CHEMICAL ENGINEERING

Courses offered by the Department of Chemical Engineering are listed under the subject code CHEMENG on the (https://explorecourses.stanford.edu/search?q=CHEMENG&view=catalog&page=0&academicYear=&filter-term-Autumn=on&filter-term-Winter=on&filter-term-Spring=on&filter-term-Summer=on&collapse=&filter-departmentcode-CHEMENG=on&filter-catalognumber-CHEMENG=on&filter-coursestatus-Active=on&filter-catalognumber-CHEMENG=on)*Stanford Bulletin's* ExploreCourses web site.

Research investigations are currently being carried out in the following fields: applied statistical mechanics, biocatalysis, bioengineering, biophysics, colloid science, computational materials science, electronic materials, hydrodynamic stability, kinetics and catalysis, Newtonian and non-Newtonian fluid mechanics, polymer science, renewable energy, rheo-optics of polymeric systems, and surface and interface science. Additional information may be found at http://cheme.stanford.edu.

The Department of Chemical Engineering offers opportunities for both undergraduates and graduate students to pursue course work and research in energy sciences and technology, which include the chemical, physical, mathematical, and engineering sciences. Courses include 25E, 35N, 140/240, 142/242, 162/262, 432, and 444 with some courses being offered only in alternate years.

In addition, both undergraduates and graduate students can pursue work in interdisciplinary biosciences, which include the chemical, biological, physical, mathematical, and engineering sciences. Courses include 150, 174/274, 181/281, 183/283, 185B, 355, 420, 450, and 454 with some courses being offered only in alternate years Students are encouraged to review course offerings in all departments of the School of Engineering and to seek academic advising with individual chemical engineering faculty. Students wishing assistance should talk with student services staff in the department.

Further information about the department also may be found on the department's website (http://cheme.stanford.edu). Undergraduates considering majoring in Chemical Engineering are encouraged to talk with faculty and to meet with student services' staff in Shriram room 129. Students interested in pursuing advanced work in chemical engineering, including coterminal degrees, should contact the student services manager. Admission to an advanced degree program for an active Stanford graduate student is by approval of a Graduate Authorization Petition. All other interested applicants should go to the Graduate Admissions (https://gradadmissions.stanford.edu) website for general and departmental information about the requirements and processes for applying for admission to a graduate degree program.

Mission of the Undergraduate Program in Chemical Engineering

Chemical engineers are responsible for the conception and design of processes for the purpose of production, transformation, and transportation of materials. This activity begins with experimentation in the laboratory and is followed by implementation of the technology in full-scale production. The mission of the undergraduate program in Chemical Engineering is to develop students' understanding of the core scientific, mathematical, and engineering principles that serve as the foundation underlying these technological processes. The program's core mission is reflected in its curriculum which is built on a foundation in the sciences of chemistry, physics, and biology. Course work includes the study of applied mathematics, material and energy balances, thermodynamics, fluid mechanics, energy and mass transfer, separations technologies, chemical reaction kinetics and reactor design, and process design. The program provides students with excellent preparation for careers in the corporate sector and government or for advanced study.

Learning Outcomes (Undergraduate)

Learning outcomes are used in evaluating students and the undergraduate program. The department expects undergraduate majors in the program to be able to demonstrate the following:

1. an ability to apply knowledge of mathematics, science, and engineering.
2. an ability to design and conduct experiments, as well as to analyze and interpret data.
3. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.
4. an ability to function on multidisciplinary teams.
5. an ability to identify, formulate, and solve engineering problems.
6. an understanding of professional and ethical responsibility.
7. an ability to communicate effectively.
8. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
9. a recognition of the need for, and an ability to engage in life-long learning.
10. a knowledge of contemporary issues.
11. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Learning Outcomes (Graduate)

The purpose of the master's program is to provide students with the knowledge and skills necessary for a professional career or doctoral studies. This is done through advanced lecture course work in the fundamentals of the field, including microhydrodynamics, molecular thermodynamics, kinetics, spectroscopy, applied mathematics, and biochemical engineering, in addition to the student's area of specialization. All students must master the fundamental chemical, physical, and biological concepts that govern molecular behavior.

The Ph.D. is conferred upon candidates who have demonstrated substantial scholarship and the ability to conduct independent research. Through course work and guided research, the program prepares students to make original contributions in Chemical Engineering and related fields.

Graduate Programs in Chemical Engineering

The University's requirements, including residency requirements, for the M.S., Engineer, and Ph.D. degrees are summarized in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin.

Current research and teaching activities cover a number of advanced topics in chemical engineering, including applied statistical mechanics, biocatalysis, biochemical engineering, bioengineering, biophysics, computational materials science, colloid science, dynamics of complex fluids, energy conversion, functional genomics, hydrodynamic stability, kinetics and catalysis, microrheology, molecular assemblies, nanoscience and technology, Newtonian and non-Newtonian fluid mechanics, polymer physics, protein biotechnology, renewable fuels, semiconductor processing, soft materials science, solar utilization, surface and interface science, and transport mechanics.

Fellowships and Assistantships

Qualified predoctoral applicants are encouraged to apply for nationally competitive fellowships, for example, those from the National Science Foundation. Applicants to the Ph.D. program should consult with their financial aid officers for application information and advice. In the absence of other awards, incoming Ph.D. students normally are awarded departmental fellowships. Matriculated Ph.D. students are supported primarily by fellowship awards and assistantship research or teaching appointments. All students are encouraged to apply for external competitive fellowships and may obtain information about various awarding agencies from faculty advisers and student services. Assistantships are paid positions for graduate students that, in addition to a salary, provide the benefit of a tuition allocation. Individual faculty members appoint students to research assistantships; the department chair appoints doctoral students to teaching assistantships. Contact departmental student services for additional information.

