation and Chemical Systems Design I	3
ChE 351 Separation Process Principles	3
ChE 361 Chemical Process Dynamics and Control	3
Engineering or Science Elective	3
Humanities/Social Sciences Elective	3
Total Credits Fall Semester	17

Spring Semester:	Credits
ChE 372 Chemical Engineering Laboratory II	2
ChE 382 Process Evaluation and Chemical Systems Design II	4
Engineering or Science Elective	3
Free Elective	3
Humanities/Social Sciences Elective	3
Total Credits Spring Semester	15

Total credits required for degree	**135**

The Chemical Engineering Department does not permit the substitution of any courses as outlined in the Course Substitutions and Credits section of the Bachelor of Engineering curriculum.

Concentrations

A concentration can be obtained by a student in chemical engineering taking any four (4) courses in one of the fields below. The courses require permission of the student's adviser and the department chair. The courses listed are examples currently in The Cooper Union catalog. Note that some may require prerequisites or permission of the instructor. Additionally, note that it is not necessary to obtain a concentration in any field in order to graduate with a bachelor of engineering in chemical engineering. Upon completion of the concentration a student should submit a list of courses that he or she wishes to be considered for certification to the department chair. Successful completion of the concentration will be acknowledged by a certificate from the department accompanied by a letter listing the concentration achieved and the courses taken.

Environmental Engineering

CE 344/Environmental Systems Engineering (also EID 344)
CE 343/Water Resources Engineering (also EID 343)
CE 414/Solid Waste Management (also EID 414)
CE 440/Industrial Waste Treatment Design (also EID 438)
CE 441/Water and Wastewater Technology (also EID439)
CE 446/Pollution Prevention or Minimization (also EID 446)
CE 447/Stream and Estuary Pollution
CE 449/Hazardous Waste Management (also EID 449)
ChE 447/Sustainability and Pollution Prevention (also EID 447)

Biomedical Engineering

Bio 201/Biology for Engineers I
Bio 202/Biology for Engineers II
Ch 340/Biochemistry
Ch 440/Biochemistry II
ChE 475/Pharmaceutical Engineering
ECE 444/Bio-instrumentation
EID 221/Biotransport Phenomena
EID 222/Biomaterials
EID 223/Injury Biomechanics and Safety Design
EID 224/Biomechanics
EID 320/ Special Topics in Bioengineering I
EID 321/ Special Topics in Bioengineering II
EID 322/ Special Topics in Bioengineering III
EID 323/ Special Topics in Bioengineering IV
EID 325/Science and Application of Bioengineering Technology
EID 327/Tissue Engineering
EID 424/Bioengineering Applications in Sports Medicine

Energy Engineering

ChE 421/Advanced Chemical Reaction Engineering
ChE 430/Thermodynamics of Special Systems (also EID 430 and ME 430)
ChE 434/Special Topics in Combustion (also ME 434)
ME 331/Advanced Thermodynamics
ME 326/Energetics (also EID 225)
ME 431/Internal Combustion Engines
ME 432/Introduction to Nuclear Power Plant Technology

Masters Program—Chemical Engineering

The Department of Chemical Engineering offers a thesis option in pursuing the Master of Engineering-Chemical Engineering degree. It does not offer a non-thesis option at this time.

In the thesis M.E. degree graduate students in chemical engineering must complete a minimum of 30 credits beyond their baccalaureate degree. Of those 30 credits 9 credits must come from the following courses:

ChE 421 Advanced Chemical Reaction Engineering

ChE 430 Thermodynamics of Special Systems or ChE 431 Advanced Chemical Engineering Thermodynamics and Molecular Theory

ChE 441 Advanced Heat and Mass Transfer (also EID 441)

Of the remaining 21 credits, 3 credits must be from Chemical Engineering graduate courses, 12 credits may be from graduate engineering or science electives, and 6 credits from a thesis project on an approved topic.

A thesis candidate must choose a full-time Cooper Union faculty member from either the chemistry or chemical engineering department as one of his or her thesis advisers. Before choosing a thesis topic, however, the student should explore various professors' research interests. Research interests of chemical engineering faculty members include non-Newtonian flow, crystal growth from high-temperature melts, polymer extrusion, heat and mass transfer with change of phase, drag coefficients in dense phase transport, construction of a database of engineering materials, mathematical modeling of bio-heat transfer in microcirculation, mathematical modeling of whole- body heat integrated gasification processes for the simultaneous disposal of sludge and garbage with concomitant production of steam and electricity, biochemical separation, protein purification, environmental engineering and mathematical modeling, evaluation of sustainability, batch process design and optimization, pollution prevention and mitigation, infinite linear programming, particle technology, multiphase flow and fluidization, pharmaceutical engineering and processes, nanomaterials and energy systems and processes.

CIVIL ENGINEERING

Mission Statement

To prepare our students as civil engineering professionals who will have the depth and breadth of knowledge, sense of social and ethical responsibility, commitment to a safe and sustainable environment, and a desire to serve society in leadership positions.

Program Educational Objectives

- Our civil engineering graduates are engaged in life-long learning to stay abreast of the latest body of knowledge and professional practices in civil engineering and allied disciplines throughout their careers.
- Our graduates are excelling in teamwork, interdisciplinary concepts, organizational skills, and problem-solving methodologies in their professional careers.
- Our graduates have attained positions of leadership as professional practitioners, government officials, academicians, inventors, researchers, etc., during their professional careers.
- Our graduates are committed to excellence, independent thinking, innovation, and modern professional practices throughout their careers.
- Our graduates are committed to professional and ethical responsibility during their careers.
- Our graduates who pursue careers in engineering have successfully achieved professional licensure in their chosen field.

Student Outcomes

The Civil Engineering Department has established the following set of outcomes that our undergraduate students are expected to achieve by the time of graduation:

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- An ability to communicate effectively with a range of audiences

- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Program Description

Civil engineering, earliest of the engineering professions, has evolved into a broad spectrum of specialties: structural, geotechnical, hydraulic, environmental, transportation, urban planning, construction management, sustainable design, urban security, and infrastructure rehabilitation. Depending on his or her interests and abilities, the modern civil engineer may also become involved in research, design, and development related to projects in alternative energy sources, space structures, protection against natural and man-made disasters, etc. The civil engineer also studies and develops new materials, new structural systems, and new strategies for optimizing design. Basic research, especially in the areas of applied and experimental mechanics, often arises either as a preliminary or adjunct requisite to these studies.

The civil engineer who wishes to practice creatively in any of these fields must be thoroughly grounded in the basic sciences, mathematics and applied mechanics, structures and structural mechanics, engineering sciences and computer applications. Members of the civil engineering faculty are actively engaged in research in their specialties, which include modern advances in structural engineering and materials, geotechnical engineering, alternative energy sources, green design of buildings, water pollution control technologies, water resources engineering, and urban security.

Within the civil engineering program, students may elect to pursue specialized study through an appropriate choice of electives in two areas:

- Structural and Geotechnical Engineering
- Water Resources and Environmental Engineering

Graduate level courses in these areas are available to seniors with superior academic records as indicated in the following lists:

Structures and Geotechnical Engineering: CE 422, CE 425, CE 426, CE 427, CE 431, CE 432, CE 433, CE 434, CE 435, CE 436, CE 438, CE 450, CE 470, CE 471, CE 481, CE 482, CE 483, CE 484

Water Resources and Environmental Engineering: CE 437, CE 414, CE 440, CE 441, CE 442, CE 444, CE 446, CE 447, CE 448, CE 449, CE 485, CE 486, CE 487

The civil engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

2020-21 Civil Engineering Enrollment and Graduation
Freshman: 38
Sophomore: 31
Junior: 23
Senior: 14
Total: 106

In May 2020 the Department of Civil Engineering graduated 27 students with a Bachelor of Engineering-Civil Engineering degree.

Graduate Program

Completion of the master of engineering degree program in civil engineering is important for entry into the profession in any of the specialized areas discussed above. The civil engineering department offers many graduate level courses in the cited areas, such as structural, geotechnical, hydraulic and environmental engineering.

Civil Engineering Curriculum

The below tables affect incoming students beginning in the Fall 2020 semester.

Freshman Year Credits

Fall Semester:	Credits
ESC000.1 Professional Development Seminar	0
Ma 110 Introduction to Linear Algebra	2
Ma 111 Calculus I	4
Ch 110 General Chemistry	3
EID 101 Engineering Design and Problem Solving	3
EID 102 Engineering Graphics	1
CS 102 Computer Programming for Engineers	2
HSS 1 Literary Forms and Expressions	3
Total credits fall semester	18

Spring Semester:	Credits
ESC000.2 Professional Development Seminar	0
Ma 113 Calculus II	4
Ph 112 Physics I: Mechanics	4
Ch 111 General Chemistry Laboratory	1.5
CE 151 Urban Transportation Planning	3
HSS 2 Texts and Contexts: Old Worlds and New	3
Total credits spring semester	15.5

Sophomore Year Credits

Fall Semester:	Credits
ESC000.3 Professional Development Seminar	0
Ma 223 Vector Calculus	2
Ma 224 Probability	2
Ph 213 Physics II: Electromagnetic Phenomena	4
Ph 291 Introductory Physics Laboratory	1.5
ESC 200 Engineering Mechanics	3
ESC 210 Materials Science	3
HSS 3 The Making of Modern Society	3
Total credits fall semester	18.5

Spring Semester:	Credits
ESC000.4 Professional Development Seminar	0
BIO 250 Biotechnology in Environmental Systems	3
Ma 240 Ordinary and Partial Differential Equations	3
Ph 214 Physics III: Optics and Modern Physics	3
ESC 201 Solid Mechanics	3
CE 220 Fundamentals of Civil Engineering	3
HSS 4 The Modern Context: Figures and Topics	3
Total credits spring semester	18

Junior Year Credits

Fall Semester:	Credits
CE 321 Structural Engineering	4.5
CE 344 Environmental Systems Engineering	4.5
ESC 330 Engineering Thermodynamics	3
ESC 340 Fluid Mechanics and Flow Systems	3
Humanities/Social Sciences Elective	3
Total credits fall semester	18

Spring Semester:	Credits
CE 322 Structural Engineering II	3
CE 331 Introduction to Geotechnical Engineering	4.5
CE 343 Water Resources Engineering	4.5
CE 341 Design of Steel Structures	3
Humanities/Social Sciences Elective	3
Total credits spring semester	18

Senior Year Credits

Fall Semester:	Credits
CE 342 Design of Reinforced Concrete Structures	3
CE 363 Civil Engineering Design I	3
CE 332 Introduction to Foundation Engineering	3
CE 346 Hydraulic Engineering	3
Engineering or Science Electives	3
Total credits fall semester	15

Spring Semester:	Credits
CE 361 Civil Engineering Experimental Projects	2
CE 364 Civil Engineering Design II	3
CE 348 Environmental and Sanitary Engineering	3
Engineering or Science Electives	6
Total credits spring semester	14
Total credits required for degree	**135**

Masters Program—Civil Engineering

The Department of Civil Engineering offers both the thesis and non-thesis option in pursuing a Master of Engineering-Civil Engineering degree. If the thesis option is chosen, the student is required to take 24 credits of course work and six credit so thesis. If the non-thesis option is chosen the student is required to take 30 credits of course work and submit a report from one of the courses.

Completion of the Master of Engineering degree program in civil engineering is important for entry into the profession. The civil engineering department offers the master's degree in two specialized areas: structural and geotechnical; water resources and environmental engineering.

The student must complete a coherent concentration of graduate-level courses approved by the department.

Thesis Project (6 credits)

Total Credits: 30

Graduate students in the department of civil engineering become equipped with the theoretical and practical knowledge needed to solve many problems facing both our built and natural environments. Coursework grounded in the principles of mathematics, structural mechanics, fluid mechanics, soil mechanics, environmental sciences, and computer applications prepares students for careers in structural engineering, construction management, infrastructure rehabilitation, geotechnical engineering, water resources and environmental engineering.

Employers of our graduates include: Thornton Tomasetti, Arup, Mueser Rutledge, Metropolitan Transportation Authority, Skanska, Gilbane, Port Authority of New York & New Jersey, NYC Department of Design and Construction.

ELECTRICAL ENGINEERING

Electrical Engineering comprises the physical systems, devices and processes that form the backbone for the Information Age, including: electronic devices and materials, integrated circuits, signal analysis and processing for communication and multimedia applications, computer architectures and processes, embedded and distributed systems and networks, machine learning, and biomedical engineering.

The Cooper Union offers both a Bachelor of Engineering and a Master of Engineering in Electrical Engineering. The Bachelor of Engineering program is accredited by the Engineering Accreditation Commission of ABET, http://www.abet.org.

Electrical engineering alumni from The Cooper Union have been very successful as professionals and leaders for the new economy emerging in the Information Age. Many pursue careers in other areas such as business and finance, law, medicine, applied mathematics and science.

The dedicated faculty and high faculty to student ratio ensure that students aren't just names on a list, but get to know the faculty as soon as they step into Cooper Union.

Mission Statement

To develop a highly trained, consummate engineer: able to lead, to practice in a professional manner, to grow with technological advances, to express himself or herself in written and in oral form, to function as a project engineer immediately upon graduation and to pursue graduate studies in a variety of professional fields.

Program Educational Objectives

- Our graduates will have positions where they function as first-class project engineers.
- Our graduates will have positions that require exceptional technical knowledge and professional design skills.
- Our graduates will engage in activities that involve professional-level written and oral expression.
- Our graduates will engage in activities that require demonstrating leadership skills.
- Our graduates will engage in activities that demonstrate a commitment to lifelong learning, research, independent thinking and innovation.

Student Outcomes

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- An ability to communicate effectively with a range of audiences
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

2020-2021 Electrical Engineering Enrollment and Graduation
Freshman: 29
Sophomore: 29
Junior: 31
Senior: 34
Total: 123
In May 2020, the Department of Electrical Engineering graduated 36 students with a Bachelor of Engineering- Electrical Engineering degree.

Advisement

Undergraduate All first year undergraduates are advised by Associate Dean Ruben Savisky. First year EE students are encouraged to discuss their studies and future plans with any full-time EE faculty.

After the first year, EE students select an advisor from among the full-time EE faculty. The selected advisor may change from one semester to another, but during any single registration cycle, only one faculty member should be approached to approve the set of courses.

The exception to this rule is that all EE students on academic probation are advised by Prof. Neveen Shlayan, the EE representative to the Committee on Academic Standards of the school of engineering.

All EE students are required to join an email google group in order to receive important information from the department faculty. Only EE students and full-time EE faculty are members of this group, and only faculty may post to this group. Contact the department chair, Prof. Fred L. Fontaine for instructions on joining these groups.

Graduate Every Master student is advised by a full-time EE faculty member. This advisor is responsible for approving the set of courses used to fulfill the requirements for the master degree.

For students following the thesis option, this advisor is also the thesis advisor. If a student has not yet selected a thesis advisor, they should identify an interim EE faculty advisor, who would approve courses for registration purposes.

Subject to the approval of the EE department chair and the full-time EE thesis advisor, a student may identify a second person who is not a full-time EE faculty member to serve as a thesis co-advisor.

Electrical Engineering Curriculum

Signal Processing and Electronics Track

Freshman Year Credits

Fall Semester:	Credits
ESC 000.1 Professional Development Seminar	0
Ch 110 General Chemistry	3
EID 101 Engineering Design and Problem Solving	3
EID 102 Engineering Design Graphics	1
Ma 110 Introduction to Linear Algebra	2
Ma 111 Calculus I	4
HSS 1 Literary Forms and Expressions	3
Total Credits Fall Semester	16

Spring Semester:	
ESC 000.1 Professional Development Seminar	0
Ch 111 General Chemistry Laboratory	1.5
ECE 150 Digital Logic Design	3
ECE 160 Programming for Electrical Engineers	3
Ma 113 Calculus II	4
Ph 112 Physics I (Mechanics)	4
HSS 2 Texts and Contexts: Old Worlds and New	3
Total Credits Spring Semester	18.5

Sophomore Year Credits

Fall Semester:	Credits
ESC 000.1 Professional Development Seminar	0
ECE 240 Circuit Analysis	3
ECE 291 EE Sophomore Projects	1
Ma 223 Vector Calculus	2
Ma 240 Ordinary & Partial Differential Equations	3
Ph 213 Physics II: Electromagnetic Phenomena	4
Ph 291 Introductory Physics Laboratory	1.5
HSS 3 The Making of Modern Society	3
Total Credits Fall Semester	17.5

Spring Semester:	
ESC 000.1 Professional Development Seminar	0
ECE 210 MATLAB Seminar: Signals and Systems	0
ECE 211 Signal Processing & Systems Analysis	3
ECE 241 Electronics I	3
ECE 251 Computer Architecture	3
Ma 224 Probability	2
Ph 214 Physics III: Modern Physics	3
HSS 4 The Modern Context: Figures and Topics	3
Total Credits Spring Semester	17

Junior Year Credits

Fall Semester:	Credits
ECE 300 Communication Theory	3
ECE 310 Digital Signal Processing	3
ECE 311 Hardware Design	3
ECE 342 Electronics II	4
ECE 393 Electrical Engineering Junior Projects I	2
Ma 326 Linear Algebra	3
Total Credits Fall Semester	18

Spring Semester:	
ECE 302 Probability Models & Stochastic Processes	3
ECE 303 Communication Networks	3
ECE 335 Engineering Electromagnetics	4
ECE 345 Integrated Circuit Engineering	3
ECE 394 Electrical Engineering Junior Projects II	3
Humanities / Social Sciences Elective	3
Total Credits Spring Semester	19

Senior Year Credits

Fall Semester:	Credits
ECE 395 Electrical Engineering Senior Projects I	3
Engineering or Science electives	6
Humanities / Social Sciences Elective	3
Non-technical elective	3
Total Credits Fall Semester	15
Spring Semester:	
ECE 396 Electrical Engineering Senior Projects II	3
Engineering or Science electives	8
Non-technical elective	3
Total Credits Spring Semester	14
Total credits required for Bachelor's degree	**135**

Computer Engineering Track

Freshman Year Credits

Fall Semester:	Credits
ESC 000.1 Professional Development Seminar	0
Ch 110 General Chemistry	3
EID 101 Engineering Design and Problem Solving	3
EID 102 Engineering Design Graphics	1
Ma 110 Introduction to Linear Algebra	2
Ma 111 Calculus I	4
HSS 1 Literary Forms and Expressions	3
Total Credits Fall Semester	16

Spring Semester:	
ESC 000.1 Professional Development Seminar	0
Ch 111 General Chemistry Laboratory	1.5
ECE 150 Digital Logic Design	3
ECE 160 Programming for Electrical Engineers	3
Ma 113 Calculus II	4
Ph 112 Physics I (Mechanics)	4
HSS 2 Texts and Contexts	3
Total Credits Spring Semester	18.5

Sophomore Year Credits

Fall Semester:	Credits
ESC 000.1 Professional Development Seminar	0
ECE 240 Circuit Analysis	3
ECE 291 EE Sophomore Projects	1
Ma 223 Vector Calculus	2
Ma 240 Ordinary & Partial Differential Equations	3
Ph 213 Physics II: Electromagnetic Phenomena	4
Ph 291 Introductory Physics Laboratory	1.5
HSS 3 The Making of Modern Society	3
Total Credits Fall Semester	17.5

Spring Semester:	
ESC 000.1 Professional Development Seminar	0
ECE 210 MATLAB Seminar: Signals and Systems	0
ECE 211 Signal Processing & Systems Analysis	3
ECE 241 Electronics I	3
ECE 251 Computer Architecture	3
ECE 264 Data Structures & Algorithms I	2
Ma 224 Probability	2
Ph 214 Physics III: Modern Physics	3
HSS 4 The Modern Context: Figures and Topics	3
Total Credits Spring Semester	19

Junior Year Credits

Fall Semester:	Credits
ECE 300 Communication Theory	3
ECE 310 Digital Signal Processing	3
ECE 342 Electronics II	4
ECE 357 Operating Systems	3
ECE 365 Data Structures & Algorithms II	2
ECE 393 Electrical Engineering Junior Projects I	2
Total Credits Fall Semester	17

Spring Semester:	
ECE 302 Probability Models & Stochastic Processes	3
ECE 303 Communication Networks	3
ECE 366 Software Engineering & Large Systems Design	3
ECE 394 Electrical Engineering Junior Projects II	3
Ma 352 Discrete Mathematics	3
Humanities / Social Sciences Elective	3
Total Credits Spring Semester	18

Senior Year Credits

Fall Semester:	Credits
ECE 395 Electrical Engineering Senior Projects I	3
Engineering or Science Electives	6
Humanities / Social Sciences Elective	3
Non-technical elective	3
Total Credits Fall Semester	15
Spring Semester:	
ECE 396 Electrical Engineering Senior Projects II	3
Engineering or Science Electives	8
Non-technical elective	3
Total Credits Spring Semester	14
Total credits required for Bachelor's degree	**135**

Masters Program—Electrical Engineering

The Department of Electrical Engineering offers a Master of Engineering in Electrical Engineering. Students have the option of doing a thesis, or pursuing a non-thesis option.

The thesis track requires 24 credits of approved graduate level coursework (400-level classes), plus 6 credits of thesis (ECE499). The non-thesis track requires 30 credits of approved graduate level coursework (400-level classes), plus an identified special project (as described below).

The Master of Engineering program in Electrical Engineering challenges students to pursue one or more areas of specialization in depth, combining rigorous theory and enhancement of analytical skills together with a significant project experience. An essential aspect of the program is the close working relationship between the student and faculty advisor.

Possible areas of concentration or thesis research topics are numerous and reflect the diverse interests of the faculty. Some examples are: digital signal processing (including speech, audio, image, video and biomedical signals); wireless communications and networks; big data, machine learning, natural language processing, and artificial intelligence; reconfigurable and distributed computing; autonomous s ystems and smart cities; and cross-disciplinary applications (e.g., sustainable engineering, connections with art and architecture).

Students are admitted into the thesis or non-thesis option, that is, this choice must be specified as part of the application to the program. Once admitted, students in the non-thesis option may petition the department to transfer into the thesis track. However, students following the thesis option may not switch to the non-thesis option.

Thesis Option: The candidate must choose a full-time Cooper Union faculty member from the electrical engineering department as one of his or her thesis advisors. In addition to supervising the thesis, that advisor, in consultation with the other faculty in the department, approves the set of courses used to fulfill the requirements for the Master's degree. There may also be a co-advisor for the thesis, approved by the principal thesis advisor and the electrical engineering department chair. Any co-advisor who is not a member of the full-time faculty of the school of engineering must also be approved by the Dean of Engineering.

Non-Thesis Option: The candidate must choose a full-time Cooper Union faculty member from the electrical engineering department as the faculty advisor. The faculty advisor, in consultation with other faculty in the department, approves the set of courses used to fulfill the requirements for the Master's degree. As part of the requirements for the degree, the student must work on a substantial project in at least one of the classes taken. Most graduate level courses involve project work, and the student in conjunction with the faculty advisor will ensure that at least one of the course projects will satisfy the requirement. The grade for the selected project must be at least a B, taken from a course with grade of at least a B. Documentation for the project, approved by the advisor, will be provided to the Engineering Dean's Office to verify that the candidate for the degree has completed this requirement.

General Requirements: As noted above, the advisor approves the set of courses used to fulfill the requirements for the master degree, subject to the following constraints. For each course, the course grade must be at least a C, and the overall GPA for the credits used to fulfill the master of engineering degree must be at least 3.00. A limited set of non-ECE courses may be permitted, but the overall course plan should indicate a strong concentration in some area within the broad discipline of electrical engineering.

Undergraduate students at The Cooper Union are permitted to take graduate level courses as long as prerequisite requirements are met. Those who take additional courses at the graduate level beyond those required for the Bachelor of Engineering degree, who then enter the Master of Engineering program, may apply those additional credits towards the requirements for the Master degree, subject to the approval of the advisor.

Students entering the Master of Engineering program in electrical engineering are expected to have a bachelor's degree in electrical engineering or a related field from an accredited institution. The exception is that Cooper Union undergraduates or alumni with an engineering degree in a major other than electrical engineering, including the Bachelor of Science of Engineering degree, would be considered for admission into the Master of Engineering program in electrical engineering if they have a demonstrated preparation for advanced studies in the field.

Undergraduate Program

Basic engineering courses along with core math, science and humanities courses are taken in the first and second years. Students are strongly encouraged to meet with a departmental faculty advisor as early as possible, preferably in the first year.

The foundation of electrical engineering in the curriculum is based on these three courses:
Gateway Courses: (9 credits)
ECE150 (F/S) Digital Logic Design 3 credits
ECE240 (F) Circuit Analysis 3 credits
ECE211 (S) Signal Processing & Systems Analysis 3 credits

In particular, students take ECE150 Digital Logic Design in their first year. It provides an introduction not only to the subject matter but also an early laboratory and design experience. Also, EE students take a C based programming course (ECE160) in their first year. Both ECE150 and ECE160 run in the fall and spring semesters.

From the second through the fourth year, students take a sequence of projects courses totaling 12 credits. Students following either track take these projects courses together, in order to foster interaction and multi-disciplinary work. The Electrical Engineering curriculum does not contain standard laboratory courses- these are project courses. That is, students do not perform prepackaged, rote experiments, but instead develop innovative designs, solve open-ended problems, and investigate topics not covered in required courses. The EE senior design courses are open only to students majoring in Electrical Engineering. Students in other majors may work with electrical engineering students on interdisciplinary projects, but they register for the capstone design project courses in their major, or EID362/363 Interdisciplinary Projects.

Sophomore, Junior & Senior Projects Courses: (12 credits)
ECE291 (F) Electrical Engineering Sophomore Projects 1 credit.
ECE393 (F) Electrical Engineering Junior Projects I 2 credits.
ECE394 (S) Electrical Engineering Junior Projects II 3 credits
ECE395 (F) Electrical Engineering Senior Projects I 3 credits
ECE396 (S) Electrical Engineering Senior Projects II 3 credits

In addition to the courses listed above, the following courses are taken by all students, regardless of the chosen track. These courses (with the exception of the general studies electives noted below) should be completed during the first two years of study:

Basic Math, Science & Engineering Courses: (33.5 credits)
MA110 (F) Introduction to Linear Algebra 2 credits
MA111 (F) Calculus I 4 credits
MA113 (S) Calculus II 4 credits
MA223 (F/S) Vector Calculus 2 credits
MA224 (F/S) Probability 2 credits
MA240 (F/S) Ordinary & Partial Differential Equations 3 credits
CH110 (F) General Chemistry 3 credits
CH111 (S) Chemistry Laboratory 1.5 credits
PH112 (S) Physics I (Mechanics) 4 credits
PH213 (F) Physics II (Electromagnetic Phenomena) 4 credits
PH214 (S) Physics III (Optics & Modern Physics) 3 credits
PH291 (F) Introductory Physics Laboratory 1.5 credits
EID101 (F) Engineering Design & Problem Solving 3 credits
EID102 (F) Engineering Graphics 1 credit

General studies: (24 credits)
HSS1, HSS2, HSS3, HSS4 Core Humanities & Social Sciences 12 credits
Electives in Humanities and Social Sciences 6 credits
Non-technical electives: 6 credits

Courses that qualify as non-technical electives include those with H/SS/Hta (humanities, social sciences, history of art) designations, as well as courses offered by the schools of art and architecture, selected courses offered by the engineering school that are generally of a non-technical nature (e.g., business, law), and advanced foreign language courses. The EE Department regularly maintains and updates a list of courses that can be used to satisfy the non-technical elective requirements; students must obtain approval from their advisor. Specific information about these courses, including necessary prerequisites, can be obtained from the schools or faculty offering the courses.

MECHANICAL ENGINEERING

Mission Statement

The Cooper Union's Department of Mechanical Engineering will produce broadly- and rigorously-educated graduates, able to practice professionally, pursue advanced studies and innovate in a wide range of fields. Together with our faculty and staff, our students will develop a commitment toward lifelong interdisciplinary learning, fulfill their potential for responsible leadership and inspire others to continuously pursue excellence by example.

Program Educational Objectives

Within a few years of graduation, our graduates will:

- Apply their broad and rigorous education to responsible, interdisciplinary problem solving.
- Embrace leadership or collaborative roles in innovative undertakings that take on technological, sustainability, economic, or societal challenges.
- Take the initiative to expand their abilities through self-study, professional development, or the pursuit of graduate or professional degrees.

Student Outcomes

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- An ability to communicate effectively with a range of audiences
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

2020-21 Mechanical Engineering Enrollment and Graduation

Freshman: 37
Sophomore: 25
Junior: 28
Senior: 28
Total: 118

In May 2020 the Department of Mechanical Engineering graduated 28 students with a Bachelors of Engineering—Mechanical Engineering degree.

Program Description

Creativity, problem-solving, and design are all at the heart of Mechanical Engineering, the broadest of the engineering disciplines. Cooper students build a strong foundation and have the flexibility to study an expansive range of theoretical and technological interests, including mechanics and materials, thermo-fluid sciences, combustion, vibrations and acoustics, dynamics and control systems, robotics, design, digital fabrication, CAD/CAM and manufacturing. From building the world-largest Rubik's-style cube to working with doctors to design next generation surgical instruments, Cooper mechanical engineering students create what seems impossible and use acquired knowledge and skills to improve the world. Our students learn by doing, using our campus as an energy efficiency testbed, designing novel musical instruments, creating overdose-reversing wearable drug delivery devices, building a Formula-style racecar from scratch, and designing drones to help firefighters. Our Mechanical Engineers are valued for their analytical and problem-solving abilities and go on to prestigious graduate programs and careers in aerospace, automotive, ocean and marine engineering, biomedical engineering, energy, finance, law and medicine.

Undergraduate Program

The sequences of courses shown in the undergraduate curriculum table emphasize the fundamental engineering sciences as well as their applications in the analysis and solution of contemporary engineering problems. By the selection of electives and of their design and research projects, students have a large degree of flexibility in exploring their own interests.

Graduate Program

Areas of research include computer-aided design/engineering/manufacturing, robotics, biomedical engineering, automotive systems, modern control systems, mechatronics, sustainable building systems, thermoelectric power generation, vibrations and acoustics, combustion and other interdisciplinary areas of engineering.

Mechanical Engineering Curriculum

Freshman Year Credits

Fall Semester:	Credits
ESC 000.1 Professional Development Seminar	0
Ma 110 Introduction to Linear Algebra	2
Ma 111 Calculus I	4
Ch 110 General Chemistry	3
EID 101 Engineering Design and Problem Solving	3
EID 102 Engineering Graphics	1
CS 102 Computer Programming for Engineers	2
HSS 1 Literary Forms and Expressions	3
Total Credits Fall Semester	18
Spring Semester:	
ESC 000.2 Professional Development Seminar	0
Ma 113 Calculus II	4
Ph 112 Physics I: Mechanics	4
EID 103 Principles of Design	3
Ch 111 General Chemistry Laboratory	1.5
ME 102 Statics	3
HSS 2 Texts and Contexts: Old Worlds and New	3
Total Credits Spring Semester	18.5

Sophomore Year Credits

Fall Semester:	Credits
ESC 000.3 Professional Development Seminar	0
Ma 223 Vector Calculus	2
Ma 240 Ordinary and Partial Differential Equation	3
Ph 213 Physics II: Electromagnetic Phenomena	4
Ph 291 Introductory Physics Laboratory	1.5
ME 200 Dynamics	3
ESC 210 Materials Science	3
HSS 3 The Making of Modern Society	3
Total Credits Fall Semester	19.5

Spring Semester:	
ESC 000.4 Professional Development Seminar	0
Ph 214 Physics III: Optics and Modern Physics	3
ESC 221 Basic Principles of Electrical Engineering	2
ESC 201 Mechanics of Materials	3
ESC 330 Engineering Thermodynamics	3
ME 211 Design and Prototyping	2
ESC 251 Systems Engineering	3
HSS 4 The Modern Context: Figures and Topics	3
Total Credits Spring Semester	19

Junior Year Credits

Fall Semester:	Credits
Ma 224 Probability	2
ESC 340 Fluid Mechanics & Flow Systems	3
ME 300 Stress and Applied Elasticity	3
ME 351 Feedback Control Systems	3
ME 352 Process Control Laboratory	1
Engineering or Science Elective	3
Humanities/Social Sciences Elective	3
Total Credits Fall Semester	18

Spring Semester:	
ME 301 Mechanical Vibrations	3
ME 342 Heat Transfer	3
ME 360 Engineering Experimentation	3
Engineering or Science Elective	3
Humanities/Social Sciences Elective	3
Total Credits Spring Semester	15

Senior Year Credits

Fall Semester:	Credits
ME 312 Manufacturing Engineering	3
ME 331 Advanced Thermodynamics	3
ME 393 Mechanical Engineering Projects	3
ME 300- or 400-level Lecture Course*	3
Free Elective	3
Total Credits Fall Semester	15

Spring Semester:	
ME 394 Capstone Senior Mechanical Engineering Design	3
ME 300- or 400-level Lecture Course*	3
Free Electives	6
Total Credits Spring Semester	12
Total credits required for degree	**135**

* Please note independent studies cannot be used to fulfill this requirement.

Masters Program—Mechanical Engineering

The Department of Mechanical Engineering offers both the thesis and non-thesis option in pursuing a Master of Engineering degree. If the thesis option is chosen, the student is required to take 24 credits of course work and six credits of ME499 for their thesis project work. If the non-thesis option is chosen the student is required to take 30 credits of course work and submit a report that fulfills the special project requirement. The student must complete a coherent concentration of graduate-level courses approved by the department.

Thesis requirements and non-thesis requirements are outlined in the master's degree requirements. Pursuing the thesis option gives students the opportunity to work under the guidance of a faculty adviser on research or an original investigation of a problem in mechanical engineering. Writing and defending a thesis describing the results of their work prepares student for further doctoral study and research and project work in industry. For some students, such as those working while completing their degree requirements, the non-thesis option is preferred.

Through course projects, research, and consulting opportunities, graduate students in the Department of Mechanical Engineering explore design and innovation, robotics, mechatronics, energy and sustainability, nanotechnology, dynamic systems and control, vibration and acoustics, biomedical engineering and cutting-edge computational methods. Courses balance analytical rigor and creative design, thereby preparing graduates for a variety of careers.

Graduates are valued for their strong project-based design skills and analytical abilities. They have successful careers as entrepreneurs and innovators in the aerospace, automotive, biomedical, energy and construction industries. They often pursue doctoral studies in a range of mechanical engineering fields.

SPECIALIZATION AND RESEARCH AREAS: computer-aided design and engineering, computational fluid dynamics, combustion, refrigeration, robotics, biomedical systems, respiratory biomechanics, automotive systems, mechatronics, thermoelectric power generation, energy-efficient buildings, vibration and acoustics

EMPLOYERS OF OUR GRADUATES: Arup, Boeing, Bloomberg LP, Consolidated Edison, Credit Suisse, Exxon, General Dynamics, General Motors, Google, Honda, IBM, Merck, NASA, Raytheon, Southwest Research Institute, SpaceX, Stryker, United States Patent and Trademark Office

To apply see application information and master's degree requirements for further details.

GENERAL ENGINEERING

The School of Engineering offers a program in General Engineering leading to the degree of Bachelor of Science (B.S.). This program is designed for students with a clear idea of their educational objectives which require a more flexible, interdisciplinary course of study.

This program is suitable for students who desire a strong, broad-based, rigorous engineering background as preparation for fields such as: chemistry, mathematics, medicine, biomedical engineering, law, finance, or entrepreneurship. Each B.S. student is advised from the Dean's Office, however, students are encouraged to identify academic advisor(s) in other departments who can specifically help them with issues associated with the areas they have chosen as their focus.

