BACHELOR OF CHEMICAL ENGINEERING PROGRAM

UNDERGRADUATE CURRICULUM GUIDE

Department of Chemical Engineering
and Materials Science

University of Minnesota

151 Amundson Hall
421 Washington Avenue, SE
Minneapolis, MN 55455

Updated August 2011

Undergraduate Student Services:

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Table of Contents

CHEMICAL ENGINEERING

http://www.cems.umn.edu/

Department version - Unofficial

For students admitted to the University of Minnesota prior to Fall 2010.

Official version at: http://cse.umn.edu/services/advising/CSE_CONTENT_188609.php

Freshman Year (many students take a lib ed elective in the May or Summer term)

	Fall Semester	crs		Spring Semester	crs
	Chem 1021 Chem Prin I	4		Chem 1022 Chem Prin II *[Chem 1021]*	4
	Math 1371 (or 1271) Calc I *(1371 Fall only)*	4		Math 1372 Calc II *[C or better in 1271 or 1371]*	4
	Phys 1301W Intro Phys I *[&Math 1271 or &Math 1371]*	4	*UD*	Phys 1302W Intro Phys II *[&Math 1272 or &1372, Phys 1301]*	4
UD	Freshman Writing - Lib Ed	3 or 4		Lib Ed* (e.g. Biol 1009)	3 or 4
	ChEn 1001 *2:30* *(Optional, highly recommended)*	1			

*** Biol 1009 is recommended in the first year.**

Junior Year

	Fall Semester	crs		Spring Semester	crs
	Chem 2311 Organic Lab *[Chem 2302 or &2302]*	4		ChEn 3401W JrChEnLab 9:05 *[UD ChEn, (3005, 3006 or &, 3101, 3102 or &, 3201 or &, Chem 2121, 2311, Writ 1301 or eq.]*	2
	ChEn 3701 Biomolec Eng *9:05* *[Chem 2302, Math 2373 or &, **2001**, h.s. biology rec'd]*	3		ChEn 3006 Mass Tran & Sepns *8 [UD ChEn, **2001**, 3005, 3101]*	4
	ChEn 3005 Fluid and Heat Transprt *10:10 [UD ChEn, **2001**]*	4		ChEn 3102 React Kin & Eng. *11:15 [UD ChEn, **2001**, 3101]*	4
	ChEn 3101 Chem Eng Thermo *1:25 [UD ChEn, **2001**, Chem 4501]*	4		ChEn 3201 Comp Mthds in ChEn *10:10 [UD ChEn, **2001**, 3005, 3006 or &]*	3
	Chem/ChEn dbl majors should take Chem 4701 12:20 this semester with Chem dept. approval; ChEn 3701 may be postponed to Sr. Fall			Lib Ed*** (e.g. Soc Sci II)	3

Sophomore Year

	Fall Semester	crs		Spring Semester	crs
	Chem 2301 Org Chem I *[Chem 1022]*	3	*UD*	Chem 2302 Org Chem II *[Chem 2301]*	3
UD	**ChEn 2001** Matl and En Bal *3:35* *[Chem 2301 or &, Math 2374 or &, Phys 1302 or &]*	4	*UD*	Chem 4501 Chemical Thermo *11:15* *[Chem 1022, Math 2263 or 2374, Phys 1302]* Chem 4501 can be taken earlier	3
$	MatS 3011 Intro MatSci *2:30* *[Chem 1021, Math 1272, Phys 1302]*	3	*UD*	Math 2373 Lin alg/diff eqs *[Math 1272 or 1372]*	4
UD	Math 2374 Multivar. Calc and Vec An *[Math 1272 or 1372]*	4		**Chem 2121** Analyt Chem 12:20 *[2302 or &, 4501 or &, ChEn only]*	3
	Lib Ed*** (e.g. Hist)	3		Lib Ed*** (e.g., Soc Sci I)	3

& Registrar symbol for concurrent registration

Bold-bordered courses are offered only once a year.

*** For eng degrees, the two Soc Sci, the Hist, the Lit, and the Other Hum lib eds must fill both a core and a theme to guarantee a 4-year degree program. These may be taken S/N.

UD You must have at least a 2.60 technical GPA for admission to upper division Chemical Engineering. This GPA includes all calculus, physics, chemistry, computer science, and engineering courses. In addition, courses with UD need to be completed before you apply, unless you have at least a 2.90 tech GPA and the courses in progress. *Applies to students admitted prior to Fall 2010.*
Students admitted after Fall 2010 and after are guaranteed admission if their technical GPA is 3.2, others admitted on a space available basis.

Senior Year

	Fall Semester (change Fall 10)	crs		Spring Semester (change Spring 11)	crs
	ChEn 4401W Senior Chem Eng. Lab *12:20 [UD ChEn, 3005, 3006, 3101, 3102 3201, 3401, Chem 2121, 2311, Writ 1301 or eq.]*	3		ChEn 4502W Chem Eng Proc Des II *8 [UD ChEn, 4501]*	2
	ChEn 4501W Chem Eng Proc Des I *11:15 [UD ChEn, 3005, 3006, 3101, 3102, 3201 3401, Chem 2311, 2121, Writ 1301 or eq.]*	3		Chem 4502 Quantum Chem *10:10* *[Chem1022, &Math 2263 or 2374, Phys 1302]* Chem 4502 can be taken earlier	3
	ChEn 4601 Process Control *8 [UD ChEn, ChEn 3102]*	3	@	ChEn 4214 Polymers *11:15* ✱ *[UD, MatS 3011, [MatS 4001 or ChEn 3101]]* ChEn 4214 can be taken earlier after Mats 3011	3
@	Tech elective I	3	@	Tech elective II	3
	Lib Ed*** (e.g. Lit)	3	@	Tech elective III	3
				Lib Ed*** (e.g. Art/Hum)	3

For some courses, prereqs and MWF lecture times are shown in italics.

$ Recommended at this position in the plan, but can be delayed with advisor approval.