Bachelor of Science in Chemical Engineering

The Chemical Engineering B.S. program requires basic courses in biology, chemistry, engineering, mathematics, and physics. The depth sequence of courses required for the major in chemical engineering provides training in applied chemical kinetics, biochemical engineering, electronic materials, engineering thermodynamics, plant design, polymers, process analysis and control, separation processes, and transport phenomena. Undergraduates who are considering and/or wish to major in chemical engineering should talk with departmental student services as early as during freshman orientation if feasible and consult the curriculum outlined in the "Undergraduate Program in Chemical Engineering" section of this bulletin. Courses taken to fulfill the requirements for the major (courses in mathematics; science; technology and society; engineering fundamentals; and engineering depth) must be taken for a letter grade if this option is offered.

Representative sequences of courses leading to a B.S. in Chemical Engineering, in both flow chart and 4-year, quarter-by-quarter formats, can be found in the *Handbook for Undergraduate Engineering Programs,* available at http://ughb.stanford.edu. These are explanatory examples, with each sequence starting at a different level and demonstrating how a student, based on his or her pre-college preparation, can complete the major in four years. These typical course schedules are available as well from departmental student services and chemical engineering faculty advisers for undergraduates. It is recommended that students discuss their prospective programs with the chemical engineering faculty advisers, particularly if they are transferring from another major such as Biology, Chemistry, Physics, or another Engineering major. With advance planning, students can usually arrange to attend one of the overseas campuses.

Students interested in a minor in Chemical Engineering should consult the requirements for a "Minor in Chemical Engineering (p. 3)" section of this bulletin.

Chemical Engineering

Completion of the undergraduate program in Chemical Engineering leads to the conferral of the Bachelor of Science in Chemical Engineering.

Mission of the Undergraduate Program in Chemical Engineering

Chemical engineers are responsible for the conception and design of processes for the purpose of production, transformation, and transportation of materials. This activity begins with experimentation in the laboratory and is followed by implementation of the technology in full-scale production. The mission of the undergraduate program in Chemical Engineering is to develop students' understanding of the core scientific, mathematical, and engineering principles that serve as the foundation underlying these technological processes. The program's core mission is reflected in its curriculum which is built on a foundation in the sciences of chemistry, physics, and biology. Course work includes the study of applied mathematics, material and energy balances, thermodynamics, fluid mechanics, energy and mass transfer, separations technologies, chemical reaction kinetics and reactor design, and process design. The program provides students with excellent preparation for careers in the corporate sector and government, or for graduate study.

Requirements*

		Units
Mathematics [1]		10
The following sequence or approved AP credit		
MATH 19	Calculus	
MATH 20	Calculus	
MATH 21	Calculus	
Select one of the following:		5-10
CME 100	Vector Calculus for Engineers	
MATH 51 & MATH 52	Linear Algebra, Multivariable Calculus, and Modern Applications and Integral Calculus of Several Variables	
Select one of the following:		5
CME 102	Ordinary Differential Equations for Engineers	
or MATH 53	Ordinary Differential Equations with Linear Algebra	
Select one of the following:		4-5
CME 104	Linear Algebra and Partial Differential Equations for Engineers	
or CME 106	Introduction to Probability and Statistics for Engineers	
Science [1]		
CHEM 31X	Chemical Principles Accelerated	5
CHEM 33	Structure and Reactivity of Organic Molecules	5
CHEM 35	Organic Chemistry of Bioactive Molecules	5
PHYSICS 41	Mechanics	4
or PHYSICS 41E	Mechanics, Concepts, Calculations, and Context	
PHYSICS 43	Electricity and Magnetism	4
CHEM 131	Organic Polyfunctional Compounds	3
Technology in Society		
One course required, see Basic Requirement 4; course chosen must be on the SoE-Approved Courses list at <ughb.stanford.edu> the year taken.		3-5
Engineering Fundamentals		
Three courses minimum; see Basic Requirement 3		
CHEMENG/ENGR 20	Introduction to Chemical Engineering	4
Fundamentals Elective from another School of Engineering department		3-5
See the UGHB for a list of courses.		
Select one of the following:		3
ENGR 25B	Biotechnology (same as CHEMENG 25B)	
ENGR 25E	Energy: Chemical Transformations for Production, Storage, and Use (same as CHEMENG 25E)	
Chemical Engineering Depth		
Minimum 68 Engineering Science and Design units; see Basic Requirement 5		
CHEMENG 10	The Chemical Engineering Profession	1
CHEMENG 100	Chemical Process Modeling, Dynamics, and Control	3
CHEMENG 110	Equilibrium Thermodynamics	3

CHEMENG 120A	Fluid Mechanics	4
CHEMENG 120B	Energy and Mass Transport	4
CHEMENG 130	Separation Processes	3
CHEMENG 150	Biochemical Engineering	3
CHEMENG 170	Kinetics and Reactor Design	3
CHEMENG 180	Chemical Engineering Plant Design	4
CHEMENG 181	Biochemistry I	4
CHEMENG 185A	Chemical Engineering Laboratory A (WIM)	4
CHEMENG 185B	Chemical Engineering Laboratory B	4
CHEM 171	Physical Chemistry I	4
CHEM 173	Physical Chemistry II	3
CHEM 175	Physical Chemistry III	3
Select four of the following: [2,3]		12
CHEMENG 140	Micro and Nanoscale Fabrication Engineering	
CHEMENG 142	Basic Principles of Heterogeneous Catalysis with Applications in Energy Transformations	
CHEMENG 160	Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life	
CHEMENG 162	Polymers for Clean Energy and Water	
CHEMENG 174	Environmental Microbiology I	
CHEMENG 183	Biochemistry II	
CHEMENG 196	Creating New Ventures in Engineering and Science-based Industries	
Total Units		125-135

1 Unit count is higher if program includes one or more of the following: MATH 51 and MATH 52 in lieu of CME 100; or CHEM 31A and CHEM 31B in lieu of CHEM 31X.