Students are required to enroll in 55 core curriculum credits in mathematics, the sciences, and the humanities (similar to the B.E. degree) in their freshman and sophomore years as they prepare to select courses open to all Engineering students. Art, Architecture, and Humanities courses may also be selected as seats in those courses become available and the respective schools/faculty grant permission .

The B.S. program is not suitable for students who wish professional licensure.

Student Outcomes

The General Engineering Department has established the following set of outcomes that our undergraduate students are expected to achieve by the time of graduation:

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- An ability to communicate effectively with a range of audiences
- An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

2020-21 Bachelor of Science Enrollment and Graduation
Freshman: 15
Sophomore: 14
Junior: 7
Senior: 6
Total: 42

In May 2020, the Department of General Engineering graduated 6 students with a Bachelors of ScienceâĐĐ General Engineering degree.

General Engineering Curriculum

The Bachelor of Science (B.S.) degree is intended for students who have a clear idea of their educational objectives in which a more flexible and interdisciplinary course of study would be more appropriate.

In the first two years, a student must complete a minimum of 55 credits in core engineering, engineering sciences (ESC) and interdisciplinary engineering (EID) courses, thereby building a strong analytical background, in addition to fulfilling all the requirements for the bachelor's degree as summarized here:

	Credits
Core Courses (freshman and sophomore)	55
Humanities and Social Sciences (over and above the core courses)	6 minimum
Engineering and Engineering Sciences (over and above the core courses)	44 minimum
Free Electives	30
Total credits	**135**

For junior and senior year, students are advised to identify one or more areas in which they would like to focus their plan of study and to find a academic advisor(s) in those fields for specific guidance. Students may choose from all courses available at The Cooper Union and may work in such interdisciplinary areas as environmental and energy resources engineering, systems and computer engineering, bioengineering and ocean and aerospace engineering.

Students who are considering applications to other professional schools after completing the engineering degree are advised to take one year of organic chemistry and one year of biology for medicine and dentistry, additional courses in the social sciences for law, and one year of economics for business or finance. Such students should consult their faculty advisors in order to design a program to meet professional goals and degree requirements.

Freshman Year Credits

Fall Semester:	Credits
ESC 000.1 Professional Development Seminar	0
Ma 110 Introduction to Linear Algebra	2
Ma 111 Calculus I	4
Ch 110 General Chemistry	3
EID 101 Engineering Design and Problem Solving	3
CS 102 Computer Programming for Engineers	2
EID 102 Engineering Graphics	1
HSS 1 Freshman Seminar	3
Total Credits Fall Semester	18
Spring Semester:	
ESC 000.2 Professional Development Seminar	0
Ma 113 Calculus II	4
Ch 111 General Chemistry Laboratory	1.5
Ch 160 Physical Principles of Chemistry	3
Ph 112 Physics I: Mechanics	4
HSS 2 Texts and Contexts: Old Worlds and New	3
Total Credits Spring Semester	15.5

Sophomore Year Credits

Fall Semester:	Credits
ESC 000.3 Professional Development Seminar	0
Ma 223 Vector Calculus	2
Ma 224 Probability	2
Ph 213 Physics II: Electromagnetic Phenomena	4
Ph 291 Introductory Physics Laboratory	1.5
HSS 3 The Making of Modern Society	3
Electives	6
Total Credits Fall Semester	18.5
Spring Semester:	
ESC 000.4 Professional Development Seminar	0
Ma 240 Ordinary and Partial Differential Equations	3
Ph 214 Physics III: Optics and Modern Physics	3
HSS 4 The Modern Context: Figures and Topics	3
Electives	10
Total Credits Spring Semester	19

CHEMISTRY

The Department of Chemistry offers a wide range of courses that are necessary for the understanding of the various engineering disciplines. All first-year engineering students enroll in General Chemistry (a general quantitative and descriptive overview of chemistry) and General Chemistry Laboratory (chemical preparation and analysis, data recording, report writing and safety). Students majoring in chemical or civil engineering also take Physical Principles of Chemistry (a quantitative treatment of chemical thermodynamics, electrochemistry and kinetic theory) during their first year.

Sophomore and junior level courses required for chemical engineering majors can also be taken as electives by those wishing to further their knowledge in the areas of analytical chemistry, biochemistry, organic chemistry and physical chemistry.

In addition, advanced elective courses in biochemistry, inorganic chemistry, theoretical chemistry and nanoscience are available, and are suitable for students interested in bioengineering, chemistry, materials engineering, nanotechnology, or pre-medical studies. Research at the undergraduate and master's levels can be conducted under the supervision of the chemistry faculty. Interested students should meet with the department faculty to discuss possible research areas.

The Department operates laboratories in general chemistry, organic chemistry, instrumental analysis, bioorganic chemistry, computational chemistry and nanochemistry for instruction and research projects.

MATHEMATICS

The primary responsibility of the Department of Mathematics is the maintenance and delivery of the core mathematics curriculum for the School of Engineering. This consists of a sequence of required courses given in the first two years covering calculus, linear algebra, probability, vector calculus and differential equations. In addition to the core courses, there are a variety of elective mathematics courses, some of which are computer-related. The mathematics curriculum will more than adequately prepare the student for professional work as well as graduate study in engineering and applied mathematics.

The faculty of mathematics strives to develop in the student a firm foundation in, and an appreciation of, the structure and methods of mathematics. Students interested in mathematics research should consult the chair for specific areas of expertise.

Minor in Mathematics

The department of mathematics offers a minor in mathematics. Students seeking a minor in mathematics must complete at least 15 credits of mathematics coursework in addition to the 17 credits required by every engineering department. These additional credits must include Mathematical Analysis I and II (Ma 350, 351), Linear Algebra (Ma 326), Modern Algebra (Ma 347) and an elective course in mathematics at or above the 300 level. An overall G.P.A., at graduation, of at least 3.0 among the mathematics portion (32 credits) of the program is required to obtain a minor in mathematics.

Mathematics Curriculum

The department of mathematics offers a minor in mathematics. Students seeking a minor in mathematics must complete at least 15 credits of mathematics coursework in addition to the 17 credits required by every engineering department. These additional credits must include Advanced Calculus I and II (Ma 350 and Ma 351), Linear Algebra (Ma 326), Modern Algebra (Ma347) and an elective course at or above the 300 level. An overall G.P.A., at graduation, of at least 3.0 among the mathematics portion (32 credits) of the program is required to obtain a minor in mathematics.

PHYSICS

The Department of Physics provides a sequence of introductory courses devised to introduce students in engineering to fundamental physical concepts that underlie all the engineering disciplines. All first-year engineering students enroll in Physics I: Mechanics. All second-year engineering students enroll in Physics II: Electromagnetic Phenomena, Introductory Physics Lab, and Physics III: Optics and Modern Physics. The Physics Department occasionally offers elective courses such as General Relativity, Physics Simulations, and Deterministic Chaos, that have been designed to provide an enhanced understanding of specially selected fields of interest in engineering science.

COURSES
CHEMICAL ENGINEERING

Undergraduate

ChE 211 **Materials Science for Chemical Engineers**
An introduction the basic principles underlying the behavior of materials. The course provides the scientific foundation for an understanding of the relationships among material properties, microstructure, and the behavior of metals, ceramics, and polymers. Students will develop a vocabulary for the description of materials and explore how atomistic properties influence larger scale morphology and macroscopic behavior. *3 credits. Prerequisites: Ch 110*

ChE 221 **Material and Energy Balances**
Introduction to the principles and techniques used in chemical engineering. Basic concepts of mathematics, physics, and chemistry are applied to solving problems involving stoichiometry, analysis of chemical process systems, and material and energy conservation equations. Also includes methods for estimation of thermodynamic and chemical properties of real fluids for engineering calculations, basic chemical equilibrium, and unsteady-state balances. *3 credits. Prerequisite: Ch 160*

ChE 232 **Chemical Engineering Thermodynamics I**
This course will apply the first and second laws of thermodynamics to batch and flow processes for single component systems. Topics include energy and entropy balances, fundamental property relationships, applications of steam tables, and an introduction to fugacity, residuals, and choosing appropriate thermodynamics models. *3 credits. Prerequisites: Ch 160 or ChE 221*

ChE 331 **Chemical Engineering Thermodynamics II**
This course will apply the concepts learned in Thermodynamics I (CHE 232) for single phase, pure systems to mixtures. Topics include fugacity, partial molar properties, activity coefficients in non-ideal mixtures, vapor-liquid equilibria, and choosing appropriate thermodynamics models. *3 credits. Prerequisites: ChE 232*

ChE 332 **Chemical Reaction Engineering**
After consideration of chemical reaction kinetics and thermodynamics, the course focuses on the design relationships for batch, semi-batch, plug-flow and mixed reactors. The application of these design relationships is explored in ideal, isothermal, non-isothermal, and adiabatic reactors. Homogeneous, heterogeneous and biological systems are discussed including the effect of transport phenomena on reaction rates and reactor design. *3 credits. Prerequisites: ChE 221 and ChE 341*

ChE 341 **Fluid Mechanics and Flow Systems**
Introductory concepts of fluid mechanics and fluid statics. Development and applications of differential forms of basic equations. Dynamics of inviscid and viscous fluids, flow measurement and dimensional analysis with applications in fluid dynamics. Friction loss and friction factor correlation; design of piping systems. *3 credits. Prerequisites: ChE 221*

ChE 342 **Heat and Mass Transfer**
Introduction to heat and mass transfer. Steady-state and unsteady-state heat transfer. Steady-state and unsteady state mass transfer. Interphase transport and transfer coefficients. Convective heat and mass transfer. Internal and external forced convection. Heat transfer equipment. Natural convection. Boiling and condensation. Radiation heat transfer. *4 credits. Prerequisites: ChE 341*

ChE 351 **Separation Process Principles**
Application of thermodynamic and transport concepts to the design of continuous-contact and staged mass transfer processes common in the chemical process industries. Separation by phase addition, phase creation, by barrier, by solid agent and by external field or gradient. Examination of the limitations of theory and empiricism in design practice. *3 credits. Prerequisites: ChE 331 and ChE 342*

ChE 352 **Process Simulation and Mathematical Techniques for Chemical Engineers**
In this course, numerical methods will be applied to chemical engineering problems in mass and energy balances, thermodynamics, fluid flow, heat transfer, separations, and chemical reactor analysis. Topics include: computer calculations and round-off error, algorithms and convergence, finding roots by bisection or Newton's method, curve fitting and interpolation / extrapolation, numerical integration and differentiation, numerical solution of initial value problems, stiffness, matrices and determinants, matrix properties, special matrices, methods of solution for systems of linear equations by matrices, eigenvalues, eigenvectors, solving systems of non-linear equations, and applications to unit operations. We will use series methods and numerical methods applied to various chemical engineering models, including the following specific methods: Euler's method, Runge-Kutta methods, the Finite difference method, and Newton-Raphson for vector systems. *3 credits. Prerequisite: ChE 341*

ChE 361 **Chemical Process Dynamics and Control**
Introduction to logic of process dynamics and principles of control in chemical engineering applications; block diagram notation, input disturbance, time response and stability criteria for chemical equipment and chemical reaction systems; single- and multiple-loop systems; phase plane analysis of reaction systems; instrumentation (types and capabilities) and higher-end automation techniques. The course concludes with automation and control system projects (design). *3 credits. Prerequisite: ChE 352*

ChE 371 **Chemical Engineering Laboratory I**
This first laboratory course emphasizes the application of engineering fundamentals to real manufacturing processes and unit operations. The experiments cover traditional engineering applications in fluid flow, reactors, and separations, as well as newer technologies that students may encounter in industry. The course is designed to provide hands-on experience which complements theories and principles discussed in chemical engineering courses. The course will emphasize statistics and design of experiments. Preparation of detailed lab reports, posters, oral presentations, and other technical communications are important components of the course.
2 credits. Prerequisites: ChE 332, ChE 342; Corequisite: ChE 351

ChE 372 **Chemical Engineering Laboratory II**
This second laboratory course emphasizes the application of engineering fundamentals to real manufacturing processes and unit operations. The experiments cover traditional engineering applications, primarily in separation processes, as well as newer technologies that students may encounter in industry. The course is designed to provide hands-on experience which complements theories and principles discussed in chemical engineering courses. The course will require application of statistics and design of experiments. Preparation of detailed lab reports, posters, oral presentations, and other technical communications are important components of the course.
2 credits. Prerequisite: ChE 371

ChE 381 **Process Evaluation and Design I**
The course uses design projects to explore process flow diagrams and initial equipment design estimates based on process and unit operation material and heat balances. Studies include equipment cost estimation methods that are developed into process economic evaluations and profitability analysis. A very important aspect of the course is the emphasis on safety, health and loss prevention in the design process. The course concludes with process and equipment design using ASPEN and/or Simulation Science's PROvision/PRO-II and an examination of optimization techniques. *3 credits. Prerequisites: ChE 342 and ChE 332*

ChE 382 **Process Evaluation and Design II**
This is a continuation of ChE 381 and is the "capstone design course" in chemical engineering. All aspects of chemical engineering are integrated into the design of a chemical process plant. The design process consists of flowsheet development, equipment selection and sizing, utility requirements, instrumentation and control, economic analysis, and formulation of safety procedures. A plant design is carried out in class and the course includes the use of professional simulation packages such as Aspen Plus. AIChE National Student Design Competition projects are often included in this course. *4 credits. Prerequisite: ChE 381*

ChE 391 **Research Problem I**
An elective course available to qualified and interested students recommended by the faculty. Students may select problems of particular interest in some aspect of theoretical or applied chemical engineering. Topics range from highly theoretical to completely practical, and each student is encouraged to do creative work on his or her own with faculty guidance. *3 credits. Prerequisite: senior standing*

ChE 392 **Research Problem II**
Continuation of ChE 391. *3 credits. Prerequisite: ChE 391*

ChE 393 **Research Problem III**
Continuation of ChE 392. *3 credits. Prerequisite: ChE 392*

ChE 394 **Research Problem IV**
Continuation of ChE 393. *3 credits. Prerequisite: ChE 393*

Graduate

ChE 411 **Polymer Technology and Engineering**
Structures and synthesis of Carbon-Carbon and heterogeneous chain polymers, mechanisms and kinetics of emulsion, condensation, ionic, and stereo-specific polymerizations. Rubber elasticity. Rheological and viscoelastic properties of polymers and polymer solutions. Survey and investigations of advanced topics are required. *3 credits.*

ChE 421 **Advanced Chemical Reaction Engineering**
Principles of chemical reaction systems and the practices of industrial reactor designers. Emphasis is on heterogeneous chemical kinetics, biochemical reaction engineering, polymerization reactions, and reactor scale-up. Modeling and computer simulation of systems are extensively applied. *3 credits. Prerequisite: ChE 332*

ChE 423 **Environmental Catalysis**
This course will cover the fundamentals of heterogeneous catalysis including preparation techniques, characterization methods, reactor design, and common deactivation mechanisms. The course will focus on the use of heterogeneous catalysis for air pollution control and new energy technologies. Background in reaction kinetics is required and topics from thermodynamics and fluid dynamics will be incorporated. *3 credits. Pre-requisite ChE 332*

ChE 430 **Thermodynamics of Special Systems**
Thermodynamic analyses of solid systems undergoing elastic strain and of magnetic, electric and biological systems. Equations of state for these and other fluid and non-fluid systems.Thermodynamics of low temperature systems. Recent advances in obtaining real fluid and solid properties. *Same as EID 430 and ME 430. 3 credits. Prerequisite: ChE 331 or ME 331*

ChE 431 **Advanced Chemical Engineering Thermodynamics and Molecular Theory**
Modern methods of applying thermodynamics and molecular physics to phase behavior of fluid mixtures, intermolecular forces and thermodynamic properties, molecular dynamic properties, molecular theory of gases and liquids, theories of liquid solutions and fluid mixtures at high pressures. *3 credits. Prerequisite: ChE 331*

ChE 433 **Rocket Science**
Transient and steady-state control volume balances (mass, momentum and energy) that involve compressible flow phenomena are applied to (primarily) aerospace applications. Fundamental topics include variable mass accelerating control volumes, variable area adiabatic flows, normal and oblique shock waves, expansion fans, friction effects (Fanno flow) and heat transfer effects (Rayleigh flows). Numerical and analytical techniques are developed. Applications include basic trajectories, water rockets, converging/diverging rocket nozzles, RAM and SCRAM jets, supersonic wakes from underexpanded and overexpanded nozzles, gas exchange in reciprocating engines. *Same as ME 433. 3 credits. Prerequisite: ESC 330 and ESC 340*

ChE 434 **Special Topics in Combustion**
Analysis of diffusion and premixed flame processes, including droplet and particle flames, combustion in sprays, chemical reactions in boundary layers, combustion instability in liquid and solid rocket engines and gas burner flames. Consideration of ignition and quenching processes and flammability limits. *Same as ME 434. 3 credits. Prerequisite: ESC 330/ChE 232*

ChE 440 **Advanced Fluid Mechanics**
Introduction to the energy equation. Steady and transient heat transfer by conduction. Convective heat transfer. Energy transport in flowing media. Free convection. Conservation of species equation. Fisk's law of binary diffusion. Mass transfer with simultaneous homogeneous or heterogeneous reaction. Multicomponent heat and mass transfer. Stefan-Maxwell equations for multicomponent diffusion. Simultaneous heat and mass transfer. Transport in electrolyte solutions. Special topics may include: membrane separation processes, drug delivery and controlled release, turbulent heat and mass transfer, boundary layer heat and mass transfer, and chemically reacting flows.
Same as EID 440 and ME 440. 3 credits. Prerequisite: ESC 340

ChE 441 **Advanced Heat and Mass Transfer**
Introduction to the energy equation. Steady and transient heat transfer by conduction. Convective heat transfer. Energy transport in flowing media. Free convection. Conservation of species equation. Fick's law of binary diffusion. Mass transfer with simultaneous homogeneous or heterogeneous reaction. Multicomponent heat and mass transfer. Stefan-Maxwell equations for multicomponent diffusion. Simultaneous heat and mass transfer. Transport in electrolyte solutions. Special topics may include: membrane separation processes, drug delivery and controlled release, turbulent heat and mass transfer, boundary layer heat and mass transfer, and chemically reacting flows.
Same as EID 441. 3 credits. Prerequisite: ChE 440 or ME 440 or EID 440

ChE 445 **Particle Technology**
Introduction to particle technology and multiphase flow. Particle properties and characterization. Granular materials and flow. Gas-solid flows. Flow through packed beds. Fluidization. Gas-solid separations. Slurry transport. Pneumatic transport. Powders and bulksolids. Mixing and segregation. Particle size reduction and enlargement. Aerosol dynamics. Industrial petrochemical and pharmaceutical processes: fluid catalytic cracking, gascyclones, hoppers, granulation, coating.
3 credits. Prerequisite: ESC 340

ChE 447 **Sustainability and Pollution Prevention**
Fuzzy-logic based methodology for defining and assessing the sustainability of an entity. Pollution prevention for chemical processes at the macroscale (life-cycle assessment) and mesoscale (unit operations). Quantitatively identifying critical components of sustainability for a corporation or other similar entity. Chemical process design methods for waste minimization, increased energy efficiency, and minimal environmental impact. *3 credits. Prerequisite: permission of instructor*

ChE 460 **Process Heat Transfer Equipment**

The chemical engineer must develop, design and engineer both the complete process and the equipment used; choose the proper raw materials; operate the plant efficiently, safely and economically; and see to it that products meet the requirements set by the customer. Chemical engineering is both an art and a science. Whenever science helps the engineer to solve a problem, science should be used. When, as is usually the case, science does not give a complete answer, it is necessary to use experience and judgment. The professional stature of an engineer depends on skill in utilizing all sources of information to reach practical solutions to processing problems. This course will concentrate specifically on the theoretical and practical principles of detailed equipment design for process heat transfer operations. Attempts will be made to emphasize modern technologies used in these operations.

3 credits. Prerequisite: permission of instructor

ChE 460.1 **Heat Transfer Equipment Design (Heat Exchangers)**

The chemical engineer must develop, design and engineer both the complete process and the equipment used; choose the proper raw materials; operate the plant efficiently, safely and economically; and see to it that products meet the requirements set by the customer. Chemical engineering is both an art and a science. Whenever science helps the engineer to solve a problem, science should be used. When, as is usually the case, science does not give a complete answer, it is necessary to use experience and judgment. The professional stature of an engineer depends on skill in utilizing all sources of information to reach practical solutions to processing problems. This course will concentrate specifically on the theoretical and practical principles of detailed equipment design for process heat transfer operations. Attempts will be made to emphasize modern technologies used in these operations.

Same as EID 460.1. 3 credits.

ChE 461 **Principles of Design and Analysis of Reactors**

The chemical engineer must develop, design and engineer both the complete process and the equipment used; choose the proper raw materials; operate the plant efficiently, safely and economically; and see to it that products meet the requirements set by the customer. Chemical engineering is both an art and a science. Whenever science helps the engineer to solve a problem, science should be used. When, as is usually the case, science does not give a complete answer, it is necessary to use experience and judgment. The professional stature of an engineer depends on skill in utilizing all sources of information to reach practical solutions to processing problems. This course will concentrate specifically on the theoretical and practical principles of detailed equipment design for process reaction operations. Attempts will be made to emphasize modern technologies used in these operations. *3 credits. Prerequisite: permission of instructor*

ChE 462 **Design and Operation of Distillation Systems**
The chemical engineer must develop, design and engineer both the complete process and the equipment used; choose the proper raw materials; operate the plant efficiently, safely and economically; and see to it that products meet the requirements set by the customer. Chemical engineering is both an art and a science. Whenever science helps the engineer to solve a problem, science should be used. When, as is usually the case, science does not give a complete answer, it is necessary to use experience and judgment. The professional stature of an engineer depends on skill in utilizing all sources of information to reach practical solutions to processing problems. This course will concentrate specifically on the theoretical and practical principles of detailed equipment design for process distillation operations. Attempts will be made to emphasize modern technologies used in these operations.
3 credits. Prerequisite: permission of instructor

ChE 474 **Drug Formulation and Delivery**
The fundamentals of drug formulation and drug delivery systems in the context of current therapeutics on the market. Specific topics include traditional drug formulation, mechanisms and kinetics of pharmaceutical stability, controlled-release devices, transdermal delivery, intravenous delivery, oral drug delivery, pulmonary delivery, and targeted drug delivery. The course is designed to cover specific drug delivery topics that are expanded upon with student driven discussions of primary literature assigned by the professor. *3 credits. Prerequisites: Ch 231 and senior standing*

ChE 475 **Pharmaceutical Engineering**
Introduction to pharmaceutical engineering. Overview of the pharmaceutical industry and drug discovery and development. Clinical trials, regulation, and validation. Scientific principles of dosage forms including solutions, disperse systems, dissolution, stability, and surface phenomena. Biopharmaceutical principles of drug delivery. Pharmacodynamics, pharmacokinetics, and biopharmaceuticals. Unit operations for solid and liquid dosage forms. Pharmaceutical plant design.
3 credits. Prerequisites: ChE 332, ChE 351, and Ch 262, or permission of instructor

ChE 488 **Convex Optimization Techniques**
This course discusses in detail different methods for the optimization of systems of engineering and economic interest using the techniques of linear and nonlinear programming. The focus is on convex optimization, which is the solution of problems with only one best cost, design, size etc. We will consider problems such as least squares, supply chain management, batch process networks, network flow, dynamic programming, portfolio optimization and other examples across all engineering

disciplines. Students will learn about optimization theory and problem formulation, with some computational component. By the end of the course, students should be able to: create optimization problems from a physical situation, identify whether the problem can be solved or not, transform problems into equivalent forms, list optimality conditions for problems, find the dual of a problem and identify its relation to the primal, and use at least one method to solve a convex programming problem using a computer. *Same as EID 488. 3 credits. Prerequisites: ChE 352 or ME 251, Ma 326 (co-enrollment is fine)*

ChE 490 **Process Synthesis**
This course provides a new basis forthe design of integrated chemical processes. The ability to predict, at the outset, achievable design targets that have a sound scientific basis is fundamental to the approach. These targets relate to energy, capital and raw materials, costs and flexibility. Topics will include review of basic thermodynamic concepts, capital/energy trade-off, process integration multiple utilities, process/utility interface, reactors and separators in the context of overallprocess power optimization, design for flexibility, total sites layout, batch processes and process plant retrofit. *3 credits. Prerequisites: ChE 381 and ChE 382 or permission of instructor*

ChE 491 **Graduate Research Problem I**
An elective research course available to qualified and interested graduate students. Students may select novel problems of particular interest in some aspect of theoretical or applied chemical engineering. Topics range from highly theoretical to completely practical; students are required to do creative work on their own with faculty advice and guidance. *3 credits. Prerequisite: permission of instructor*

ChE 491 **Graduate Research Problem I ChE 492 Graduate Research Problem II**
Continuation of ChE 491. *3 credits. Prerequisite: ChE 491*

ChE 493 **Graduate Research Problem III**
Continuation of ChE 492. *3 credits. Prerequisite: ChE 492*

ChE 494 **Graduate Research Problem IV**
Continuation of ChE 493. *3 credits. Prerequisite: ChE 493*

ChE 499 **Thesis/Project**
Masters of Engineering candidates are required to conduct, under the guidance of a faculty adviser, an original investigation of a problem in chemical engineering, individually or in a group, and to submit a written thesis describing the results of the work. *6 credits. This is a full-year course*

CIVIL ENGINEERING

Undergraduate

CE 220 **Civil Engineering Fundamentals**
Planning, execution and interpretation of drawings and specifications for civil engineering projects. Sample drawingsand specifications. Contractual requirements. Sample contracts. Permitting, scheduling and cost estimation. Basic operations of design and construction firms. Interface with other disciplines on civil engineering projects. *3 credits. Prerequisite: EID 101*

CE 251 **Urban Transportation Planning**
Historical background and evolution of current procedures used in the urban transportation planning process. Covered are the historical framework, urban development theories, land use, trip generation, trip distribution models, traffic assignment techniques, modal split and introduction to urban transportation systems. *3 credits. Prerequisite: permission of instructor*

CE 321 **Structural Engineering I**
Discussion of materials, loads and forms of structures. Analysis of determinate structures. Displacements of structures and their importance in applications. Experimental aspects of materials behavior in structural applications. Emphasis is placed on basic experimental techniques, design of experiments, selection and use of appropriate instrumentation and interpretation of results. *4.5 credits (3 hours of lecture, 3 hours of laboratory). Prerequisite: ESC 201*

CE 322 **Structural Engineering II**
Modern methods of structural analysisof indeterminate structures. Discussion of energy methods, force methods and displacement methods. Formulation of elementary matrix stiffness and flexibility methods. Computer applications in structural analysis. *3 credits. Prerequisite: CE 321*

CE 331 **Introduction to Geotechnical Engineering**
Introduction to various indexing tests of soils, clay mineralogy, permeability, seepage and flow nets, stress distribution in soil masses, one dimensional consolidation theory, strength characteristics of soils, application of Mohr's Circle to soil mechanics, stability of slopes. *4.5 credits (3 hours of lecture, 3 hours of laboratory). Prerequisite: ESC 101, ESC 340*

CE 332 **Introduction to Foundation Engineering**
Layout of subsurface investigation program, SPT (Standard Penetration Test), Dutch-cone penetrometer. Analysis and design of spread footings on cohesive and cohesion less soil by stability and settlement procedures, combined footings, strap footings, floating foundations and pile foundations. Settlement analysis due to deep-seated consolidation. *3 credits. Prerequisite: CE 331*

CE 341 **Design of Steel Structures**
Study of behavior and design of structural steel components and their connections. Understanding and development of design requirements for safety and serviceability, as related to latest structural steel specifications by the American Institute of Steel Construction (A.I.S.C.). Current design emphasizing LRFD, fabrication and construction practices. Composite design. *3 credits. Prerequisite: CE 321; corequisite: CE 322*

CE 342 **Design of Reinforced Concrete Structures**
Study of the behavior and design of structural concrete components and their connections. Understanding and development of design requirements for safety and serviceability, as related to latest specifications by the American Concrete Institute (A.C.I.). Current design, fabrication and construction practices. Introduction to pre-stressed concrete. *3 credits. Prerequisite: CE 322*

CE 343 **Water Resources Engineering**
Problems in conservation and utilization of water. Hydrologic techniques. Surface water and ground water supplies. Water transmission and distribution. Flood control, navigation and irrigation. Introduction to open channel flow and pipe networks. Design of hydraulic structures. Experimental aspects of hydraulic phenomenon. Emphasisis placed on basic experimental techniques, design of experiments, selection and use of appropriate instrumentation and interpretation of results.
This course is the same as EID 343. 4.5 credits (3 hours of lecture, 3 hours of laboratory). Prerequisite: ESC 340; Same as EID 343

CE 344 **Environmental Systems Engineering**
Qualitative and quantitative treatment of water and wastewater systems as related to domestic and industrial needs and their effect on the environment. Introduction to air pollution sources and control and solid/hazardous waste engineering. Design of water and wastewater treatment plants. Field and laboratory techniques for measurement of water quality parameters. Laboratory analysis of representative waters and wastewaters for commonly determined parameters as related to applications in water environment. *This course is the same as EID 344. 4.5 credits (3 hours of lecture, 3 hours of laboratory). Corequisite: ESC 340; Same as EID 344*

CE 346 **Hydraulic Engineering**
An integration and application of the principles of fluid mechanics to problems concerned with water supply and distribution. Open channel flow and design of hydraulic structures. *3 credits. Prerequisite: CE 343*

CE 348 **Environmental and Sanitary Engineering**
Engineering (same as EID 348) Topics include types of environmental pollution and their effects; water quality standards and introduction to laboratory analyses of water quality parameters; sources and estimates of water and wastewater flows; physico-chemical unit treatment processes. Integrated lecture and design periods cover water supply network, wastewater collection system and water treatment design projects. *Same as EID348. 3 credits. Prerequisites: CE/EID344*

CE 351 **Urban Transportation Planning**
Historical background and evolution of current procedures used in the urban transportation planning process. Covered are the historical framework, urban development theories, land use, trip generation, trip distribution models, traffic assignment techniques, modal split and introduction to urban transportation systems. *3 credits. Prerequisite: permission of instructor (for those students who entered September 2015 or earlier).*

CE 352 **Elements of Transportation Design**
Review of urban transportation planning process. Specific design elements of various highway and public transportation systems. Included are locational design, traffic service, environmental impact analyses, alternatives evaluation, geometric design elements, operations and capacity and level-of-service analysis.Also, selected topics in urban transportation systems. *3 credits. Prerequisite: permission of instructor*

CE 361 **Civil Engineering Experimental Projects**
Exploratory experimental projects inmaterials, hydraulics, soils, environmental or other civil engineering specialties. Projects are conceived, designed and executed by groups of students under faculty supervision. *2 credits. Prerequisite: permission of instructor. (Students are required to have taken introductory civil engineering subject(s) related to project)*

CE 363 **Civil Engineering Design I**
Individual or group design projects based upon the interests of the students and with the approval of the instructor. Final engineering reports and formal oral presentations are required for all projects. Lectures by faculty and professional practitioners cover the following topics: engineering, environmental and economic feasibility assessment issues; preparation of plans and specifications; cost estimates; progress chart and critical path; interfacing with community, etc. Field visits to major New York City projects under construction. *3 credits. Prerequisite: permission of instructor. (Students are required to have taken introductory CE subject(s)) related to project)*

CE 364 **Civil Engineering Design II**
Continuation of CE 363. *3 credits. Prerequisite: CE 363*

CE 369 **Civil Engineering Project**
Individual design, research or experimental projects. Open only to well-qualified students. *3 credits. Prerequisite: permission of instructor*

CE 390 **Introduction to Sustainable Design**
Sustainable design minimizes the impact on the environment by site planning and design, energy and water conservation and interior environmental quality. This course will focus on the design of a prototype structure using sun, light, air, renewable materials, geological systems, hydrological systems and green roofing. Each student will develop a project outlined by the U.S. Green Building Council rating system known as LEED. The six areas that will be developed to design the project are: sustainable sites, water efficiency, energy and atmosphere, material and resources, indoor environmental quality and innovative design process. Class time is separated into a series of lectures, private consultations and student presentations.
Same as EID 390. 3 credits. Prerequisite: ESC 340, CE 322 or ME 300 and permission of instructor

CE 391 **Laboratory Testing of Building Materials**
Laboratory testing of common building materials such as concrete, steel, and laminated glazing. Concrete mix design. Casting, curing, and strength testing of concrete cylinders at 7, 21, and 28 days. Casting, curing, and testing of a reinforced concrete beam for stress, strain, and deflection. Casting, curing, and strength testing of a reinforced concrete column. Deflection testing of a steel beam. Buckling of slender steel columns. Vibrations of a steel beam and a steel frame. Control of deflections through bracing and stiffeners. Impact testing of laminated glazing panels. The course will consist of 3-hour weekly laboratory sessions for 15 weeks. *3 Credits. Prerequisites: This course is open to third-year architecture and third-year civil engineering students. Art students and engineering students of majors other than civil engineering require permission of instructor.*

CE 414 S**olid Waste Management**
Engineering aspects of solid waste collection, transport and disposal, including sanitary landfill design, incineration, composting, recovery and re-utilization of resources. Optimization techniques of facility-siting and collection route selection and economic evaluation of factors affecting selection of disposal methods.
3 credits. Prerequisite: permission of instructor

CE 422 **Finite Element Methods**
Shape functions and generalized displacements. Assemblage of elements. Convergence criteria.Triangular, rectangular and quadrilateral elements in plane stress and plane strain. Isoparametric formulations.General solids. Hexahedral and tetrahedral elements. Flexure in plates.General shells. Natural coordinates. Computer programs. *Same as EID 422. 3 credits. Prerequisite: CE 322 or ME 300*

CE 424 **Plates and Shells**
Discretized grid-work and grillage analysis by matrix techniques. Development of the classical thin plate theory. Mathematical and numerical solutions of the plate equation. Introduction to thin shell theory. Practical applications such as cylindrical shell roofs, spherical shell with an edge ring and various cases of shells of revolution. *3 credits. Prerequisite: CE 322*

CE 425 **Structural Dynamics**
Dynamic behavior and design of structures subjected to time-dependent loads. Included in the load systems are earthquakes, blasts, wind and vehicles. Shock spectra and pressure impulse curves. Special applications in blast mitigation design. *Same as EID 425. 3 credits. Prerequisite: CE 322*

CE 426 **Advanced Structural Design**
Discussion of principal design codes (AISC, ACI and AASHTO) as they relate to ASCE Standards, the International Building Code (IAC) and NYC Building codes Advanced materials behavior. Strength and serviceability requirements. Design of composite girders and slabs. Limit state response and formation of plastic hinges in steel and concrete structures. Structural upgrade and retrofit of existing structures.
3 credits. Prerequisite or corequisite: CE 341

CE 427 **Behavior and Design of Prestressed Concrete Structures**
Behavior and design of prestressed members in flexure, shear, bond and torsion; continuous beams; columns; prestressed systems; loss of prestress. Emphasis is placed on ultimate strength design and the background of latest ACI code. *3 credits. Prerequisite: CE 342*

CE 431 **Foundation Engineering I**
Layout of subsurface investigation program, SPT (Standard Penetration Test), Dutch-cone penetrometer. Analysis and design of spread footings on cohesive and cohesion less soil by stability and settlement procedures, combined footings, strap footings, floating foundations and pile foundations. Settlement analysis due to deep-seated consolidation. *3 credits. Prerequisite: CE 331*

CE 432 **Foundation Engineering II**
Analysis and design of foundations subjected to vibratory loading, beamson elastic foundation (vertical subgrade modulus), laterally loaded piles (with software applications), Wave Equation Analysis of Piles (with software application of WEAP).
3 credits. Prerequisites: CE 331 and permission of instructor