@ Preapproved or with DUS/ChEn-advisor approval. Several restrictions apply.
Max 2 cr. nontechnical, max 6 cr. transfer, even if approved.
✱ Tech electives must be 9 cr., in addition to ChEn 4214 (or DUGS-approved substitute to ChEn 4214).

7/13/2011

I. Preface

This program bulletin is intended to guide current Chemical Engineering majors and to inform prospective ChEn majors. It should be used in conjunction with the Undergraduate Catalog found on the Web at <http://www.catalogs.umn.edu/ug/index.html>. Pay particular attention to the section of the Undergraduate Catalog devoted College of Science and Engineering policies <http://www.catalogs.umn.edu/download/TCug/cse10-12.pdf> and on the Chemical Engineering program, at <http://onestop2.umn.edu/programCatalog/viewCatalogProgram.do?programID=24&strm=1089>.

The College of Science and Engineering (CSE) website <http://cse.umn.edu/> is also a valuable source of official information on all aspects of academic and student life. Click on the link for "Students". At this site you will find information dealing with college-wide policy and procedures such as the honors program, GPA requirements for program entrance, Liberal Education Requirements, dropping and adding classes, entering Upper Division, and changing majors. Pay close attention to the Liberal Education Requirements because the courses that meet the requirements change. If you have taken a course that fulfills a requirement in the past, you will be grandfathered in and the completed course will still fulfill the requirements. For the most up-to-date information visit the OneStop website: <http://onestop.umn.edu/degree_planning/lib_eds/index.html>.

II. Mission

The mission of the Department of Chemical Engineering and Materials Science is to perform the nation's highest quality education and research, at the undergraduate and graduate levels, in the behavior and structure of chemical processes and materials.

III. What Do Chemical Engineers Do?

The chemical engineer develops a chemical process from its laboratory beginning through semi-works equipment to full-scale production. Chemical engineering is based on applications of chemistry, biology, physics, materials science, mathematics and economics. The chemical engineering curriculum includes the study of applied mathematics; material and energy balances; properties and physics of gases, liquids, and solids; fluid mechanics; heat and mass transfer; thermodynamics; chemical and biological reaction kinetics and reactor design; and the integrating subjects of process design, control, and economic optimization. Because of this broad-based foundation, emphasizing both basic and engineering science, the chemical engineer is considered the universal engineer.

Chemical engineers work on a wide variety of projects: basic and applied research, product development, design and modification of processes and equipment, and plant operation. Some enter sales, marketing, management, consulting, government agencies, consulting, or teaching. Because of the breadth and flexibility of the chemical engineering major, it is chosen by some students who plan to pursue graduate study in medical sciences, materials science, business administration, or patent and environmental law.

Chemical engineering deals with operations such as materials handling, mixing, fluid flow and metering, extrusion, coating, heat exchange, filtration, drying, evaporation, distillation, absorption, extraction, ion exchange, combustion, catalysis, and processing in chemical and biochemical reactors. These operations are vital to the commercial success of industries based on the chemical and physical transformation of matter. While of course a chemist or a biologist uses these operations in a laboratory, developing these operations for complex and large-scale industrial processes requires a complete and quantitative understanding of the chemical engineering principles as well as the scientific principles on which the operations rest.

Because many industries are based on chemical and physical transformation of matter, the chemical engineer is much in demand. He or she may work in the manufacture of inorganic products such as acids, alkalis, ammonia, fertilizers, paint pigments, ceramics, semiconductors and other electronic materials; in

the manufacture of organic products such as polymer fibers, films, coatings, textiles, cellulose, paper, dyes, explosives, rubber, rocket propellants, solvents, plastics, agricultural chemicals, pharmaceuticals, coal-based fuels, petrochemicals; or in the manufacture of materials such as graphite, calcium carbide, abrasives, or those in wet and dry batteries, fuel cells, and more complex materials systems; in the electroplating, metallurgical, and materials processing industries; in food processing; in the fermentation industry for the production of antibiotics, feed supplements, and other biochemical products; or in the field of biotechnology, where applications range from utilization of the activities of microorganisms and cultured cells, to enzyme engineering, to the manufacture of foods, and in the biomedical field to the design of prosthetic devices and artificial human organs. Chemical engineers are also particularly well suited to dealing with problems associated with the disposal of industrial wastes and other forms of pollution, as well as with environmental protection. And of course chemical engineering underlies most of the energy field, including the efficient production and utilization of coal, petroleum, natural gas, tar sand, oil shale, geothermal deposits, and nuclear energy.

IV. Chemical Engineering Program Objectives and Outcomes

Program Educational Objectives (PEO's)

To provide educational experiences which challenge students to:

1. Be employed as a chemical engineer or in a related engineering or science position, using and developing his or her skills based on the demands of the job.
2. Enter into a graduate or professional program, applying his or her knowledge and experience toward an advanced or professional degree.
3. Be an effective team member, using and developing communication and teamwork skills.
4. Be a responsible engineer/scientist or professional, demonstrating ethical and professional responsibility and continuing to learn through formal and informal educational experiences.

Program Outcomes (PO's) (adapted to Chemical Engineering from ABET Criteria <http://www.abet.org/>**)**

Graduates who have:

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 multi-disciplinary 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.

V. Requirements for the BChE Degree

To earn a Bachelor of Chemical Engineering degree one must complete the following requirements, in addition to meeting the University's liberal education requirements. The degree program is fully accredited by the Accreditation Board for Engineering and Technology (ABET).

Lower Division
Successfully complete the pre-chemical lower division program of chemistry, mathematics, physics and writing proficiency courses as listed in the semester course plan for the first two years. A slightly different program may satisfy this requirement, as in the case of a student who transfers from another curriculum or from another university, but only with the approval of the CSE Academic Advising Office (this would be evaluated upon consideration for admission into upper division). All required lower division chemistry, physics, and mathematics courses must be taken on the A/F grade basis.