2 Any two acceptable except combining 160 and 162.

3 Students may substitute two of the depth electives with two other science and engineering 3-unit lecture courses. See Handbook for Undergraduate Engineering Programs (UGHB) (http://ughb.stanford.edu) for additional details.

4 A course may only be counted towards one requirement; it may not be double-counted. All courses taken for the major must be taken for a letter grade if that option is offered by the instructor. Minimum Combined GPA for all courses in Engineering Fundamentals and Depth is 2.0.

* For additional information and sample programs, see the Handbook for Undergraduate Engineering Programs (UGHB) (http://ughb.stanford.edu)

Honors Program in Chemical Engineering

The Department of Chemical Engineering offers a program leading to the degree of Bachelor of Science in Chemical Engineering with Honors. Qualified undergraduate majors conduct independent study and research at an advanced level with faculty mentors, graduate students, and fellow undergraduates. This three quarter sequential program requires concurrent participation each quarter in the CHEMENG 191H Undergraduate Honors Seminar; completion of a faculty-approved thesis; and participation in the Chemical Engineering Honors Poster Session held annually during the Mason Lecture Series Spring Quarter. The last requirement may be fulfilled through an alternative, public, oral presentation with the approval of the department chair. A research proposal/application must be submitted at least five quarters prior to graduation with work to begin at a minimum of four quarters prior to graduation.

Admission to the honors program is by application and submission of a research proposal and is subject to approvals by faculty advisers, sponsors, and the chair of the department. Declared Chemical Engineering majors with a cumulative grade point average (GPA) of 3.5 or higher are encouraged to apply. Students must submit their applications no later than the first week in March during Winter Quarter of their junior year, assuming a June degree conferral the following year, e.g. the 2018-2019 deadline is March 1, 2019. An application includes a Stanford transcript in addition to the research proposal, approved by both the student's research thesis adviser, a faculty reader, and, if required, a chemical engineering faculty sponsor. The research adviser or the reader or, alternatively, a faculty sponsor, must be a faculty member in the Department of Chemical Engineering. Students must start their research no later than Spring Quarter their junior year and are encouraged to consider incorporating research opportunities such as those sponsored by Undergraduate Academic Life into their honors research proposal; see http://ual.stanford.edu/OO/research_opps/Grants. See departmental student services staff in Shriram Center room 129, for more information about the application process, a proposal template, and other assistance.

In order to receive departmental honors, students admitted to the honors program must:

1. Maintain an overall grade point average (GPA) of at least 3.5 as calculated on the unofficial transcript.
2. Complete at least three quarters of research with an aggregate enrollment of a minimum of nine units in CHEMENG 190H Undergraduate Honors Research in Chemical Engineering for a letter grade; up to three units may be used towards the Chemical Engineering depth elective requirements. All quarters must focus on the same topic. The same faculty adviser and faculty reader should be maintained throughout if feasible.
3. Enroll in CHEMENG 191H Undergraduate Honors Seminar, concurrently with each quarter of enrollment in CHEMENG 190H Undergraduate Honors Research in Chemical Engineering.
4. Participate with a poster and oral presentation of thesis work at the Chemical Engineering Honors Poster Session held during the Mason Lectures week, Spring Quarter, or, at the Undergraduate Program Committee's discretion, at a comparable public event. Submit at the same time to student services one copy of the poster in electronic format.
5. Submit final drafts of a thesis simultaneously to the adviser and the reader and, if appropriate, to the Chemical Engineering faculty sponsor, no later than April 8, 2019, or the first school day of the second week of the quarter in which the degree is to be conferred.
6. Complete all work and thesis revisions and obtain indicated faculty approvals on the Certificate of Final Reading of Thesis forms by April 30, 2019, or the end of the first month of the graduation quarter.
7. Submit to departmental student services two (2) final copies of the honors thesis, as approved by the appropriate faculty. Include in each thesis an original, completed, faculty signature sheet immediately following the title page. The 2018-2019 deadline is May 2, 2019.
8. Submit to student services a copy of the honors thesis in electronic format at the same time as the final copies of the thesis.

Upon faculty approval, departmental student services to submit one copy of each honors thesis to Student Affairs, School of Engineering.

Chemical Engineering Minor

The following core courses fulfill the minor requirements:

		Units
ENGR 20	Introduction to Chemical Engineering	4
CHEMENG 100	Chemical Process Modeling, Dynamics, and Control	3
CHEMENG 110	Equilibrium Thermodynamics	3
CHEMENG 120A	Fluid Mechanics	4

CHEMENG 120B	Energy and Mass Transport	4
CHEMENG 170	Kinetics and Reactor Design	3
CHEMENG 185A	Chemical Engineering Laboratory A	4
CHEM 171	Physical Chemistry I	4
CHEMENG 180	Chemical Engineering Plant Design	4
Select one of the following:		3
CHEMENG 140	Micro and Nanoscale Fabrication Engineering	
CHEMENG 142	Basic Principles of Heterogeneous Catalysis with Applications in Energy Transformations	
CHEMENG 160	Soft Matter in Biomedical Devices, Microelectronics, and Everyday Life	
CHEMENG 162	Polymers for Clean Energy and Water	
CHEMENG 174	Environmental Microbiology I	
CHEMENG 181	Biochemistry I	
Total Units		36

Master of Science in Chemical Engineering

A range of M.S. programs comprising appropriate course work is available to accommodate students wishing to obtain further academic preparation before pursuing a chemical engineering career or a degree program. The degree requirements are lecture course based; there are no research or thesis requirements. This is a terminal M.S. degree, i.e. this degree is not a prerequisite for nor does it lead to admission to the department's Ph.D. program.