CE 433 **Lateral Earth Pressures and Retaining Structures I**
Introduction to classical lateral earth pressure theories (Rankine and Coulomb). Analysis and design of cantilever and gravity retaining walls, cantilevered and anchored sheetpile bulkheads, anchorage systems (individual and continuous deadmen, grouted tiebacks) and braced cofferdams. Gravity Wall Systems (Gabion Walls, Criblock Walls and Double Wall). *3 credits. Prerequisite: CE 331*

CE 434 **Lateral Earth Pressures and Retaining Structures II**
Analysis and design of cellular cofferdams, reinforced earth-retaining structures, slurry walls and retaining structures subjected to earthquake loading, soil nailing.
3 credits. Prerequisites: CE 331 and permission of instructor

CE 435 **Special Topics in Geotechnical Engineering I**
Analysis of slopes using translatory slides and available software packages (PCSTABL). Ground improvement technologies: including dynamic compaction, grouting, ground freezing and reinforced earth technologies. *3 credits. Prerequisite: permission of instructor*

CE 436 **Special Topics in Geotechnical Engineering II**
Stresses in homogeneous and layered systems due to surface and buried loads. Development of flow network concepts and the Terzaghi one dimensional consolidation theory, secondary consolidation, site preloading, sand drains and prefabricated vertical drains. *3 credits. Prerequisite: permission of instructor*

CE 437 **Geo-Environmental Engineering**
Discussion of pertinent regulations and regulatory programs relevant to contaminated soil. Identification and characterization of contaminated soils, discussion of current treatment technologies both ex-situ and in-situ. Geotechnical design of waste facilities, closure and improvement of waste facilities. Utilization of waste for engineering purposes. Reuse and recycling of contaminated soil.
3 credits. Prerequisites: ESC 340, CE 331, CE 344, and permission of instructor

CE 438 **Forensic Geotechnical Engineering**
Types of damage-architectural, functional and structural. Investigate problems the forensic geotechnical engineer encounters: settlement of structures, damage to soil expansion, lateral movement of buildings, damage due to seismic energy of earthquakes, slope erosion, deterioration due to sulfate attack and frost, seepage. Development of repair recommendations and the presentations of case studies.
3 credits. Prerequisite CE 331 or permission of instructor

CE 440 **Industrial Waste Treatment Design**
Integrated lecture and design periods that cover the sources of industrial wastewaters, their quantities and characteristics, and their treatability by physical, chemical and biological processes. Status of regulations involving categorical standards, local and state industrial pretreatment programs, NPDES permits, etc. Problems and solutions involved in combining municipal and industrial waste treatment. Case studies. *3 credits. Prerequisite: permission of instructor*

CE 441 **Water and Wastewater Technology**
Wastewater sources and estimates of domestic, commercial and industrial flows. Integrated lecture and design periods that cover unit processes for water and waste-water treatment. Design projects include hydraulic and process design of oxidation ponds, screening, grit removal, sedimentation tanks, secondary biological treatment, other physicochemical processes and outfall design. *3 credits. Prerequisite: permission of instructor*

CE 442 **Open Channel Hydraulics**
Derivation of the general one dimensional equations of continuity, momentum and energy used in open channel flow analysis. Steady uniform flow and boundary resistance. Steady nonuniform flows, channel transitions and controls, hydraulic jumps, surges, surface curves for gradually varied flow including the effects of lateral inflow. Unsteady flow in open channels. Dynamic waves, method of characteristics, surge formation. Kinematic waves, flood routing and overland flow. Design of channels and other hydraulic structures. *3 credits. Prerequisite: CE 343*

CE 444 **Hydrology**
Hydrology of the water cycle related to air mass movement, precipitations, evaporation, stream flow, floods, infiltration and groundwater including statistical hydrology. Design of irrigation systems. *3 credits. Prerequisite: CE 343*

CE 446 **Pollution Prevention or Minimization**
Introduction to the new concept and regulations in the U.S. and Canada of Pollution Prevention or Waste Minimization for managing hazardous pollution and protecting the environment and public health. Methodology of conducting environmental audits and lessons learned from successful pollution prevention programs. Case studies of various programs in industry, etc. *3 credits. Prerequisite: permission of instructor*

CE 447 **Stream and Estuary Pollution**
Application of basic concepts of fluid kinetics and dynamics to the analysis of dispersal and decay of contaminants introduced into lakes, streams, estuaries and oceans. Analysis and modeling of leachate and other contaminants into groundwater.
3 credits. Prerequisite: CE 343

CE 448 **Environmental and Sanitary Engineering**
Engineering (same as EID 448) Topics include types of environmental pollution and their effects; water quality standards and introduction to laboratory analyses of water quality parameters; sources and estimates of water and wastewater flows; physico-chemical unit treatment processes. Integrated lecture and design periods cover water supply network, wastewater collection system and water treatment design projects. *Same as EID 448. 3 credits. Prerequisite: permission of instructor*

CE 449 **Hazardous Waste Management**
Definition and characteristics of hazardous wastes. Generation, transport, treatment, storage and disposal of hazardous wastes. Leachate characteristics and management. Treatment technologies. Monitoring and safety considerations. Obligations under Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). Field trips. *3 credits. Prerequisite: permission of instructor*

CE 450 **Civil Engineering Construction**
Preparation of plans and specifications.The bidding and award process. Contractual relations between the owner and the contractor. Preparation of cost estimate for a competitively bid project. Preparation of a progress chart and critical path. Sequencing various job elements. Engineering the actual construction. Management of labor. Interlacing with the community. Environmental requirements. Job safety. Changes and unanticipated conditions. Contract disputes and their resolutions.
3 credits. Prerequisite: CE 341

CE 460 **Innovations in Urban Infrastructure Design**
Innovations in the design, delivery, monitoring and rehabilitation of urban infrastructure. Recent advances in methods and technologies such as remote sensing, visualization, data acquisition systems, non-destructive testing, data mining, geographica linformation systems (GIS), and building information modeling (BIM). Emphasis will be placed on applications relating to real-world projects in large urban centers in the United States and the world. *3 credits. Prerequisite: CE 321 or ME 301*

CE 469 **Independent Research Project**
The purpose of this course is to allow graduate students to pursue an independent study or research project other than their thesis, with the supervision of their thesis adviser or another professor. A student is only allowed to register for this course once towards the master's degree. An interim and a final written report are required. *3 credits.*

CE 470 **Urban Security**
Design of urban systems to protect against terrorism. Analysis of blast loads. Blast mitigation design considerations. Technology transfer:military/defense to civilian sector. Response spectra. Pressure-Impulse Curves. Stand off distances. Blast mitigation measures for buildings, bridges and tunnels. Prevention of progressive collapse in tall buildings. Design of glazing. Retrofit upgrade of existing urban infrastructure. Proposed changes in New York City Building Code to protect against terrorism. Insurance issues forcommercial buildings. *Same as EID 470. 3 credits. Prerequisites: CE 322 or ME 301 and permission of instructor*

CE 471 **Engineering Risk Analysis**
The main objective of this course is to introduce students to the basic terminology and tools related to probability theory, statistics, and decision theory in the context of solving civil engineering problems. A secondary objective is to expose students to the many uncertainties inherent in civil engineering and to the tools that are available for modeling and analyzing such uncertainties. Topics to be covered include probabilistic modeling, statistical inference, Bayesian statistics, and decision under uncertainty. *3 credits. Prerequisites: MA 224 (Probability) or graduate standing.*

CE 481 **Bridge Engineering**
Codes and Applicability. General forms and components- trusses, segmental, cable-stayed and suspension. Primary loads and load combinations. Serviceability vs. strength. Consideration of extreme events. Design of superstructures-deck design, girder design, floor-beam design. Design of substructures-piers, abutments, frames and foundations. Scour and other adverse considerations. Wind, seismic and push-over analyses. Bearings, expansion joints and barriers. *3 credits. Prerequisite CE 322 or permission of instructor.*

CE 482 **Resilient Civil Infrastructure**
Hazard mitigation including quantification of resilience. Multi-scale and/or multi-hazard risk assessement. Smart/adaptive systems to protect against natural and human-created hazards. Predictive science toward forecasting infrastructure response to climate change or extreme events. Development of frameworks for optimization of infrastructure networks. Complex systems approaches to the analysis of the interconnected nature of civil infrastructure and its interdependencies.
3 Credits. Prerequisite: permission of instructor

CE 483 **Building Information Modeling**
Introduction to Building Information Modeling (BIM). Generation and management of digital representations of physical and functional characteristics of a facility. Extensive use of BIM as a shared knowledge resource among the various stakeholders to support decision-making about a facility from earliest conceptual stages, through design and construction, and through its operational life and eventual demolition. *3 credits. Prerequisite: permission of instructor*

CE 484 **Civil Engineering Project Management**
This course provides an overview of the guiding principles of civil engineering project management. Five groups of project management processes will be considered: initiating, planning, executing, monitoring and controlling, and closing. The focus will be on developing the core competencies and skill sets required for planning and controlling civil engineering projects and understanding interpersonal issues that drive successful project outcomes. *3 credits. Prerequisite: Permission of instructor*

CE 485 **Green Sustainable Cities**
Design and modeling of green streets green walls, green roofs, blue roofs, and green parking lots; concepts and practical considerations. Study of evapotranspiration, radiation, and drainage of vegetative systems. Sustainable management and reuse considerations of urban storm water; sustainable and positive environmental impact design concepts. Management and reuse/recycle considerations for urban gray water. Examples of international projects and case studies. Team design projects with class powerpoint presentations. *3 Credits. Prerequisite: permission of instructor*

CE 486 **Urban Megaprojects and Environmental Impacts**
The political embrace of city competition internationally has combined with the globalization of banking, real estate development, and architecture to make Urban Megaprojects seemingly inevitable. With the world economy slowed, it is time to delve into the motivation for and consequences (including environmental impacts) of the now-ubiquitous and globally-entrenched Urban Megaprojects. The aim of this course is to understand the causes and consequences of new scales and forms of territorial restructuring in a steadily globalizing world by focusing on Urban Megaproject development. Case studies from cities such as Bilbao, Budapest, Abu Dhabi, New York, Paris, Sao Paulo, Shanghai, Detroit, Philadelphia, and Mexico City will be presented in an interdisciplinary approach including sociology, planning, architecture, and environmental impacts. Individual term papers on case studies will be presented to class with powerpoint. *3 credits. Prerequisite: instructor's approval*

CE 487 **Alternative Energy Projects**
The design parameters and pros and cons of all types of alternative energy production systems currently in use around the world will be presented. Concepts, practical considerations, environmental impacts, and economics will be evaluated. Alternative energy production systems such as solar, wind power, geothermal, hydropower, pumped storage, industrial growth of algae for biodiesel, will be examined and cade studies from around the world will be presented. Individual term papers on case studies will be presented to class by PowerPoint.
3 credits. Prerequisite: instructor's approval

CE 499 **Thesis/Project**
Master's candidates are required to conduct, under the guidance of a faculty adviser, an original investigation of a problem in civil engineering, individually or in a group, and to submit a written thesis describing the results of the work. *6 credits for the full year*

ELECTRICAL AND COMPUTER ENGINEERING

Undergraduate

ECE 150 **Digital Logic Design**
Theoretical and practical issues concerning design with combinational and sequential logic circuits, and programmable logic devices. Number systems, Boolean algebra, representation and simplification o fBoolean functions, universal logic families. Finite-state machines, state tables and state diagrams, flip-flops, counters, registers. Adders, decoders, comparators, multiplexers, memories and applications. Programmable devices: PLA, PLD, etc. Principles of analog circuits are presented in the context of real world problems, such as 'glitches,' power and ground bounce, contact bounce, tri-state logic and bus interfacing, timing circuits, asynchronous versus synchronous circuit components. Characterization of electronic and logical properties of digital circuits. Course work involves individual and team projects in which: digital circuits are designed and prototypes are constructed and tested on breadboards; designs involving programmable logic devices are developed using CAD tools. The projects, approximately 50 percent of the course grade, are used to assess technical writing, oral presentation, teamwork and project management skills. *3 credits. Open to all students.*

ECE 160 **Programming for Electrical Engineers**
Programming in C, in a Unix-style environment, with an emphasis on fundamental concepts of practical programming languages, software development and programming methodology. Environment topics include: use of command line interfaces, file system structure, editors, utilities and shell programming. C topics include: binary representations of numbers, operators and expressions, data types, arrays, strings, structures, pointers, static and dynamic memory allocation; control flow; subroutines and recursion; file and peripheral I/O; numerical and text processing; introduction to data structures such as stacks and linked lists. *3 credits.*

ECE 210 **MATLAB Seminar: Signals & Systems**
A weekly hands-on, interactive seminar that introduces students to MATLAB, in general, and the Signal Processing Toolbox in particular. Students explore scientific computation and scientific visualization with MATLAB. Concepts of signal processing and system analysis that are presented in ECE 211 or other introductory courses on the subject are reinforced through a variety of demonstrations and exercises. It is strongly encouraged for students taking a first course in signals and systems, or for students expecting to use MATLAB in projects or courses. *0 credits. Prerequisite: MA 113. Recommended co-requisite: ECE 211 or equivalent*

ECE 211 **Signal Processing**

This course presents a unified approach to signals and systems. Signal-space concepts for representation and approximation: inner product, orthogonal expansions, projection, Lp-norms, eigenanalysis, least-square problems, SVD. Phasors, complex baseband, line spectra. Sampling, aliasing and imaging. Analog and digital LTI systems in the time, frequency and transform domains: convolution, frequency response, transfer functions. Fourier, Laplace and z-transforms. FIR and IIR digital filters. Block diagrams, stability, feedback, initial conditions, transient modes, damping factor, Bode plots. Analog and digital state-space, transition and transfer function matrices. Random signals and vectors: correlation matrices, Gaussian vectors and signals, white noise, stationarity, ergodicity, power spectral density, ARMA models. Extensive use of MATLAB. *3 credits. Prerequisite: Ma 113; corequisite or prerequisite: ECE 210 .*

ECE 240 **Circuit Analysis**

Circuit components, dependent and independent sources, Kirchhoff's laws, loop and nodal analysis. Superposition, Thevenin and Norton equivalent circuits, and other techniques for circuit simplification. Time-domain analysis of RLC circuits, initial conditions, transient response and steady-state. Phasor analysis, complex power. Ideal op-amps. *3 credits. Prerequisite: Ma 113. Ma 240 is a suggested corequisite*

ECE 241 **Electronics I**

Semiconductor physics: band theory, carrier distributions and transport mechanisms. PN-junctions, PN junction devices. Diode circuits. BJTs: current relationships, operating region. Biasing circuits, DC Analysis; small-signal models, AC analysis. BJT amplifier configurations. *3 credits. Prerequisite: ECE 240*

ECE 251 **Computer Architecture**

Introduction to the design of computers and computer systems. Topics include: integer and floating-point representations and operations: ALU design; von Neumann and Harvard architectures; accumulator, general purpose register and stack-based processor design; RISC and CISC architectures; addressing modes; vector operations; microprogrammed and hard-wired controllers; machine language and assembly language programming; static and dynamics memory operation, timing and interfacing; cache; virtual memory; I/O systems: bus design and data transfer, DMA; interrupts and interrupt handling, polling; disk operation and organization; pipelined processor design. The course has a substantial project component that includes assembly language programming and the design and construction of systems that contain micro–controllers, programmable logic, and a variety of I/O devices. *3 credits.*

Prerequisite: ECE 150

ECE 264 **Data Structures & Algorithms I**

An introduction to fundamental data structures and algorithms, with an emphasis on practical implementation issues and good programming methodology. Topics include lists, stacks, queues, trees, hash tables and sorting algorithms. Also an introduction to analysis of algorithms with big-O notation. Assignments include programming projects and problem sets. *2 credits. Prerequisite: ECE 150 or ECE 161*

ECE 291 **Electrical Engineering Sophomore Projects**

This course focuses on one particular complex system (e.g., music synthesizer, wireless transceiver, radar) to introduce a wide range of electrical engineering principles such as frequency response, noise, feedback, loading and interfacing. In a laboratory setting, students investigate the design of subsystems that may include amplifiers, oscillators, RF or opto-electronic circuits, A/D and D/A converters, and power circuits. By measuring the impact of the operating conditions on circuit performance, students learn the principles of systems engineering, development of a testbench, and proper documentation. By the end of the semester, the class will have developed a complete functioning system through reverse engineering.
1 credit. Prerequisite or corequisite: ECE150. Corequisite: ECE240

ECE 300 **Communication Theory**

Information theory: entropy, information, channel capacity, rate-distortion functions, theoretical limits to data transmission and compression. Error control coding: block, cyclic and convolutional codes, Viterbi algorithm. Baseband and bandpass signals, signal constellations, noise and channel models. Analog and digital modulation formats (amplitude, phase and frequency), MAP and ML receivers, ISI and equalization. Coherent and non- coherent detection, carrier recovery and synchronization. Performance: computation of SNR, BER, power and bandwidth requirements. Multiple access schemes. OFDM. *3 credits. Prerequisites: Ma 224 and ECE 211*

ECE 302 **Probability Models & Stochastic Processes**

Topics in probability, random variables and stochastic processes applied to the fields of electrical and computer engineering. Probability, events, random variables, expectation, moments, characteristic functions, conditional probability and expectation. Functions of random variables, random vectors, Gausian random vectors, Poisson points. Bounding and limit theorems. Relations among important distributions and probability models.Stochastic processes: stationarity, ergodicity, Brownian motion, Markov processes. Deterministic systems with stochastic inputs, correlation and power spectral density, ARMA models. Hilbert space and applications: orthogonality principle, discrete Wiener and Kalman filters, linear prediction, lattice filters.
3 credits. Prerequisites: Ma 224 and ECE 300, or ECE 310 or permission of instructor

ECE 303 **Communication Networks**
Analysis and design of communication networks. Network protocols, architecture, security, privacy, routing and congestion control, Internet, local area networks, wireless networks, multimedia services. Physical layer, multiple access techniques, transport layer. Introduction to probabilistic and stochastic analytic techniques for communication networks. *3 credits. Prerequisites: ECE 150 and Ma 224*

ECE 310 **Digital Signal Processing**
Review of Laplace and z-transforms. Minimum-phase and all-pass functions. Multidimensional signals, systems and Fourier analysis. Analog filter design, digital IIR and FIR filter design. Sampling, multirate systems and filterbanks, A/D and D/A converter models. Discrete-time state-space. Filter structures, quantization effects and design to mitigate quantization effects. DFT and FFT. Spectral analysis of deter–ministic and random signals. Introduction to adaptive filters. Differential coding, transform coding. Speech, audio and video signals. Extensive use of MATLAB.
3 credits. Prerequisites: Ma 240 and ECE 211

ECE 311 **Hardware Design**
Development methodologies for signal processing hardware systems: RTL, HDL, synthesis and verification. Special processors including FPGA, multicore, ARM and GPU. ADC and DAC, interchip and intrachip communication, mixed-signal systems, clock and power distribution, loading, sensors and actuators, embedded systems. PCB and surface mount devices. Systems engineering. Course work including proj-ects involving hardware realizations, simulation and emulation, and software tools for system design. *3 credits. Prerequisites: ECE 211, ECE 241, ECE 251. For students entering Fall 2016 or later: required for signals/electronics track (3rd yr. fall).*

ECE 314 **Audio Engineering Projects**
An introduction to design, implementation, fabrication and modification of musical and audio electronics and hardware in a laboratory environment. Projects will include analog and digital signal processing for audio signals, with focus on implementation of real-time algorithms in hardware. Additional projects will include design and implementation of electro-mechanical systems and transducers for audio input / output / display. Formal and informal lectures will include examples drawn from standard implementations, safety concerns, audio specific design and construction techniques; participation in oral presentations and technical reports will be required.
3 credits. Prerequisite: ECE 150 and ECE 241 or permission of instructor

ECE 320 **Control Systems**

Block and signal-flow diagrams, Mason's theorem. Laplace transform ,frequency response, Bode plots, root locus, Routh-Hurwitz array. Analysis of feedback control systems: open-loopand closed-loop gain, Nichols chart, Nyquist diagram, gain and phase margin. Continuous-time state-space analysis, state-variable feedback, canonical forms, observability and controllability. Second-order models, transient and steady-state performance. Emphasis on analog systems, although digital control systems will be discussed as time allows. Extensive use of MATLAB. *3 credits. Prerequisites: Ma 240 and ECE 211*

ECE 323 **Embedded System Design**

Hardware and software design for embedded systems. SBC and microcontroller architectures, A/D andD/A conversion, signal conditioning, interfacing and controlling electronic and electro-mechanical systems. Assembly language and high-level language programming, efficient use of computational and physical resources, considerations for speed and robustness, debugging methods, use of simulators and in-circuit emulators.The course is project-based, andstudents are required to design and construct an embedded system. *3 credits. Prerequisites: ECE 320 and ECE 251*

ECE 332 **Electro-Mechanical Energy Conversion**

Analysis of energy sources and energy converters. Principles of electro-mechanical energy conversion; singly and multiply excited systems; rotating and linear machines; three phase circuits; magnetic circuits and transformers; torque and induced voltage from field considerations; synchronous machines; induction motors; DC machines. Introductionto power electronics. Applications including high-speed transportation, energy storage and interconnection of distant generating stations. *3 credits. Prerequisites: ESC 220 or ECE 240 and Ph 213*

ECE 335 **Engineering Electromagnetics**

This course emphasizes time-varying fields, with topics presented from electrostatics and magnetostatics as necessary. Maxwell's equations, constitutive relations, phasor vector fields, wave and Helmholtz equations, potentials, boundary conditions. Planewaves in lossless and lossy materials, polarization, incidence. Transmission lines: transient analysis, TDR, phasoranalysis, standing wave diagrams, Smith chart, impedance matching. Guided waves: TEM, TE and TM modes, dispersion, evanescence, cavity resonators. Microwave network analysis and device characterization with scattering parameters. Antennas, antenna arrays and Fourier optics. Additional topics from microwaves and optics will be covered as time allows. Students use a vector network analyzer to perform measurements at high frequencies.
4 credits. Prerequisites: Ma 223, Ph 213, ECE 240 and ECE 211

ECE 342 **Electronics II**

MOS circuits: DC operation and analysis. Single stage MOS amplifiers, circuit design, DC and small signal analysis. Cascode amplifier. Current mirrors, active loads. BJT and MOS differential amplifiers. Monolithic operational amplifiers. Output stages. Frequency response. Introduction to feedback theory, amplifier topologies. Circuit design and analysis are supplemented with industry standard CAD software. *4 credits. Prerequisites: ECE 241 and ECE 211*

ECE 345 **Integrated Circuit Engineering**

Feedback theory, frequency compensation. Integrated circuit fabrication and technology. Device modeling, thermal effects. VLSI CAD design tools. Circuit layout, extraction and simulation. Design and analysis of multistage MOS operational amplifiers, OTA architectures. Nonlinear circuits, comparators. Analog switches. Digital phase-locked loops. Sample and hold circuits. Data converter architectures. Switched capacitor circuits. Bandgap reference circuits. MOST digital circuit design and layout, hierarchical approaches. Final design project is a mixed analog/digital circuit (e.g., Flash A/D converter, phase-locked loop), which is sent for fabrication.
3 credits. Prerequisites: ECE 342. For students entering prior to Fall 2016: required in electronics track For students entering Fall 2016 or later: required in signals/electronics track (3rd yr. spring)

ECE 357 **Computer Operating Systems**

Theory and implementation of modern computer operating systems. Message based and multiprocessor kernels. Networking and interprocess communication. Security, auditing and authentication. Device drivers, interrupt handling, task switching, virtual memory, memory management, scheduling, synchronization and locking. File systems, resource allocation and management. Real-time, fault-tolerant and high security operating systems. User environment and interface issues. Projects in operating system design and programming, case studies. *3 credits. Prerequisites: ECE 251 and either ECE 160 or ECE 161*

ECE 365 **Data Structures & Algorithms II**

A continuation of ECE 264, also with an emphasis on practical implementation issues and good programming methodology. Topics include graphs, graph-related algorithms and dynamic programming techniques. Also an introduction to some advanced topics such as Turing machines, computability and NP-complete systems. Assignments include programming projects and problem sets. *2 credits. Prerequisite: ECE 264*

ECE 366 **Software Engineering & Large Systems Design**
This course teaches about the development stages of large, robust, expandable software systems developed as part of a team. Topics include project management, capturing requirements, system design, UML, program design, testing, delivery and maintenance. The class will develop a large project as a team using Java throughout the semester. Tools, libraries and techniques necessary for the project will be covered in class,e.g., Eclipse, Javadoc, XML, SOAP, servlets, threads and processes, Swing, JUnit, mySQL, JDBC, etc. The specific resources might change from semester to semester. *3 credits. Prerequisite: ECE 365*

ECE 371 **Data Visualization**
Exploring, discovering, and creating narratives using data science, design, and storytelling. Introduction to techniques to provide new and innovative approaches to explore, discover, and create narratives from and for the evolving artistic, social, political, scientific and technological landscapes. Introduction of a progressive framework for data and design. Real world examples and applications of the tools and methodologies introduced will be presented. *3 credits. Prerequisites CS 102/ECE 160*

ECE 391 **Research Problem**
An elective course open to qualified upper division students. Students may approach an EE faculty member and apply to carry out research on problems of mutual interest in theoretical or applied electrical and computer engineering. Student performs creative work with faculty guidance. *3 credits. Prerequisite: Instructor approval*

ECE 392 **Research Problem II** (continuation of ECE 391) *3 credits. Prerequisite: instructor approval*

ECE 393 **Junior Electrical Engineering Projects I**
An introduction to laboratory techniques for electrical and computer engineering. Electronic test equipment including: DVM, oscilloscope, curve tracer, spectrum analysis. Circuit analysis and design, discrete and integrated electronic components and circuits. Several projects of limited scope provide an understanding of the fundamental building blocks employed in the more advanced designs in successive projects courses. Students give weekly oral presentations and demonstrate laboratory proficiency through in-class demonstrations and concise, formal technical reports. *2 credits. Prerequisites: ECE 211 & ECE 241 & ECE 291. Co-requisite: ECE 342*

ECE 394 **Junior Electrical Engineering Projects II**
Principles learned in ECE 393 are applied to the design, construction and characterization of electrical and computer engineering projects of significant complexity. Assignments typically involve both analog and digital design, and students are free to pursue any solution that satisfies the engineering requirements and meets with the instructor's approval. Formal and informal lectures are given on safety, circuit operation and design, and construction techniques; participation in design reviews and technical reports. *3 credits (effective Spring 2019); 4 credits (prior to Spring 2019). Prerequisite: ECE 393*

ECE 395 **Senior Electrical Engineering Projects I**
ECE 395 and ECE 396 constitute the year-long senior design project. Students work in small groups on projects chosen with the advice and consent of the faculty adviser. Projects may be oriented towards research or product development, and may be in any area of electrical and computer engineering, such as in: computer engineering, signal processing (imaging, sensor arrays, multimedia), telecommunications, computer networks, microwaves, optics, advanced electronics, VLSI chip design, or an interdisciplinary area such as robotics or bioengineering. Students perform all aspects of project management, such as scheduling, budgeting, system design and developing milestones, as well as technical work including hardware and software implementation, testing and performance evaluation. Students also give several spontaneous and rehearsed oral presentations and prepare written reports. Students attend weekly lectures covering: social, economic, legal and ethical issues; safety and laboratory practice; design methodologies; technical writing; preparation of multimedia presentations and tailoring presentations to target audiences.
4 credits. Prerequisite: ECE 394. This course will be 3 credits effective Fall 2019

ECE 396 **Senior Electrical & Computer Engineering Projects II**
This course concludes the senior project begun in ECE 395. Students submit two complete theses, one in short form and the other in long form, and give at least two presentations,one short and one long. The initial goal is to a achieve a functioning system. Afterwards, students undertake the completion of the prototyping cycle, which may involve improving the circuit implementation (such as by employing PCBs populated with surface mount chips), adding a user-friendly interface, obtaining precise performance evaluations, or developing demonstrations and a user's manual. Advanced students are strongly encouraged to complete their project early and commence a master's thesis. *3 credits. Prerequisite: ECE 395*

ECE 399 **Selected Topics in Electrical & Computer Engineering**
Subjects may include seminars on topics related to advances in technology, current research areas. Also individual research, design and development or study of subjects in electrical and computer engineering. *1-3 credits. Prerequisite: permission of instructor*

Graduate

ECE 401 **Selected Topics in Communication Theory**
Advanced topics in communications engineering, selected according to student and instructor interest. *3 credits. Prerequisites: ECE 300 and permission of instructor*

ECE 402 **Selected Topics in Probability & Stochastic Processes**
Advanced topics in applied probability or stochastic processes. Possible areasof study include: Markov processes, queuing theory, information theory, stochastic systems, financial engineering. *1-3 credits. Prerequisite: ECE 302 or permission of instructor*

ECE 403 **Advanced Communications Networks**
A continuation of topics from ECE 303. Technical readings, case studies, and research in network architectures and protocols. Related topics such as distributed computing and ad hoc sensor networks may be covered as well. Topics from probability, stochastic processes and graph theory are presented as needed for the analysis and simulation of communication networks. *3 credits. Prerequisite: ECE 303*

ECE 404 **Satellite Communication**
This course covers the design of satellite systems for applications such as communication, weather, sensing, research, GPS. Basic planetary physics, orbit selection, spacecraft lifetime. Reliability and component requirements, environmental effects and impact on electrical performance. Common modulation schemes and selection strategy. "Bent pipe" spacecraft configuration, atmospheric effects and loss (e.g., rain fade effects). Earth station configuration, uplink and downlink configurations, spectral maps and spectral power requirements and stresses. System level link budgets. Time delay and synchronization, frequency planning and re-use. Antenna beams and configurations.
3 credits. Prerequisites: ECE300

ECE 405 **Advanced Digital Communications**
Advanced digital modulation including formats with memory, continuous phaseand constant-envelope schemes.Performance analysis for AWGN and other channels. Multitone and multicarrier communications. Spread spectrum with applications to multiple access schemes and secure communications. CDMA: PN sequence generation and properties, multi user detection. Additional topics as time permits.
3 credits. Prerequisites: ECE 300 and ECE 302

ECE 407 **Wireless System Design**
Hands-on exposure to the design and implementation of modern digital communication systems using software-defined radio (SDR) technology. The prototyping and realtime experimentation of these systems via SDR will enable greater flexibility in the assessment of design trade-offs as well as the illustration of 'realworld' operational behavior. Laboratory modules for performance comparisons with quantitative analytical techniques will be conducted in order to reinforce digital communication system design concepts. A large course project consisting of original research will be required. Course topics include SDR architectures and implementations, digital signaling and data transmission analysis in noise, digital receiver structures (matched filtering, correlation), multicarrier communication techniques, radio frequency spectrum sensing and identification (energy detection, matched filtering), and fundamentals of radio resource management. *3 credits. Prerequisites: ECE 300 and ECE 310*

ECE 408 **Wireless Communications**
Survey of cellular mobile radio systems and formats, including market trendsand technological advances. The emphasis is on CDMA and 3G systems,and emerging schemes such as WiFi networks, although TDMA systems will be discussed as well. Propagation and multipath fading channel models and simulation. Cellular system capacity, traffic models, multiple-access techniques, hand off and power control algorithms. Modulation formats, detection schemes and performance. Mitigating fading: pulse shaping, DFE, MLSE (Viterbi). DSP algorithms for baseband processing. *3 credits. Prerequisite: ECE 300*

ECE 410 **Radar & Sensor Array Processing**
Terminology and system overview for modern radar and sensor array systems; antenna parameters; radar signals and waveforms; Doppler processing; detection; synthetic aperture imaging (SAR); beam forming and space-time array processing (STAP); adaptive methods; additional topics may be covered according to student and instructor interest. Computer simulations and readings in the technical literature. *3 credits. Pre-requisites or co-requisites: ECE300 and ECE310*

ECE 411 **Selected Topics in Signal Processing**
Advanced topics in signal processing selected according to student and instructor interest. *3 credits. Prerequisites: ECE 310 and permission of instructor*

ECE 412 **Speech & Audio Processing**
Selected topics in digital speech and audio processing. Speech analysis, synthesis and recognition. Acoustics and acoustic modeling. Auditory perception. Audio feature extraction including complex cepstrum and LPC coefficients. Hidden Markov models and other speech recognition approaches. Speech and audio coding such as MP3 and CELP. Text to speech. Music synthesis, analysis and retrieval. *3 credits. Prerequisites: Ma 224 and ECE 211. Prerequisite or corequisite: ECE 302*

ECE 413 **Music & Engineering**
Spectral representation and analysis of music. Analog and digital music signals, instruments and synthesizers, analog circuits and digital processing. Description of musical quality and perception, introduction to acoustics, stereo and special effects. Computer interfacing with MIDI and laboratory experiments. *3 credits. Prerequisites: ECE 211 and ECE 150*

ECE 415 **Wavelets and Multiresolution Imaging**
Wavelets and multiresolution signal processing with an emphasis on 2Dand 3D cases. STFT, wavelet analysis, wavelet packets, DWT. Multirate filterbanks, PR and parauni-tary conditions, multidimensional filters, multidimensional sampling lattices. Bases, frames and sparse representations. Image and video applications such as: compres-sion, noise reduction, tomography and other inverse problems, hyperspectral imag-ing, compressive sensing. Coursework includes MATLAB projects and readings in the technical literature. *3 credits. Same as MA 415. Prerequisites: ECE 310 and Ma 326 or permission of instructor*

ECE 416 **Adaptive Filters**
Statistical signal processing theory: discrete-time Wiener and Kalmanfilters, linear prediction, steepest descent and stochastic gradient. LMS, normalized LMS, LS, RLS, QR-RLS, order-recursive algorithms. Applications include equalization, noise cancel-lation, system identification, sensor array processing. Numerical linear algebra: eigenanalysis, SVD, matrix factorizations. Transversal filters, lattice filters, systolic arrays. Performance: convergence, learning curves, misadjustment, tracking in nonstationary environments. Additional topics such as adaptive IIR filters, neural networks and quantization effects may be covered as time allows. Extensive use of MATLAB. *3 credits. Prerequisite: ECE 211*

ECE 417 **Design for Custom DSP Hardware**

Design of programmable and custom digital signal processors, and realization of DSP algorithms in specialized architectures. Features of programmable DSPs such as data stationary and time-stationary coding, MAC and ACS ALUs, circular buffers.Very Long Instruction Word (VLIW) processors. Applications of graph theory and passivity theory to map DSPalgorithms to custom structures: SFGs, DFGs, retiming, folding and unfolding, lattice and orthogonal filters, scheduling and allocation, systolic architectures. Optimization with respect to number of hardware units, speed (sample period and latency), VLSI area, power consumption and performance (quantization effects). Special CAD tools and languages for rapid prototyping. Case studies and programming exercises. *3 credits. Prerequisites: ECE 310 and ECE 251*

ECE 418 **Digital Video**

Digital video coding, compression, processing and communications. Target applications from low bit-rate, low quality to high bit-rate, high quality. Two- and three-dimensional sampling, color spaces, motion representation. Motion estimation: optical flow, blockmatching; constrained optimization: Bayesian methods, simulated annealing, Gibbs random fields. Mathematical basis for compression standards such as JPEG and MPEG, and digital television including HDTV. Rate-distortion based compression for optimal bit allocation via dynamic programming (Viterbi algorithm). Scalability in multimedia systems. *3 credits. Prerequisite: ECE 310*

ECE 419 **Digital Image Processing**

This course covers a variety of methods for image representation, analysis, enhancement and compression. Color spaces, geometric projections and transformations. Multidimensional signals and systems: Fourier analysis, sampling, filtering. Transforms (e.g., DCT and wavelet). Gibbs-Markov random fields, Bayesian methods, information theoretic methods. Multiresolution schemes (e.g., pyramidal coding). Morphological and nonlinear methods. Edges, boundaries and segmentation. Applications of PDEs (e.g., anisotropic diffusion). Compressive sensing. Technical readings and projects in MATLAB (or other suitable language). *3 credits. Prerequisites: ECE 310 and Ma 224*

ECE 421 **Advanced Control System Design**

Design of control systems using two degrees of freedom and PID compensators. Ackermann's formula, H-infinity control theory and applications. Analysis and design for nonlinear systems using describing function, state-variables, Lyapunov's stability criterion and Popov's method. Introduction to optimal control theory (dynamic programming). Design problems and extensive use of MATLAB.