As you near completion of these courses in your sophomore year, you should apply to the upper division Chemical Engineering program. You can find the application online at <http://cse.umn.edu/services/advising/CSE_CONTENT_188611.php>. Applications and attachments are turned in to 196 Shepherd Labs (temporary for 2011-12) The requirements for admission to upper division Chemical Engineering should be discussed with your adviser as they are dependent on when you entered the University.

Transfer Students
If you are transferring into the upper division Chemical Engineering program from another school, you must apply to College of Science and Engineering (CSE) through the Office of Admissions <http://admissions.tc.umn.edu/admissioninfo/trans.html>. The CSE website will provide additional transfer information <http://cse.umn.edu/admissions/transferadm/>.

It is required that you have completed at least the first year curriculum. Transfer students should visit the "Future Transfer Students" website <http://cse.umn.edu/admissions/transferadm/index.php> to determine course equivalencies located under the "Technical course plans". The site also includes transfer plans for various schools under "Transfer Plans". Links are provided for international colleges and universities at <http://cse.umn.edu/admissions/intladm/CSE_CONTENT_188221.php>. Information on both course transfer plans and international course equivalencies is available. In very rare instances students are admitted to upper division provisionally, contingent on completion of the remaining requirements. The student must complete the remaining requirements in the coming semester. If you have questions, you are encouraged to email, call, or make an appointment to visit Ben Koch, CSE Transfer Admission Counselor (<koch0137@umn.edu>, 240 Williamson Hall, 612-625-6403).

Upper Division
To complete the BChE degree requirements one must finish the upper division courses in the Chemical Engineering curriculum. One must complete at least 128 semester credits, including 48 credits of upper division ChEn requirements, and 12 credits of technical electives.

VI. Scheduling Your Program and Using the Plan to Graduation

At the beginning of this brochure you will find an ideal schedule of coursework if you start as a Freshman at the U of MN – Twin Cities. The four year plan on the CEMS website <http://www.cems.umn.edu/downloads/ug/ChEn/typ_plan_post_2011.pdf> is kept more up-to-date than the one in this Curriculum Guide, so you will want to double check there to be sure you have the most current plan. Following this schedule you should be able to obtain your BChE degree in four years without

attending summer school. Your own situation may lead you to depart from this generic schedule, particularly as you plan your Liberal Education classes and your technical electives.

In planning your program, remember that many courses are offered only once a year, either Fall or Spring, but not both. In addition, these classes may have prerequisites that must be satisfied before attempting your intended courses. Prerequisites are strongly enforced within the Department. Finally, you must make sure the courses you intend take do not meet at the same time. Department and University policies prohibit taking two courses offered with overlapping class hours.

Using the UM Graduation Planner

Each course in the Chemical Engineering program uses concepts from previous courses. Therefore it is of the utmost importance that the courses be taken in their proper sequence. The Graduation Planner <http://plan.umn.edu> is an on-line form used to facilitate the advising process and to ensure that you plan your timely progress to graduation. If you are not sure which technical electives you wish to take, you can note in the comments section that you plan to take X number of credits in the term as technical electives. When completing the form, be sure to include necessary coursework to make up for missing high school preparation requirements if applicable. Newly-admitted upper division students are required to fill out the graduation planner, and attend a mandatory information meeting. The mandatory meeting is usually held as part of the ChEn 2001 class. If you miss it, you will need to make it up. Contact Ms. Laura Ericksen to make the arrangements. When you complete these two requirements, the hold on your record will be pushed back or removed and you will be able to register for the upcoming semester.

You must use the most current class schedules to know what semesters and class-times correspond to courses you are planning. You must ensure that you will have no class-time conflicts and that you will have the prerequisites for your planned courses. (Instructor permission may be given when adequate preparation is clear.)

Please be sure to fill out semesters for all the courses you plan to take, including technical electives. You may revise your plan at any time after submitting it and it is expected that you will keep the plan current.

IMPORTANT: The APAS is the officially recognized tracking of your progress toward the degree. The Plan to Graduation is merely a tool to help you plan to fulfill all the requirements on the APAS. See Ms. Laura Ericksen or Prof. Satish Kumar to ensure your APAS is correct.

VII. Advising and Technical Electives

Advising on routine upper division Chemical Engineer matters is usually done by Prof. Satish Kumar, Prof. Raul Caretta, or Ms. Laura Ericksen. Probation students need to meet with Prof. Kumar.

In addition, when selecting your technical electives you will choose an advisor (determined by the associated emphasis area, as described below). It is important for you to talk with a professor who can help you think about career paths and elective course choices. The professors are more than happy to talk over your plans! If you have trouble catching them by phone or by dropping by their offices, try going to their offices during their office hours to suggest an appointment time, or email them for an appointment.

When you graduate, you will need one or more faculty members as references for job or graduate school applications; advising is a good way to get to know the faculty and for them to get to know you. (Most graduate schools require three academic reference letters.) When requesting letters of recommendation or putting faculty names on your resume as prospective references be sure to a) send the faculty member an email requesting that they serve this function; b) provide the faculty member all the materials (e.g. resume, essay, etc.); c) if a letter is requested, provide stamped, addressed envelopes.

International students with questions related to their international standing should contact Adam Pagel (105 Lind; pagel@umn.edu; 612-624-8013). He can help you take advantage of opportunities available to, or responsibilities incumbent upon, the international student.

Choosing technical electives

You must take 12 semester-credits of technical elective courses. This is usually accomplished by taking four 3-credit courses, and at least two of these courses must be science or engineering courses at the 4000-level or above. One of your technical electives must be ChEn 4214 Polymers, unless we approve a substitution. Double Chemical Engineering and Chemistry majors will take Chem 4214. The substitution of another polymers course usually from Materials Science or Chemistry, will be viewed more favorably than other requests. You may apply up to 2 credits of directed research toward your technical electives if approved as such by your advisor*. At least six credits of your non-polymer technical electives must be taken at the University of Minnesota. *N.B.*: Only with special permission will transferred courses be allowed for technical electives. At least half of the technical electives must be upper division approved U of M courses.