Coterminal master's students should see the specific requirements for the coterminal degree below.

For conferral of a master's degree in Chemical Engineering, the following departmental requirements must be met.

Unit and Course Requirements for the Master's Degree

*S*tudents terminating their graduate work with the M.S. degree in Chemical Engineering must develop a graduate-level, thematic M.S. program consisting of a minimum of 45 completed units of academic work that includes:

1. Four (4) Chemical Engineering core graduate lecture courses selected from the CHEMENG 300 series listed below.

		Units
May select from:		
CHEMENG 300	Applied Mathematics in the Chemical and Biological Sciences	3
CHEMENG 310	Microhydrodynamics	3
CHEMENG 320	Chemical Kinetics and Reaction Engineering	3
CHEMENG 340	Molecular Thermodynamics	3
CHEMENG 345	Fundamentals and Applications of Spectroscopy	3
CHEMENG 355	Advanced Biochemical Engineering	3

2. An additional four (4) Chemical Engineering graduate-level lecture courses. May not use CHEMENG 699 Colloquiumor any CHEMENG500-level course.
3. Three (3) units of CHEMENG 699 Colloquium.
4. An additional 18 units, selected from graduate-level science, math, or engineering lecture courses (3 units or more) in any appropriate department. Of these 18 units, 6 must be graduate-level science, math, or engineering lecture courses. The remaining 12 units can come from a combination of the following categories:
   - An additional 3-12 units of graduate-level science, math, or engineering lecture courses.
   - No more than 6 units of non-science, math, or engineering lecture courses.
   - No more than 6 units of lab courses.
   - No more than 6 units combined of research units or seminar courses on science, math, or engineering topics under the following conditions:
     - Up to 6 units of research.
     - No more than 3 of these 6 units can be taken as seminar courses; examples include: 1 unit seminar and 5 units research; 2 units seminar and 4 units research; 3 units seminar and 3 units research.

Credit toward the required minimum of 45 completed units for the M.S. degree is not given for Chemical Engineering special topics courses numbered in the 500 series.

To ensure that an appropriate Chemical Engineering graduate program is pursued by each M.S. candidate, students who first matriculate at Stanford at the graduate level must do the following, during the first quarter, no later than the seventh week:

1. Complete a Program Proposal for a Master's Degree form, that is approved by the M.S. adviser.
2. Submit this petition form to departmental student services, for review by the graduate curriculum committee.
3. Obtain approval for any subsequent program change or changes, using a freshly completed Program Proposal form, from the M.S. adviser and the faculty chair of the graduate curriculum committee.

All M.S. candidates must obtain approvals for the final M.S. program no later than the seventh week of the quarter preceding the quarter of degree conferral*,* in order to permit amendment of the final quarter's study list if the faculty deem this necessary. Students with questions should contact departmental graduate student services.

Minimum Grade Requirement

Any course used to satisfy the 45-unit minimum for the Master of Science degree must be taken for a letter grade, if offered. An overall grade point average (GPA) of 3.0 must be maintained for these courses.

Research Experience

Students in the M.S. program wishing to obtain research experience should talk with departmental student services and work with the M.S. faculty adviser on the choice of research adviser as early as feasible and in advance of the anticipated quarter(s) of research. Once arrangements are mutually agreed upon, including the number of units, students enroll in the appropriate section of CHEMENG 600 Graduate Research in Chemical Engineering. A written report describing the results of the research undertaken must be submitted to and approved by the research adviser. Research units may not be substituted for any of the required four 300-level core lecture courses.

Coterminal Master's Degrees in Chemical Engineering

Stanford undergraduates with strong academic records may apply to study for a master's degree while at the same time completing their bachelor's degree(s). Interested students should discuss their educational goals with their faculty advisers and talk with departmental graduate student services about the application requirements before submitting an application in Axess. Students, who have completed at least 120 units toward an undergraduate degree and complete their applications by the seventh week of a quarter, may be admitted to the Chemical Engineering M.S. program the following quarter.

University Coterminal Requirements

Coterminal master's degree candidates are expected to complete all master's degree requirements as described in this bulletin. University requirements for the coterminal master's degree are described in the "Coterminal Master's Program (http://exploredegrees.stanford.edu/cotermdegrees)" section. University requirements for the master's degree are described in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees/#masterstext)" section of this bulletin.

After accepting admission to this coterminal master's degree program, students may request transfer of courses from the undergraduate to the graduate career to satisfy requirements for the master's degree. Transfer of courses to the graduate career requires review and approval of both the undergraduate and graduate programs on a case by case basis.

In this master's program, courses taken during or after the first quarter of the sophomore year are eligible for consideration for transfer to the graduate career; the timing of the first graduate quarter is not a factor. No courses taken prior to the first quarter of the sophomore year may be used to meet master's degree requirements.

Course transfers are not possible after the bachelor's degree has been conferred.

The University requires that the graduate adviser be assigned in the student's first graduate quarter even though the undergraduate career may still be open. The University also requires that the Master's Degree Program Proposal be completed by the student and approved by the department by the end of the student's first graduate quarter.

Master of Science in Chemical Engineering

A range of M.S. programs comprising appropriate course work is available to accommodate students wishing to obtain further academic preparation before pursuing a chemical engineering career or a degree program. The degree requirements are lecture course based; there are no research or thesis requirements. This is a terminal M.S. degree, i.e. this degree is not a prerequisite for nor does it lead to admission to the department's Ph.D. program.