3 credits. Prerequisites: ECE 310 and either ECE 320 or ME 351

ECE 425 **Digital Control Systems**
Basic components of digitally controlled dynamic systems. Sampling and reconstruction: the ideal sampler, zero and higher order hold elements.The pulse transfer function and the ztransfer function description of dynamic systems. Stability criterion and analysis by the Nyquist, root locus and Bode methods. The modified Routh-Hurwitz and Jury stability criteria. The state-variable approach: state equations of dynamic systems with sample and hold devices, state equations of systems with all-digital elements. Digital simulation and approximation. Controllability, observability and stability. State and output feedback, state observers and the separation principle. Digital control system design by state feedback.
3 credits. Prerequisite: ECE 320

ECE 431 **Microwave Engineering**
Passive circuits, open-boundary waveguides, perturbation theory, coupled modes, waveguide junctions, microstrip. Two- and three-terminal devices; varactor diodes, Gunn diodes; IMPATT and MESFET technology. Design of RF amplifiers and phase-shifters.Computer-aided simulation and design. *3 credits. Prerequisite: ECE 335*

ECE 433 **Optical Communications Devices & Systems**
PIN, avalanche and Schottky photodiodes; risetime, noise, amplifier requirements. Semiconductor optical devices: radiative and non-radiative recombination, quaternary semiconductors, heterojunctions, quantum wells, bandwidth minimization, lasers, distributed feedback, vertical cavity structures. Internal and external modulation, electro-optic modulators, Stark effect. Optical fibers: mode structure, attenuation, dispersion, PM fibers, WDM. System architecture, analog/digital communications, terabit datalinks. Solitons. *3 credits. Prerequisite: ECE 342; Prerequisite or corequisite: ECE 335*

ECE 441 **Digital Integrated Circuit Engineering**
Design of static and dynamic CMOS combinational logic gates, layout and simulation. Standard cell construction. Sequential logic systems-registers, latches, clocks. Design of arithmetic building blocks, ALU, multipliers. Memory circuits and organization. FPGAs. System design-hardware description languages, floor planning, system architecture. A major component of the course is the design and fabrication of an ASIC using a variety of VLSI CAD tools. *3 credits. Prerequisite: ECE 345*

ECE 442 **Communication Electronics**
Circuit design for advanced communications applications. Design of high-frequency amplifiers, oscillators and mixers using large signal analysis. Effects of noise and non-linearities are examined from the diode and transistor level to board level. Communication subsystems of interest include phase locked loops, modulators and demodulators (AM, PM FM), and signal processors for multiple access systems(TDMA, FDMA, CDMA). Course work includes computer-aided simulation and design projects. *3 credits. Prerequisites: ECE 300ECE 342. Corequisite: ECE 335*

ECE 443 **Thin-Film Electronics**
Properties of polycrystalline,amorphous, liquid and organic semiconductors. Methods of deposition: vacuum and nonvacuum techniques, epitaxial and non epitaxial growth. Assessment of thin film semiconductors: structural, optical, electrical. Thin film semiconductor devices: transistors, displays, photovoltaics, flexible conductors. Optical coatings and architectural applications. Thin film superconductors: metallic, allow and high Tc, fabrication and assessment. Superconducting devices: Cooper pairs, Josephson junctions, SQUIDS, Josephson computers. *3 credits. Prerequisite: ECE 342*

ECE 444 **Bio-instrumentation and Sensing**
The basic human vital signs and some related elementary physiology viewed from an engineering standpoint with special emphasis placed upon current electronic measurement methods. Electrocardiographic and electromyographic signals. Safety problems related to electrical isolation. Guarded, fully isolated, modulated carrier operational amplifiers and microvolt-level amplification. Solid-state "grain of wheat" pressure sensors, microelectrodes, thermal probes, ultrasonic transducers and other biosignal sensors. Course work includes instrumentation and sensing projects.
3 credits. Prerequisites: ECE 211 and ECE 342

ECE 445 **Design with Operational Amplifiers**
Analysis and design of operational amplifier circuits with various applications, including amplifiers, filters, comparators, signal generators, D/A and A/D converters and phaselocked loops. Introduction to issues such as static and dynamic limitations, noise and stability. Use of industry standard CAD software. *3 credits. Prerequisite: ECE 342*

ECE 446 **Low-Voltage, Low-Power Electronic Circuit Design**
The physics and modeling of submicron MOS transistors for analog and digital circuit design. Circuit techniques for the design of low-power, low-voltage digital combinatorial logic, multipliers, memory and system design. Circuit techniques for the low-power, low voltage analog circuits including the design of low-voltage constant g_m differential amplifiers. The use of switched capacitor circuits for analog signal processing. The course will culminate with the design and simulation of a low-voltage low-power mixed signal circuit. *3 credits. Prerequisites: ECE 342, ECE 345 or permission of instructor*

ECE 447 **Digital VLSI System Design**
This course focuses on the top-down, automated digital system design flow using CMOS logic: RTL design/simulation, timing/power driven circuit synthesis, automated place-and-route, and post-layout simulation with emphasis on test/manufacturability in deep sub-micron technologies. The course culminates with the tape-out of a large design project covering functional specification to sign-off layout. *3 credits. Prerequisites: ECE 251, ECE 342*

ECE 448 **Power Electronics**
Principles of power electronics. Operating characteristics of Bipolar Junction Transistors, IGBTs, MOSFETs and Thyristors, power converters, basic switching circuits, AC/DC, DC/DC, DC/AC converters and their applications. Students are required to design, construct, diagnose and test power electronics converters.
3 credits. Prerequisites: ECE241.

ECE 449 **Recent Advances in Bioelectronics**
Introductory neurobiology: action potentials, mechanisms of the resting membrane potential. Neural recording and stimulating devices and electronics. The "big data" problem when there are too many electrodes. Spike sorting algorithms. Modern challenges of wireless power and data in a biological setting. Disease detection and DNA sequencing. Noninvasive imaging systems. *3 credits. Prerequisites: ECE310, ECE342.*

ECE 453 **Advanced Computer Architecture**
This course studies modern, advanced techniques used to design and produce current, state-of-the-art computer architectures. Technology, performance and price. The quantitative principle and Amdahl's law. Instruction sets; addressing modes, operands and opcodes; encoding instruction sets. RISC versus CISC architectures; MIPS. Pipelining; the classic five-stage pipeline, hazards, exceptions, floating point operations. Advanced pipelining techniques: dynamic scheduling, branch prediction. Multiple issue, speculation. Limits of parallelism. Compiler support for parallelism, VLIW. Caches. Examination of modern processors. *3 credits. Prerequisite: ECE 251*

ECE 455 **Cybersecurity**
This course covers both attacker and defender perspectives of applied information security. Topics will include networked and embedded applications, access control systems and their failure modes, privilege escalation, intrusion detection, privacy and data breaches and applied cryptography. Each topic will be approached through analysis and discussion of historical cybersecurity incidents and possible mitigations. Safe coding practices and OS flaw mitigation will be explored through case studies and reinforced through security sensitive programming projects. Coursework will include penetration testing, code auditing, and independent projects. *3 credits. Prerequisites: ECE 303, ECE 357*

ECE 460 **Selected Topics in Computer Engineering**
Advanced topics in computer hardware or software engineering selected according to student and instructor interest. Prerequisites will depend onthe topics to be covered. *3 credits. Prerequisite: permission of instructor*

ECE 462 **Computer Graphics**
Graphical primitives, windows, clipping and viewports. Two- and three dimensional geometric transformations and translations; rotation, pan and zoom. Hidden line and surface removal. Region filling and shading. The architecture of high performance graphical engines. Representing lighting, shading and textures. Rendering. Rotation. GUIs. Animation. Course work includes design projects. *3 credits. Prerequisite: ECE 264*

ECE 464 **Databases**
Engineering and design of databases. Topics to be covered may include: data models, database and scheme design; schema normalization and integrity constraints; query processing and optimization; distributed and parallel databases; SQL and XML. *3 credits. Prerequisite: ECE 264*

ECE 465 **Cloud Computing**
Critical, foundational technology components that enable cloud computing, and the engineering advancements that have led to today's ecosystem. Students design, build and test representational software units that implement different distributed computing components. Multi-threaded programming in Java. Functional programming (MapReduce). Hadoop: a programmer's perspective; building and configuring clusters; Flume as an input engine to collect data; Mahout as a machine learning system to perform categorization, classification and recommendation; Zookeeper for systems coordination. *3 credits. Prerequisites: ECE 251, ECE 264*

ECE 466 **Compilers**

The theory, design and implementation of a practical compiler. Finite automata, LL and LR parsing, attribute grammars, syntax-directed translation, symbol tables and scopes, type systems and representations, abstract syntax trees, intermediate representation, basic blocks, data and control flow optimizations, assembly language generation including register and instruction selection. Students apply tools such as Flex and Bison to writing a functional compiler for a subset of a real programming language such as C. *3 credits. Prerequisites: ECE 151 and ECE 165*

ECE 467 **Natural Language Processing**

This course focuses on computer applications that involve the processing of written or spoken human languages. The exact content may vary from year to year. The course is divided into three parts. Topics from conventional, statistical natural language processing will likely include text normalization, N-grams, part-of-speech tagging, information retrieval, and text categorization. Topics from conventional computational linguistics will likely include grammars, parsing, and semantic representations. Topics from deep learning and NLP will likely include word embeddings, feed-forward neural networks, recurrent neural networks, sequence-to-sequence models, attention, and transformers. Course work will include programming projects and quizzes. *3 credits. Prerequisite: ECE 264*

ECE 468 **Computer Vision**

Visual perception and imaging geometry. Pixels, pixel neighborhoods and pixel connectivity. Image transforms: Fourier, Hadamard, Walsh, Discrete Cosine, Haar, Slant and others. Techniques for image manipulation and enhancement in both the frequency and spatial domains. Histogram equalization, image subtraction and local averaging. Filtering, homomorphic methods. Color models and use of monochrome techniques on RGB channels. Image restoration: camera movement cancellation, scratch removal. Image compression techniques, lossy and lossless. Image segmentation, edge detection, edge linking, boundary detection; region growing, splitting and merging. Image representation as a hierarchical collection of objects, chain codes, Fourier descriptors. Object recognition, signatures.

3 credits. Prerequisites: ECE 211 and ECE 161, or ECE 264

ECE 469 **Artificial Intelligence**
This course covers many subtopicsof AI, focusing on a few important subtopics in detail. The "intelligent agent" approach is explained and forms a foundation for the rest of the course. Intelligent search: uninformed search, depth-first search, breadth-first search, iterative deepening; informed search, best-first search, A*, heuristics, hill climbing; constraint satisfaction problems; intelligent game playing, minimax search, alpha-beta pruning. Machine learning: probability, Bayesian learning; decision trees; statistical machine learning, neural networks, Naive Bayes, k-nearest neighbors, support vector machines. Natural language processing: syntax, semantics and pragmatics; real-world knowledge; parsing; statistical NLP. Philosophy of AI: AI and consciousness, the Turing test, the Chinese room experiment. Coursework includes two large individual programming projects. *3 credits. Prerequisite: ECE 264*

ECE 471 **Selected Topics in Machine Learning**
Advanced topics in machine learning, selected according to student and instructor interest. *3 credits. Prerequisite: permission of instructor. Open to all students.*

ECE 472 **Deep Learning**
Differentiable directed acyclic graphs covering applications in unsupervised learning, as well as generative and discriminative modeling. Gradient-based methods for optimization (stochastic gradient descent, Nesterov momentum, adam). Fast gradient computation for arbitrary computational graphs (automatic differentiation). Exploding and vanishing gradient problems. Convolutional networks. Arbitrary graphs for regression, classification and ranking. Autoencoders, adversarial networks and variations for unsupervised representation learning, generative modeling and other applications. Focus on applications in computer vision, speech processing and research problems in communication theory. *3 credits. Prerequisites: MA223, MA224 and either ECE211, ChE352 or ME251.*

ECE 474 **Bayesian Machine Learning**
Machine learning from a primarily Bayesian perspective. Conjugate priors. Bayesian linear regression, model evidence, linear classification using generative models, logistic regression and the Laplace approximation. Kernel methods and Gaussian process regression. Mixture models, expectation maximization, hidden Markov models, sampling methods and Markov chain Monte Carlo. *3 credits. Prerequisites: MA 223, MA 224; either ECE 211, ChE 352 or ME 251.*

ECE 475 **Frequentist Machine Learning**
Machine learning from a primarily Bayesian perspective. Conjugate priors. Bayesian linear regression, model evidence, linear classification using generative models, logistic regression and the Laplace approximation. Kernel methods and Gaussian process regression. Mixture models, expectation maximization, hidden Markov models, sampling methods and Markov chain Monte Carlo. *3 credits. Prerequisites: MA 223, MA 224; either ECE 211, ChE 352 or ME 251*

ECE 476 **Data Science for Social Good**
Applications of machine learning, data science and software engineering to projects in the areas of education, equality, justice, health, public safety, economic development or other areas. Projects will be done in collaboration with external partners, and will be focused on solving problems with an emphasis on the greater New York City Area. Students will work with external partners to specify problems and investigate possible solutions. Students will work between disciplines to develop new machine learning based solutions. Additionally, students will work collaboratively to visually convey the insights and results generated. *3 credits. Prerequisite: Prior course in ML or AI, and permission of instructor.*

ECE 478 **Financial Signal Processing**
Quantitative finance is presented from a signal processing perspective. Probability measure and stochastic processes: filtrations, Radon-Nikodym derivative, martingales, Markov processes; discrete-time and continuous-time random walks, Wiener process, Ito calculus, stochastic differential equations, Black-Scholes; introduction to statistics. Modeling and analysis of financial concepts such as arbitrage, replicating portfolios, hedging, liquidity, derivatives, volatility, futures, options. Markovitz portfolio theory, capital asset pricing model, the greeks, portfolio optimization, sparse methods, trading strategies. Analysis of single and multiple correlated nonstationary time series, GARCH. Machine learning in finance. Course work includes programming projects in Python or MATLAB to analyze real financial data. *3 credits. 3 contact hours per week. Prerequisite: ECE211 or permission of instructor.*

ECE 491 **Selected Topics in Electrical & Computer Engineering**
Subjects may include study in electrical and computer engineering, or seminars on topics related to advances in technology. This course may not be used to expand the number of credits of thesis, or cover material related to the thesis. *1-3 credits. Prerequisite: permission of instructor. Open to all students.*

ECE 499 **Thesis/Project**
Master's candidates are required to conduct, under the guidance of a faculty adviser, an original individual investigation of a problem in electrical and computer engineering and to submit a written thesis describing the results of the work. *6 credits over 1 year*

MECHANICAL ENGINEERING

Undergraduate

ME 102 **Statics**
This foundation course develops a sound problem solving methodology, basic laboratory experience and technical communication skills based on engineering applications that involve forces acting on non-accelerating structures. Topics include equivalent system of forces; equilibrium; moments and couples; centroids and distributed forces; forces in structures (trusses, frames, machines); friction forces. Laboratory modules focus on the measurement of force from both mechanical and electrical signals. *3 credits*

ME 105 **Drawing and Sketching for Engineers**
This course introduces engineering students to the fundamentals of freehand drawing and sketching with an emphasis on the interpretation and communication of insights, concepts and dimensioned solutions. Drawings and sketches are often the first steps in innovative engineering solutions and invention. The primary goal of this course is to provide a comprehensive foundation in traditional drawing and sketching methods for engineers. *Same as EID 105. 2 credits. Prerequisites: none*

ME 200 **Dynamics**
This course introduces the general principles of kinematics (the description of motion) and kinetics (the relationship between motion and the forces that cause it) that are necessary to understand, design, and analyze the motion of engineering systems. Topics include Newton's laws of motion; two and three dimensional kinematics and kinetics of particles and rigid bodies; relative motion; work and energy relations; impulse and momentum relations; introduction to vibrations. Laboratory modules focus on numerical solutions of equations of motion. *3 credits. Prerequisites: ME 102*

ME 211 **Design and Prototyping**
A mechanical engineering hands-on workshop geared towards the understanding and practice of basic engineering design and fabricationtools. Topics include hand tools, simple machining, mold making, casting, materials, fasteners, adhesives, and finishes. 3-D digitizing, solid modeling, rapid prototyping and computer interfacing will also be presented. Team projects will familiarize the students with typical tools and processes employed in realizing a design concept, from sketch to functional prototype. Each student will participate in and contribute to the team-learning and creation process. *2 credits. Prerequisites: EID 101 and EID 103. Open to all students.*

ME 231 **Energetics**

Current and near-term energy sources, including coal, oil, natural gas, nuclear fission, hydroelectric, oil shale and refuse. Description of contemporary methods of energy conversion including conventional utility power plants and nuclear power plants. Introduction to direct energy conversion; magnetohydrodynamics, fuel cells, thermionic and thermoelectric. Design of the thermodynamic operation of a steam power plant. *Same as EID 231. 3 credits. Prerequisite: ESC 330 or Ch160 or permission of instructor*

ME 251 **Systems Engineering**

An introductory course to the mathematical modeling of systems.Topics include mechanical elements and systems, electric circuits and analogous systems, fluid elements and systems, analysis of systems using transfer functions, state spac eequations, analog simulation and digital simulation. Also covered are block diagrams, Laplace transforms, and linear system analysis. Computer projects will be assigned that will use MATLAB software. *Same as ESC 251. 3 credits. Prerequisites: Ma 240*

ME 300 **Stress and Applied Elasticity**

Three-dimensional theory of elasticity; state of stress, state of strain, elastic stress-strain relations. Applications include elementary three-dimensional problems, plane stress and plane strain, Saint Venant's long cylinder, beams and plates. Computer-aided design projects. *3 credits. Prerequisite: ESC 201*

ME 301 **Mechanical Vibrations**

Mechanical systems with single and multiple degrees of freedom longitudinal, torsional and lateral vibrations; free and forced oscillations; vibration testing, dynamic stability, vibration isolation, design criteria. Computer-aided design assignments and vibration project. *3 credits. Prerequisites: ESC 201 and Ma 240*

ME 310 **Design Elements**

Application of the principles of mechanics to the design of basic machine elements; study of components subjected to static, impact and fatigue loading; influence of stress concentration; deflection of statically determinate and indeterminate structures by the energy method. Design projects apply basic criteria to the design of shafts, springs, screws and various frictional elements; design projects make use of computer, experimental and modeling techniques. *3 credits. Prerequisite: ME 300*

ME 311 **Mechanical Design**
Mechanical design of basic transmission elements; design optimization by blending fundamental principles and engineering judgment; design criteria for the various frictional machine elements. Design projects provide authentic involvement in problems from industry; design projects make use of computer, experimental and modeling techniques. *3 credits. Prerequisite: ME 310*

ME 312 **Manufacture Engineering**
Study of metal processing theory and application with emphasis on casting, machining, and metal deformation processes; plastic forming; special processing techniques; work-holder design principles. Specific are as studied include stages of processing, mathematical modeling of processes, equipment determination, relationship of plant layout, tooling, metrology, and product design to product cost.
Same as EID 312. 3 credits. Prerequisites: ME 342 and ME 211

ME 313 **Introduction to Industrial Design**
The collaborative relationship between art, engineering and industrial design, academically and professionally, is a pivotal relationship in the development of new ideas. This course serves as an introduction to the world of industrial design and its wide-ranging applications. The students will learn about the history of design and design concepts and methodology through lectures, discussions, and small projects; and will explore, develop, and execute a term design as part of a class project as the course progresses. The main goals of this course are to develop a better understanding of the perspective of an industrial designer and to gain experience in the practice of industrial design. *3 credits. Prerequisite: ME 211 or permission of instructor. Open to all students.*

ME 314 **Cloud-Based Design and Manufacture**
Introduction to today's cloud-based design and manufacture (CBDM) technology. Topics include: fundamentals of geometric modeling; cloud-based computer-aided design (CAD); overview of commercially available, cloud-based CAD platforms; impact of deploying cloud-based design methodology on engineering practices; collaborative team design project management; extension of cloud-based CAD to manufacture and performance simulation applications. Students will gain hands-on experiences in managing collaborative team design projects. *Same as EID 314. 3 credits. Prerequisites: EID 102*

ME 331 **Advanced Thermodynamics**
Equations of state; properties of pure substances; ideal and real gas and gas vapor mixture properties, fundamental process and cycle analysis of ideal and real systems; modern gas and vapor power cycles and refrigeration cycles. Computer applications to problem solving. *3 credits. Prerequisite: ESC 330*

ME 342 **Heat Transfer: Fundamentals and Design Applications**
One-dimensional steady-state conduction. Two-dimensional steady state conduction and transient conduction: finite-difference equations and computational solution methods. Convection; introduction to laminar and turbulent viscous flows; external and internal forced convection problems, including exact and numerical solution techniques; free convection. Introduction to radiation heat transfer and multimode problems. Open-ended design projects will include application to fins, heat exchangers, tube banks and radiation enclosures and will make use of computer-aided design techniques. *3 credits. Prerequisite: ESC 340*

ME 351 **Feedback Control Systems**
Modeling and representation of dynamic physical systems: transfer functions, block diagrams, state equations, and transient response. Principles of feedback control and linear analysis including root locus and frequency response methods. Practical applications and computer simulations using MATLAB. Discussions of ethics will be integrated into the curriculum. *3 credits. Prerequisite: ME 251*

ME 352 **Process Control Laboratory**
An introduction to process control using DC motor, liquid-level tank, and heat exchanger experimental rigs. Students will characterize systems, implement on-off control and PID-control, and apply various tuning methods. Practical applications and assignments cover actual heating, ventilation, air conditioning, and building automation systems. *1 credit. Co-requisite: ME351*

ME 353 **Mechatronics**
Topics include computer architecture, PIC processor overview, dynamic modeling, sensors, data acquisition, digital PID control theory, and utilization of assembly language to code the controller. Students will design, build and test a controller board and present a final prototype of a control system. Engineering economics will be introduces and integrated into the final project. *3 credits. Same as EID 353. Prerequisite: ME 351 or ECE 211 (Signals) or ChE 361.Open to all students.*

ME 360 **Engineering Experimentation**
Election, calibration and use of subsystems for the measurement of mechanical, thermal/fluid and electrical phenomena. Laboratory work includes investigations of heat exchangers, fluid systems and internal combustion engines. Emphasis is placed on data collection and statistical reduction, computational methods and written and oral presentation skills. *3 credits. Prerequisites: junior standing or permission of instructor*

ME 363-364 **Selected Topics in Mechanical Engineering**
This course will deal with current technological developments in various fields of mechanical engineering. Projects and design will be emphasized. *3 credits each. Prerequisite: ME faculty permission*

ME 365 **Mechanical Engineering Research Problem**
An elective course available to qualified students. Students may elect to consult with an ME faculty member and apply to carry out independent research on problems of mutual interest in theoretical or applied mechanical engineering. *3 credits. Prerequisites: ME faculty permission and senior standing. May be repeated*

ME 393 **Mechanical Engineering Projects**
Original investigations, involving design and experimental work which allow the application of engineering sciences to the analysis and synthesis of devices or systems and permit the deepening of experience in engineering decision making. Projects are carried out in small groups and are supervised by the instructor in accordance with professional practice. *3 credits. Prerequisite: ME360 or permission of instructor*

ME 394 **Capstone Senior ME Design**
The application of open-ended design work to the synthesis of engineering devices and systems for the satisfaction of a specified need. Consideration of market requirements, production costs, safety and esthetics. Projects are carried out in small groups and are supervised by the instructor in accordance with professional practice. The goal of the course is to create a working design, clearly defined in drawings and specifications. *3 credits. Prerequisite: ME 393*

Graduate

ME 401 **Advanced Mechanical Vibrations**
Combined analytical and experimental approach to mechanical vibration issues; characterization of the dynamic behavior of a structure in terms of its modal parameters; digital data acquisition and signal processing; experimental modal analysis procedures and excitation techniques; extraction of modal parameters from measured frequency response functions. Students will acquire hands on experience with impact hammer and shaker data acquisition and analysis. *3 credits. Prerequisite: ME 301*

ME 405 **Automotive Engineering Fundamentals**
An introductory course in modern automotive design, covering aspects of prime movers, aerodynamics, brakes, tires, steering, transmission, suspension and handling, chassis and advanced hybrid powertrain concepts. Simulations and physical prototyping give students a hands-on approach to the design, optimization, fabrication and testing of various vehicle subsystems in a team-based learning environment. *3 credits. Pre-requisites: ESC 251 and ESC 330, or permission of instructor*

ME 407 **Introduction to Computational Fluid Dynamics**
The need for and applications of computational fluid dynamics (CFD). Introduction to CFD analysis and commercially available codes. Governing equations and numerical solution methodologies for basic fluid flow systems. Geometric modeling and grid generation. Examination of various physical models. Use of a commercial CFD code. *3 credits. Prerequisite: ESC 340 or ChE 341*

ME 408 **Introduction to Computer Aided Engineering (CAE)**
Theory and practical applications of computer aided engineering methodologies, and use of multiphysics software, in mechanical engineering practices. Topics include principal modeling and solution techniques, computational geometry applications, modeling of mechanical engineering problems, and non-linear and dynamic problem solving. Students use typical commercial software packages to work on practical case studies. *3 credits. Prerequisite: ESC 201*

ME 412 **Autonomous Mobile Robots**
The objective of the course is to build a mobile robot capable of competing in a competitive robot tank battle game. This course introduces basic concepts, technologies, and limitations of autonomous mobile robots. Topics include digital and analog I/O, tactile sensing, IR sensing and range finding, light sensing, sonar, magnetic field sensing, inertia sensing, encoders, electric motor actuators, high-level microprocessor control, low-level microprocessor control, power management, and prototyping. Students will form teams to design and build autonomous mobile robots configured to compete in a singles-match game, or to perform a team-oriented task. During the semester, students are expected to demonstrate progress on the development of their robot and complete project assignments that will lead to the final competition-ready robot and accompanying quality research paper. *3 credits. Prerequisite: ME 353 or ECE 251*

ME 413 **Advanced Product Development**
Developing a physical product for the market is a complicated and exciting process that requires expertise in design, engineering, business, and marketing. As part of this course, students will choose and research a market segment, create an innovation for that market, and develop that innovation into a manufacturable product. Along the way they will constantly test and validate their product's functionality and marketability. Ultimately the students will develop a functional prototype and product launch strategy, which will include a brand identity, marketing campaign and a viable product channel. At the end of the semester students will present a physical prototype and comprehensive product display as part of the end of the year show and develop a portfolio of their product development process. *3 credits. Prerequisites: ME 211 or Instructor's Permission*

ME 415 **Introduction to Nanotechnology**
Understanding and control of matter at dimensions in the range from one to100 nanometers for novel applications are the main objectives of nanotechnology. The scope of this course encompasses nanoscale science and engineering. Typical topics will include the unique properties of some nanometer scale materials, processiong and fabrication technologies for nanomaterials, imaging, measuring, modeling and manipulating matter at this length scale. In addition, laboratory demonstrations on nanomaterials processing, nanoarchitecturing and self-assembling of nanostructures will be included. *3 credits. Prerequisite: ESC 210 or ESC 211*

ME 416 **Materials in a Circular Economy**
In this course students evaluate the roles of technology and industry in a circular economy with an emphasis on material properties, resource extraction and processing, and end-of-life reuse. Engineers, architects, and artists significantly impact the planet through their choice of materials, processes, and forms. Building on a foundation of materials, the primary goal of this course is to investigate contemporary research and construct a personal view on responsible design. Students will be expected to focus on a project and support their findings with a presentation and a report. *3 credits. Same as EID 416. Prerequisites: ESC210 or ChE211 or equivalent. Material Science prerequisite can be waived with appropriate background and permission of instructor.*

ME 422 **Fundamentals of Aerodynamics**
Theory and application of advanced fluid mechanics in aerospace engineering; airplane wing geometry, general governing equations of aerodynamics, potential flow theory, theory of lift for the wing, comparison of theory to wind tunnel experiments, the boundary layer and drag. *3 credits. Prerequisite: ESC 340*

ME 424 **Space Dynamics**
Advanced dynamics of particles and rigid bodies with applications to aerospace engineering; spacecraft trajectories, rocket performance, gyroscopic motion, Lagrange's equations and Hamilton's principle. *3 credits. Prerequisite: ME 200*

ME 431 **Internal Combustion Engines**
A broad analytical and experimental review of the governing parameters involved in piston engine design and optimization. Thermodynamics, fluid mechanics, heat transfer, combustion, emissions, thermochemistry, dynamic and static loading, and fuel efficiency, as they apply to different engine cycles and types, are covered. Varied research examples from industry, government, and academia, with particular emphasis on automotive engine design, are analyzed from first principles. Students develop hands-on learning skills through computational and experimental assignments. *3 credits. Prerequisite: ME 331 or permission of instructor*

ME 432 **Introduction to Nuclear Power Plant Technology**
Nuclear power provides a high potential form of alternative energy, with significant safety constraints. The course centers on the study of a typical US commercial nuclear power plant its design philosophy and analysis of nuclear steam supply system and balance of plant systems (including heat exchangers, pumps, relief valves, etc.) for normal operation and steady state and transient accident analysis, and longer term spent fuel storage. The course utilizes disciplines/methods of thermodynamics, heat transfer and fluid flow, and plant drawings and data. Analysis includes Three Mile Island Accident, a small break loss-of-coolant accident. When feasible, this course includes a tour of an operating nuclear power plant.
3 credits. Prerequisites: ESC 330 and ESC 340

ME 433 **Rocket Science**
Transient and steady-state control volume balances (mass, momentum and energy) that involve compressible flow phenomena are applied to (primarily) aerospace applications. Fundamental topics include variable mass accelerating control volumes, variable area adiabatic flows, normal and oblique shock waves, expansion fans, friction effects (Fanno flow) and heat transfer effects (Rayleigh flows). Numerical and analytical techniques are developed. Applications include basic trajectories, water rockets, converging/diverging rocket nozzles, RAM and SCRAM jets, supersonic wakes from underexpanded and overexpanded nozzles, gas exchange in reciprocating engines. *Same as ChE 433. 3 credits. Prerequisite: ESC 330 and ESC 340*

ME 434 **Special Topics In Combustion**
Analysis of diffusion and premixed flame processes, including droplet and particle flames, combustion in sprays, chemical reactions in boundary layers, combustion instability in liquid and solid rocket engines and gas burner flames. Consideration of ignition and quenching processes and flammability limits. *Same as ChE 434. 3 credits. Prerequisite: ESC 330*

ME 440 **Advanced Fluid Mechanics**
Introduction to the fundamental constitutive relations and conservation laws of fluid mechanics. Steady and transient velocity distributions of viscous flow. Stream functions, potential flow, and creeping flow. Boundary layer theory. Modeling of turbulent flow. Special topics may include: hydrodynamic stability, vorticity dynamics and mixing, waves in fluids, airfoil theory, lubrication theory, compressible flow, multiphase flow, bubbles and droplets, non-Newtonian flow, and computational fluid dynamics.
Same as EID 440 and ChE 440. 3 credits. Prerequisites: ESC 340 and permission of instructor

ME 451 **Modern Control**
An introduction to the concepts and techniques utilized in the analysis and design of robust control systems. Topics include a review of state-space control systems concepts; standard regulator problem; reduced order observers and state feedback controllers; optimal and robust control design methods; utilization of computer-aided optimal control systems design software such as MATLAB. Techniques developed will be applied, in the form of student design projects, to a variety of challenging control systems design problems. *3 credits. Prerequisite: ME 351*

ME 452 **Heating, Ventilation, and Air Conditioning**
The course will develop and apply the general methods used in HVAC calculations, including heating, air conditioning and refrigeration. The basic HVAC equipment and processes include piping, fittings, valves, pumps, fans, heat exchangers, mass exchangers, heat pumps, process variables monitoring and control, multi-node flow and energy networks, and these will be examined and modeled. This will involve the theory and results from thermodynamics, fluid dynamics, heat transfer and mass transfer (and transport phenomena and boundary layer theory), process control, and computer simulation. In addition to the general HVAC calculations, more advanced analysis methods will be developed. *3 credits, Prerequisites: ESC 330 and ESC 340*

ME 453 **Energy Efficient Building Systems**
Equipment fundamentals, energy management and control systems used in buildings to manage heating, ventilating, and air conditioning systems and components. Proper commissioning, operation and maintenance and their impact on efficiency, equipment life, energy consumption and carbon footprint. Students will perform energy savings calculations, learn processes to identify and correct building operational problems that lead to waste, identify energy conservation measures and analyze trend data and historical operation. Technical projects and site visits provide exposure to open-ended problems related to actual HVAC and building management systems. *3 credits. Prerequisites: ESC 330, ESC 340, and ME 352 or permission from instructor. Open to all students.*

ME 458 **Industrial Robots**
Basic concepts, techniques, and limitations of modern industrial robots; industrial automation; robot programming languages; definition and description of a robot work space; application of transform and operator matrices in industrial robotics. Student projects include computer programming of forward and inverse kinematics, and application programming with an industrial robot. *Same as EID 458. 3 credits. Prerequisite: ME 351 or ECE 320*

ME 465 **Sound and Space**
Fundamentals of acoustics, including sound waves, room and hall acoustics, and metrics of sound. Audio engineering, including microphones, signal processors, amplifiers and loudspeakers. Applications of psychoacoustics including virtual acoustic environments over headphones and loudspeakers. *3 credits.Same as EID 465.*
Prerequisites: ESC 251 or ECE 211 or equivalent or prior approval of the instructor

ME 493-494 **Selected Advanced Topics in Mechanical Engineering**
These courses will deal with current advanced technological developments in various fields of mechanical engineering. Projects and design will be emphasized.
3 credits. Prerequisites: ME faculty permission and graduate standing

ME 499 **Thesis/Project**
Master's candidates are required to conduct, under the guidance of a faculty adviser, an original investigation of a problem in mechanical engineering, individually or in a group and to submit a written thesis describing the results of the work. *6 credits for full year*

ME423 **Aircraft Engineering Fundamentals**
An introductory course to conceptual aircraft design focusing on commercial aviation. The aircraft system is explained and the interdependencies of main design parameters are analyzed. Students will assess the technical and commercial feasibility of an aircraft design and will explain the advantages and disadvantages of different configurations. They will calculate the flight performance for the different flight phases and understand different flight envelopes. Wing design is explained in detail, considering different requirements. The course closes with the introduction to other types of aircraft like helicopters, paragliders and ornithopters.
3 credits. Prerequisites: ESC 340 and ESC 251, or permission of instructor

ENGINEERING SCIENCES

Undergraduate

ESC 000.1-000.4 **Engineering Professional Development Seminars**
The Engineering Professional Seminars and Workshops offer students an introduction to the profession of engineering as well as deal with their development as students. The Cooper Union's CONNECT program is an integral part of these courses and provides intensive training in effective communications skills. A wide range of topics is covered in addition to communications skills including ethics, environmental awareness, life-long learning, career development, conflict resolution, entrepreneurship, marketing, work-place issues, team dynamics, professional licensure and organizational psychology.