Your advisor is the faculty person associated with the emphasis area you choose from the list below. Under each group heading is a list of courses already approved by the emphasis advisor. You must get approval from your advisor (using a Form 1014 Technical Elective Approval Form) to use other courses as ChEn technical electives. If you wish to select electives from more than one emphasis area your emphasis will be "General" and Prof. Kumar will be your advisor.

*For directed research or directed studies to be considered for technical elective credit you must file a final report with Ms. Laura Ericksen in 151BB Amundson. To start the process, complete Form 2010 Research as Technical Elective Approval Form.

Before selecting technical electives read the four points below very carefully.

- All Technical Electives must be taken A-F.
- If you are a senior ChEn major and do not have exact pre-requisites for a desired course, you may contact the department offering the course and at that department's discretion obtain permission numbers. The department often gives it, if you have your ChEn adviser's recommendation.
- Check the online class schedule to confirm actual offerings.
- Information below is taken from the online catalog in August 2011. If the information on the online catalog changes, it is the definitive source. It is in your best interest to confirm the below information. The website is <https://webapps-prd.oit.umn.edu/courses/designators.jsp?campus=UMNTC>

Biomedical Engineering – Tranquillo

You must take into consideration the four points on page 9.

NOTE: BMEN 3101 and 3301 will NOT be approved as ChEn technical electives.

BMEN 5001 **- Advanced Biomaterials**
(3.0 cr; Prereq-3301 or MatS 3011 or grad student or #; A-F or Aud)
Commonly used biomaterials. Chemical/physical aspects. Practical examples from such areas as cardiovascular/orthopedic applications, drug delivery, and cell encapsulation. Methods used for chemical analysis and for physical characterization of biomaterials. Effect of additives, stabilizers, processing conditions, and sterilization methods.

BMEN 5041 **- Tissue Engineering**
(3.0 cr; Prereq-CSE upper div or grad student or med student or #)
Fundamentals of wound healing and tissue repair; characterization of cell-matrix interactions; case study of engineered tissues, including skin, bone marrow, liver, vessel, and cartilage; regulation of biomaterials and engineered tissues.

BMEN 5151 **- Introduction to BioMEMS and Medical Microdevices**
(2.0 cr; Prereq-CSE sr or grad student or medical student; A-F or Aud)
Design/microfabrication of sensors, actuators, drug delivery systems, microfluidic devices, and DNA/protein microarrays. Packaging, biocompatibility, ISO 10993 standards. Applications in medicine, research, and homeland security.

BMEN 5501 **- Biology for Biomedical Engineers**
(3.0 - 4.0 cr [max 4.0 cr]; Prereq-Engineering upper div or grad student)
Concepts of cell/tissue structure/function. Basic principles of cell biology. Tissue engineering, artificial organs. (Non-BME majors can also take the associated lab on a space-available basis.)

BIOL 4004 **- Cell Biology**
(3.0 cr; Prereq-[3021 or BIOC 3021 or BIOC 4331], [4003 or BIOC 4332])
Processes fundamental to cells. Emphasizes eukaryotic cells. Assembly/function of membranes/organelles. Cell division, cell form/movement, intercellular communication, transport, secretion pathways. Cancer cells, differentiated cells.

PHSL 5061 **- Principles of Physiology for Biomedical Engineering**
(4.0 cr; Prereq-Biomedical engineering grad, one yr college chem and physics and math through integral calculus)
Human physiology with emphasis on quantitative aspects. Organ systems (circulation, respiration, renal, gastrointestinal, endocrine, muscle, central and peripheral nervous systems), cellular transport processes, and scaling in biology.

Biomolecular Engineering – Hu

You must take into consideration the four points on page 9.

BIOC 3021 **- Biochemistry**
(3.0 cr; =[BIOC 6021]; Prereq-[Biol 1002 or 1009], Chem 2301)
Fundamentals of biochemistry including structure and function of proteins, nucleic acids, lipids and carbohydrates; metabolism and regulation of metabolism; quantitative treatments of chemical equilibria, enzyme catalysis and bioenergetics; the chemical basis of genetic information flow.

NSCI 3101 **- Introduction to Neuroscience I: From Molecules to Madness**
(3.0 cr; =[BIOL 3101, PHSL 3101]; Prereq-BioC 3021 or & BioC 3021 or BioC 4331 or & BioC 4331 recommended; A-F or Aud)
Basic principles of cellular/molecular neurobiology and nervous systems.

BIOL 4003 **- Genetics**
(3.0 cr; =[GCD 3022]; Prereq-[[BIOC 3021 or BIOC 4331], [any CBS major or major in [animal science or applied plant science or BA biology or BA microbiology or nutrition or physiology or biology/society/environment]]] or #)
Introduction to the nature of genetic information, its transmission from parents to offspring, its expression in cells/organisms, and its course in populations.

BIOL 4004 **- Cell Biology**
(3.0 cr; Prereq-[3021 or BIOC 3021 or BIOC 4331], [4003 or BIOC 4332)
Processes fundamental to cells. Emphasizes eukaryotic cells. Assembly/function of membranes/organelles. Cell division, cell form/movement, intercellular communication, transport, secretion pathways. Cancer cells, differentiated cells.

BMEN 5001 **- Advanced Biomaterials**
(3.0 cr; Prereq-3301 or MatS 3011 or grad student or #; A-F or Aud)
Commonly used biomaterials. Chemical/physical aspects. Practical examples from such areas as cardiovascular/orthopedic applications, drug delivery, and cell encapsulation. Methods used for chemical analysis and for physical characterization of biomaterials. Effect of additives, stabilizers, processing conditions, and sterilization methods.

BMEN 5041 **- Tissue Engineering**
(3.0 cr; Prereq-CSE upper div or grad student or med student or #)
Fundamentals of wound healing and tissue repair; characterization of cell-matrix interactions; case study of engineered tissues, including skin, bone marrow, liver, vessel, and cartilage; regulation of biomaterials and engineered tissues.