The Honors Cooperative Program (HCP) online MS program, which is a part-time program, makes it possible for academically qualified engineers and scientists in industry to be part-time graduate students in Chemical Engineering while continuing professional employment. Prospective HCP online MS students follow the same admissions process and must meet the same admissions requirements as full-time residential MS students.

For conferral of a master's degree in Chemical Engineering, the following departmental requirements must be met.

Unit and Course Requirements for the Master's Degree

*S*tudents terminating their graduate work with the M.S. degree in Chemical Engineering must develop a graduate-level, thematic M.S. program consisting of a minimum of 45 completed units of academic work that includes:

1. Four (4) Chemical Engineering core graduate lecture courses selected from the CHEMENG 300 series listed below.

		Units
May select from:		
CHEMENG 300	Applied Mathematics in the Chemical and Biological Sciences	3
CHEMENG 320	Chemical Kinetics and Reaction Engineering	3
CHEMENG 340	Molecular Thermodynamics	3
CHEMENG 345	Fundamentals and Applications of Spectroscopy	3
CHEMENG 355	Advanced Biochemical Engineering	3

2. An additional four (4) Chemical Engineering graduate-level lecture courses. May not use CHEMENG 699 Colloquium or any CHEMENG500-level course.
   - One (1) additional core Chemical Engineering lecture course from the CHEMENG 300 series.
   - Three (3) graduate electives in Chemical Engineering.

		Units
CHEMENG 262	Polymers for Clean Energy and Water	3
CHEMENG 283	Biochemistry II	3
CHEMENG 296	Creating New Ventures in Engineering and Science-based Industries	3

3. HCP online students may use any of the following to satisfy this requirement:
   - Three (3) units of a seminar/speaker series in engineering, science, or math.
   - A three-unit graduate course in engineering, science, or math.
4. An additional 18 units, selected from graduate-level science, math, or engineering lecture courses (3 units or more) in any appropriate department. Of these 18 units, 6 must be graduate-level science, math, or engineering lecture courses. The remaining 12 units can come from a combination of the following categories:
   - An additional 3-12 units of graduate-level science, math, or engineering lecture courses.
   - No more than 6 units of non-science, math, or engineering lecture courses.
   - No more than 3 units of seminar courses on science, math, or engineering topics.

Credit toward the required minimum of 45 completed units for the M.S. degree is not given for Chemical Engineering special topics courses numbered in the 500 series.

To ensure that an appropriate Chemical Engineering graduate program is pursued by each M.S. candidate, students who first matriculate at Stanford at the graduate level must do the following, during the first quarter, no later than the seventh week:

1. Complete a Program Proposal for a Master's Degree form, that is approved by the M.S. adviser.
2. Submit this petition form to departmental student services, for review by the graduate curriculum committee.
3. Obtain approval for any subsequent program change or changes, using a freshly completed Program Proposal form, from the M.S. adviser and the faculty chair of the graduate curriculum committee.

All M.S. candidates must obtain approvals for the final M.S. program no later than the seventh week of the quarter preceding the quarter of degree conferral, in order to permit amendment of the final quarter's study list if the faculty deem this necessary. Students with questions should contact departmental graduate student services.

Minimum Grade Requirement

Any course used to satisfy the 45-unit minimum for the Master of Science degree must be taken for a letter grade, if offered. An overall grade point average (GPA) of 3.0 must be maintained for these courses.

Research Experience

Students in the M.S. program wishing to obtain research experience should talk with departmental student services and work with the M.S. faculty adviser on the choice of research adviser as early as feasible and in advance of the anticipated quarter(s) of research. Once arrangements are mutually agreed upon, including the number of units, students enroll in the appropriate section of CHEMENG 600 Graduate Research in Chemical Engineering. A written report describing the results of the research undertaken must be submitted to and approved by the research adviser. Research units may not be substituted for any of the required four 300-level core lecture courses.

Engineer in Chemical Engineering

The degree of Engineer is awarded after the completion of a minimum of 90 units of graduate work beyond the B.S. degree and the satisfactory completion of all University requirements plus the following departmental requirements. Application to this program is open only to active chemical engineering M.S. or Ph.D. candidates. This degree is not a prerequisite for the Ph.D. program.

Unit and Course Requirements

A minimum of 90 completed units is required, including a component of a minimum of 45 units in science and engineering courses, consisting of 42 lecture units and 3 CHEMENG 699 Colloquium units. The required CHEMENG courses are listed below.

		Units
CHEMENG 300	Applied Mathematics in the Chemical and Biological Sciences	3
CHEMENG 310	Microhydrodynamics	3
CHEMENG 320	Chemical Kinetics and Reaction Engineering	3
CHEMENG 340	Molecular Thermodynamics	3
CHEMENG 345	Fundamentals and Applications of Spectroscopy	3
CHEMENG 355	Advanced Biochemical Engineering	3
Plus 3 units of:		
CHEMENG 699	Colloquium	1

The additional lecture courses, (24 units), may be chosen from graduate level science and engineering courses according to the guidelines given in the "Master's (p. 4)" section and with the consent of the graduate curriculum committee chair and the department chair. In fulfilling the required 45-unit requirement for lecture course units, the course work may not include chemical engineering's 500 level seminar courses or similar 1-2 unit courses in other departments. The remaining 45 units are primarily research units.

Students seeking the Engineer degree may petition to add a M.S. program and apply for the M.S. degree once the requirements for that degree have been fulfilled. See General Requirements in the “Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)” section of this bulletin and Chemical Engineering's “Master's (p. 4)” section.

Minimum Grade Requirement

Any course intended to satisfy the Engineer degree requirements must be taken for a letter grade, if offered. An overall grade point average (GPA) of 3.0 must be maintained.