Each successfully completed semester of ESC 000 will be noted on the student's external transcript. Failure to participate in ESC 000, or failure to successfully complete one or more semesters of the program will not be noted on any external transcript (such as is provided to employers or graduate schools)

ESC 200 **Engineering Mechanics**
Equivalent system of forces, distributed forces; forces in structure; friction forces. Particle and rigid body mechanics; kinematics, kinetics. Newton's laws of motion; work and energy; impulse and momentum. *3 credits. Prerequisite: Ph 112*

ESC 201 **Mechanics of Materials**
Introduction to solid mechanics; analysis of stress and deformation. Extension; flexure; torsion. Axisymmetric problems, beam theory elastic stability, yield and failure theory. *3 credits. Prerequisite: ESC 200 or ME 200*

ESC 210 **Materials Science**
The objective of this course is to promote an understanding of the relationship between the molecular structure of a material and its physical properties. Topics include bonding in atoms and molecules, crystallinity, metals and alloys, polymers, mechanical properties of inorganic materials and composite materials. *3 credits. Prerequisites: none*

ESC 220 **Principles of Electrical Engineering**
Survey of Electrical Engineering for the non-major. Signal and circuit analysis, DC and AC circuits, transients, frequency response and filters, power systems. Additional topics may be covered as time permits. *3 credits. Prerequisite: Ma 113*

ESC 221 **Basic Principles of Electrical Engineering**
Selection of topics from ESC 220. This class meets with ESC 220 for the first ten (10) weeks. *2 credits. Prerequisite: Ma 113*

ESC 330 **Engineering Thermodynamics**
Rigorous development of the basic principles of classical thermodynamics. Zeroth, first and second laws of thermo-dynamics and their applications to open and closed systems. Analysis of thermodynamic processes, properties of real substances and thermodynamic diagrams.
3 credits. Prerequisites: none

ESC 340 **Fluid Mechanics and Flow Systems**
Introductory concepts of fluid mechanics and fluid statics. Development and applications of differential forms of basic equations. Dynamics of inviscid and viscous fluids, flow measurement and dimensional analysis with applications in fluid dynamics. Friction loss and friction factor correlation; design of piping systems.
3 credits. Prerequisite: ESC 200 or ME 200

INTERDISCIPLINARY ENGINEERING

Undergraduate

EID 101 **Engineering Design and Problem Solving**
Students work on cutting-edge, exploratory design projects in interdisciplinary groups of 20 to 25. Each project has an industrial sponsor/partner who is available for student/faculty consultation and support. Oral and visual presentations as well as formal written reports are required for all projects. Professional competencies, teamwork, human values and social concerns are stressed in the engineering design. *3 credits. Open to all students.*

EID 102 **Engineering Graphics**
An introduction to graphical representation of 3-dimensional objects. After learning the principles of technical drawing using precision hand tools, students utilize CAD software to create professional caliber engineering drawings. An introduction to solid modeling is given. Topics include orthographic projections, linetypes, geometric dimensioning and tolerancing, layers, layouts, solid modeling, part assemblies and finite element analysis. *1 credit. Prerequisites: none.*

EID 103 **Principles of Design**

This course is designed to introduce students from all disciplines to theconcepts of rational design. It is open to first-year students and sophomores. In the first part of the course students will learn by hands-on experience the importance of giving attention at the design stage to consideration of accessibility, repair, replacement, choice of materials, recycling, safety, etc. Students will develop the ability to make observations and record them in suitable form for further analysis of the design process. From this, concepts of 'good' design will be developed, and students will be introduced to the formal design axioms and principles.This will lead to the second part of the course which will consist of a comprehensive, realistic design problem. Creativity, intuition and cultivation of engineering 'common sense' will be fostered within the framework of design principles and axioms. The course will constitute a direct introduction to the disciplines in their interdisciplinary context.

3 credits. Prerequisite: EID 101.Open to all students.

EID 105 **Drawing and Sketching for Engineers**

This course introduces engineering students to the fundamentals of freehand drawing and sketching with an emphasis on the interpretation and communication of insights, concepts and dimensioned solutions. Drawings and sketches are often the first steps in innovative engineering solutions and invention. The primary goal of this course is to provide a comprehensive foundation in traditional drawing and sketching methods for engineers. *Same as ME 105. 2 credits. Prerequisites: none*

EID 116 **Musical Instrument Design**

Theory and use of musical scales, including just intonation and equal temperament systems. Musical harmony and basic ear training. Human hearing and the subjective measures of sound: pitch, loudness and timbre. Acoustic analysis of design and operating principles of traditional instruments, including members of the percussion, string and wind families. Prototyping and testing of original musical instrument concepts. *3 credits. Open to all students.*

EID 210 **Engineering Design Graphics**

In this class, Building Information Modeling (BIM) is used to create both Architectural and Structural models. Along the way, students learn about the Revit Program's user interface & modeling tools essential for working with 3D models. Other topics include creating Sheets, Custom Building Elements, Topography, Landscaping, Perspectives, Rendering & Animation. As students gain expertise in using Revit, they are assigned various Structural & Architectural projects to develop and present to the class. At the end of the semester, a Final Independent Design Project is presented by each student using the Revit Modeling Program. *3 credits. Open to all students.*

EID 220 **Foundations of Bioengineering**
An introduction to the engineering study of biological systems. Basic physiochemical and organization principles applicable to biologica lsystems. Topics include membrane structure and function, physiology of the circulatory system, and an introduction to biorheology and biological transport phenomena. *3 credits. Prerequisite: Ch 160*

EID 221 **Biotransport Phenomena**
Engineering principles are used to mathematically model momentum, heat and mass transfer processes that occur in biological systems. After a general introduction to human anatomy and physiology, topics examined include blood rheology, circulatory system fluid dynamics, whole body heat transfer, vascular heat transfer, oxygen transport in tissue and blood, pharmacokinetics and the design of an artificial kidney (hemodialysis). *3 credits. Prerequisite: junior standing*

EID 222 **Biomaterials**
The course is a study of both natural and synthetic materials and how they interact with the human body. Topics covered include mechanical properties, design considerations, biocompatibility, the immune response, potential for allergic response and carcinogenic ramifications, mechanical compatibility, effects of long-term implantation, and government regulations. Students will develop a vocabulary for different classes of biomaterials and explore how atomistic properties influence larger scale morphology and macroscopic behavior inside the human body. After a general introduction to biomedical materials, case studies involving physiological systems are considered, and design of artificial parts and materials are investigated.
3 credits. Prerequisite: permission of instructor

EID 223 **Injury Biomechanics and Safety Design**
Frequency and severity of common injuries. Mechanisms of musculoskeletal, soft tissue and brain injuries. Injury criteria, reference values and their role in safety design. Experimental and computational methods for safety design and acciden treconstruction. Automotive safety. Biomechanical test dummies. Seatbelts, airbags, and energy absorbing structures and materials. Repetitive stress injuries and occupational health. Government regulation and legal liability. Expert witness practice and qualifications. *3 credits. Prerequisites: ESC 200 or ME 200 and ESC 210*

EID 224 **Biomechanics**
An in-depth treatment of orthopaedic biomechanics, including freebody analysis applied to the musculoskeletal system, applied statics, dynamics and kinematics. Clinical problems relating to biomechanics. Lubrication theory applied to hard and soft tissues. Mechanical testing of tissue, including both static tests and dynamics tests.Tensor treatment of kinematic motions. Extensive reference to current literature. Muscle function, evaluation and testing. Exploration of the concepts of development of muscular power, work and fatigue. *3 credits. Prerequisites: ESC 200 or ME 200 and permission of instructor*

EID 231 **Energetics**
Current and near-term energy sources, including coal, oil, natural gas, nuclear fission, hydroelectric, oil shale and refuse. Description of contemporary methods of energy conversion including conventional utility power plants and nuclear power plants. Introduction to direct energy conversion; magnetohydrodynamics, fuel cells, thermionic and thermoelectric. Design of the thermodynamic operation of a steam power plant. *Same as ME 231. 3 credits. Prerequisite: ESC 330 or Ch 160 or permission of instructor*

EID 260 **Acoustics, Noise and Vibration Control**
Interdisciplinary overview of acoustics and its applications in industrial and environmental noise control, acoustics of buildings, vibration systems and control. Topics include: sound levels, decibels and directivity, hearing, hearing loss and psychological effect of noise, noise control criteria and regulations, instrumentation, source of noise, room acoustics, acoustics of walls, enclosures and barriers, acoustics materials and structures, vibration control systems; design projects. *3 credits. Prerequisite: permission of instructor. Open to all students.*

EID 270 **Engineering Economy**
Comparison of alternatives in monetary terms; meaning and use of interest rates; results evaluation including intangibles; risk in alternatives; principles underlying the determination of economic life; depreciation and depreciation accounting; financing business ventures; financial statement analysis; replacement of capital assets. *3 credits.*

EID 278 **Ethics of Computer Science**
A study of the political, ethical, and social dimensions of living in a world increasingly governed and defined by networked, computational systems, from their personal everyday impacts to their planetary ones. Drawing from a mix of historical and contemporary case studies, philosophy, and science fiction, students will explore frameworks for understanding technology not merely as artifact or product but as practice and ideology. As a final project, students will propose and prototype a framework for their own approach to ethical engineering and design.
3 credits. Prerequisites: None

EID 300 **Special Research Project**
Students will work on individual projects in engineering under supervision of faculty. Problems will vary according to individual interest. Permission to register is required from the Office of the Dean of Engineering. Students on academic probation are ineligible for registration. *3–6 credits. Prerequisite: permission of Faculty and Dean's office*

EID 312 **Manufacturing Engineering** *Same as ME 312. 3 credits. Prerequisite: ME 342 and ME 211*

EID 314 **Cloud-Based Design and Manufacture**
Introduction to today's cloud-based design and manufacture (CBDM) technology. Topics include: fundamentals of geometric modeling; cloud-based computer-aided design (CAD); overview of commercially available, cloud-based CAD platforms; impact of deploying cloud-based design methodology on engineering practices; collaborative team design project management; extension of cloud-based CAD to manufacture and performance simulation applications. Students will gain hands-on experiences in managing collaborative team design projects. *Same as ME 314. 3 credits. Prerequisites: EID 102. Open to all students.*

EID 320–323 **Special Topics in Bioengineering I–IV**
Seminars on topics of current interest in biotechnology. *3 credits. Prerequisites: a basic understanding of engineering mechanics and materials and permission of instructor. May be repeated*

EID 325 **Science and Application of Bioengineering Technology**
The overall purpose of the course is to provide the student with a genera loverview of the scope of bioengineering. The major areas in the course are design in biomedical engineering, tissue engineering, medical imaging, cardiovascular, vision, rehabilitation, masculaskeletalsystem, robotic surgery and medical business.
3 credits. Prerequisite: permission of instructor

EID 327 **Tissue Engineering**

Tissue Engineering involves the application of engineering and the life sciences to gain a fundamental understanding of structure-function relationships in normal and pathological tissues and the development of biological substitutes to restore, maintain or improve tissue functions. This course will provide an introduction to the science, methods and applications of tissue engineering. Topics include quantitative cell biology, tissue characterization, engineering design and clinical implementation. *3 credits. Prerequisites: working knowledge of engineering fundamentals, senior standing or instructor approval*

EID 343 **Water Resources Engineering**

Same as CE 343. .5 credits (3 hours of lecture, 3 hours of laboratory). Prerequisite: ESC 340

EID 344 **Environmental Systems Engineering**

Same as CE 344. 3 credits. Prerequisite: permission of instructor

EID 348 **Environmental and Sanitary Engineering**

Engineering (same as EID 348) Topics include types of environmental pollution and their effects; water quality standards and introduction to laboratory analyses of water quality parameters; sources and estimates of water and wastewater flows; physico-chemical unit treatment processes. Integrated lecture and design periods cover water supply network, wastewater collection system and water treatment design projects. *Same as CE348. 3 credits, Prerequisites: CE/EID344*

EID 353 **Mechatronics**

Topics include computer architecture, PIC processor overview, dynamic modeling, sensors, data acquisition, digital PID control theory, and utilization of assembly language to code the controller. Students will design, build and test a controller board and present a final prototype of a control system. Engineering economics will be introduces and integrated into the final project. *Same as ME 153. 3 credits. Prerequisite: ME 351 or ECE 211 (Signals) or ChE 361. Open to all students.*

EID 357 **Sustainable Engineering and Development**
Sustainable engineering is examined, starting with an analysis of resources, (materials, energy, water) upon which manufacturing is based. Each resource is critically examined in terms of its availability and form and the ultimate impact of its usage on the state of theplanet. A comparison of the design and construction of contemporary and primitive structure is used to illustrate the differences between the required infrastructure and environmental footprint, leading to a definition of 'green' design. The technologies required to support contemporary lifestyles in the developed and the developing world are discussed within the context of manufacturing techniques, usage of natural resources and the generation of waste. Workshops, guest lectures and a term project incorporating the concepts of minimalism, materials usage, and aesthetic design are used to present students with a unique perspective engineering. *3 credits. Prerequisite: material covered in core engineering science and mathematics in Freshman and Sophomore years. Open to all students.*

EID 362 **Interdisciplinary Senior Project I**
Individual or group design projects in interdisciplinary areas of engineering.These projects are based on the interest of the students and must have the approval of their adviser(s) and course instructor. Periodic and final engineering reports and formal presentations are required for all projects. In addition to technical aspects projects must also address some of the following: economic feasibility environmental impact social impact, ethics, reliability and safety. *3 or 4 credits. Prerequisite: students are required to have completed necessary preparatory engineering courses related to the project topic*

EID 363 **Interdisciplinary Senior Project II** Continuation of EID 362
3 or 4 credits. Prerequisite: EID 362

EID 364 **Interdisciplinary Engineering Research Problem**
An elective course, available to qualified upper division students. Students may approach a faculty mentor and apply to carry out independent or group projects in interdisciplinary fields. *3 credits. Prerequisite: permission of advisor and appropriate Department Chair.*

EID 365 **Engineering and Entrepreneurship**
Students will learn the fundamentals of being an entrepreneur and operating a successful business. From its original idea to the open market, students wil lchoose an engineering related project or service and learn the principles of accounting, marketing, managing, financing, and continuing research. Students are required to choose their own service or product and write a business plan as their final project. Lectures include case studies on the various projects and guest speakers from the industry. Readings include articles from journals and textbooks. *3 credits. Prerequisite: EID 101*

EID 366 **Lean Launchpad**

Lean Launchpad guides students on their own search for a scalable, repeatable business model for a high-tech company. Students use a customer centric approach to brainstorm and evaluate potential ideas. Working in small groups, students will continuously refine their business models through a process that includes exhaustive interviewing of potential customers, fast iteration cycles, and a flipped classroom model that dictates more than half of class hours be used for student presentations and critiques. A panel of local industry experts including engineers, executives and venture capitalists will serve as mentors to the teams and will evaluate their progress and presentations throughout the semester in person. Teams are encouraged to design and prototype the technological solutions developed during their search if appropriate.
3 Credits. Prerequisite: EID 101

EID 370 **Engineering Management**

An exploration of the theories and techniques of management beginning with the classical models of management and continuing through to Japanese and American contemporary models. The course is specifically directed to those circumstances and techniques appropriate to the management of engineering. Lecture, discussion and case studies will be used. *3 credits. Prerequisite: permission of instructor*

EID 371 **Operations Management**

An in-depth exploration of specific problems and techniques applicable to the management of production and large operating systems (e.g., engineering projects). The specific problems of demand analysis, capacity planning, production and inventory planning as well as scheduling and progress control will be presented. In addition, the concepts of total quality management, material requirements planning and statistical quality control will be presented. The presentation will include lectures and case problems.
3 credits. Prerequisite: EID 370

EID 372 **Global Perspectives in Technology Management**

Current global political, social and economic developments and future trends as they relate to technology management are discussed. Students learn to address issues of international technology transfer, multinational sourcing, quality control, diverse staff management, environmental considerations, etc. Working in teams on case studies and projects, students learn to conduct international negotiations and develop solutions to complex business problems. Special emphasis is placed on team cooperation and personal leadership.Oral presentations and written reports are required. *3 credits. Prerequisite: EID 101*

EID 374 **Business Economics**

In this course, the class will carry out a real-time forecast of the U.S. economy and explore its implications for the bond and stock markets. The course will build upon principles of both macro- and micro-economics. It will provide an introduction to the work done by business economists and the techniques they use. Students will become familiar with the database looking for relationships between key economic variables, and studying movements in interest rates over the period 1960-present. The class will be divided into teams of two students with each team choosing a particular aspect of the economy to forecast. The class will also work with various leading indicators of economic activity and will prepare forecasts of the key components of gross domestic product and other important variables. A formal presentation of the economic with invited guests from the Wall Street investment world will take place. To put forecasting exercise in context, there will be class discussions of business cycles, credit cycles, long waves in inflation and interest rates and the impact of the Internet on the economy and the stock market.

3 credits. Prerequisite: either S 334, S 347, EID 270 or permission of instructor. Open to all students.

EID 375 **Applied Food Science and Engineering**

Fundamentals of food science and engineering. Food preparation, characterization, and preservation. Food safety and sanitation. Regulatory, financial, and ethical implications of food and food products. Multiphase systems (foams, slurries, emulsions). Food engineering unit operations: sterilization, pasteurization, lyophilization, fermentation, filtration, crystallization, milling, distillation. Design, analysis, and optimization of food processes, products, and formulations.

3 credits. Prerequisite: Senior standing and permission of instructor.

EID 376 **Economics of Alternative Energy**

The goal of this course is to explore the economics of alternative energy technologies. As always, engineering considerations determine the feasibility of any technology while economics determine the practicality of the technology in the likely environment of the next five years. The students participating in this course will explore a wide range of alternative energy technologies. It is expected that their analyses will combine both economic and engineering principles in an interesting and creative way. Each student will choose a particular technology to analyze in depth: wind, solarphotovoltaic, passive solar, geothermal, bio-fuels, etc. There will be periodic presentations of their work to the class as a whole. One goal of these class discussions will be to highlight the advantages and disadvantages of the various technologies. At the end of the semester, there will be a formal presentation of the students' conclusions to an audience of Cooper faculty, industry experts and Wall Street analysts. *3 credits. Prerequisite: EID 270, EID 374, or permission of the instructor. Open to all students.*

EID 377 **Distributed Artificial Intelligence and Blockchain Applications**
Introduction to distributed Artificial Intelligence/multiagent theories and techniques and studying their role in designing next generation blockchain applications. Topics will include algorithms for agent interaction in cooperative and competitive environments, the role of coordination and promoting cooperative behaviors in large-scale distributed networks and the internet economy, consensus formation and negotiation in distributed systems, smart contracts, public vs private blockchains, cryptographic hash functions and digital signatures. In addition to programming assignments, these techniques will be used to implement a blockchain application where a trusted environment for all transactions is essential. Applications can range from health data exchange to trade/channel finance and food safety.
3 credits. Prerequisites: CS102 and permission of instructor.

EID 390 **Introduction to Sustainable Design**
Sustainable design minimizes the impact on the environment by site planning and design, energy and water conservation and interior environmental quality. This course will focus on the design of a prototype structure using sun, light, air, renewable materials, geological systems, hydrological systems and green roofing. Each student will develop a project outlined by the U.S. Green Building Council rating system known as LEED. The six areas that will be developed to design the project are: sustainable sites, water efficiency, energy and atmosphere, material and resources, indoor environmental quality and innovative design process. Class time is separated into a series of lectures, private consultations and student presentations.
Same as CE 390. 3 credits. Prerequisite: ESC 340, CE 322 or ME 300 and permission of instructor.

Graduate

EID 414 **Solid Waste Management** *Same as CE 414. 3 credits. Prerequisite: permission of instructor*

EID 416 **Materials in a Circular Economy**
In this course students evaluate the roles of technology and industry in a circular economy with an emphasis on material properties, resource extraction and processing, and end-of-life reuse. Engineers, architects, and artists significantly impact the planet through their choice of materials, processes, and forms. Building on a foundation of materials, the primary goal of this course is to investigate contemporary research and construct a personal view on responsible design. Students will be expected to focus on a project and support their findings with a presentation and a report. *Same as ME 416. 3 credits. Prerequisites: ESC210 or ChE211 or equivalent. Material Science prerequisite can be waived with appropriate background and permission of instructor. Open to all students.*

EID 422 **Finite Element Methods**
Shape functions and generalized displacements. Assemblage of elements, Convergence criteria. Triangular, rectangular and quadrilateral elements in plane stress and strain. Isoparamentric formulations. General Solids. Hexahedral and tetrahedral elements. Flexure in plates. General solids. Natural Coordinates. Special applications in blast mitigation design. Computer codes. *Same as CE 422. 3 credits. Prerequisite: CE 322 or ME 300*

EID 423 **Synthetic Biology**
Construction and testing of synthetic genetic circuits for synthetic biology applications; DNA assembly; reporter gene assays; inducible promoters; cloning of genes; genetic modification of cells. *3 credits. Prerequisite: Ch 340 or Bio 201*

EID 424 **Bioengineering Applications in Sports Medicine**
Application of engineering principles to athletic performance and injury. Topics include athletic training; mechanical causes of sport injuries; methods of injury prevention; design of protective and prophylactic sport devices; proper application of wound dressing, taping and bandaging; first aid for musculoskeletal sports injuries and healing and rehabilitation. Students will work in teams on case studies and projects. *3 credits. Prerequisite: permission of instructor*

EID 425 **Structural Dynamics**
Dynamic behavior and design of structures subjected to time-dependent loads. Included in the load systems are earthquakes, blasts, wind and vehicles. Shock spectra and pressure impulse curves. Special applications in blast mitigation design. *Same as CE 425. 3 credits.*

EID 430 **Thermodynamics of Special Systems**
Thermodynamic analyses of solid systems undergoing elastic strain and of magnetic, electric and biological systems. Equations of state for these and other fluid and non-fluid systems.Thermodynamics of low temperature systems. Recent advances in obtaining real fluid and solid properties. *Same as EID 430 and ChE 430. 3 credits. Prerequisite: ChE 331 or ME 331*

EID 437 **Geo-Environmental Engineering** *Same as CE 437. 3 credits.*

EID 438 **Industrial Waste Treatment Design** *Same as CE 440. 3 credits. Prerequisite: permission of instructor*

EID 439 **Water and Wastewater Technology** *Same as CE 441. 3 credits. Prerequisite: permission of instructor*

EID 440 **Advanced Fluid Mechanics**
Introduction to the fundamental constitutive relations and conservation laws of fluid mechanics. Steady and transient velocity distributions of viscous flow. Stream functions, potential flow, and creeping flow. Boundary layer theory. Modeling of turbulent flow. Special topics may include: hydrodynamic stability, vorticity dynamics and mixing, waves in fluids, airfoil theory, lubrication theory, compressible flow, multiphase flow, bubbles and droplets, non-Newtonian flow, and computational fluid dynamics.
Same as ChE 440 and ME 440. 3 credits. Prerequisite: ESC 140

EID 441 **Advanced Heat and Mass Transfer**
Introduction to the energy equation. Steady and transient heat transfer by conduction. Convective heat transfer. Energy transport in flowing media. Free convection. Conservation of species equation. Fick's law of binary diffusion. Mass transfer with simultaneous homogeneous or heterogeneous reaction. Multicomponent heat and mass transfer. Stefan-Maxwell equations for multicomponent diffusion. Simultaneous heat and mass transfer. Transport in electrolyte solutions. Special topics may include: membrane separation processes, drug delivery and controlled release, turbulent heat and mass transfer, boundary layer heat and mass transfer, and chemically reacting flows. *Same as ChE 441. 3 credits. Prerequisite: EID 440 or ChE 440*

EID 446 **Pollution Prevention of Minimization**
Same as CE 446. 3 credits. Prerequisite: permission of instructor

EID 447 **Sustainability and Pollution Prevention**
Fuzzy-logic based methodology for defining and assessing the sustainability of an entity. Pollution prevention for chemical processes at the macroscale (life-cycle assessment) and mesoscale (unit operations). Quantitatively identifying critical components of sustainability for a corporation or other similar entity. Chemical process design methods for waste minimization, increased energy efficiency, and minimal environmental impact. *3 credits. Prerequisite: permission of instructor*

EID 448 **Environmental and Sanitary Engineering** *Same as CE 448. 3 credits. Prerequisite: permission of instructor*

EID 449 **Hazardous Waste Management** *Same as CE 449. 3 credits. Prerequisite: permission of instructor*

EID 451 **Nanomaterials**
Nanoscience is the study and manipulation of matter on an atomic and molecular level. At this scale, materials often exhibit new properties that do not exist in their large-scale counterparts because of the increased importance of surface area/volume ratios and quantum effects. This course will focus on understanding the physical properties and methodologies for the formation (i.e. molecular self-assembly, photolithographic patterning, scanning probe lithography), and characterization (i.e. optical spectroscopy, atomic force microscopy, scanning tunneling microscopy, and electron microscopy) of nanomaterials. *Same as Ch 451. 3 credits. Prerequisites:Ch 110, Ch 111, and Ph 213, or permission of instructor*

EID 458 **Industrial Robots**
Basic concepts, techniques, and limitations of modern industrial robots; industrial automation; robot programming languages; definition and description of a robot work space; application of transform and operator matrices in industrial robotics. Student projects include computer programming of forward and inverse kinematics, and application programming with an industrial robot. *Same as ME 458. 3 credits. Prerequisite: ME 351 or ECE 320*

EID 460.1 **Heat Transfer Equipment Design (Heat Exchangers)** *Same as ChE 460.1. 3 credits.*

EID 465 **Sound and Space**
Fundamentals of acoustics, including sound waves, room and hall acoustics, and metrics of sound. Audio engineering, including microphones, signal processors, amplifiers and loudspeakers. Applications of psychoacoustics including virtual acoustic environments over headphones and loudspeakers. *Same as ME 465. 3 credits. Prerequisites: ESC 251 or ECE 211 or equivalent or prior approval of the instructor*

EID 469 **Independent Study Project** *Same as CE 469. 3 credits.*

EID 470 **Urban Security**
Design of urban systems to protect against terrorism. Analysis of blast loads. Blast mitigation design considerations. Technology transfer; military/defense to civilian sector. Response spectra. Pressure/impulse diagrams. Stand off distances. Blast mitigation measures for buildings, bridges and tunnels. Prevention of progressive collapse in tall buildings. Design of glazing. Retrofit upgrade of existing urban infrastructure. Building code and insurance issues. *Same as CE 470. 3 credits. Prerequisites: CE 122 or ME 101 and permission of instructor*

EID 486 **Urban Megaprojects and Environmental Impact Assessment**
Same as CE 486. 3 credits.

EID 488 **Convex Optimization Techniques**
This course discusses in detail different methods for the optimization of systems of engineering and economic interest using the techniques of linear and nonlinear programming. The focus is on convex optimization, which is the solution of problems with only one best cost, design, size etc. We will consider problems such as least squares, supply chain management, batch process networks, network flow, dynamic programming, portfolio optimization and other examples across all engineering disciplines. Students will learn about optimization theory and problem formulation, with some computational component. By the end of the course, students should be able to: create optimization problems from a physical situation, identify whether the problem can be solved or not, transform problems into equivalent forms, list optimality conditions for problems, find the dual of a problem and identify its relation to the primal,and use at least one method to solve a convex programming problem using a computer. *Same as ChE 488. 3 credits. Prerequisites: ChE 352 or ME 251, Ma 326 (co-enrollment is fine)*

BIOLOGY

Bio 201 **Biology for Engineers I**
This course will examine in depth the genetics, molecular and cellular biology, pathology, toxins, microbiology and environment as they relate to humans and disease using organ-based or systems biology approaches (e.g., gastrointestinal pulmonary, cardiovascular, urinary endocrine, etc.) Major assignments will be individualized to student's interests and majors when possible. As such, this course will provide the biological fundamentals for further study in biotransport, biochemistry, graduate school in biomedical engineering, etc. Combined with Biology 202 and Biochemistry, it will provide a solid foundation for medical school. *3 credits. Prerequisites: Ch 110 or permission of the instructor. Credits includes lab experience.*

Bio 202 **Biology for Engineers II**
This course will provide human biology fundamentals to springboard into research projects at the intersection of biology and engineering. Topics will include anatomy and physiology of musculoskeletal and other major organ systems not covered in Bio 101, imaging modalities, concepts behind diagnostic and therapeutic surgical procedures, and their limitations, human body repair, artificial organs, tissue engineering, immunology and cancer. Students will develop an extensive biological vocabulary and have requisite knowledge for further study in biomechanics, rehabilitation medicine, biomaterials, bioremediation, etc. *3 credits. Prerequisite: Sophomore standing preferred, but freshman with AP Biology welcome. Open to all students.*

Bio 250 **Biotechnology in Environmental Systems**
Application of biotechnology to environmental challenges; microbiology; ecology; microplate reader assays; biomaterials; genetic modification of microbes, bioremediation, biosafety biomimicry. *3 credits. Prerequisite: None*

Bio 422 **Protein Expression, Purification and Analysis**
Lectures cover chemical properties of proteins, protein folding, solubility, charge, structure, posttranslational modifications; protein synthesis, recombinant protein expression including cloning strategies, expression plasmids, expression systems; chromatography techniques for protein purification. Laboratory work involve making gels and SDS-PAGE electrophoresis, purification of native proteins with ion exchange and salting out technique; purification of GST tagged proteins on glutathione agarose column and His-tagged proteins on Ni-NTA column; measuring of protein concentration and assays for protein activity; Western blot. *3 credits. Prerequisites: Bio 201 and Ch 340 or permission of instructor.*

CHEMISTRY

Undergraduate

Ch 110 **General Chemistry**
An introduction to the general scientific principles associated with chemistry. This course will deal with fundamental ideas such as the concept of the atom, the molecule, the mole and their applications to chemical problems. The classical topics include: dimensional analysis and significant figures; atomic weights; periodic properties; chemical reactions and stoichiometry; redox reactions; ideal gas law and real gas equations of state; the liquid state and intermolecular forces; solution concentrations; chemical equilibrium and equilibrium constants; acids and bases; solubility equilibria; nomenclature of inorganic and organic compounds. The topics for atomic and molecular properties include: atomic structure and the quantum theory; electronic structure of atoms; the covalent bond and bond properties;molecular geometries and hybridization; molecular orbital theory.
3 credits. Open to all students.

Ch 111 **General Chemistry Laboratory**
Methods of quantitative analysis are used to explore chemical reactions and analyze unknowns. Modern chemical instrumentation as well as 'classic' wet chemistry analytical techniques are covered. Statistical analysis of the experimental data is used to analyze results. Chemical laboratory safety and industrial chemical regulations are covered, as are the fundamentals of writing a technical report. *1.5 credits. Prerequisite: CH110.*

Ch 160 **Physical Principles of Chemistry**
The study of physicochemical properties will be extended and advanced. The laws of thermodynamics, which involve energy, enthalpy, entropy and free energy concepts, will be applied to chemical systems. Other topics include: vapor pressures and colligative properties of solutions; the phase rule; kinetics of homogeneous reactions; electrolytic conductance and electrochemistry. *3 credits. Prerequisite: Ch 110, Ma 111; corequisite: Ch 111*

Ch 231 **Organic Chemistry I**
Bond types and strengths, structural theory, bond angles and hybrid bonds; covalent bonds, polarity of bonds and molecules; dipole moments; molal refraction; melting points and boiling points relative to properties and natures of molecules; solubilities based on structures; functional groups; critical temperature, pressure and volume as a function of structure and functional groups, prediction of vapor pressure curves, latent heats. Nomenclature isomers and properties. Resonance and delocalization of charge phenomena; acidity and basicity (Lewis concept). *3 credits. Prerequisite: Ch 160*

Ch 232 **Organic Chemistry II**
Extension of Ch 231 to systematic study of aliphatic and aromatic compounds, with emphasis on functional behavior and interpretation of mechanisms and bond types, polyfunctional compounds, carbohydrates and heterocyclic compounds.
3 credits (2 lecture hours). Prerequisite: Ch 231; co-requisite: Ch 233

Ch 232.1 **Principles of Organic Chemistry II** Selection of topics from Ch 232
This class meets with Ch 232 for the first ten (10) weeks. *2 credits. Prerequisite: Ch 231; corequisite Ch 233*

Ch 233 **Organic Chemistry Laboratory**
Laboratory work will cover subject matter studied in Ch 231 and Ch 232, including synthesis and type reactions and identification of organic compounds.
2 credits (4 laboratory hours) Prerequisite: Ch 231

Ch 250 **Analytical Chemistry**
Fundamental principles, operation, and limitations of instrumental methods in scientific research will be covered. This involves determining the best analytical method for analyses, assessing the reliability of the measurements and understanding the meaning of S/N and how to optimize it. Specific instrumental methods include electroanalytical techniques (potentiometry, coulometry, voltammetry), spectroscopic techniques (infrared, and UV-visible molecular spectroscopy, as well as atomic absorption spectroscopy), microscopy methods (atomic force and scanning tunneling microscopy), and analytical separations (high pressure liquid chromatography and gas chromatography). *3 credits. Prerequisites: Ch 110, Ch 111, or permission of instructor.*

Ch 340 **Biochemistry**
This course in the fundamentals of biochemistry will cover the following: Chemistry of carbohydrates, lipids, amino acids, proteins, and nucleotides; bioenergetics; kinetics and mechanisms of enzymes; and an introduction to molecular genetics, and biochemical dynamics of DNA and RNA. *3 credits. Prerequisites: Bio 201 and Ch 231*

Ch 351 **Instrumental Analysis Laboratory**
Fundamental principles of instrumental methods will be covered, including laboratory applications and limitations in scientific research. Specific methods include electrometric, such as polarography, electro-gravimetry and potentiometry; optical (such as visible and ultraviolet absorption), spectroscopy, emission spectroscopy and infrared spectroscopy; and other techniques such as chromatography and mass spectroscopy shall be included. *2 credits (4 laboratory hours). Prerequisite: Ch 160 and Ch 233*

Ch 361 **Physical Chemistry I**
With an emphasis on the basic theoretical justifications underlying observed physical phenomena, quantum mechanics will be developed and applied to the study of chemical systems with an emphasis on interpreting spectroscopic data. Modern methods of computational molecular modeling are introduced. Statistical mechanics is introduced as a link between quantum mechanics and thermodynamics.
3 credits. Prerequisites: Ch 160 and Ph 214

Ch 362 **Physical Chemistry II**
Continuation of Ch 261 with emphasison electrochemistry, chemical kinetics and solid state chemistry. Selected topics. *2 credits. Prerequisite: Ch 361*

Ch 364 **Solid-State Chemistry**
Solid-state reactions; nucleation and diffusion theory; thin films of elements and compounds; current topics. *3 credits. Prerequisite: Ch 362*

Ch 365 **Chemical Kinetics**
Fundamental study of chemical reaction systems in gaseous and condensed phases; absolute rate theory; collision theory; energetics from molecular and macroscopic viewpoints. Experimental rate techniques, interpretation of experimental data. Reaction mechanisms and models for complex and elementary reactions. Homogeneous and surface catalysis; enzyme-controlled reaction rates. *3 credits. Prerequisite: Ch 362*

Ch 370 **Inorganic Chemistry**
The vast and fascinating chemistry of inorganic compounds and materials will be covered. Atomic structure and the periodic table; molecular symmetry and spectroscopy selection rules; coordination chemistry; lig and-field theory and other electrostatic bonding models; superacids; reaction mechanisms; organometallic chemistry; chemistry of the heavy elements; nuclear chemistry. Chemistry and physics of ionic and molecular solids; atomic and molecular clusters; chemisorption and physisorption of surface-bound species; cage compounds and catalysts; bioinorganic chemistry. A useful course for chemical engineers to extend their knowledge of inorganic chemistry beyond the content of Ch 110. Strongly recommended for students interested in graduate work in chemistry.
3 credits. Prerequisites: Ch 110, Ch 160, Ch 231 and Ch 361

Ch 380 **Selected Topics in Chemistry**
Study of topics related to specialized areas as well as advanced fundamentals.
2-6 credits. Prerequisite: Chemistry faculty approval required

Ch 391 **Research Problem I**
An elective course available to any qualified and interested student irrespective of year or major. Students may approach a faculty member and apply to carry out independent research on problems of mutual interest, in pure or applied chemistry. Topics may range from the completely practical to the highly theoretical, and each student is encouraged to do creative work on his or her own with faculty guidance.
3 credits. Prerequisite: permission of instructor

Ch 392 to 398 **Research Problem II to VIII**
This is intended to allow students to continue ongoing research. *3 credits each. Prerequisite: permission of research adviser and student's adviser(s)*

Graduate

Ch 433 **Advanced Organic Chemistry**
Modern areas of organic chemistry, including synthesis, structure determination, stereo-chemistry and conformational analysis, reaction mechanisms, photochemistry, conservation of orbital symmetry, molecular rearrangements and other selected topics. Advanced laboratory studies in research problem form. Typical problems would involve studies of the synthesis, structure and properties of organic compounds, utilizing modern instrumental techniques. Independent laboratory work may be arranged.
3 credits. (2 hours of lecture; 4 hours of Laboratory). Prerequisite: Ch 232

Ch 440 **Biochemistry II**

Discussion of metabolism: Glycolysis, Glycogen Metabolism, Transport through membranes including ATP-Driven Active Transport and Ion Gradient-Driven Active Transport, Citric Acid Cycle, Electron Transport and Oxidative Phosphorylation, Lipid Metabolism including Fatty Acid Oxidation and Biosynthesis, Cholesterol Metabolism, Arachidonate Metabolism: Prostaglandins, Prostacyclins, Thromboxanes and Leukotrienes; DNA Repair and Recombination, Eukaryotic Gene Expression including Chromosome Structure, Genomic Organization, Control of Expression, Cell Differentiation.