BMEN 5151 **- Introduction to BioMEMS and Medical Microdevices**
(2.0 cr; Prereq-CSE sr or grad student or medical student; A-F or Aud)
Design/microfabrication of sensors, actuators, drug delivery systems, microfluidic devices, and DNA/protein microarrays. Packaging, biocompatibility, ISO 10993 standards. Applications in medicine, research, and homeland security.

CHEN 5751 **- Biochemical Engineering**
(3.0 cr; Prereq-[3005 or 4005], [&3006 or &4006], [&3102 or &4102]; A-F or Aud)

Chemical engineering principles applied to analysis/design of complex cellular/enzyme processes. Quantitative framework for design of cells for production of proteins, synthesis of antibodies with mammalian cells, or degradation of toxic compounds in contaminated soil.

CHEN 5753 **- Biological Transport Processes**
(3.0 - 4.0 cr [max 4.0 cr]; =[BMEN 5311, ME 5381]; Prereq-3005 or 4005 or equiv; A-F or Aud)
Fluid, mass, heat transport in biological systems. Mass transfer across membranes, fluid flow in capillaries, interstitium, veins, and arteries Heat transfer in single cells/tissues. Whole organ, body heat transfer issues. Blood flow, oxygenation. Heat/mass transfer in respiratory systems. Biotransport issues in artificial organs, membrane oxygenators, drug delivery applications.

MICB 3301 **- Biology of Microorganisms**
(5.0 cr; =[BIOL 2032, MICB 3303, VBS 2032]; Prereq-[BIOL 1002 or BIOL 1009 or BIOL 2002], CHEM 2301, &CHEM 2302; A-F or Aud)
Taxonomy, anatomy, physiology, biochemistry, pathogenesis, immunology, ecology of microbes. Molecular structure in relation to bacterial function/disease. Includes lab.

MICB 4121 **- Microbial Ecology and Applied Microbiology**
(3.0 cr; =[[SOIL 4121, ES 4121]; Prereq-3301; A-F or Aud)
Evolution/structure of microbial communities. Population interaction within ecosystems. Quantitative/habitat ecology. Biogeochemical cycling. Molecular microbial ecology, gene transfer in the environment. Molecular phylogeny of microorganisms. Application of microbes in agriculture. Production of commodity chemicals, drugs, and other high-value products.

MICB 4131 **- Immunology**
(3.0 cr; =[VPM 4131]; Prereq-[2022 or VPB 2022 or BIOL 2032 or VPB 2032 or VBS 2032 or 3301 or BIOL 3301], [BIOC 3021 or BIOL 3021 or BIOC 4331)
Molecular, genetic, and cellular bases for humoral/cell-mediated immunity. Innate immunity. Antigen recognition by B/T lymphocytes. Interactions between lymphocytes and other cells of immune system. Cytokines. Immunoregulation. Key aspects of clinical immunology.

Chemistry – Frisbie

You must take into consideration the four points on page 9.

CHEN 4214 **- Polymers**
(3.0 cr; Prereq-[[MATS 3011, [3101 or 4101 or MATS 4001], [upper div MatS or ChEn]]] or #; A-F or Aud)
Polymer structure-property relations: structure/morphology of crystalline/amorphous states. Crystallization kinetics. Vitrification and the glass transition. Mechanical properties, failure, permeability, optical/electrical properties, polymer composites, effect of processing on properties.

CHEN 4708 **- Advanced Undergraduate Chemical Rate Processes: Analysis of Chemical Reactors**
(3.0 cr; Prereq-[3102 or 4102], ChEn major upper div; A-F only)
Design of reactors for heat management, with catalytic processes. Analysis of steady state, transient behavior. Polymerization, combustion, solids processing, environmental modeling. Design of multiphase reactors.

CHEM 4011 **- Mechanisms of Chemical Reactions**
(3.0 cr; Prereq-[2302, 3501] or equiv)
Reaction mechanisms, methods of study. Mechanistic concepts. Gas phase reactions. "Electron pushing" mechanisms in organic/enzymatic reactions. Kinetic schemes, other strategies.

CHEM 4021 **- Computational Chemistry**
(3.0 cr; Prereq-3502 or equiv)
Theoretical methods for study of molecular structure, bonding, and reactivity. Ab initio and semi-empirical calculations of molecular electronic structure. Theoretical determination of molecular electronic structure and spectra; relation to experimental techniques. Molecular mechanics. Structure determination for large systems. Molecular properties and reactivity. Computational tools. Critical assessment of methods and theoretical work in the literature. Lab.

CHEM 4201 **- Materials Chemistry**
3.0 cr; =[CHEM 8201]; Prereq-[[3502 or equiv], 4701] or #)
Crystal systems/unit cells, phase diagrams, defects/interfaces, optical/ dielectric properties, electrical/thermal conductivity, X-ray diffraction, thin film analysis, electronic structure, polarons/phonons, solid state chemistry, liquid/molecular crystals, polymers, magnetic/optical materials, porous materials, ceramics, piezoelectric materials, biomedical materials, catalysts.

CHEM 4221 **- Introduction to Polymer Chemistry**
(3.0 cr; =[CHEN 8221, MATS 5221, MATS 8221, CHEN 5221, CHEM 8221]; Prereq-[2302, 3501] or #; fall, every year)
Condensation, radical, ionic, emulsion, ring-opening, metal-catalyzed polymerizations. Chain conformation, solution thermodynamics, molecular weight characterization, physical properties.

CHEM 4223W **- Polymer Laboratory (WI)**
(2.0 cr; =[MATS 4223W, CHEN 4223W]; Prereq-4221 or 4214 or CHEN 4214 or MATS 4214 or #)
Synthesis, characterization, and physical properties of polymers. Free radical, condensation, emulsion, anionic polymerization. Infrared spectroscopy/gel permeation chromatography. Viscoelasticity, rubber elasticity, crystallization.

CHEM 4311W **- Advanced Organic Chemistry Lab (WI)**
(2.0 cr; Prereq-2311)
Reactions, techniques, and instrumental methods in synthetic organic chemistry.