Reading Committee Requirement

All candidates are required to have an initial meeting with their reading committees by the end of their ninth quarter. The committee must have a minimum of two members, both of whom are Chemical Engineering faculty members. The reading committee meetings are intended to be discussion sessions, to help to focus and guide the thesis project; they are not examinations.

Students are responsible for reporting meeting dates to departmental student services.

Thesis Requirement

The thesis must represent a substantial piece of research equivalent to nine months of full-time effort and must be approved by the student's reading committee.

Qualification for the Ph.D. Program by Students Ready to Receive the Degree of Engineer

After completing the requirements for the Engineer degree, a student may petition to be examined on the research work completed for that degree, for the purpose of qualifying for admission to Ph.D. candidacy. If the petition is approved, the student's thesis must be approved by the reading committee and available in its final form for inspection by the entire faculty at least two weeks prior to the scheduled date of said examination.

Doctor of Philosophy in Chemical Engineering

The University's general requirements for the Ph.D. are specified in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin.

The Ph.D. degree is awarded after the completion of a minimum of 135 units of graduate work as well as satisfactory completion of any additional University requirements and the following departmental requirements. Completion of a M.S. degree is not a prerequisite for beginning, pursuing, or completing doctoral work.

Unit and Course Requirements

A minimum of 135 completed units is required, including a component of a minimum of 45 units in science and engineering courses, consisting of 42 lecture units and 3 units of CHEMENG 699 Colloquium.

1. CHEMENG 699 should be taken all years each quarter of the academic year; all these units count toward the required 135 units.
2. The research units for CHEMENG 399 count toward the required 135 units, but may not be counted toward the 45 unit component.
3. Students working with a research adviser should enroll each quarter in the 500 series, 600, and 699 as appropriate and as study list unit limits permit. All these seminar and research units are included within the required minimum of 135 units for degree.

Students with questions or issues should contact departmental graduate student services (http://cheme.stanford.edu/about/contact).

The following courses are required:

		Units
CHEMENG 300	Applied Mathematics in the Chemical and Biological Sciences	3
CHEMENG 310	Microhydrodynamics	3
CHEMENG 320	Chemical Kinetics and Reaction Engineering	3
CHEMENG 340	Molecular Thermodynamics	3
CHEMENG 345	Fundamentals and Applications of Spectroscopy	3
CHEMENG 355	Advanced Biochemical Engineering	3
CHEMENG 399	Graduate Research Rotation in Chemical Engineering	1

CHEMENG 699	Colloquium	1
Plus two courses at the 400 course level; in 2017-18 the following are available:		
CHEMENG 420	Growth and Form	3
CHEMENG 444	Electronic Structure Theory and Applications to Chemical Kinetics	3
CHEMENG 454	Synthetic Biology and Metabolic Engineering	3
CHEMENG 456	Microbial Bioenergy Systems	3
CHEMENG 466	Polymer Physics	3

These courses are to be taken at Stanford, and any petition to substitute another graduate-level course for any of these core courses must be approved by the department chair. The remaining graduate-level science and engineering lecture courses may be chosen from any department. A student may petition the department chair for approval to include an upper-division undergraduate science or engineering lecture course. All proposals for Ph.D. required course work must be approved by the student's adviser and the department chair or the chair of the department's Graduate Curriculum Committee. Students with questions, concerns, or issues should contact student services staff in the department office in Shriram Center, room 129.

Ph.D. students may petition to add a M.S. degree program to their university record; submit in a Graduate Authorization petition in Axess. Once the online petition is approved, the M.S. candidate must complete a Program Proposal for a Master's Degree form and submit it to departmental student services.

Ph.D. students with a M.S. program apply in Axess for M.S. degree conferral. (See the "Master of Science in Chemical Engineering (p. 4)" section in this bulletin.) The M.S. degree must be awarded within the University's candidacy period for completion of a master's degree.

Minimum Grade Requirement

Any course intended to satisfy the Ph.D. degree requirements must be taken for a letter grade, if offered. A GPA of 3.0 or above is required by the end of the first year, in order to continue in the Ph.D. program. The overall grade point average (GPA) of at least 3.0 must to be maintained.

Degree Milestones

Degree milestones indicate progress toward degree. They are listed on unofficial transcripts and document satisfactory and timely completion of various events, such as securing research advisers, candidacy examinations, submission of completed degree progress forms, dates of reading committee meetings, assisting with the teaching CHEMENG courses. Report and submit forms as appropriate to departmental student services. Students with questions or issues should talk with student services staff; students approaching a milestone should be aware of intradepartmental communications and support, and students with concerns should discuss them with student services staff.

Candidacy

To be advanced to Ph.D. candidacy, the student must secure a research dissertation adviser (and any required co-adviser), successfully complete a Ph.D. candidacy examination, and submit a completed Application for Candidacy for Doctoral Degree form.

First, the research adviser and any required co-adviser must be established by the end of the second quarter in the Ph.D. program. Failure to do so leads to termination of a student's study toward a Ph.D. in Chemical Engineering; however, the student may continue to work toward an M.S. degree (see the "Master of Science in Chemical Engineering (p. 4)" section of this bulletin). Departmental Ph.D. financial support does not continue.

Second, the Ph.D. candidacy examination before a faculty committee is at the end of the fourth quarter. It consists of (a) a student's oral presentation of their thinking about their research proposal and current progress and (b) an examination by faculty members of the proposal specifics as well as the student's understanding of the fundamental chemical, physical, and biological concepts that govern the molecular behavior of the system being studied. Upon successful completion of this examination, candidates must submit an Application for Candidacy for Doctoral Degree form, approved by their research adviser(s), to departmental graduate student services within two months.