3 credits. Prerequisite: Ch 340

Ch 451 **Nanomaterials**

Nanoscience is the study and manipulation of matter on an atomic and molecular level. At this scale, materials often exhibit new properties that do not exist in their large-scale counterparts because of the increased importance of surface area/volume ratios and quantum effects. This course will focus on understanding the physical properties and methodologies for the formation (i.e. molecular self-assembly, photolithographic patterning, scanning probe lithography), and characterization (i.e. optical spectroscopy, atomic force microscopy, scanning tunneling microscopy, and electron microscopy) of nanomaterials.

Same as EID 451. 3 credits. Prerequisites: Ch 110, Ch 111, and Ph 213, or permission of instructor

Ch 452 **Electrochemistry**

Electrochemistry allows the simultaneous recording of kinetic and thermodynamic information about a chemical reaction. This makes it a powerful tool in a wide variety studies. Since the reactions that define electrochemistry only occur within a few nanometers of the electrode's surface, mass transport coefficients and surface properties can be uncovered using electrochemical methods. The course will present the fundamentals electrochemistry, including electrical potentials, standard reduction potentials, batteries, reference electrodes, ion-selective electrodes, ionic mobilities, calculating junction potentials. Modern electrochemical methods, including cyclic voltammetry, electrogravimetry, ultra-microelectrodes and nanoelectrodes. *3 credits. Prerequisites: Ch 231, Ch 250, Ch 351, Ch 362*

Ch 460 **Statistical Mechanics and Computational Chemistry**

Topics covered include: Quantum and classical statistical mechanics, phase space, and fluctuations. Intermolecular forces and their experimental and theoretical determination. Computational molecular modeling, including Monte Carlo and molecular dynamics methods. Applications to gases, liquids, solids, spin systems, nanoclusters, polymers, surface adsorbates and biomolecules are considered.

3 credits. Prerequisites: Ch 361, Ch 362 or permission of instructor

COMPUTER SCIENCE

CS 102 **Introduction to Computer Science**
Introduction to Engineering Problem Solving using algorithms and their design. Logics and basic analysis techniques are explored using programming languages C and Python. Students will also master one or more significant engineering design packages such as MATLAB, AUTOCAD, Solid Works, etc. Projects will be assigned. *2 credits.*

CS 278 **Ethics of Computer Science**
A study of the political, ethical, and social dimensions of living in a world increasingly governed and defined by networked, computational systems, from their personal everyday impacts to their planetary ones. Drawing from a mix of historical and contemporary case studies, philosophy, and science fiction, students will explore frameworks for understanding technology not merely as artifact or product but as practice and ideology. As a final project, students will propose and prototype a frame-work for their own approach to ethical engineering and design. *3 credits. Prerequisites: None*

CS 371 **Data Visualization**
Exploring, discovering, and creating narratives using data science, design, and storytelling. Introduction to techniques to provide new and innovative approaches to explore, discover, and create narratives from and for the evolving artistic, social, political, scientific and technological landscapes. Introduction of a progressive framework for data and design. Real world examples and applications of the tools and methodologies introduced will be presented. *3 credits. Prerequisites CS 102/ECE 160*

MATHEMATICS

Undergraduate

Ma 110 **Introduction to Linear Algebra**
Vectors in two- and three-dimensions, vector algebra, inner product, crossproduct and applications. Analytic geometry in three dimensions: lines, planes, spheres. Matrix algebra; solution of system of linear equations, determinants, inverses. *2 credits. Prerequisites: none*

Ma 111 **Calculus I**

Functions; limit of functions, continuity. The derivative and its applications: curve sketching, maxima and minima, related rates, velocity and acceleration in one dimension; trigonometric, exponential, logarithmic and hyperbolic functions. Definite and indefinite integrals; area, the fundamental theorem, techniques of integration.
4 credits. Prerequisites: none

Ma 113 **Calculus II**

Applications of definite integrals: area, volume, improper integrals, work, arc length, surface area, centroid. Polar coordinates. Parametric curves in two and three dimensions: velocity, speed and accelerations. Partial derivatives and the chain rule, properties of the gradient. Maxima and minima. Sequences and series: convergence of sequences and series, Taylor and Maclaurin series, power series.
4 credits. Prerequisite: Ma 111; prerequisite or corequisite: Ma 110

Ma 151.1 **Mathematics in Art**

This course deals with the period beginning with Pythagoras in ancient Greece and goes up to the present day. Topics include: Goedel's incompleteness theorem. Euclidean and non-Euclideangeometries, infinity, paradoxes, soap film experiments. Also discussed are black holes, the Big-Bang theory, relativity and quantum theory. The course is open to all Cooper Union students but is primarily oriented toward making the above-mentioned concepts comprehensive to those with very little mathematics in their background. Engineering students should see the Mathematics faculty and their adviser(s) for permission to take this course. The relatedness of seemingly distant fields (science, art, mathematics, music) is a central theme of the course. *3 general studies credits. Spring only. Bailyn*

Ma 223 **Vector Calculus**

Double and triple integrals and their applications. Vector fields. Gradient, divergence and curl. Line and surface integrals. Theorems of Green, Gaussand Stokes. Path independence of line integrals. *2 credits. Prerequisites: Ma 110 and Ma 113. Usually given in fall and spring semesters*

Ma 224 **Probability**

Sample spaces. Random variables. Probability. Distribution and density functions. Expectation. Mean and variance. Moments and generating function. Central limit theorem. *2 credits. Prerequisite: Ma 113; corequisite: Ma 223. Usually given in both fall and spring semesters*

Ma 224.1 **Probability and Statistics**
This course deals with sample spaces, random variables, probability. Distribution and density functions. Expectation. Mean and variance. Moments and generating function. Central limit theorem. Point estimation. Confidence intervals. Hypothesis tests. Chi-square. ANOA. Estimations, sampling theory. *3 credits. Prerequisite: Ma 113; corequisite Ma 223*

Ma 240 **Ordinary and Partial Differential Equations**
Ordinary differential equations of the first order. Linear equations of higher order with constant coefficients. Power series solutions. Laplace transformation. Fourier series. Partial differential equations: method of separations of variables, applications to vibration and heat flow. *3 credits. Prerequisite: Ma 113*

Ma 326 **Linear Algebra**
Finite-dimensional vector spaces. Linear independence. Dimension. Basis. Subspaces. Inner product. Matrices. Rank. Determinant. Systems of linear equations. Matrix algebra. Coordinate transformation. Orthogonal matrices. Linear transformation. Eigen values and eigen vectors. Quadratic forms. Canonical form.
3 credits. Prerequisite: Ma 223

Ma 336 **Mathematical Statistics**
Statistical central limit theorem. Decision theory. Estimation: properties of estimators, point estimation, confidence intervals. Hypothesis testing: simple and composite hypothesis, Neyman-Pearson lemma, sequential methods, relationship to estimation. Normal distribution tests: t-test, chi-square, F-test. Introduction to non-parametric methods, regression and analysis of variance. *3 credits. Prerequisites: Ma 223 and Ma 224*

Ma 337 **Operations Research**
Linear programming, simplex method, graphs and network theory, dynamic programming, game theory, queues, variational techniques, duality, Markovchains, Monte Carlo simulation, decision theory. Special topics depending on student interest, possibly including language questions, integer programming, nonlinear programming and topics from mathematical biology, econometrics and other applications of mathematics to the sciences and social sciences.
3 credits. Prerequisite: Ma 224

Ma 341 **Differential Geometry**
Theory of curves and surfaces, curvature, torsion, mean and Gaussian curvatures length, area, geodesics, 1st and 2nd quadratic forms, conformal mapping, minimal surfaces, tensor formulation and applications. *3 credits. Prerequisites: Ma 223 and permission of instructor*

Ma 344 **Tensor Analysis**
Tensor algebra, covariant and contravariant tensors, metric tensors, Christoffel symbols and applications. *3 credits. Prerequisite: Ma 326*

Ma 345 **Functions of a Complex Variable**
Topological properties of complex plane, complex analytic functions, Cauchy-Riemann equations, line integrals, Cauchy's integral theorem and formula. Taylor series, uniform convergence, residues, analytic continuation, conformal mappings and applications. *3 credits. Prerequisite: Ma 223*

Ma 347 **Modern Algebra**
Sets and mappings, the integers: well ordering, induction residue class arithmetic, Euler-Fermat theorems. Permutation groups: cyclic decompositions. transpositions, conjugate classes of permutations. Abstract groups: morphisms, subgroups, cyclic groups, coset decompositions. Factor and isomorphism theorems. Direct products of groups. Sylow's theorems. *3 credits. Prerequisite: Ma 326*

Ma 350 **Mathematical Analysis I**
Sets and functions, topological properties of real line, continuity and uniform continuity, differentiability, mean value theorems, the Riemann-Stieltjes integral and Taylor's theorem. *3 credits. Prerequisite: Ma 223*

Ma 351 **Mathematical Analysis II**
Uniform convergence. Differentitation of transformations, inverse and implicit function theorems. Applications to geometry and analysis. *3 credits. Prerequisite: Ma 350*

Ma 352 **Discrete Mathematics**
Relations. Mathematical structures. Number theory. Algorithms. Complexity of algorithms. Cryptology. Recurrencerelations. Graph theory. A shortest-pathalgorithm. Planar graphs. Trees. Amaximal flow algorithm. Finite-state automata. Languages and grammars. Turing machines. The Church-Turing thesis. Unsolvable problems. *3 credits. Prerequisite: Ma 110*

Ma 370 **Selected Topics In Mathematics**
This is a seminar course involving discussion of topics in pure or applied mathematics that will be chosen by mutual agreement between the students and the instructor. Students will work independently on projects that may be of special interest to them.
3 credits. Prerequisites: Ma 326 and permission of the mathematics faculty

Ma 371 **Selected Topics in Mathematics**
This course is intended to allow undergraduate students to continue Ma 370 with related topics. *3 credits. Prerequisites: Ma 370 and permission of the mathematics faculty*

Ma 381 **Seminar**
Individual investigation of selected topics in pure or applied mathematics, centered on a subject to be agreed on between students and the faculty leader. Emphasis will be on training in independent reading of mathematical literature, oral presentations and group discussions of the theory and problems. *Credits and class hours to be determined by faculty on individual basis. Prerequisite: Ma 223*

Ma 382 **Seminar** (continuation of Ma 381)
Individual investigation of selected topics in pure or applied mathematics, centered on a subject to be agreed on between students and the faculty leader. Emphasis will be on training in independent reading of mathematical literature, oral presentations and group discussions of the theory and problems.
Credits to be determined by faculty on individual basis. Prerequisite: Ma 381

Ma 391 **Research Problem 1**
An elective course available to qualified advanced undergraduate students.Students may approach a faculty member and apply to carry out independent research on problems of mutual interest in pure or applied mathematics. Each student is encouraged to do independent creative work with faculty guidance.
3 credits. Prerequisites: Ma 240 and permission of research adviser

Ma 392 **Research Problem 2**
This course, a continuation of Ma 391, is intended to allow undergraduate students to continue ongoing research. *3 credits. Prerequisites: Ma 391 and permission of research adviser*

Graduate

Ma 401 **Boundary Value Problems**
Orthogonal polynomials, Fourier series; properties of Legendre polynomials and Bessel functions. Applications to the wave equation and the differential equations of heat transfer in several dimensions. *3 credits. Prerequisites: Ma 223 and Ma 240*

Ma 402 **Numerical Analysis**
Techniques for the solutions of ordinary and partial differential equations, the classical problems of linear algebra, integration and systems of nonlinear equations. Error analysis, convergence and stability theory. Course assignments will include use of computing facilities. *3 credits. Prerequisites: Ma 223 and Ma 240*

Ma 403 **Special Topics in Applied Mathematics**
Introduction to the general theory of partial differential equations; existence and uniqueness of solutions; integral equations; computational techniques using finite-element and probabilistic methods. Other current topics in engineering may be included also. *3 credits. Prerequisites: ECE 114 and Ma 326 or permission of instructor*

Ma 415 **Wavelets and Multiresolution Imaging**
3 credits. Prerequisites: ECE 114 and Ma 326 or permission of instructor

Ma 417 **Mathematics of Medical Imaging**
Mathematical basis for various medical imaging methods including CT, MRI, PET. Radon transform, tomography (recovery from projections), inverse problems, artifacts and noise. Mathematical physics of related topics such as wave propagation, signal generation and detection, quantum mechanics. *3 credits. Prerequisites: Ma 240, Ma 326 or permission of instructor*

Ma 470 **Selected Advanced Topics in Mathematics**
Selected topics in Mathematics treated at an advanced level.
Credits to be determined by Mathematics faculty. Prerequisites: Ma 326 and permission of faculty member

Ma 471 **Selected Topics in Mathematics**
This course is intended to allow graduate students to continue Ma 470 with related topics. *3 credits. Prerequisites: Ma 470 and permission of the mathematics faculty*

Ma 491 **Research Problem 1**
An elective course available to qualified graduate students. Students may approach a faculty member and apply to carry out independent research on problems of mutual interest in pure or applied mathematics. Each student is encouraged to do independent creative work with faculty guidance. *3 credits. Prerequisites: Permission of research adviser*

Ma 492 **Research Problem 2**
This is intended to allow graduate students to continue ongoing research.
3 credits. Prerequisites: Ma 491 and permission of research adviser

PHYSICS

Undergraduate

Ph 112 **Physics I: Mechanics**
Static equilibrium, kinematics, Newton's Law's, non-inertial frames of reference, system of particles, work and energy, linear and angular momentum, rigid body motion, conservation laws, oscillation. *4 credits. Prerequisites: Ma 110, Ma 111; corequisite: Ma 113*

Ph 165 **Concepts of Physics I**
An introduction to physics with an emphasis on statics and dynamics.
2 credits. Prerequisites: Ma 160, CS 102; corequisite: Ma 163. Cannot be used to satisfy any degree requirement in the School of Engineering

Ph 166 **Concepts of Physics II**
This is a continuation of Ph 165. Additional topics include optics, waves and an introduction to structural analysis. *2 credits. Cannot be used to satisfy any degree requirement in the School of Engineering. Prerequisite: Ph 165; corequisite: Ma 164.*

Ph 213 **Physics II: Electromagnetic Phenomena**
Oscillations; transverse and longitudinal waves. Electric fields; Gauss' Law; electric potential; capacitance; D.C. circuits; magnetic fields; Faraday's law; inductance; A.C.circuits; electromagnetic waves. *4 credits. Prerequisite: Ph 112; corequisite: Ma 223*

Ph 214 **Physics III: Optics and Modern Physics**
Geometric and physical optics, electrical and magnetic properties of matter. The quantum theory of light. The quantum theory of matter..Atomic structure.
3 credits. Prerequisite: Ph 213

Ph 235 **Physics Simulations**
Students will be taught how to numerically solve ordinary differential equations using 4th order techniques such as Runge-Kutta and Adams-Bashforth-Moulton in the Python programming language. These techniques will be used to solve diverse physics problems not amenable to simple analytical solution, such as n-body gravitational motion, the motion of charged particles in a magnetic bottle, the behavior of a car's suspension on a bumpy road. Emphasisis placed on physically accurate modeling (e.g. satisfying conservation laws to high accuracy) and the effective use of computer graphics/animation for the presentation of results. (Students need not have significant programming experience for this course.)
3 credits. Prerequisites: CS102, Ph112, Ma113, and permission of instructor

Ph 291 **Introductory Physics Laboratory**
Physical measurements and analysis of experimental data. The experiments test and apply some basic principles selected from the following fields: mechanics, sound, electromagnetism, optics and modern physics. Experiments and topics may vary each semester. Digital and analog laboratory instruments; computer acquisition and analysis of data. Estimate of systematic and random error, propagation of error, interpretation of results. This course complements three lecture courses, Ph 112, Ph 213, Ph 214. *1.5 credits. Prerequisite: Ph 112; corequisites: Ph 213, Ma 240*

Ph 327 **Topics in Modern Physics**
Seminar course with student participation in several topics of current interest in experimental and theoretical science. *3 credits. Prerequisite: Ph 214*

Ph 328 **Relativity and Electrodynamics**
Introduction to tensures; formulation of electromagnetic theory. Special and general theories of relativity. Topics include space time transformations, electromagnetic stress-energy momentum tensor, four space curvature and gravitational field equations, description of basic experiments, gravitational waves, cosmological models. *2 credits. Prerequisite: Ph 214*

Ph 348 **Flow Visualization**
Study of a broad range of uid ow phenomena emphasizing the features and patterns characteristic of each. Introduction to visualization techniques used to reveal and capture details of these ows, leading to the application of these techniques to actual ows in the lab or in the eld. Essential photographic methodology for still images and movies, including lighting, exposure, depth of eld and digital image post-processing. Use of tracers, including dyes, vapor, bubbles and particles as well as optical tools,

such as schlieren and/or shadowgraph. Natural and engineering ows will be examined, beginning with mathematical and physical analysis of visualizable properties, including buoyancy, interfaces, vorticity, streamlines and pathlines, and concluding with an actual image or movie. Motivated by the immense scientic and engineering importance of ow visualization in vehicle design, dispersal of environmental pollutants, biomedical ows and many others, ow images are an important form of technical communication and will be critiqued and improved, culminating in a nal project exhibition. *3 credits. Prerequisites: ESC 340 and permission of instructor. Open to all students.*

Ph 360 **Special Projects in Physics**
Special projects in experimental or theoretical physics.
Credits and prerequisites determined in each case by the physics faculty

Graduate

Ph 429 **Deterministic Chaos with Engineering Applications**
A simple mathematical formalism explains how a nonlinear system with no random element may be intrinsically unpredictable even when its governing equations are known. The mathematics of chaos (including fractals) will be presented, with applications drawn from mechanical, biological, chemical processes; the weather; electric circuits; lasers; general relativity; models of war; the economy; the spread of epidemics, etc. *3 credits. Prerequisites: Ph 214, Ma 113 (Ma 240 preferred) and CS 102*

VERTICALLY INTEGRATED PROJECTS (VIP)

1 Credit Each Semester for 3-6 Semesters

Multidisciplinary course supporting student and/or faculty-initiated projects guided by faculty mentorship and professional research. Undergraduate students that join VIP teams earn one credit each semester for their participation in design/discovery efforts that enable them to explore their interests through long term projects. Students are encouraged to take the course for at least three consecutive semesters

Students

- In the first semester, they will familiarize themselves with the project, gain knowledge/skills, and begin making meaningful contributions
- In the second semester, they will begin to master the foundations within the discipline, pursue needed knowledge/skills, make meaningful contributions, and assume technical/leadership responsibilities.
- In the third semester, they will have mastered the foundations within the discipline, pursue further knowledge/skills, make meaningful contributions, and assume significant technical/leadership responsibilities.
- In the fourth semester, they will pursue needed knowledge/skills, make meaningful contributions, provide leadership in technical area and team management.

The teams are

- Multidisciplinary - drawing students from all disciplines on campus;
- Vertically-integrated - maintaining a mix of freshmen through senior students each semester;
- Long-term - each undergraduate student may participate in a project for up to three years.

The continuity, disciplinary depth, and professional breadth of these teams intend to

- Provide the time and context necessary for students to learn and practice many different professional skills, make substantial technical contributions to the project, and experience many different roles on a large, multidisciplinary design/discovery team.

- Support long-term interaction between the students and faculty on the team. The more senior students mentor the undergraduates as they work on the design/discovery projects embedded in the course.
- Enable the completion of large-scale design/discovery projects that are of significant benefit to faculty members' research.

Course Pre-requisites

Students must be pursuing their undergraduate degree in order to enroll in VIP for credit. Enrollment is based on a rolling application process with a decision made before the beginning of each semester.

VIP@Cooper Possible Course Structure

- All VIP teams are listed as different sections of
  VIP 381X: students taking it for the first time
  VIP 382X: students taking it for the second time
  VIP 383X: students taking it for the third time
  VIP 384X: students taking it for the fourth time
  VIP 385X: students taking it for the fifth time
  VIP 386X: students taking it for the sixth time

Each team is designated by a section letter and course code.

- VIP courses are open to all Cooper Students from any school.

VIP Sections

Fall 2020 Section 1: Smart Cities Course Description

Advisors: Neveen Shlayan, Mili Shah, Dirk Luchtenburg, Ben Davis

The Autonomy of "Smart" Cities is a cross-disciplinary course that is dedicated to finding technology-based solutions to some of the most pressing issues that are currently facing our cities. This course will focus on closed-loop systems in order to explore a more sustainable transportation, energy, and urban agricultural structures that promote the autonomy of our communities and enhance the livability of our cities. Students will be expected to develop complete solutions (design and implementation) integrating ideas and concepts from different disciplines such as: design, ML, Robotics, IoT, hardware design, vision, lighting, and control theory.

Example Projects:
- Self-Drive: an autonomous vehicle project.
- Net-Zero-Surrey: designing a sustainable transportation solution for more livable future cities.
- Urban Agriculture: enabling the urban community to produce their own food.
- Robotics Arms: modeling human motion with robotics arms.
- Drones: sling load and cooperative drones

Section 2: Solar Decathlon Course Description
Advisors: Cosmas Tzavelis, Lorena Del Rio, David Wooton, Neveen Shlayan

The Solar Decathlon course forms a cross-disciplinary team that engages in a design phase and a build phase of highly efficient and innovative buildings powered by renewable energy. Students are expected to prepare creative solutions for real-world issues in the building industry. The focus of this course will be High-performance building design includes comprehensive building science, energy efficiency, optimized structural and mechanical systems, indoor air quality, resilience, and water conservation while maintaining the highest spatial design standards. Engineering students will be working closely with Architects to design an efficient and innovative system to support the functional and aesthetic characteristics of their projects while experimenting with the use of standard as well as unconventional materials.
Students will be taught the basics of statics, strength of materials, structural analysis and design. Teams will be expected to participate in the Solar Decathlon Design and Build Challenge: https://www.solardecathlon.gov/about.html.

Course Objectives
- Introduce students to state of the state-of-the-art industry standard technology to better prepare them to enter the workforce.
- Allow students to engage with their specialized knowledge and skills in the contexts of a team-based research project.
- Provide students with the opportunity to conduct research at an early stage to better prepare them for possible academic careers.
- Enable students to work in multidisciplinary teams in the pursuit of designing effective solutions to modern complex issues.

ADMINISTRATION, FACULTY AND STAFF

Administration

Barry L. Shoop
Dean; Professor, Electrical Engineering
Ruben Savizky
Associate Dean for Academic Affairs; Professor, Chemistry
Lisa A. Shay
Associate Dean for Educational Innovation; Professor

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Administrative Associate
Elizabeth Leon
Administrative Associate
Nori Perez
Administrative Manager
Betsy Quitugua
Administrative Assistant
Beth Slack
Administrative Associate Budget Analyst
Elizabeth Waters
Associate Director, STEM Outreach

Full-Time Faculty

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Professor; Chair of Mathematics
Melody Baglione
Professor; George Clark Chair of Mechanical Engineering
Fabiola Barrios-Landeros
Assistant Professor, Chemistry
Joseph C. Cataldo
Professo, Civil Engineering
Benjamin J. Davis
Professor, Chemical Engineering
Fred L. Fontaine
Jesse Sherman Professor, Electrical Engineering; Chair of Electrical Engineering; Director of the Retraining Program for Immigrant Engineers
Vito A. Guido
Professor; George Fox Chair of Civil Engineering
Sam Keene
Professor, Electrical Engineering
Stuart Kirtman
Associate Professor, Electrical Engineering
Ja-beom "JB" Koo
Assistant Professor, Electrical Engineering
Cynthia Lee
Assistant Professor, Civil Engineering
Daniel H. Lepek
Professor, Chemical Engineering
Eric Lima
Professor, Mechanical Engineering; Director, The Open-Source Hardware Laboratory
Dirk Martin Luchtenburg
Assistant Professor, Mechanical Engineering
Stanislav Mintchev
Associate Professor, Mathematics
Andrea Newmark
Professor; Chair of Chemistry
Ogbonnaya Charles Okorafor
Professor; Chair of Chemical Engineering
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Professor, Computer Engineering
Mili Shah
Associate Professor, Mathematics
Neveen Shlayan
Assistant Professor, Electrical Engineering
George W. Sidebotham
Professor, Mechanical Engineering
Amanda Simson
Assistant Professor, Chemical Engineering
Robert W. Smyth
Professor, Mathematics
Robert Q Topper
Professor, Chemistry
Cosmas Tzavelis
Professor, Civil Engineering
Leonid Vulakh
Professor, Mathematics
Chih-Shing (Stan) Wei
Professor (retired)
Jennifer Weiser
Assistant Professor, Chemical Engineering
Alan N. Wolf
Professor (retired); Former Chair of Physics
David M. Wootton
Professor, Mechanical Engineering
Constantine Yapijakis
Professor, Civil Engineering
Philip Yecko
Professor, Physics; Chair of Physics

Adjunct Faculty

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Tensae Andargachew
Michael Bambino
Robert Barrett
Peter Bastos
Mohammed Billoo
Sheryl Birke
Scott N. Bondi
Ingrid Burrington
Thomas Carberry
Andy Cavatorta
Dong Chang
Michael Chen
Christopher Curro
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Timothy R. Hoerning
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Neil Jackman
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Thomas Koch
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Ian J. Kremenic
Michael Kumaresan
Lembit Kutt
Brian Frost LaPlante
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Benjamin Menschel Visiting Professor in Engineering
Richard Lo
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Bogdan Wilk
Hui (Grace) Yu

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Dean Emeritus
Simon Ben-Avi
Professor Emeritus
John Bove
Professor Emeritus
Shang-I Cheng
Professor Emeritus
Wallace Chinitz
Professor Emeritus
Ralph L. Knapp
Professor Emeritus
Jean Le Mee
Professor Emeritus
Melvin Sandler
Professor Emeritus

Staff

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Biofluids Research Fellow
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Estuardo Rodas
Laboratory Manager and Project Coordinator, Mechanical Engineering

Douglas Thornhill
Laboratory and Technician Manager, Mechanical Engineering
Luis Vega
Technician
Brian Yudin
Student Shop/ME Design Studio Technician

FACULTY OF THE HUMANITIES AND SOCIAL SCIENCES

Mission

The Cooper Union is committed to the principle that an education in the Humanities and Social Sciences provides the ethical, social and humanistic framework crucial to personal development, professional excellence, and engaged citizenship. Through their work in Hss disciplines, students will gain a deeper awareness of the world in which they must live and act. They learn to think, write and speak clearly and effectively. Most significantly, an education in the liberal arts offers students the opportunity to become attentive to the social and humanistic implications of their professional work and to acquire the basis for a satisfying cultural and intellectual life.

Curriculum

All students take a four-semester core curriculum of required courses in the humanities and social sciences. In addition, students in the School of Art take a required sequence in art history. The core curriculum is a prerequisite to all elective offerings in Humanities and Social Sciences. During the third and fourth years, students have considerable latitude to explore the humanities and social sciences through elective courses. All students are expected to take core curriculum courses at The Cooper Union.

Minor

Students who complete a minimum of 12 upper-division credits in a specific field of liberal arts may qualify for a minor in that field of Humanities and Social Sciences. Minors are offered and may be designated on student transcripts in the following five fields. Please contact HSS Academic Advisor, Professor Sohnya Sayres.

Art History
Economics and Public Policy
History and Society
Literature
Science, Technology, and Society

HSS Program Level Objectives

The objective, supporting The Cooper Union's overarching mission, is to instill an understanding of the breadth and richness of intellectual discovery across the humanities and social sciences. This includes developing a familiarity with representative literary texts, major historical themes and ideas, and analytical methods. Students will learn how to relate this humanistic knowledge to their professional, civic, and personal lives. This broad objective might be further articulated as:

- Developing in the student skills in critical analysis within a range of disciplinary structures
- Developing in the student skills necessary for engaged citizenship
- Developing an appreciation of world cultures and of America within a global context
- Developing in the student skills in writing and non-written expression enabling that student to take part in active citizenship and to compete effectively in her or his professional arena

HSS Course Objectives

HSS Core

By the end of the four-course sequence, we expect students will be able to:

- Analyze literary texts as both aesthetic objects and cultural artifacts
- Contextualize cultural understanding within a set of political, economic, and scientific developments
- Identify transformations in political, economic, social, scientific, and civic experience over time
- Consolidate analytical, contextual, and historical understanding through argumentation, comparison, and research

HSS1 The Freshman Seminar

HSS1 develops college-level skills in reading and writing, analysis, and argumentation through engagements with major texts and themes. Through close reading and extended discussion, students learn to craft evidence based arguments in written and spoken form. Students experience one of four tracks that share the common goals of encouraging aesthetic understanding of the literature of major historical periods and developing the writing and speaking skills necessary for college-level work.

HSS2 Text and Contexts: Old Worlds and New

Through the semester students will:

- Engage with foundational texts in the creation of the Modern age through close reading and class discussion. Students develop further their skills in reading and interpreting a range of texts in a range of genres (letter, report, treatise, essay, drama, non-fiction narrative)
- Describe how course texts differently perform, reflect upon, elide or otherwise register the major social, political, and intellectual developments of their respective periods, in particular a) the transformations and conflicts produced by European expansion, b) the movement of ideas, people, and commodities across oceans, c) the reception of ideas and impact of migration and commerce within regions and emerging national contexts
- Distinguish, and provide critical definitions for, the major periods and movements in the Early Modern Period, specifically History - Renaissance Humanism, the Reformation, the Puritan Revolution and the Enlightenment - with an appreciation for the problems of periodization
- Outline the contribution of the Scientific Revolution to the nature of knowledge, and describe in more detail the role of one major figure such as Bacon, Galileo, Descartes or Newton
- Trace and analyze, by citing specific authors and historical experiences, the changing conceptions of the political realm, including the development of the modern state; the relationship between politics and religion; and the rise of political individualism

HSS3 The Making of Modern Society

The Making of Modern Society is a history course in which students explore the key political, social and intellectual developments of the nineteenth and twentieth centuries. The course is organized chronologically, beginning with the Industrial and French Revolutions and ending with the transformations brought about by the end of the Cold War and the challenges of twenty-first century violence and globalization. Lectures provide students with an analysis of particular events and a survey of change over time. In their work in sections students discuss how assigned readings, including contemporary texts, illuminate the complexities of historical experiences of modernity. Throughout the semester students will use a textbook that outlines the historical links and comparisons between Europe, Asia, Africa, the Americas, and the Middle East. Students will learn:

- To identify and trace the transformations in politics brought about by challenges to the old regime in Europe and the Americas and changing ideals of political, civil and human rights
- To identify and trace the transformations in society, economy and politics brought about by urbanization, industrialization, and the rise of industrial capitalism
- To identify and trace experiences of empire, war, and genocide, and their contemporary legacy, in Europe, Asia, Africa and the Americas. With the goal of broadening historical understanding, developing clear communication skills, and improving research skills students will write analytic essays, read texts, and speak and discuss with each other about issues that engage them as professionals in training and citizens of their local, national, and global communities.

HSS4 The Modern Context: Figures and Topics

HSS4 introduces students to the process of writing and research in the humanities and social sciences by focusing on a critical figure or topic from the modern period for the duration of the semester, cultivating depth of understanding rather than breadth of knowledge. Toward this end, the course develops the skills that students need to:

- Produce a substantial research essay with an original argument
- Marshal a variety of secondary sources (e.g., books, journal articles, images, Internet resources, interviews) in support of the argument
- Present research findings in oral form
- Engage in collaborative research activities (e.g., peer review, group projects)
- Master the conventions of citing both primary and secondary sources

CURRICULUM

Core Curriculum

Peter Cooper believed that a truly practical education should offer students a means of livelihood and a sense of intellectual curiosity as well as encouraging involvement in the cultural and political life of the city and the nation. So important did he hold the education of the citizenry to be that courses in the social sciences were to be considered preeminent. The core curriculum offered by the Faculty of Humanities and Social Sciences continues Peter Cooper's commitment to liberal learning, social awareness and active citizenship. Through critical examination and discussion of primary materials students develop a broad understanding of the origins of modern

society and the conflicts within it. The courses encourage conversation and collaboration to engender a community of inquiry and expertise, preparing students for professional careers and for active participation in society.

The core curriculum of Cooper Union is a required four-semester sequence from HSS1: Literary Forms and Expressions through HSS4: The Modern Context. The core curriculum requirement is satisfied by completing these four semesters in order. HSS1 and HSS3 are offered in fall semesters; HSS2 and HSS4 are offered in spring semesters.

HSS 1: The Freshman Seminar A literature course concentrating on poetry and drama. Selected texts from antiquity and the Renaissance are common to all sections.

HSS 2: Texts and Contexts: Old Worlds and New A study of texts and topics from 1500 to 1800. Sections read common texts and some selections by individual instructors, with emphasis on literary expression and cultural context. Requirements include written analysis and class discussion.

HSS 3: The Making of Modern Society A study of the key political, social and intellectual developments of modern Europe in global context. This course is organized chronologically, beginning with the Industrial and French Revolutions. Monday 11-12 lecture in LL117 (Rose Auditorium). All students enrolled in HSS3 must attend the Monday 11-12 lecture in addition to one of the below sections.

HSS 4: The Modern Context: Figures and Topics A study of important figures or topics from the modern period whose influence extends into Contemporary culture. Requirements include individual research and writing projects. In choosing a section, students should consider its figure or topic for study.

Art History (HTA 101, 102) While contributing to the required curriculum of students enrolled in the School of Art, both the Art History Core and art history electives are also available to students in the other Schools.