CHEM 4321 **- Organic Synthesis**
(3.0 cr; Prereq-[2302 or equiv], 3501, #)
Fundamental concepts, reactions, reagents, structural/stereochemical issues, mechanistic skills for organic chemistry.

CHEM 4322 **- Advanced Organic Chemistry**
(3.0 cr; Prereq-[2302 or equiv], 3501, #)
Topics vary by instructor. Examples: natural products, heterocycles, asymmetric synthesis, organometallic chemistry, polymer chemistry.

CHEM 4411 **- Introduction to Chemical Biology**
(3.0 cr; Prereq-[2302 or equiv], 3501)
Chemistry of amino acids, peptides, proteins, lipids, carbohydrates, and nucleic acids. Structure, nomenclature, synthesis, and reactivity. Techniques to characterize biomolecules.

CHEM 4413 **- Nucleic Acids**
(3.0 cr; Prereq-2302, [3501 or equiv])
Chemistry/biology of nucleic acids. Structure, thermodynamics, reactivity, DNA repair, chemical oligonucleotide synthesis, antisense approaches, ribozymes. Techniques for nucleic acid research. Interactions with small molecules/proteins.

CHEM 4511W **- Advanced Physical Chemistry Lab (WI)**
(2.0 cr; Prereq-3501-3502, chemistry major)
Experiments illustrating principles and methods of thermodynamics, reaction kinetics, and quantum mechanics.

CHEM 4701 **- Inorganic Chemistry**
(3.0 cr; Prereq-[2311 or &2311], [3501 or &3501 or 3502 or &3502])
Periodic trends. Structure/bonding in compounds where s and p electrons are important. Descriptive chemistry of solids and transition metal compounds. Transition metal chemistry. Topics in main group and materials chemistry.

CHEM 4711W **- Advanced Inorganic Chemistry Lab (WI)**
(2.0 cr; Prereq-4701, chem major; A-F or Aud)
Lab experiments in inorganic/organometallic chemistry illustrating synthetic/spectroscopic techniques.

CHEM 4725 **- Organometallic Chemistry**
(3.0 cr; Prereq-4701 or equiv, chem major or #)
Synthesis, reactions, structures, and other properties of main group and transition metal organometallic compounds; electronic

and structural theory, emphasizing their use as stoichiometric and homogeneous catalytic reagents in organic and inorganic systems.

CHEM 4745 **- Advanced Inorganic Chemistry**
(3.0 cr; Prereq-4701, chem major, #)
Topics in main group and transition metal chemistry. Emphasizes synthesis, structure, physical properties, and chemical reactivity.

CHEM 5210 **- Materials Characterization**
(4.0 cr; Prereq-grad student or #; A-F or Aud)
Modern tools/techniques for both bulk- and thin-film characterization. Topics may include ion-solid interactions, Rutherford back scattering, secondary ion mass spectrometry, solid-state NMR, x-ray photoelectron spectroscopy, small-angle x-ray/neutron scattering, transmission/scanning electron/probe microscopy, near-field scanning optical microscopy, porosimetry, adsorption techniques, and ellipsometry.

MATS 4212 **- Ceramics**
(3.0 cr; Prereq-[3011, [4001 or CHEN 3101], [MatS or ChEn upper div]] or #; A-F or Aud)
Crystal structures, non-crystalline (glass) structures, microstructure. Ceramic phase relationships: binary/ternary diagrams. Ceramic properties: thermal, mechanical, electrical, magnetic, optical. Computer applications.

MATS 4511W **- Corrosion and Electrochemistry of Corrosion (WI)**
(4.0 cr; Prereq-MatS 3011 or #, upper div CSE or grad; A-F or Aud)
Electrochemical thermodynamics, electrochemical kinetics, theory of aqueous corrosion, theory of high temperature oxidation; specific topics include general corrosion, passivation, pitting, galvanic protection/corrosion, environmental degradation of mechanical properties, corrosion of electronic components, growth of oxide scales by diffusion, materials selection and design. Computers used to collect lab data.

Computational/Numerical Analysis – Derby or Daoutidis or Kumar

You must take into consideration the four points on page 9.

CSCI 5304 **- Computational Aspects of Matrix Theory**
(3.0 cr; Prereq-2031 or 2033 or #)
Perturbation theory for linear systems and eigenvalue problems. Direct/iterative solution of large linear systems. Matrix factorizations. Computation of eigenvalues/eigenvectors. Singular value decomposition. LAPACK/other software packages. Introduction to sparse matrix methods.

CSCI 5451 **- Introduction to Parallel Computing: Architectures, Algorithms, and Programming**
(3.0 cr; Prereq-4041 or #)
Parallel architectures design, embeddings, routing. Examples of parallel computers. Fundamental communication operations. Performance metrics. Parallel algorithms for sorting. Matrix problems, graph problems, dynamic load balancing, types of parallelisms. Parallel programming paradigms. Message passing programming in MPI. Shared-address space programming in openMP or threads.

MATH 5485 **- Introduction to Numerical Methods I**
(4.0 cr; Prereq-[2243 or 2373 or 2573], familiarity with some programming language)
Solution of nonlinear equations in one variable. Interpolation, polynomial approximation, numerical integration/differentiation, numerical solution of initial-value problems.

MATH 5486 **- Introduction To Numerical Methods II**
(4.0 cr; Prereq-5485)
Direct/iterative methods for solving linear systems, approximation theory, methods for eigenvalue problems, methods for systems of nonlinear equations, numerical solution of boundary value problems for ordinary differential equations.

Drug Delivery Design and Evaluation - McCormick or Prof. Cheryl Zimmerman in the Pharmaceutics Department

You must take into consideration the four points on page 9.

BIOC 4521 **- Introduction to Physical Biochemistry**
(3.0 cr; Prereq-CHEM 1022, MATH 1272, PHYS 1202; 4331 recommended)
Physical chemical principles, their applications in biochemistry. Thermodynamics, kinetics, spectroscopy, and solution dynamics as applied to biochemical reactions and biopolymers.