Teaching Requirement

Teaching experience is considered an essential component of pre-doctoral training because it assists in the further development and refinement of candidates' skills in conveying what they know, think, and conclude, based on articulated assumptions and knowledge. All Ph.D. candidates, regardless of the source of their financial support, are required to assist in the teaching of a minimum of two chemical engineering courses.

Reading Committee Requirement

Reading committee meetings are intended to be discussion sessions with all members of the reading committee participating that help to focus and refine the dissertation project; they are not examinations.

By the end of the second year, all Ph.D. candidates are required to assemble reading committees and submit Doctoral Dissertation Reading Committee forms signed by research advisers to student services.

By the end of the first quarter of the third year, candidates are required to have an initial meeting with the complete reading committee. It is the candidate's responsibility to schedule committee meetings, and the faculty's to respond in a timely manner to scheduling requests. The composition of the reading committee may be amended; submit appropriate form to student services. Candidates are responsible for reporting meeting dates to departmental student services.

The faculty strongly encourage doctoral candidates to take advantage of the benefits of annual committee meetings, to enable candidates to benefit from this type of open discussion, support, and recommendations from faculty.

Research Poster Requirement

Experience in analyzing and presenting one's research to diverse audiences also is an essential component of predoctoral training, and faculty strongly encourage candidates to do so several times each year, starting in the second year. All candidates in their third year are required to prepare and present a research poster during the annual Mason Lectures week in spring quarter.

Dissertation and Oral Defense Requirements

A dissertation based on a successful investigation of a fundamental problem in chemical engineering is required. A student is expected to have fulfilled all the requirements for this degree, including the completion of a dissertation approved by his or her research adviser(s) and reading committee members within approximately five years after enrolling the Ph.D. program. Upon adviser approval (s), copies of the final draft of the dissertation must be distributed to each reading committee member. No sooner than three weeks after this distribution, a student may schedule an oral examination. This examination is a dissertation defense, based on the candidate's dissertation research, and is in the form of a public seminar followed by a private examination by the faculty members on the student's oral examination committee. Satisfactory performance in the oral examination and acceptance of an approved dissertation by Graduate Degree Progress, Office of the University Registrar, leads to Ph.D. degree conferral.

Ph.D. Minor in Chemical Engineering

The University's general requirements for the Ph.D. minor are specified in the "Graduate Degrees (http://exploredegrees.stanford.edu/graduatedegrees)" section of this bulletin. An application for a Ph.D. minor must be approved by both the major and minor departments.

A student proposing a Ph.D. minor in Chemical Engineering must work with a minor program adviser who has a faculty appointment in Chemical Engineering. This adviser must be included as a member of the student's reading committee for the doctoral dissertation, and the entire reading committee must meet at least once with the candidate. This meeting should occur at least one year prior to the scheduling of the student's oral examination; the department strongly prefers that regular meetings of the complete reading committee start in the second year of graduate study. In addition, the Chemical Engineering faculty member who is the minor adviser must be a member of the student's University oral examination committee.

The Ph.D. minor program must include at least 20 units of graduate-level lecture courses (numbered at the 200 level or above), but may not include any 1-2 unit lecture courses in the 20-unit minimum. The list of courses must form a coherent program and must be approved by the minor program adviser and the chair of this department. All courses for the minor must be taken for a letter grade, and a GPA of at least 3.0 must be earned for these courses.

For a statement of University policy on graduate advising, see the "Graduate Advising (http://exploredegrees.stanford.edu/graduatedegrees/#advisingandcredentialstext)" section of this bulletin.

Master's Student Advising

The Department of Chemical is committed to providing academic advising in support of our M.S. students' education and professional development. When most effective, this advising relationship entails collaborative engagement by both the adviser and the advisee. As a best practice, advising expectations should be discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

At the start of graduate study, normally at the beginning of the Fall quarter, each student is assigned a master's program adviser: a member of our faculty who will provide guidance in course selection and in exploring academic opportunities and professional pathways. The department's graduate handbook (https://cheme.stanford.edu/masters-handbook) provides information and suggested timelines for advising meetings. Usually, the same faculty member serves as program adviser for the duration of master's study, but the handbook does describe a process for formal adviser changes.

In addition, the Chair of the Graduate Committee meets with all the master's students at the start of the first year, and is available during the academic year by email and during office hours.

Our department's student services office is also an important part of the master's advising team. They inform students and advisers about university and department requirements, procedures, and opportunities, and they maintain the official records of advising assignments and approvals.

Finally, graduate students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program.

For a statement of University policy on graduate advising, see the "Graduate Advising (http://exploredegrees.stanford.edu/graduatedegrees/#advisingandcredentialstext)" section of this bulletin.

Ph.D. Student Advising

The Department of Chemical Engineering is committed to providing academic advising in support of doctoral student scholarly and professional development. When most effective, this advising relationship entails collaborative and sustained engagement by both the adviser and the advisee. As a best practice, advising expectations should be periodically discussed and reviewed to ensure mutual understanding. Both the adviser and the advisee are expected to maintain professionalism and integrity.

Faculty advisers guide students in key areas such as selecting courses, designing and conducting research, developing of teaching pedagogy, navigating policies and degree requirements, and exploring academic opportunities and professional pathways. The department's graduate handbook provides information and suggested timelines for advising meetings in the different stages of the doctoral program.

Ph.D. students are initially assigned a program adviser at the outset of their matriculation at Stanford. This faculty member will provide initial guidance in course selection, in exploring academic opportunities and professional pathways, and in identifying doctoral research opportunities. The department does require formal lab rotations during two quarters prior to selecting a doctoral research/thesis adviser.