HTA 101, 102 Modern to Contemporary: An Introduction to Art History This two-semester art history core course, developed as part of the the Foundation year for students in the School of Art but open to all students, is organized around a set of themes running through the history of modernity from the 18th century to the present. Within specific themes, significant works, figures, and movements in art/design will be presented chronologically. Students will be able to identify and critical evaluate significant works, figures, and movements in art/design in the modern period; be able to describe the main social and political contexts for the changes in art/design over the last two hundred years; and engage, in writing and class discussion, with theoretical perspectives on art/design production. The course will involve museum visits. Grading will be based on class participation, papers, and exams.

Electives The Faculty of Humanities and Social Sciences offers a varied and flexible elective program that provides rigorous study while responding to the changing needs of students. The complete Cooper Union course catalog with course descriptions, academic standards and other useful information is available online and maintained by the Registrar's office.

See the class schedule for available electives during the current or upcoming semester.

HSS Policy on Plagiarism and Academic Dishonesty

Plagiarism is the presentation of another person's words, phrases, ideas, or conclusions as your own—even when the identity of the person is not known, as is often the case with sources on the Internet. Ethically, plagiarism is false assumption of authorship: the act of taking another person's language or thought—or language or thought from an anonymous source—and presenting it as your own. Plagiarism or academic dishonesty may take any of the following forms:

- Repeating another person's sentences or phrases as your own
- Presenting another person's argument or central ideas as your own
- Letting another person write your paper
- Copying or downloading a paper (or part of a paper) from the Internet
- Misrepresenting in any way how the work was actually done in the submission of a research report
- Purchasing a paper for submission under your own name
- Selling or otherwise distributing any written material with the intent or understanding that another person may submit the work as his or her own
- Cheating on a written examination, such as referring to notes, books, laptop computers (or other electronic devices) without the explicit permission from the instructor
- Submitting work written or prepared for one course to fulfill requirements for a second course without prior permission from the instructors in both courses (regardless of whether or not the courses are taken in the same semester)

These are all acts of plagiarism or academic dishonesty whether they are done intentionally or unintentionally, on any essay, examination, exercise, report (including oral reports), or other type of writing assignment.

The means to prevent plagiarism in essays are: quotation marks around passages taken verbatim from sources; names of sources cited frequently in paraphrases or summaries; and complete documentation of sources in the text of essays and in footnotes, endnotes, or lists of "works cited" or "references," including language or ideas taken from an Internet source. **Students uncertain how to avoid plagiarism should discuss plagiarism with their instructors or with associates in the Center for Writing.**

In the Faculty of Humanities and Social Sciences at The Cooper Union, the guidelines for cases of plagiarism, whether intentional or unintentional, are as follows:

The essay or examination will receive a grade of **F**.

The instructor will inform the Dean of The Faculty of Humanities and Social Sciences, who will report the plagiarism to the appropriate academic Dean in the School in which the student is enrolled.

At the discretion of the instructor, the student may be allowed to rewrite the essay or examination on acknowledgement of plagiarism and instruction on plagiarism in The Center for Writing and Language Arts.

At the discretion of the instructor, the student may be withdrawn immediately from the course and given a grade of F in it. In such cases, further action may be taken, such as probation, suspension, or dismissal.

Every Faculty member is obligated to report all cases of plagiarism to the Dean of the Faculty of Humanities and Social Sciences so that appropriate action may be taken.

Academic Regulations

Credits Unless otherwise noted, HSS courses with the prefixes HUM and SS carry three credits and courses with the prefix HTA carry two credits.

Prerequisites The prerequisites for all courses with the prefixes HUM and SS are HSS1, 2, 3 and 4. HTA 1, 2 and 3 or HTA 101 and 102 are prerequisites for HTA electives. Exceptions may be granted by special permission of the dean.

Grades At the end of every semester, each student receives a grade for his or her semester's work in each subject. Grades, with their official significance, are as follows: **A** Outstanding performance **B** Very good performance **C** Average performance **D** Passing but unsatisfactory **F** Failure to meet minimum requirements **I** Work of the course not completed and assignment of grade and credit postponed. This designation will be given only in cases of illness (confirmed by authorized physician's letter) or of other documented extraordinary circumstances beyond the student's control, and only with the approval of the dean of the Faculty of Humanities and Social Sciences.

The deadline for removal of an I designation will be determined by the instructor, but will not be later than six weeks after the start of the spring semester for students who receive such a grade in the fall semester and not later than two weeks after the start of the fall semester for students who receive such a grade in the spring semester. If the I is not removed within the set time limit, either by completing the work in the subject or by passing a reexamination, the I will automatically become an F unless the dean of the Faculty of Humanities and Social Sciences extends the time or the student withdraws from school.

W Withdrawal (see below)

WU Unauthorized withdrawal (see below)

Indicators of plus (+) and minus (-) are used with the grades A, B, C and D. (The grade of A+ is, however, not given.) These indicators are included in computing grade point averages.

Change of Program

Adding a Course A student is permitted to add a course only during the first week of a semester, during the drop/add period, and only with the adviser's approval. Adding a course after the drop/add period is not permitted even if the student has been attending the class.

Dropping a Course A student may drop a course during the first week of the semester, during the drop/add period, with the adviser's approval. A course dropped during the first week of the semester will be deleted from the transcript.

Withdrawing from a Course A student anticipating inability to continue an assigned program should immediately see his or her adviser. After the drop/add period a student may withdraw from a course through the eighth week of the semester. It is the student's responsibility to obtain the necessary permission from the adviser and to notify the instructor in order to withdraw from a course. A grade of W will appear on the transcript. A student who stops attending a course without permission of the adviser will receive a grade of WU. However, if the student is failing the course at the time of the unauthorized withdrawal, the instructor is free to record a grade of F. A student is not permitted to drop or withdraw from a course if doing so would impede satisfactory progress towards the degree.

Assignments

Students are required to complete all assignments and examinations on time. In the case of schedule conflict or an unavoidable delay in completing an assignment, the student should discuss the problem with his or her instructor. Failure to complete assignments on time may result in an F grade for the course.

Attendance
Students are expected to attend all classes. No more than the equivalent of one week of unexcused absences will be permitted. In the event of absence a student should contact the instructor in advance. Students who miss more than the equivalent of one week of classes in any one course may receive a reduction of the final grade or, at the discretion of the instructor, may be required to withdraw from the course.

Lateness
Students are expected to be punctual. Late students may be refused entry to a class. Chronic, unexcused lateness may result in a reduction of the final grade or in failure.

Academic Integrity
The Faculty of Humanities and Social Sciences expects all students to demonstrate the highest levels of academic integrity. Violations of academic integrity have consequences, including, but not limited to, failure for the course. The Dean of the student's school will be notified. See more information or a paper copy of the policy may be obtained from the HSS dean's office.

Student Behavior
Students are expected to conduct themselves in accordance with the guidelines in the Code of Conduct.

Transfer Credit
Transfer credits may be granted for courses with a grade of B or better upon review by the office of the dean of Humanities and Social Sciences to determine that the work accomplished meets the Faculty's requirements. Students may be required to provide evidence of work completed in the course: syllabi, papers, etc. In rare circumstances, the freshman and sophomore requirements may be waived if an equivalent course of study has been satisfactorily completed elsewhere. Eligible credits should be transferred during a student's first semester at The Cooper Union. Interested students should make an appointment with the dean or the academic adviser of the Faculty of Humanities and Social Sciences during the first week of classes in the fall semester. (Revised and Approved, March 27, 2018)

Advanced Placement Credit
The Faculty of Humanities and Social Sciences rarely grants AP credit. However, a student who has attained a grade of 5 in an AP course may petition the dean for permission to waive a core requirement and to substitute an appropriate elective course.

COURSES

Core Curriculum

HSS 1 Freshman Seminar

A literature course concentrating on poetry and drama. Selected texts from antiquity and the Renaissance are common to all sections, with works from other genres, periods and cultures chosen by individual instructors. The course develops aesthetic appreciation of literary texts and encourages a range of critical responses. Through close reading, and extended discussion, students learn to articulate their responses in written and spoken form. *3 credits*

HSS 2 Texts and Contexts: Old Worlds and New

A study of texts and topics from 1500 to 1800, with emphasis on literary expression and cultural context. Topics include the formation of states, exploration, the encounter with the New World, the crises in religious orthodoxy, the origins of modern science and the beginnings of political and economic individualism. This semester develops both cultural and political understanding through close reading, class discussion and careful writing. *3 credits*

HSS 3 The Making of Modern Society

A study of the key political, social and intellectual developments of modern Europe in global context. Thiscourse is organized chronologically, beginning with the Industrial and French Revolutions. Students develop an understanding of the political grammar and material bases of the present day by exploring the social origins of conservatism, liberalism, feminism, imperialism and totalitarianism. In discussions and in lectures students learn to study and to respond critically in written and spoken form to a variety of historical documents and secondary texts. *3 credits*

HSS 4 The Modern Context: Figures and Topics

A study of an important figure or topic from the modern period whose influence extends into contemporary culture. The figures and subjects are chosen from a broad range of disciplines (including literature, history, politics, technology and art history, among others). Through concentration on a single figure or focused topic students are encouraged to develop a deep awareness of works of great significance and to understand them in the context of modernity. Guided independent writing projects and oral presentations give students an appreciation for what constitutes research in the humanities and social sciences. *3 credits. May be repeated for Free Elective credit in the Schools of Art and Engineering. May be repeated for Elective credit in the School of Architecture, provided the minimum requirement of six elective credits in Humanities and Social Sciences is fulfilled by elective-level courses. In both cases, permission of the Dean of Humanities and Social Sciences is required.*

HUMANITIES

HUM 105 **Fundamentals of Music**
A study of the elements and forms of music and consideration of how they define the stylistic characteristics of the literature of music from the late Renaissance to the present. There will be extensive use of recordings, as well as attendance at concerts and recitals. *3 credits*

HUM 242 **Greek Mythology**
The course will concentrate not just on the endlessly fascinating stories of the gods drawn from the classic sources, but on a critical analysis of the question: How do the gods fare throughout the course of western history? Periods to be focused on include the time of Homer, Hesiod and the Homeric Hymns; the Archaic period (the time of the Lyric poets); the high Classical period (the golden age of Greek tragedy); the late Classical and Hellenistic periods (the age of the great philosophers and their schools); the Augustan era of the Roman Empire (the time of Virgil and Ovid); and the Renaissance. *3 credits*

HUM 243 **The Fairy Tale**
This course introduces students to the development of fairy and folk tales through history, and across cultures and geographies. While we focus on these tales in their originary contexts, we will consider the work they perform in such diverse modern appropriations as Disney cartoons, gaming, and the men's movement. Excerpts from the major collections of Western Europe, West Africa, the Middle East, South and East Asia will furnish our primary readings. We pay particular attention to the collected tales of the brothers Grimm, the Panchatantra, The Thousand and One Arabian Nights, The Tales of Anansi and Brer Rabbit, and Miscellaneous Morsels from Youyang. Our investigation will be interdisciplinary, with our critical approach drawing from theorists such as Freud, Jung, and Frazer, and modern scholars such as Maria Tatar and Jack Zipes. *3 credits*

HUM 250 **Shakespeare: Hamlet**
For Fall' 20 the topic will be: Hamlet -Who is Hamlet? What is Hamlet? Shakespeare's most famous play has a complex history and an even more complex legacy. This semester's Shakespeare course will focus on one play – but what a play. Hamlet has been a celebrated stage work, an inspiration for artists and writers, and a headache for scholars: Shakespeare didn't leave us a manuscript, and we have two different versions of the text, so any performance of the play requires a lot of decisions. Hamlet's story has become an international story, and the title role has been taken up

both by male and female actors. The first half of the course will be an intensive, careful reading of the play and its historical context. In the second half, we will look at adaptations and disseminations – Hamlet in the visual and cinematic arts, in ballet, in famous stage interpretations, and as a means of connecting cultures: Hamlet off the coast of Sierra Leone, a Hamlet-figure in Indian cinema, Shakespeare's play in contemporary China. For four centuries, Hamlet has been a figure of youth struggling against system, caught between identity and obligation. We will work together to understand what Hamlet—and Ophelia, Gertrude, Claudius, Polonius, Laertes, and Old Hamlet—are up against, why they do what they do, and why the world has given them so much attention. Course requirements: unfailing attendance to our class meetings, weekly response paper-ettes, two research papers, and a bit of memorization. *3 credits*

HUM 305 **Leonardo, Scientist and Engineer**
This course uses the life and work of Leonardo da Vinci (1453–1519) to explore science, medicine, engineering and art in Renaissance Europe. We will use Leonardo's notebooks, work of his contemporaries and writing about his interests across the centuries to examine the institutions and influences that served Leonardo's imagination, his inventiveness, and his arts. *Same as SS 305. 3 credits*

HUM 307 **Theatre Collaborative**
An examination of theater-making both theoretical and practical, students will work together to explore the act of play from the various perspectives of the actor, writer, director, designer, and producer. The class will explore ensemble driven devised theater-making as well as more traditional methodologies in a study of process that will culminate in group projects inspired by the myth of Icarus. Throughout the semester students will be expected to attend several performances and subsequent in-class talkback sessions with guest artists. *3 credits*

HUM 308 **Creative Writing**
Starting with exercises and word games, then moving to, e.g., the objective poem, collage and concrete poetry, metrics, translations. As well as writing, students are expected to read widely in poetry and fiction. Attendance at a poetry or prose reading is obligatory. Grade based on class performance and portfolio of work. *3 credits*

HUM 309 **Art and the Crisis of Modernity**
This course will develop a parallel reflection on the world in which the art of our time expresses itself, and which art, in turn, tries to shape. In the first part, we analyze different interpretations of the crisis of modernity, which aim to offer, through different historical and philosophical approaches, other meanings of the age of 'postmodernity'. In the second part, we initially focus on some of the artistic revolutions that took place almost simultaneously in the early twentieth century, a time of enormous tension that led to radical changes of worldviews. Thereafter, the discourse develops around some of the avant-garde movements that staged an aesthetic explosion from mid-century onward, such as abstract expressionism, minimalism or post-minimalism; a choice, however, that does not imply the possibility of defining a unique direction in the artistic experience of our time. Yet, precisely the re-definition of time that emerges in the work of some of these artists can be seen as a metaphor of the art of our time. As T.W. Adorno observes in Aesthetic Theory, it is precisely through a fragmentary and 'not closed' form, through a 'synthesis of the dispersed' which renounces the idea of consonance, that art can express the reality of our time. *3 credits*

HUM 315 **Science and Contemporary Thought**
The aim of this course is to reflect on the role of science in our society, with particular emphasis on the philosophical, political and social aspects of contemporary thought. Although the importance of science in our daily life is indisputably assumed—giving rise to a sort of myth of technology—it is important to analyze its influence on other aspects of contemporary thought, as well as on the very concept of knowledge. The essence of science, in fact, lies in the desire for searching, leading to a necessarily provisional knowledge which survives as a paradigm until it is eventually contradicted by new investigations. Moreover, it is important to acquire consciousness of the political, economic, and cultural constraints acting on both the methodology and the goals of contemporary science. Nowadays these constraints cannot be ignored, but few are really prepared to reflect free from political or philosophical bias. *3 credits*

HUM 318 **Creative Nonfiction Writing**
This course will explore the creative possibilities of writing about reality. Students will read and produce many different genres, including the personal essay, cultural criticism, prose poetry, literary journalism, song lyrics, podcasts, even Twitter threads. By the end of this course, students should be able to write comfortably in a variety of forms, and to think critically about how each of those forms describes reality -what it includes and excludes, enables and disables. They should be able to find expressive possibilities in almost any subject, as well as to actively notice the world around them—natural, technological, social, intellectual - and then to articulate the things they notice. *3 credits*

HUM 323 **The Presence of Poetry**
This will be a class in which the center of attention is the poem itself. We will concentrate on modern English and American poetry. The common text will be The Norton Anthology of Modern and Contemporary Poetry Vol. 2, third edition (Jahan Ramazani, Richard Ellmann, and Robert O'Clair) but students are encouraged to look into other anthologies and studies of Poetry. *3 credits*

HUM 324 **Polar Imagination**
This course will explore our fascination with the ends of the earth: the Arctic and the Antarctic. What is the history of our engagement with these regions long thought to be uninhabitable? What's important about the search for the Northwest Passage and the landless "North Pole," first in the age of big ice and now in the era of polar melt? At the other end of the globe, what does the vast and forbidding Antarctic continent have to tell us? What are the polar regions to us now, in times of re-escalating political tensions and rising temperatures? To give shape to these questions we will look at literary works inspired by the planet's extreme regions (for example, Mary Shelley, Coleridge, Edgar Allan Poe, Jules Verne and other nineteenth-century authors as well as contemporary writers), histories of famous explorations (for example, Shackleton's voyage to Antarctica), and recent scholarship on climate change and polar history. Along the way we will look at questions of conflict between the technologies of developed nations and indigenous peoples' habits of sustainability; the geopolitics of research stations; art activism; documentary filmmaking; polar tourism; and the fate of polar species in an environment whose climate is rapidly shifting. In short, the course is an advanced introduction—no prerequisites other than the HSS core sequence—to an interdisciplinary subject that touches upon history, science, technology, politics, literature, and art. *3 credits*

HUM 325 **Puppet, Automaton, Robot**
They are us, and not us: puppets, automata, and robots are toys or machines that look like us (or parts of us). From antiquity to the present, we have imagined, and then invented, organic and inorganic versions of ourselves, sometimes for entertainment, sometimes to perform essential tasks. This course will draw upon an interdisciplinary range of materials –from philosophy, the history of science, anthropology, and psychoanalysis to literature, popular culture, and art. Instead of separating the "scientific" from the "poetic," this course will introduce and explore ways in which we can think about what we want from our "artificial life," and how the boundaries between the living and the non-living require constant rethinking. *3 credits*

HUM 327 **The History of the Cinema**
A history of the motion picture from its origins until now, emphasizing the evolution of the language of cinematic representation—in feature, documentary, animated and experimental filmmaking. Canonical works and the major figures of the silent and sound cinema are treated, including Griffith, Chaplin, Eisenstein, Vertov, Renoir, Welles, Deren, Hitchcock and Godard. *3 credits*

HUM 330 **Postmodernism and Technology**
This course will explore postmodern theory and practice and its relationship to the problems and solutions posed by technology in contemporary society. *3 credits*

HUM 331 **Eros in Antiquity**
This course will study the theory and practice of love in the ancient world and its legacy in the modern. Working with primary textual sources, the course will consider Plato's erotic dialogues and writings from the Neo-Platonic tradition extending up to Shelley's poetry as well as Ovid's Amores and the Art of Love. These major texts will be supplemented with examples of erotic poetry from ancient Egypt, Mesopotamia, Archaic and Classical Greece, and Rome, as well as works of visual art. *3 credits*

HUM 332 **Lucretius, On the Nature of Things**
On the Nature of Things Stephen Greenblatt's Pulitzer Prize-winning 2011 book, The Swerve: How the World Became Modern, re-introduced Lucretius and his amazing philosophical epic poem, De Rerum Natura, to the modern world. Its title derived from the most famous theory associated with the Roman philosopher/poet, Greenblatt's book features a fascinating chronicle of the discovery in 1417 by Poggio Bracciolini, in the library of a remote German monastery, of the only surviving manuscript of Lucretius' Latin text. Greenblatt skillfully interweaves a real-life detective story with a comprehensive account of how this chance discovery caused the modern world itself to "swerve." The Swerve (via Greenblatt's energetic style and flair for story-telling, no doubt) has inspired a resurgence of interest in this relatively little known but highly influential Epicurean philosopher of the first century B.C.E., whose magnum opus, De Rerum Natura (best translated, "On the Nature of Things"), stands as the richest extant repository of our knowledge of ancient atomism and Epicurean philosophy, otherwise lost with the exception of a few fragments of Epicurus, himself. On the Nature of Things is hands-down the most important philosophical poem ever written (what a delightful way to get your philosophy!), and the single most important source for our knowledge of one of the most important and influential schools of Hellenistic philosophy, Epicureanism. But it is also an exquisitely beautiful work of poetic art and a gold mine of information and ideas on subjects as wide-ranging as

mythology, religion, morality, science, sex, cosmology, geology, history, horticulture, agriculture, meteorology, astronomy, humanism, sociology, the senses, pleasure, life in the late Roman Republic, and much more besides. The course, which will be conducted seminar-style, focuses exclusively on a close-reading of the six books of De Rerum Natura in translation (the instructor has also read much of the text in the original Latin), ending with a reading of Greenblatt's The Swerve and a discussion of the modern reception of Lucretius. Along with the text of Lucretius, we will read excerpts of many additional primary texts which either influenced or were influenced by De Rerum Nature. *3 credits*

HUM 333 **The Age of Augustus**
Augustan Rome presents the only serious ancient contender for comparison with the "Golden Age" of Periclean Athens. In all categories of art, architecture, and literature, the age of the first Roman emperor, Augustus (27 BCE-14 CE), rivals that of high Classical Greece. The course thus combines the disciplines of history the visual arts, and literature, with the heaviest emphasis on literature to arrive at a comprehensive picture of a relatively short, but disproportionately consequential moment in the history of civilization. *3 credits*

HUM 334 **Plato's Republic**
A seminar devoted entirely to a close reading and critical analysis of Plato's greatest dialogue, the Republic, and its reverberations down through the ages as a model of political theorizing, if not a template for an ideal society. As we work through the text book by book, we will create our own "Socratic dialogue," that is, a series of problems, questions, deliberations, and considerations that would run parallel to the text, with the ultimate aim of assessing what Plato means, and intends, with this enigmatic work. Comparative material in the form of historical and contemporary (to Socrates and Plato) influences, precedents, and references will be introduced where appropriate. We will then venture briefly into the analogous genre of "utopian" literature which the Republic inadvertently engendered, finishing with the most influential modern critique, that of Popper. *3 credits*

HUM 335 **Pythagoras: The Philosophy of Number**
This course explores the intense and extensive intellectual activity of the Pythagorean school, which extends from mathematics to philosophy, from cosmology to music, and whose legacy had a decisive influence from the Greek world to the Renaissance. For the Pythagoreans, in effect, those we now consider as separate disciplines were inseparable aspects of a unique inquiry, inspired by a mystical enthusiasm and carried out through a profound philosophical and mathematical search. In Pythagoreanism,

then, sifted through Platonic philosophy, we may find the first historical antecedent of many of the components which contributed to the birth of the modern world. The course starts from such premises and explores the meaning and the implications of the mysticism of number in Pythagoreanism, with particular emphasis on its influence on mathematics, art, and philosophy. Advanced knowledge of mathematics is not expected of students taking the course. *3 credits*

HUM 337 **Philosophy & Contemporary Art**
It is not easy to express the 'meaning' of art. Even less, certainly, in the era of post-modernity, when not only the splintering of perspectives prevents from seeing a single line, but the artist, along with the search for meaning, definitively renounces the idea of defining what art should be, merely expressing the 'appearance of an instant'. Hence that fragmented nature concerning both the works and the reading of the art of our time. As Adorno writes in his Aesthetic Theory, it is precisely through a fragmentary form, through a 'synthesis of the diffuse' which renounces the idea of consonance, that art can express the reality of our time. Still, it is not possible to escape this need to express the inexpressible, even knowing that thought can only approach the essence of things, never achieving it. But it is precisely through this, as a negative presentation, that such an invisible essence can sometimes be understood. *3 credits*

HUM 348 **Greek Tragedy**
An in-depth introduction to Greek tragedy, both as literature and performance. The methodology throughout will be close-reading, using comparative translations, with portions of the texts performed in class. The genre of tragedy will be presented against the background of its historical and cultural context, Athens of the fifth century, BCE. The most significant surviving ancient critical treatise on Greek tragedy, Aristotle's Poetics, will be measured against the authority of surviving works. Some important secondary readings will be assigned, but the emphasis throughout will be on primary source materials. *3 credits*

HUM 352 **The Personal Essay**
In this course we will study and discuss essays in Philip Lopate, ed., The Art of the Personal Essay, and we will also write our own, on any topics we choose, on all manner of subjects—the daily round, pleasures and pains, taking a walk, solitude, friendship, social issues, in short, our personal responses to any number of topics and situations, enlarging ourselves in the process. *3 credits*

HUM 355 **Race & Gender in Literature**
In this course we will engage different contexts in which women have been and are communicating their responses to the social, political, religious, and engendered conditions of their respective nations. Our themes include the politics of canon formation, the challenges of language, "Third World" and Western feminism. Thus, we consider the larger traditions into which women's writings have been absorbed, or which their writings resist, or change. We will explore the following questions: Can we probe the traditional value of mothers and wives with the gender roles and behavioral expectations that go with them, without banishing them from the realm of political resistance or without reifying them? What rhetorical or narrative methods are used to express gendered realities where acts of writing do not always equate with authority, truth, or stability? How are politics inscribed on the gendered and racialized body? What narrative styles are deployed to articulate gendered participation in the national fabric? While we engage primarily in literature, we will also consider music and visual art. The works we will explore include Sojourner Truth, Jamaica Kincaid, Assia Djebar, Betool Khedairi, among others. *3 credits*

HUM 356 **Issues in Contemporary Fiction**
Study of literary topics including particular genres, themes, sensibilities and critical approaches. The focus of this course will change in individual semesters. *3 credits*

HUM 358 **Studies in Cinema**
A seminar based on a special topic in the study of cinema. The seminar may be repeated for credit with the permission of the dean of the Faculty of Humanities and Social Sciences. *3 credits*

HUM 363 **Caribbean Societies**
The Caribbean region is known for lush landscapes, pristine beaches, and iconic bits of culture such as reggae, Rastafarianism, salsa, calypso, and carnival. The beauty of these islands belies serious economic, political, and social issues of which visitors are generally unaware. However, the history and cultural practices of the region paint a different picture. In this course, we will examine how the earliest institutionalized and intertwined forms of violence and economics--including genocide of the indigenous population, slavery, the rise of the plantocracy, and the impact of globalization on the economies of the region—and their attendant/resultant forms of cultural production continue to shape present Caribbean life. We will examine the various systems of colonial and imperial power, past and ongoing, and their lasting impact in various ways across the region. Finally, we will consider the idea of the Caribbean as a haven for tourists that depends upon a sanitized representation of the region's

history of institutionalized violence and exploitation. We shall conduct our investigations through film, literature, history, sociology, and theory. Students will submit weekly 2-page analytical response papers before weekly meetings, and a final 10-page argument driven sourced essay grounded in questions, issues, problems and concepts arising during study. *3 credits*

HUM 373 **Seminar in Humanities**
Seminar giving close attention to special topics in the Humanities.
May be repeated for credit with the permission of the dean of the Faculty of Humanities and Social Sciences. For Fall' 20 topic will be HUM 373 H Seminar: Literature of Climate Change and Sustainability-Writing Climate Change 3 credits

HUM 374 **Contemporary Culture and Criticism**
A survey of the cultural climate since the 1950s, including the influence of works by such writers as Benjamin and Bakhtin and the concern with contemporary life in terms of fundamental shifts in community, representation, identity and power. *3 credits*

HUM 375 **Critical Theory**
This course begins with the post World War II generation of social thinkers and critics, such as Barthes, de Beauvoir, Foucault, Adorno, Horkheimer, Lacan, in the development of what later became known of as the critical theory of culture. We then proceed to more recent critics, each time taking our clues from real life examples. This course emphasizing learning how to "see" and think in "cultural practices." It offers a chance to have our understanding extended into everyday life and its ways of making us cultural beings. *3 credits*

HUM 383 **Opera**
This course will examine the history, materials and structures of opera, a rich and complicated art that is both musical and theatrical. We will address such topics as the origins of opera in 17th-century Italy, the Baroque style, the art of bel canto, opera and politics, Wagner's revolutionary ideas, realism and impressionism in music, experiments in tonality, and opera in English. Several works will be considered in detail. Classes will combine lecture-discussion and screenings of performance on DVDs. An interest in music is essential, but no ability to read scores or play an instrument is required. *3 credits*

HUM 392 **Ethics**
Did human beings invent ideas of right and wrong? Are there such things as moral facts, that is, facts that dictate how we ought to live and what sorts of actions are worth pursuing? This course surveys three central traditions in ethical theory in the West as typified by the works of Aristotle, Immanuel Kant, and J. S. Mill, together with a radical critique by Friedrich Nietzsche and ending with selections from 20th-century philosophy. *3 credits*

HUM 394 **World Religions**
An introduction to the five major world religions: Hinduism, Buddhism, Judaism, Christianity and Islam. The course considers ancient and contemporary religious practices as it examines faith and belief, ritual, scripture and scriptural interpretation, religious art, orthodoxy and heresy, mysticism, and pilgrimage through a comparative lens. Focus is on origins, textual traditions and central doctrines with further attention to religion "on the ground" as a living and evolving phenomenon. *3 credits*

HUM 99 **Independent Study (Humanities)**
Only juniors and seniors in good academic standing are eligible for independent study. Independent study may be taken for a maximum of two credits per semester. The student must obtain permission of both the instructor and the dean of the Faculty of Humanities and Social Sciences. The major consideration in approving proposals for independent study is the educational value of the study project within the structure of degree requirements. The Faculty of Humanities and Social Sciences insists on very high standards as a condition for approving any independent study project.

SOCIAL SCIENCES

SS 304 **Economic Growth and Innovation**
Economic growth is the oldest sub-discipline in economics. It is technically the core of economic policy because growth makes people better off in the long run. Economic growth is closely related to various other sub-disciplines, such as economic demography, human capital, productivity and technological advances, macro-economic policy, and public policy. In addition, studying economic growth calls for a survey of both economic and general. This may, therefore, be one of the most interdisciplinary courses you will take, where you get to see how economics interacts with other social sciences.

In this course, emphasis will be placed on theoretical development, issue discussion, and policy formulation. In the first half of the course, we will go over the development of growth theory starting from Adam Smith's capital accumulation to Romer's endogenous growth theory. We will explore how modern growth theory relates to human capital accumulation and innovation. We will hold comparisons between developed and developing countries and try to think why fast-growing economies might end up stagnating. In the second half of the course, we will look at case studies in an attempt to link the theoretical models to countries' experiences. This part of the course will mostly be led by students, based on their research and in-class presentations.

Those with existing knowledge of Macroeconomics will be especially suited to this course. Student self-study groups will be established for the review of algebraic equations and basic concepts of macroeconomics to make sure everyone is on the same page. *3 credits*

SS 305 **Leonardo, Scientist and Engineer**
This course uses the life and work of Leonardo da Vinci (1453–1519) to explore science, medicine, engineering and art in Renaissance Europe. We will use Leonardo's notebooks, work of his contemporaries and writing about his interests across the centuries to examine the institutions and influences that served Leonardo's imagination, his inventiveness, and his arts. *Same as HUM 305. 3 credits*

SS 308 **Public Policy in Contemporary America**
Issues such as conservation, environmental law and policy, mass transportation, transfer of development rights, incentive zoning and historic preservation, beginning with an introduction to and general analysis of the policy process.
3 credits

SS 318 **Seminar in Social Science**
Seminar giving close attention to special topics in the Social Sciences. Recent topics have included sustainability and the economy. *May be repeated for credit with the permission of the dean of the Faculty of Humanities and Social Sciences.*
3 credits

SS 321 **The American Presidency**
The nature and sources of the power of the American presidency, the ways in which it is wielded and the Constitutional restraints upon its exercise. *3 credits*

SS 323 **Politics and Collective Memory**
The political uses of collective memory can range from defining national and social identities to shaping public opinion. In exploring the interactions between memory and politics, this course will focus on the nature and forms of collective memory, its development and reconstruction and its relationship to structures of authority. Emphasis will be placed on examples from recent political history. *3 credits*

SS 333 **Politics of Ethnonational Conflict**
An examination of the movements for national liberation and independence that have become an increasingly important phenomenon in the second half of the 20th century. Among the movements considered are those of Algeria, Nigeria, Cyprus, Bangladesh, Northern Ireland, Quebec, Lebanon and the PLO. *3 credits*

SS 334 **Microeconomics**
This course presents an overview of the principles of theeconomics of scarcity and choice; supply and demand; output and price. It utilizes marginal analysis as well as theories of the firm. It considers the market system in terms of both its virtues and vices. It focuses especially on the distribution of income and the labor market of the United States but also includes a section on the stock and bond markets. In addition, it covers the role of government in the economy. *3 credits*

SS 335 **Science and Technology in the Long 18th Century (1687-1839)**
This course will examine the changing roles of science and technology in the West during the 18th and early 19th centuries. We will use a case-study approach to consider such topics as color in theories (light and optics) and color in practice (painting, dyeing and glassmaking); geology mineralogy and the development of ceramic industries in Europe; the invention, use (and misuse) of the natural classifications; and automation and automatons: Vaucanson's duck, Jacquard's loom, Babbage's Difference Engine. *3 credits*

SS 339 **African History: History of West Africa**
This course is an introduction to some of the major themes and debates in the study of West African history. Students will gain an appreciation for the diversity, depth, and dynamism of West African history. Students are encouraged to think broadly about historical processes, lasting changes, and the movement of people and ideas across geographic and intellectual space. The course is rooted in West Africa, but it places West Africa and West Africans at the center of dynamic global movements. We will study how Africa and Africans shaped many world orders, from Islam to the Atlantic World to the Third World. This course begins with the great West African empires and

continuing through the eras of slave trades, the formation and consolidation of the Islamic and Atlantic worlds, and the end of colonization. We conclude with some post-colonial questions and debates with great bearing on independent Africa. Throughout the roughly 700 years this course spans, we will ask questions about long-term processes of change. How have states and state power changed over the course of the seven hundred years or so this course covers? Equally importantly, how have people's relationships to states changed? How did Africans build new forms of power and authority? How did they resist others? How did different dividing lines—ethnic, gender, race, and class—change over time in African social, political, and cultural life? *3 credits*

SS 340 **Cause and Effect**
Does providing social welfare benefits spoil the poor? Do Nike ads increase their shoes sales? Does having an Amazon Prime membership leads you to buy more from Amazon? Does health insurance improve people's health? Does hiring a new professor improve the academic performance of Cooper students? Does giving aid to poor countries improve their economic performance? We can get data on all these variables and run regressions and come up with answers, but are they the right answers? Probably not. In all these questions, the direction of the causation can go both ways (For instance, with a Prime membership you are more likely to order from Amazon because it is easier, but also you probably got the Prime membership because you shop online a lot). Also in all these question, there is a potential that other factors can affect the relationship and in most cases we cannot control for all these factors. Therefore, simply running regressions does not necessarily give us the right answer. This course will help you think about how to answers these cause-and-effect questions. After taking this course, your attitude towards the world will change. You will doubt many claims that are being thrown at you by news reporters, President Trump (definitely), and even your professors! The course will teach you to think systematically about various types of cause-effect questions and use various types of datasets to try to answer them. You can apply the skills you learn in this course to questions in economics, psychology, business, politics, and even the sciences. *3 credits*

SS 342 **Anthropology of Ritual**
The study of ritual takes us to the heart of anthropological approaches to experience, performance, symbolism and association. Once thought to be "vestigial" organs of archaic societies, rituals are now seen as arenas through which social change may emerge and are recognized to be present in all societies. Throughout the course we will explore varying definitions of ritual and its universal and particular aspects, while surveying ethnographic case studies from around the world. *3 credits*

SS 345 **The Raymond G. Brown Seminar: Varying Topics**
A seminar in the Social Sciences on a topic central to the interests of the late Professor Raymond G. Brown. For the Fall' 20 semester, we will examine Sociology of Race and Ethnicity *3 credits*

SS 346 **Urban Sociology: Reading the City**
Over 75 percent of Americans and 40 percent of the world's population live in urban areas. These figures are growing. Consequently, the city has become one of the most important and powerful social phenomenon of modern times. It is therefore imperative that we come to understand its influence on our lives. This course will provide a basic introduction to urban life and culture from the framework of urban sociology. Classic and modern theories of urbanization and urbanism will be examined in order to understand the historical growth, decline and renewed growth of cities, along with the lifestyles they evoke. While the main frame is a sociological one, perspectives taken from urban planners, architects, landscape architects, artists, political economists, and writers will also be incorporated as will economic and political dynamics and their role in creating and resolving problems. Most importantly, we will consider the effect that urban environments have on our social interactions and daily lives. *3 credits*

SS 347 **Macroeconomics**
The development of modern macroeconomic theory as it evolves in response to a succession of economic problems and crises. Emphasis on the recent Keynesian/monetarist debates and the role of the Federal Reserve Bank. *3 credits*

SS 350 **Colonial Cities**
Colonial cities were major centers of trade, commerce and manufacturing, attracting money and immigrants from across the world. By focusing on the ways in which they shaped industrialization, urbanization and culture production, we will learn about technology and modern work practices, developments in housing, infrastructure and urban planning, new ideas of political resistance and artistic expressions of discontent that originated in these cities. In doing so, we will highlight the prominent role of colonial cities in shaping modern cosmopolitan life as well as the lasting legacies of colonial rule. *3 credits*

SS 351 **20th Century History "What we are talking about when we talk about Fascism"**
This is a transnational history course that seeks to sharpen our thinking about definitions and resonances of fascism; it examines the past and asks, how such investigation might help us to act in the present when we confront situations that seem to be, or are quickly termed, "fascist." Using theoretical and historical sources, we will study the European origins of fascism beginning with the dramatic upheavals of World War 1 and the interwar years through World War II, the Holocaust, and its aftermath, and then turn our attention to the development of a new global authoritarian populism and right-wing nationalist xenophobic leaders and regimes in the 21rst century. We will examine historical roots and current appeal as well as efforts at resistance, in a variety of contexts from Britain, Western and Eastern Europe to Russia, India, the Middle East, and East Asia. All of our work will require close analysis of entangled categories and experiences of race, class, nation, and gender and reference to "current events' in the United States as well as globally.