BIOC 5527 **- Introduction to Modern Structural Biology**
(4.0 cr; Prereq-[intro biochemistry, intro physics] or physical chemistry or #)
Methods employed in modern structural biology to elucidate macromolecular structures. Primary focus on X-ray diffraction, nuclear magnetic resonance (NMR) spectroscopy and mass spectrometry. Principles underlying structural biology and structure/function relationships.

BMEN 5001 **- Advanced Biomaterials**
(3.0 cr; Prereq-3301 or MatS 3011 or grad student or #; A-F or Aud)
Commonly used biomaterials. Chemical/physical aspects. Practical examples from such areas as cardiovascular/orthopedic applications, drug delivery, and cell encapsulation. Methods used for chemical analysis and for physical characterization of biomaterials. Effect of additives, stabilizers, processing conditions, and sterilization methods.

BMEN 5311 **- Advanced Biomedical Transport Processes**
(3.0 - 4.0 cr [max 4.0 cr]; =[CHEN 5753, ME 5381]; Prereq-CSE upper div or grad student or #; [ChEn 5103 or ME 5342] recommended)
Introduction to biological fluid, mass, and heat transport. Mass transfer across membranes. Fluid flow in vessels/interstitium. Heat transfer in cells, tissues, and body. Applications to blood oxygenation, respiration, drug delivery, and tissue engineering.

PHAR 6163 **- Pharmacokinetics**
(3.0 cr; Prereq-Calculus II (quarter), calculus I (semester) or equiv, 6162; A-F or Aud)
Physiological basis for drug absorption, distribution, metabolism and excretion; use of mathematical principles and equations to describe these processes as well as design dosage regimens for individual patients.

PHAR 6164 **- Biopharmaceutics**
(3.0 cr; Prereq-6163, & 6175; A-F or Aud)
Applied theory of dosage form design for optimal drug activity and bioavailability for all routes of drug administration.

PHAR 6224 **- Pharmacogenomics: Genetic Basis for Variability in Drug Response**
(2.0 cr; Prereq-2nd or 3rd yr pharmacy; A-F or Aud)
Theory/practice of pharmacogenomics. Principles of human genetics/genomics. Applications to scientific education, problems in drug therapy optimization, and patient care.

PHCL 5110 **- Introduction to Pharmacology**
(3.0 cr; Prereq-Grad student or #; A-F or Aud)
Basic principles of Pharmacology. Focuses on molecular mechanisms of drug action.

PHSL 5061 **- Principles of Physiology for Biomedical Engineering**
(4.0 cr; Prereq-Biomedical engineering grad, one yr college chem and physics and math through integral calculus)
Human physiology with emphasis on quantitative aspects. Organ systems (circulation, respiration, renal, gastrointestinal, endocrine, muscle, central and peripheral nervous systems), cellular transport processes, and scaling in biology.

PUBH 6161 **- Regulatory Toxicology**
(2.0 cr; Prereq-Background in toxicology or pharmacology or related field is recommended)
In-depth introduction to laws (and associated regulations) of U.S. federal regulatory agencies, such as CPSC, EPA, FDA, OSHA, and DOT, that require/use toxicological data/information in their mission of protecting human/environmental health.

Environmental Engineering – Cussler

You must take into consideration the four points on page 9.

NOTE! CE 3501 Environmental Engineering is not approved as a ChEn emphasis elective.

CE 4502 **- Water and Wastewater Treatment**
(3.0 cr; Prereq-3501 or CHEN 2001; A-F or Aud)
Theory of chemical, physical, and biological processes in treating water and wastewater. Sequencing of processes. Design of treatment facilities.

CE 4561 **- Solid Hazardous Wastes**
(3.0 cr; Prereq-CSE or grad, Chem 1022, 3501 or #)
Solid and hazardous waste characterization; regulatory legislation; waste minimization; resource recovery; chemical, physical, and biological treatment; thermal processes; disposal practices. Analysis and design of systems for treatment and disposal.

CE 4562 **- Environmental Remediation Technology**
(3.0 cr; Prereq-[3501, 4501] or #; A-F or Aud)
Technologies designed for removal of pollutants from groundwater and soils. Advances in technological design. Emerging technologies such as in situ bioremediation, phytoremediation. Role of environmental biotechnology in pollution abatement.

CHEN 5551 **- Survey of Renewable Energy Technologies**
(3.0 cr; Prereq-[Upper div or #], basic knowledge of chemistry, thermodynamics; A-F or Aud)
Technologies to generate renewable energy/chemicals. Biomass, solar, wind, hydroelectric. Emphasizes biomass processing using chemical/biological methods. Renewable technologies compared with fossil fuel technologies.

CHEN 5751 **- Biochemical Engineering**
(3.0 cr; Prereq-[3005 or 4005], [&3006 or &4006], [&3102 or &4102]; A-F or Aud)
Chemical engineering principles applied to analysis/design of complex cellular/enzyme processes. Quantitative framework for design of cells for production of proteins, synthesis of antibodies with mammalian cells, or degradation of toxic compounds in contaminated soil.

Food Engineering – Hu

You must take into consideration the four points on page 9.

BBE 4723 **- Food Process Engineering**
(3.0 cr; =[BBE 5723]; Prereq-[[4013 or &4013] upper div CSE] or #;; A-F or Aud)
Application of principles of heat transfer and fluid flow to design of food processing operations such as thermal/aseptic processing, freezing, pumping, drying, evaporation, extrusion. Marketing, government regulation, nutrition issues.

CHEN 5751 **- Biochemical Engineering**
(3.0 cr; Prereq-[3005 or 4005], [&3006 or &4006], [&3102 or &4102]; A-F or Aud)
Chemical engineering principles applied to analysis/design of complex cellular/enzyme processes. Quantitative framework for design of cells for production of proteins, synthesis of antibodies with mammalian cells, or degradation of toxic compounds in contaminated soil.