Students will identify their doctoral research/thesis adviser prior to the end of the first year of study. The process and timing of adviser selection is described in the Graduate Academic Policies and Procedures (GAP) (https://gap.stanford.edu/handbooks/gap-handbook/chapter-3/subchapter-3/page-3-3-1). The research supervisor assumes primary responsibility for the future direction of the student, taking on the roles previously filled by the program adviser, and will ultimately direct the student's dissertation. Most students find an adviser from among the primary faculty members of our department. However, the research adviser may be a faculty member from another Stanford department who is familiar with supervising doctoral students and able to provide both advising and funding for the duration of the doctoral program. When the research adviser is from outside our department, the student will also identify a program adviser from our primary faculty, to provide guidance on departmental requirements and opportunities.

The Chair of the Graduate Committee (CGC) meets with all the doctoral students at the start of the first year, and is available during the academic year by email and during office hours. Our department's student services office is also an important part of the doctoral advising team: they inform students and advisers about university and department requirements, procedures, and opportunities, and they maintain the official records of advising assignments and approvals. Students are encouraged to talk with the CGC and the student services office as they consider adviser selection, or for guidance in working with their adviser(s).

Our doctoral students are active contributors to the advising relationship, proactively seeking academic and professional guidance and taking responsibility for informing themselves of policies and degree requirements for their graduate program.

Emeriti: (Professors) Andreas Acrivos, George M. Homsy, Robert J. Madix, Channing R. Robertson

Chair: Zhenan Bao

Professors: Zhenan Bao, Stacey F. Bent, Curtis W. Frank, Gerald G. Fuller, Chaitan Khosla, Eric S. G. Shaqfeh, Alfred M. Spormann, James R. Swartz

Associate Professors: Alexander R. Dunn, Thomas F. Jaramillo, Andrew J. Spakowitz

Assistant Professors: Matteo Cargnello, Jian Qin, Elizabeth S. Sattely, William A. Tarpeh, Roseanna N. Zia

Courtesy Professors: Lynette S. Cegelski, Jennifer R. Cochran, Sarah C. Heilshorn, Daniel Herschlag, Christina D. Smolke, H. Tom Soh, Robert M. Waymouth

Senior Lecturer: Lisa Y. Hwang

Lecturers: Frank Abild-Pedersen, Melis Duyar, Ricardo B. Levy, Shari B. Libicki, Sara Loesch-Frank, Howard B. Rosen

Adjunct Professors: Ying-Chih Chang, John Moalli, Do Y. Yoon

Cognate Courses for Advanced Degrees in Chemical Engineering

In addition to core CHEMENG graduate courses in the 300 series and elective CHEMENG graduate courses in the 200 and 400 series, students pursuing advanced degrees in chemical engineering include elective courses offered by other departments. The following list is a partial list of the more frequently chosen courses and is subdivided into five focus areas.

		Units
Broadly Applicable		
APPPHYS 207	Laboratory Electronics	4
CHEM 221	Advanced Organic Chemistry I	3
CHEM 271	Advanced Physical Chemistry	3
CHEM 273	Advanced Physical Chemistry	3
EE 261	The Fourier Transform and Its Applications	3
STATS 200	Introduction to Statistical Inference	3
Biochemistry and Bioengineering focus *		
BIOE 331	Protein Engineering	3
BIOPHYS/SBIO 241	Biological Macromolecules	3-5
CBIO 241	Cellular Basis of Cancer	4
MCP 256	How Cells Work: Energetics, Compartments, and Coupling in Cell Biology	4
SBIO 241	Biological Macromolecules	3-5
Fluid Mechanics, Applied Mathematics, and Numerical Analysis focus **		
AA 218	Introduction to Symmetry Analysis	3
CME 200	Linear Algebra with Application to Engineering Computations	3
CME 204	Partial Differential Equations in Engineering	3
CME 206	Introduction to Numerical Methods for Engineering	3
CME 212	Advanced Software Development for Scientists and Engineers	3
ME 351A	Fluid Mechanics	3
ME 457	Fluid Flow in Microdevices	3
Materials Science focus ***		
MATSCI 210	Organic and Biological Materials	3
MATSCI 251	Microstructure and Mechanical Properties	3
MATSCI 316	Nanoscale Science, Engineering, and Technology	3
MATSCI 343	Organic Semiconductors for Electronics and Photonics	3
MATSCI 380	Nano-Biotechnology	3
Microelectronics focus ****		
AA 218	Introduction to Symmetry Analysis	3
CME 200	Linear Algebra with Application to Engineering Computations	3
CME 204	Partial Differential Equations in Engineering	3
CME 206	Introduction to Numerical Methods for Engineering	3
CME 212	Advanced Software Development for Scientists and Engineers	3
ME 457	Fluid Flow in Microdevices	3
Microelectronics focus		
AA 218	Introduction to Symmetry Analysis	3
CME 200	Linear Algebra with Application to Engineering Computations	3
CME 204	Partial Differential Equations in Engineering	3
CME 206	Introduction to Numerical Methods for Engineering	3
CME 212	Advanced Software Development for Scientists and Engineers	3
ME 457	Fluid Flow in Microdevices	3

* e.g., with CHEMENG 281 Biochemistry I, CHEMENG 283 Biochemistry II, CHEMENG 454 Synthetic Biology and Metabolic Engineering, CHEMENG 456 Microbial Bioenergy Systems.

** e.g., with CHEMENG 462 Complex Fluids and Non-Newtonian Flows.

*** e.g., with CHEMENG 442 Suspension Mechanics, CHEMENG 464 Polymer Chemistry, CHEMENG 466 Polymer Physics.

**** e.g., with CHEMENG 240 Micro and Nanoscale Fabrication Engineering.