General Course description: A study of the dramatic ruptures of Europe's 20th century, haunted by imperialism, war and genocide. Topics include the First World War; modernity and modernism in interwar culture; fascism, National Socialism and the Holocaust; postwar displacements and migrations; decolonization, the cold war and the postwar economic miracle; 1968 and 1989 in both East and West; and the ongoing challenges of integration and multiculturalism. *3 credits*

SS 352 **Environmental Sustainability**
This course will be a dialogue on sustainability, the concept of a society that flourishes by living within the limits of, and in harmony with, the natural environment. Taking an integrative approach to all aspects of sustainable development, the course will stress the ecological character of human life and human history, how both have been shaped by the natural environment and have shaped it in return, and how issues of environmental sustainability shape our lives and careers. *3 credits*

SS 354 **New York, 1820-1920: An Urban and Cultural History**
A presentation of two "maps" to the city. The first is a history of the built environment, focusing on the changing systems of transportation, the development of building forms and the way the city's population and functions have been distributed in that space. The second historical map is made up from people's imaginative responses to those changes, especially as seen in literature and visual iconography. Among the areas singled out for special examination are the Bowery and the Lower East Side, Central Park and the "downtown" of amusement and vice, wherever it happened to be at the time. *3 credits*

SS 358 **Social History of Food**
A study of the transformations in food production and consumption, 1492 to the present. The course examines the passage of "new world" foods into Europe and Asia, the rise of commercial agriculture in the colonies, especially sugar, the rise of national cuisines, the advent of restaurant culture and the perils of fast and industrial food. *3 credits*

SS 360 **American Intellectual History**
A study of major works in intellectual and literary history written from 1780 to the present, focusing on changing notions of the self, character and community and the ways these concepts have gained intellectual and literary expression in the United States. *3 credits*

SS 361 **Urban Archaeology**
New York City will serve as our model for exploring how the history of urban land use is illuminated through archaeology, and what archaeological excavation in an urban context entails. In class lectures and field trips, we will look at the geography and physical history of the city as preserved both in documents and in the archaeological remains of sites and artifacts characteristic of its successive culture periods from the prehistoric era to the early 20th century. *3 credits*

SS 369 **Cognitive Pyschology: Conversations on Consciousness and Attention**
Consciousness is often called the main mystery in cognitive science. At the same time conscious experience seems to be trivial, we don't see changes in our awareness until we make a mistake in a simple cognitive task or someone tells us that we missed something salient. Consciousness studies is a multidisciplinary field in science that includes approaches and methods from neuroscience and physics, philosophy and anthropology, artificial intelligence and linguistics. We will try to learn more about the contribution of all these sciences, all aimed at answering one question: "What does it mean to have consciousness?" Some representative questions we will be discussing are: What is the function of consciousness? How intelligent is the unconscious? What is the relationship between consciousness and attention? Can a machine ever be conscious? Is consciousness fundamental in the universe (as Eastern philosophies argue) or did it emerge as matter became ever more complex (as Western science insists)? Is there a stream of consciousness or is this just an illusion? What could happen if we didn't have consciousness? The course brings together modern and historical ideas to give a perspective on how the problem of consciousness could be addressed. Each topic presents a question that we will try to answer, each topic includes reading part, demonstration of effects and experiments and a small written review task. *3 credits*

SS 371 **"Am I That Name?" Topics in Gender and Sexuality**
This course offers an introduction to the fields of inquiry that have come to be known as women's, gender, and/or queer studies, and to the feminist theory that informs those studies. Students will engage in an interdisciplinary examination of the ways in which gender (that is, feminity and masculinity) has been constructed by visual media, literature, political theory, and social, political, and economic institutions; the historical bases for these constructions; and the activism that challenges some of these gender constructs. We will pay particular attention to the interlocking of gender with other forms of hierarchy, including race, ethnicity, class, and sexuality. We will read current scholarship in works of literature, film, history, social science, and theory, but above all, we will work our way through some of the "canonical" texts which inform that current scholarship, theory, and indeed popular culture (and our own ideas about women and men, gender and sexuality). *3 credits*

SS 372 **Global Issues**
This course will examine current issues of global significance and their implications for policy and decision-making. Among the trends we will consider are the tensions between resource competition and authority; the emergence of a global economy; the environment and sustainable development; demographic change; and the emergence of new security issues, including societal and environmental stress. *3 credits*

SS 374 **Contemporary Social Psychology**
Utilizing a variety of social psychological perspectives, general issues such as human nature, socialization, attitude formation and change, verbal and non-verbal language, interpersonal behavior and the art of persuasion will be explored with interest in cross-cultural comparisons. The core questions we will explore include: What does it mean to be human? How is the self defined and determined? What impact do social groups, culture and the (built) environment have on the development of the self and on our everyday behavior? *3 credits*

SS 382 **Game Theory**
Since its introduction in 1943 by John von Neumann and Oskar Morgenstern, the general theory of games has been instrumental to our understanding of various social behaviors. With key contributions of such renowned scholars as John Nash, Kenneth Arrow, Thomas Schelling and John Harsanyi, among other Nobel Laureates, game theory has quickly gained a large following among students of economics, evolutionary biology and even political science. Though at times seemingly abstract, game theory has shown us that it has practical value with applications in firm-level management and strategic decisions making in military campaigns. The course has two dimensions: the first is to explore the theoretical basis of games; the second is to consider the application of these concepts in economics and political science. *3 credits*

SS 384 **Anthropology and the Other**
This course provides an introduction to concepts in social-cultural anthropology. Students will rethink such concepts as culture, race, ethnicity, nationalism, transnationalism, gentrification, power and memory. We will use these concepts to address the questions of human universals and the origins of cultural differences. At the bases of these inquiries will be the question of the "Other." Who are the "Others" in culture or society? *3 credits*

SS 390 **The Rise of the Modern City in the European Middle Ages**
Explores how early medieval landscapes with castles and small villages became wider communities—the first modern cities. Focuses on the major debates of the Middle Ages: the tensions between country and city life; the role of the church; Scholasticism; the debate between reason and faith; the role of the French cathedral in medieval life; the lay reaction to ecclesiastical control and the rise of communal Italian cities such as Florence, Venice and Siena centered around the civic palace; and the early requirements for city beautification. We will "visit" (virtually) the first hospital, universities and prototypical housing. Everyday life will be illustrated from the material remains of art and architecture through a cross section of different social environments. *3 credits*

SS 391 **Introduction to Mind and Brain**
The goal of this is to introduce the student to the basic principles of psychology, to guide the student through the brain and to provide a basic understanding of the relationship between the brain and mind addressing issues of consciousness. The first third of the course will examine the brain and underlying theories in psychology. The majority of the course will be focused on the relationship between the brain and consciousness including self-awareness, theory of mind, deception, abstract reasoning, art, music, spatial abilities and language. Steeped in recent findings in both psychology and neuroscience, the goal of this class will be to provide a modern foundation in the mind and the brain. *3 credits*

SS 99 **Independent Study (Social Sciences)**
Only juniors and seniors in good academic standing are eligible for independent study. Independent study may be taken for a maximum of two credits per semester. The student must obtain permission of both the instructor and the dean of the Faculty of Humanities and Social Sciences. The major consideration in approving proposals for independent study is the educational value of the study project within the structure of degree requirements. The Faculty of Humanities and Social Sciences insists on very high standards as a condition for approving any independent study project.

HISTORY AND THEORY OF ART

Core

HTA 101, 102 **Modern to Contemporary: An Introduction to Art History**
This two-semester art history core course, developed as part of the Foundation year for students in the School of Art but open to all students, is organized around a set of themes running through the history of modernity from the 18th century to the present. Within specific themes, significant works, figures and movements in art/design will be presented chronologically. Students will be able to identify and critically evaluate significant works, figures and movements in art/design in the modern period; be able to describe the main social and political contexts for the changes in art/design over the last two hundred years; and engage, in writing and class discussion, with theoretical perspectives on art/design production. The course will involve museum visits. Grading will be based on class participation, papers, and exams. *2 credits each semester*

Electives

HTA 209 **Medieval Art and Architecture**
Investigates the art, architecture and archaeology of medieval Europe from Constantine (fourth century) to approximately 1450, a period when different cultures clashed and mixed together to shape the eclectic Western medieval world that rose from Roman imperial ruins and ideals. This course will follow a chronological sequence, but use recent data from medieval excavations to challenge traditional art historical statements. Early Christian, Byzantine, Barbarian, Islamic, Romanesque and Gothic periods are examined. *2 credits*

HTA 211 **The Renaissance in Italy**
An investigation of the art produced during the 15th and 16th centuries in Italy, where a revival of classical learning led to an unprecedented artistic flowering. In painting, the course deals with the period from Fra Angelico to Titian; in architecture, from Brunelleschi to Palladio; and in sculpture, from Ghiberti to Michelangelo and Benvenuto Cellini. The course will touch on such themes as the classical ideal, town planning, country villas, fresco painting, patronage, the development of perspective, and the rise of the portrait. *2 credits*

HTA 220 **Japanese Art**
An introduction to the art of Edo period Japan (1603-1867), covering painting, print-making, and the allied arts. *2 credits*

HTA 221 **Buddhist Art: Origins to Modernity**
As a part of the ongoing discourse on the tripartite interrelation among art, religion and modernity, this class investigates "Buddhist art," the visual culture of one the world religions, rooted in the premodern societies of India, Central, South East and East Asia and Tibet, from which its distinctive material forms, visual principles and ritual practices developed. More recently, the presence of Asian Buddhist material/visual cultures has asserted itself anew through transnational exchanges and confrontations, particularly between Asia and the modern and contemporary West. This course attempts to historicize this phenomenon by taking a macro approach to Buddhist art (without sacrificing specifics related to individual cases) by investigating two possible constituents of modern/contemporary Buddhist art: its core historical principles carried over from its origins, which have been considered "timeless," and its uniquely "timely" complication of or deviation from its original systems.

We will spend half of the course studying some original principles of historical Buddhist art in areas such as visuality, representation, copy, agency, function and performativity, while quickly tracing the geo-historical spread of the religion throughout Asia over a period of more than 2,400 years. In this section, we will visit selected works and sites that represent some typologies of premodern Buddhist art, such as relics, icons, mandala, pagoda, gardens and "Zen art," and examine them in "context," i.e., concerning their relations to the ritualistic/symbolic practices and fundamental philosophy of the religion. The latter half of the class will explore the issue of collisions in modernity between two claims: an insistence on the immutability and authenticity of persistent premodern systems of Buddhist art and experimentations reflecting the ever changing globalizing identities of the religion and regions in Asia, corresponding to recent social, political and cultural landscapes, including museum displays, temple politics, Orientalizing commodification and appropriation by avant-garde artists. *2 credits*

HTA 231 **History of Industrial Design**
In tracing the history of industrial design from its emergence at the beginning of the Industrial Revolution to the present, this course will examine not only aesthetics (of furniture and the decorative arts, typography, advertising, machinery, toys, etc.) but also the social and political forces that have shaped the many styles. Throughout, we will also demonstrate how movements in industrial design relate to parallel developments in the history of painting, sculpture, and architecture. *2 credits*

HTA 232 **Is Painting like Poetry?**
Inspired by the famous dictum, "ut pictura poesis" (literally, 'as painting, poetry,' or more loosely, 'poetry is like painting'), from Horace's Art of Poetry, the course examines the interconnections between literature and the visual arts, whether as rivals or as allies, from antiquity through the present. A diverse group of topics will be considered, within a specific historical time frame and context, with the goal of seeking a common ground for a discourse with which to evaluate the nature, significance, and aesthetic parameters of each of the two modes of expression in the shared enterprise of the representation of reality and/or the world of ideas. *2 credits*

HTA 240 **Asian Contemporary Art**
Chinese Contemporary art for Spring 2018. Over the past three decades, modern and contemporary art scenes have spanned the globe and thus had a great impact on Chinese art. A greater number of Chinese artists have emerged and addressed in their work the issues of modernity contemporaneity in China in terms of political tensions, cultural conflicts, globalization, changing social and family conditions, as well as gender issues within their own cultural context. Topics of the course will cover political Pop, installation art, New Literati Paintings, experimental ink paintings, conceptual art, performance art and feminist art. We will attempt to investigate the phenomena of social-political transition in contemporary China as the background of its contemporary art, the impact of western ideas on the Chinese contemporary art world and their various interpretations, as well as the struggle to maintain tradition and cultural identity. *2 credits*

HTA 263 **African Art**
An introduction to the stylistic, conceptual, functional and historical aspects of sub-Saharan African sculpture and architecture, the place of these arts in the traditional context of black African life and their relationship to the worldview of the African.
2 credits

HTA 264 **Contemporary Artists of the Black Atlantic (1960's-Present)**
This course explores the contemporary work of artists of African descent based in Africa, Europe and the Americas from the Black Power Movement in the United States and the Independence era of Africa to the present day. This course will probe the assertion of "black Atlantic identities" and will include photography, installation art, as well as internet based work. *2 credits*

HTA 270 **The Art of Greece and Rome**
An introduction to the sculpture, painting, and architecture of ancient Greece and Rome with attention to the impact of the classical imagination on the art of succeeding ages. *2 credits*

HTA 273 **History of Photography**
Writing by the critics, historians and photographers that have influenced creation and reception of photography throughout its history. Issues include definitions and redefinitions of art, documentary debates and revisionist canons and histories. *2 credits*

HTA 275 **Twentieth-Century Art History**
Considers the flourishing "isms" of the 20th century, as well as historical events, intellectual currents and conflicting aesthetic views. For Fall' 20 semester we will examine: Multiculturalism and Identity Politics through the Lens of Curatorial Practice. *2 credits*

HTA 278 **Modernism in Latin America**
This course examines the emergence and development of Latin American modernisms in their so-called first and second waves. The first one, which unfolded from the 1920s to the 1940s in Brazil, Mexico and Cuba, witnessed the artists' combination of imported European avant-garde tendencies—such as post-impressionism and Cubism—with local motifs to produce an art that could reflect a national identity. The second wave pertains to the post World War II raise of abstract tendencies in South America, specifically, concrete abstraction in Argentina and Brazil, and op and kinetic art in Venezuela. Artistic modernisms in the region will be studied in connection with the political and cultural context in Latin American countries, specifically, the process of nation-state building, the rise of populist ideologies, and the incidence of developmentalism in the Southern Cone during the 1950s and 1960s. We will analyze a range of artists, such as Tarsila do Amaral, Candido Portinari, Diego Rivera, David Alfaro Siqueiros, Frida Kahlo, Wifredo Lam, Mario Carreño, Pedro Figari, group MADÍ, Lygia Clark, Helio Oiticica, Carlos Cruz-Diez and Jesús Rafael Soto. Topics might include: the strategies of modernity in Latin America, the new concept of "inverted utopia," the role of the avant-garde group manifestos, the post-colonial, and the meaning of abstraction within a turbulent political milieu. We discuss crucial concepts that define cultural modernism in Latin America; among them, identity, indigenismo, costumbrismo, transculturation, syncretism, hybridization, and race politics. *2 credits*

HTA 280 **International Futurism**
Futurism (1909-1944) was the first avant-garde movement to emerge from the peripheries of modernity. Founded by Italian and Egyptian artists, Futurism embraced a problematic ideology. Yet the movement has functioned ever since as a strategic model for several groups of artists fighting against dynamics of exclusion. The first part of the course focuses on Futurism and its international network. The second part discusses more recent artistic movements from Russia, Argentina, Japan, Italy, and the US, which have adopted Futurism's guerrilla-like methods to strike an attack on the hegemonic center. *2 credits*

HTA 281 **Ancient Mediterranean World**
This course is intended to address selected topics concerning the reciprocal relationships among the fascinating and diverse civilizations of the ancient Mediterranean littoral and their neighbors to the East. The primary focus this semester will be on the Bronze Age-- the "Age of Heroes," to the beginning of the Classical era, and the setting of the Homeric epics, the Iliad and the Odyssey--with special emphasis on the interrelationships between Egypt, the Near East and the Greek Aegean during the time period ca. 3000 – 1100 B. C. We will look at the art, architecture, archaeology and a sampling of the literature of the periods and places under consideration. *2 credits*

HTA 283 **The "Genius" of the Baroque**
This course examines the genius of European Baroque art as distilled in the work of its greatest exemplars. We will also address the ideology of the counter-reformation church, the emergence of Protestant capitalism and a pluralist, bourgeois society in the north, patronage and social identity, propaganda, religious faith, skepticism, sexual identity and the family, all focused through the position of the artist in society. In no other period were body and spirit, sensual and sublime, so closely intermeshed. Art history resides precisely in the relation between our present interest in these artists and the past conditions in which they worked. *2 credits*

HTA 285 **Single-Work Seminar**
A seminar devoted entirely to a single monument or work of art that had a particularly profound and wide resonance in the socio-political, economic, and cultural milieu in which it was created and whose range of influence extended well beyond its historical time frame. The focused nature of the course material allows for both a breadth and a depth of analysis to a greater degree than is possible in other elective art history courses. Past topics have included Duccio's "Maesta." *2 credits*

HTA 296 **The Portrait: Re-examining Portraiture and the New Subject**
This course will re-examine the genre of portraiture beginning in the mid-19th century when photography enters discourse as an alternate medium to painting and sculpture. Starting with Nadar's studio practice we will trace new subjects that emerge during modernity. Likewise, we will investigate marginalized subjects that are newly represented during the 20th century in the works by James Van der Zee, Dorethea Lange, Gordon Parks and the social documentary movement. Contemporary figures in both photography and painting such as Andy Warhol, Alice Neel, Robert Mapplethorpe and Cindy Sherman will be examined. The course will question the reemergence of painting in contemporary practices by figures such as Kehinde Wiley, Martin Wong, Jordan Casteel and Kerry James Marshall. We will conduct a case study of the recent acclaimed exhibition "Posing Modernity: The Black Model from Manet and Matisse to Today" at the Wallach Gallery. *2 credits*

HTA 297 **History of Printmaking**
Explores the history of printmaking and its various processes from the 15th century to the present with an eye to the unique contribution of this graphic art to the history of visual language in both popular and fine art. While major printmakers (e.g., Durer, Rembrandt, Daumier, the Nabis, the German Expressionists, Jasper Johns) will be addressed, attention will also be given to the practical and popular use of prints through the centuries. *2 credits*

HTA 298 **History of Graphic Design**
A study of important avant-garde and graphic design movements starting with the Industrial Revolution through the 20th century including: Futurism, Dada, Constructivism, De Stijl, the influence of the Bauhaus and the New Typography, the rise of the modern movement in America, pre and post-war design in Switzerland and Italy, the International Typographic Style, the New York School, corporate identity, postmodernism and more. We'll examine the evolving design styles and the role of the pioneer designer in society, with an emphasis on notable works, subjects and themes; and their cultural, political and social connections. Course includes slide lectures, readings, discussions, looking at original materials (posters, advertisements, booklets, etc.), individual research assignments and written essays. *2 credits*

HTA 299 **Ceramics Within and Beyond Categories**
Ceramics, or fired clay, in its intrinsically multifaceted and global nature, resists a straightforward categorization, such as "crafts." It signifies a medium-defined genre of visual art, that of material culture as well as socio-political practices which have been prized around the world throughout human history. Due to the absence of a core mega-narrative and central theories, investigating ceramics across the globe can be

flexible and exploratory, dealing with various identities and cross culturally-connected and disconnected diverse lineages within its world history. This course will experiment with one scenario of the world history of the medium by unpacking ceramics as thing (material, technologies and objects), value (symbols, identities, aesthetics and concepts) and ritual (display, performance, community and daily life) through time and space. The class will proceed in two parts: reviewing selected historical episodes telling stories of contacts and exchanges; and introducing some major critical discourses and issues over the multivalent status of ceramics in relation to modern/contemporary art and society. As a point of entry to history, our global, chronological mapping will start with East Asia, one of the hubs of world ceramic cultures, examining its prehistoric and later enshrinement of the medium, and moving through the Ages of Exploration, Empires and colonial/postcolonial periods in Europe, Africa, Middle East. We will then return to an Asia in contact and conflict with 20th and 21st century Euro-America, where some artists/designers exploring ceramics' new potential as a distinctive material/medium have emerged as cultural celebrities. *2 credits*

HTA 300 **Single-Artist Seminar**
A course devoted entirely to the life and work of one important artist, selected anew from across the spectrum of world art each time it is offered. The seminar is designed to allow for an in-depth experience in the discipline of Art History that extends well beyond what is possible in period survey courses. For Fall' 20 the topic will be: HTA 300/ARCH 225.02 Single Artist: John Hejduk. *2 credits*

HTA 303 **Global Renaissance**
This course seeks to reframe the Renaissance in a global context by analyzing the migration of visual culture via conditions of reception and cross-cultural contact. In doing so, it revisits the euro-centric humanist model of the Renaissance and seeks instead to offer a new paradigm based on an analysis of global exchange. Themes covered include art, empire and propaganda, colonial identities, hybridity, rituals of devotion and the translation of sacred space. In addition to an understanding of post-colonial theory, and the cultural mediation of images, the course considers hybrid objects in the words of Homi Bhabha as not having a single fixed meaning, but as incorporating "slippages," that are part of the conditions of colonialism. It also offers up a critique of any analysis based on a simplistic framework of cultural parallelism, and seeks to present hybrids as having multiple and at times contradictory meanings evolving from cross-cultural exchange. In addition to lectures and readings, students will participate in one museum field trip. Attendance on this field trip is mandatory. Although the format of this class is a lecture, student participation in weekly discussions is encouraged and expected. *2 credits*

HTA 306 **Ephemeral Art**

This course will examine the notion of the ephemeral, in other words, objects and materials of short duration, and how they raise questions of time, materiality, and matter that relate to changing political, social, and cultural contexts. Art historians have long focused their attention on the singular masterpiece and their attendant notions of enduring value, aesthetic perfection, and the ideal. Yet recent scholarship in fields such as media studies have demonstrated that the ephemeral and obsolescence or the outdated have played an equal role in our understanding of the work of art and its materials. What if a work of art was meant to last for just 15 minutes? What would it mean to make a work of art that lasted the span of a snapchat? We will explore the notion of the ephemeral through a series of readings organized around conceptual terms such as dust, the archive, the monumental, celebrity, and happenings. Theoretical readings and class discussions will be anchored in the study of works of art ranging from paintings, sculpture, decorative arts, film, and performance art, from antiquity to the present. These discussions will be supplemented by visits to museum collections and conservation labs at the Metropolitan Museum of Art, the Morgan Library and Museum, and other institutions in the New York area. The aim of the course is to demonstrate that artworks are not only the object of an artist's intentionality, but subject to changing cultural perceptions of time. *2 credits*

HTA 312 **Art Beyond Sight**

This course develops from recent developments in museum education regarding the inclusion of a larger diversity of audience, namely visitors with disabilities. While this course will focus on the visual arts and its access to the visual impaired, it will also address various current initiatives beyond vision. Students will become familiar with the canonical and often rare literature on the subjects, including references in: access to art, museum education, blindness, sensorial perception, etc. Students become aware and evaluate the relevance and challenges presented by verbal description, conversation, sensory experiences, and creative practice as educational tools for in those programs. Along with the course, students will have the opportunity to meet professionals in the field of museum education as well as participants in museum programs for visually impaired visitor. They will also be given opportunities to work on tangible projects that could improve access to art. Then, one of the goals for this course is to give students firsthand opportunities to contribute to bridging the existing gaps between visual arts and the visually impaired audience. *2 credits*

HTA 313 **Seminar in Art History**
A seminar based on a special topic in the study of Art History. The seminar may be repeated for credit with the permission of the dean of the Faculty of Humanities and Social Sciences. For Fall' 20 topics include: HTA 313 A1 Seminar: Oral Art History; HTA 313 B1 Seminar: Rembrandt and Representation: Social Histories and Current Approaches; HTA 313 C1 Seminar: Holocaust Representation in Art; HTA 313 X Seminar: The Harlem Renaissance. *2 credits*

HTA 314 **Art Exchange Across National Boundaries**
The course focuses on the exportation and promotion of contemporary art across national boundaries, from the mid-20th century to the present. Exhibitions, publications, and artists' global mobility can function as vehicles of cultural dialogue and mutual understanding, but also as means of propaganda or cultural imperialism. We will study the exportation of art as a translation process and we will raise questions about the transformative effect of this process on both ends of the dialogue. *2 credits*

HTA 315 **Mysteries of Northern Renaissance Art**
This course examines some of the most hauntingly beautiful and enigmatic works in the history of art, from a period of deep religiosity and aristocratic ideals, emerging contrary middle-class values and exceptional artistic ambition and self-consciousness. We will begin with a solution for the still unsolved riddle of the Ghent Altarpiece and the birth of modern painting in the north, move through debates about disguised symbolism and new conceptions of the artwork in Robert Campin and Rogier van der Weyden, the crisis of modernity in Hieronymus Bosch and the emergence of a new (sublime) order in the art of Pieter Bruegel, among others. *2 credits*

HTA 316 **Monuments, Artist Interventions and the Struggle for Memory**
On August 12, 2017 white supremacist and Neo-Nazi groups converged on Charlottesville, Virginia to protest the city's planned removal of a Robert E. Lee statue. In the aftermath of the violence in Charlottesville, citizens in Durham, North Carolina took matters into their own hands, felling a Confederate soldier monument. This course considers the contentious debates involved in erecting and removing such artworks. We will ask: What visual strategies have artists used to commemorate controversial histories in the 20th-century Americas? How have subsequent generations questioned, reimagined, and subverted these strategies? The course centers on debates over racial justice and monuments to the US Civil War and slavery, but will also consider memorials to other violent histories across the Americas. Students will gain an understanding of public sculpture since the late 19th century, while also exploring embodied and ephemeral practices such as parades, reenactments, performance, and graffiti. *2 credits*

HTA 317 **Art and Architecture of Ancient Peru**
Introduction to the ancient cultures of Peru from about 3000 B.C.E. to the Spanish conquest, as seen in architecture, stone sculpture, ceramics, metalwork and textiles. *2 credits*

HTA 319 **Reading Surfaces: painting techniques over time**
The course will consider the histories of artists' materials, tools and techniques as they play out on the surfaces of primarily Western paintings c.1300-1800. Close and long looks will be given to paintings inside local museum collections. These sensory experiences will provide a tactile overview of past strategies to represent aspects of the world in two dimensions, from light to dark grounds, from direct to indirect application of color, and from egg to oil. Mechanisms by which paintings deteriorate, and the methods used to stall or quiet that deterioration, to restore the image, will also be observed and discussed. We will begin with 14th century Italian paintings and move forward in time with alternating focus on paintings from northern and southern Europe, and with connections and contrasts drawn to contemporary Ethiopian, Persian, and Latin American paintings. The relative sparseness of research focused on non-Western painting traditions will be critically engaged. Attention will be given to how technique can interact with content, how duration of gaze can manipulate perception, how mutability persists within every apparently static physical object, and how past methods of making can inspire those of today. *2 credits*

HTA 322 **Global Mediterranean Culture (391–1492)**
The focus of this course will be the Mediterranean Sea, between the late antique and modern period (ca. 391 and 1492), in a number of its distinctive manifestations, political, religious, social, cultural, and economic. Once upon a time, the Mediterranean Sea was possessively defined as the mare nostrum (our sea), and claimed by the Roman Empire or some other superpower. As a result, the Mediterranean, since then, has been viewed almost exclusively with a Euro centricity, founded on colonialism and exploitation.

Current historiography, the social sciences, has broken away from that single local, and ultimately incomplete narrative for the Mediterranean. The primary goal for this course is to provide a "wider and more humane history" that is more inclusive of "invisible people and cultures" and provides alternate narratives to the ones currently in the history books. The conception of the 'Great Sea' as a boundary-less space allows us to address the many lacunae in its history that are now being acknowledged. *2 credits*

HTA 324 **Museum as Frame: Art in New York**
Through class meetings and museum visits we will investigate the idea of the museum, its history, cultural significance, meaning and societal influence. In particular, we will consider how the museum experience affects the attitudes and assumptions of museum visitors. We will explore the intellectual under-pinnings of the modern museum since the Enlightenment, with special attention to issues of nationalism and eurocentrism; the complexities of museum sponsorship (public, private, and corporate), and how they shape cultural presentation; and the emergence, since the 1960s, of community-oriented museums alongside the growing importance in society of multi-culturalism and ethnic identity. We will also consider standard art-historical issues of style and society as they relate to the various artworks we see. *2 credits*

HTA 325 **Native American Art**
This course presents a broad overview of the visual arts of Native America in their historical and contemporary contexts. For the majority of the lectures, we will proceed geographically, examining artworks produced by peoples of the Southwest (Anasazi, Mimbres, Hohokam, Pueblo, Navajo, Apache), East (Archaic, Woodland, Mississippian, Chitimacha, Seminole, Miccosukee, Cherokee), West (Mandan, Cheyenne, Crow, Kiowa, Metis), Far West (Chumash, Pomo, Wiyot, Washoe), North (Beothuk, Innu, Cree, Dene, Inuit), and Northwest Coast (Proto-Salish, Makeh, Tlingit, Haida, Tsimshian, Kwakwaka'wakw).

During our last lecture, we will look to art produced after 1900, when a pan-Indian identity began to develop, resulting in works that are not always easily categorized by specific tribal communities or geographic areas. The works that we will consider over the course of the semester span a wide spectrum of media: pottery, basketry, textiles, architecture, sculpture, painting, performance, installation, photography, etc. We will grapple with complex questions regarding whether or not all of the objects under review should be deemed "art" in the Euro-American sense of the term, which in many cases has been retroactively accorded these objects. We will also be attendant to the effects that new economies, markets, materials, technologies, and patronage have had upon the circulation of these works, as well as the production/reception of newer works. *2 credits*

HTA 328 **Dada and Surrealism**
Since their appearance early in the 20th century, Dada and Surrealism have had a profound and lasting influence on the arts. This course explores the art and ideas of these two movements within the social, political, intellectual and art historical context of the years 1914–1947. *2 credits*

HTA 333 **Islamic Art and Architecture**
A chronological study of Islamic art and architecture, including an introduction to Islamic aesthetics, history and philosophy. The course will examine samples from religious and literary texts, architectural monuments, painting, ceramics, metal works and calligraphy from Spain, North Africa, the Levant, Iraq, Central Asia and India. *2 credits*

HTA 334 **Art and Architecture of Islamic India**
A chronological study from the 16th century to the 19th century of the development of the art and architecture of the Mughals; and an examination of the Arab, Persian, Indian and European influences that shaped that culture. *2 credits*

HTA 335 **Art and Architecture of the Ancient Near East**
From the temples of the land of Sumer to the tower of Babylon, this course provides an overview of the civilizations of ancient Mesopotamia (modern-day Iraq) and Iran, as well as surrounding regions, from the Neolithic period to the 1st millennium B.C.E.—some 10,000 years. We will study the architecture and artifacts excavated at major sites in the fertile crescent including Jericho, Uruk, Ur, Nineveh and many others. In addition, we will discuss major landmarks in the history of civilization such as the development of agriculture, the beginning of urban settlement, the invention of writing, and the discovery of metallurgy, and their impact on the manufacture of art and artifacts and their iconography. *2 credits*

HTA 342 **Exhibition as Medium**
This course explores key moments in the history and theory of art exhibitions, from the experimental shows organized by Futurist and Dada artists in the early twentieth century to the present. Rather than focusing on the objects on display, as in an art history survey, we will discuss how the mode of display, the venue, the language, and other curatorial choices help shape the experience of an art exhibition. We will also explore the economy, politics, geography, and institutional framework of art shows as an integral part in the construction of meaning. Special emphasis will be placed on artists who, starting in the 1960s, have used exhibitions as their medium. *2 credits*

HTA 343 **Expanded Curatorial Practice**
The recent "decolonial" and "global" turn in museums and curatorial practice often ignores the fact that art history provides the disciplinary foundation for the museum as a colonial institution. What would it mean to curate against Euro-American narratives of art history? How do you curate artists and exhibition histories that aren't found in institutional archives? How does curatorial practice offer alternate art

historical evidence? This course thinks through such questions by engaging with theories and activist practices of decolonization, postcolonial theory, Black studies and Asian studies to move towards other epistemologies and methods of curatorial practice. It will foreground minoritized artists and transnational exhibition histories across Western Europe and North America, and the global South, while considering alternate epistemologies, aesthetics and collections beyond the hold of both art history and the museum. We will study texts, artists, artifacts, art objects, embodied practices, museum collections, exhibition histories, and modes of display and their relationship to questions of history, temporality, translation, untranslatability, spectatorship, provenance, stewardship and the life of objects. *2 credits*

HTA 99 **Independent Study (History and Theory of Art)**
Only juniors and seniors in good academic standing are eligible for independent study. Independent study may be taken for a maximum of two credits per semester. The student must obtain permission of both the instructor and the dean of the Faculty of Humanities and Social Sciences. The major consideration in approving proposals for independent study is the educational value of the study project within the structure of degree requirements. The Faculty of Humanities and Social Sciences insists on very high standards as a condition for approving any independent study project.

ADMINISTRATION, FACULTY AND STAFF

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Nada Ayad
Assistant Dean

Cynthia Hartling
Administrative Associate to the Dean of the Faculty of Humanities and Social Sciences
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William Germano
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Atina Grossmann
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Diego Malquori
Assistant Professor,Philosophy
Sohnya Sayres
Associate Professor
Mary Stieber
Professor
Brian Swann
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Rose Oluronke Ojo-Ajayi
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