FSCN 4112 **- Food Chemistry and Functional Foods**
(3.0 cr; Prereq-3102, BIOC 3021)
Most-important food constituents, their occurrence, structures, functional properties, and health benefits. Proteins, lipids, carbohydrates, water. Vitamins, minerals, enzymes, phytochemicals, food additives, contaminants.
FSCN 4121 **- Food Microbiology**
(3.0 cr; Prereq-BIOC 3021, [2021 or VBS 2032 or MICB 3301]; OPT No Aud)
Microorganisms involved in food-borne disease, food fermentations, and food spoilage. Methods for their control/detection. Food microbiology. Foodborne pathogens. Microbial food spoilage. Control of microorganisms in food.

FSCN 4122 **- Food Fermentations and Biotechnology**
(2.0 cr; Prereq-[MICB 3301, BIOL 4003] or #)

Major food fermentations important for food industry. Microbiological components. Impact of biotechnology on food production. Genetic tools. Improvement of microbes used in food production by biotechnological approaches.

FSCN 4311 **- Chemical Reactions in Food Systems**
(2.0 cr; Prereq-4112, 4312W)
Chemical structure of major food constituents, carbohydrates, lipid, and proteins. Reaction/interaction pathways. Function within complex food matrix under various storage/processing conditions.

FSCN 4332 **- Food Processing Operations**
(3.0 cr; Prereq-4331 or BAE 4744; A-F or Aud)
Engineering principles applied to commonly used food processing operations. Blanching, pasteurization, sterilization, frying, baking, milling, extrusion. Meat processing, water treatment, waste management.

FSCN 4342 **- Properties of Water in Foods**
(4.0 cr; Prereq-BBE 4744, [&4xxx or &5xxx] FSCN course)
Principles of processing, handling, and storing frozen, dry, and intermediate moisture biological materials (foods, drugs, biologics). Emphasizes physio-chemical properties of water in food.

FSCN 5441 **- Introduction to New Product Development**
(2.0 cr; Prereq-4111, 4331)
Interactive course that introduces students to the principles of new product development, from identification and testing of new product concepts, through prototype testing, to basic process design using examples from industry.

FSCN 5461 **- Food Packaging**
(2.0 cr; Prereq-1102, 3102, Phys 1102 or Phys 1302)
Materials, principles, and procedures of packaging as they apply to food products. Emphasis is on consumer products, but the principles also apply to bulk and institutional foods and ingredients.

General Chemical Engineering – Kumar

You must take into consideration the four points on page 9.

This area is a selection of courses and experiences meant to best prepare you for a wide range of chemical engineering jobs and for graduate study. You may take ANY course listed with ANY emphasis area. In addition, the following courses are especially recommended.

CHEN 4214 **- Polymers** (preferred)
((3.0 cr; Prereq-[[MATS 3011, [3101 or 4101 or MATS 4001], [upper div MatS or ChEn]]] or #; A-F or Aud)
Polymer structure-property relations: structure/morphology of crystalline/amorphous states. Crystallization kinetics. Vitrification and the glass transition. Mechanical properties, failure, permeability, optical/electrical properties, polymer composites, effect of processing on properties.

CHEN 4701 **- Advanced Undergraduate Applied Math I: Linear Analysis**
(3.0 cr; Prereq-[2311 or &2311], [3501 or &3501 or 3502 or &3502])
Periodic trends. Structure/bonding in compounds where s and p electrons are important. Descriptive chemistry of solids and transition metal compounds. Transition metal chemistry. Topics in main group and materials chemistry. Undergraduate version of 8201.

CHEN 4702 **- Advanced Undergraduate Rheology**
(2.0 cr; Prereq-[3005 or 4005], #; A-F only)
Deformation/flow of non-Newtonian/viscoelastic fluids, plastic materials, perfectly elastic solids. Phenomenological/molecular interpretation of rheology of elastomers, polymer melts, polymer solutions. Application of rheology to polymer processing. Undergraduate version of 8102.

CHEN 4703 **- Advanced Undergraduate Applied Math II: Nonlinear Analysis**
(3.0 cr; Prereq-[3005 or 4005], ChEn major upper div; grad course in linear analysis recommended; A-F only)
Nonlinear mathematical problems (nonlinear ordinary/partial differential equations) using theoretical/numerical analysis.

Undergraduate version of 8202.

CHEN 4704 **- Advanced Undergraduate Physical Rate Processes I: Transport**
(3.0 cr; Prereq-[3005 or 4005], ChEn major upper div; A-F only)
Mass transfer, dilute/concentrated diffusion, Brownian motion. Diffusion coefficients in polymers, of electrolytes, at critical points. Multicomponent diffusion. Correlations/predictions. Mass transfer, chemical reaction.

CHEN 4706 **- Advanced Undergraduate Physical and Chemical Thermodynamics**
(3.0 cr; Prereq-CHEM 3502, [3101 or 4101], [3005 or 4005], ChEn major upper div; background in undergrad engineering or chemistry courses in thermodynamics recommended; A-F only)
Principles of classical thermodynamics, introduction to nonequilibrium thermodynamics. Applications in chemical engineering, materials science.

CHEN 4707 **- Advanced Undergraduate Statistical Thermodynamics and Kinetics**
(3.0 cr; Prereq-ChEn 3005 or 4005, 3101 or 4101, CHEM 3501, CHEM 3502, ChEn major upper div; A-F only)
Introduction to statistical mechanical description of equilibrium/non-equilibrium properties of matter. Emphasizes fluids, classical statistical mechanics.

CHEN 4708 **- Advanced Undergraduate Chemical Rate Processes: Analysis of Chemical Reactors**
(3.0 cr; Prereq-[3102 or 4102], ChEn major upper div; A-F only)
Design of reactors for heat management, with catalytic processes. Analysis of steady state, transient behavior. Polymerization, combustion, solids processing, environmental modeling. Design of multiphase reactors.

CHEM 4221 **- Introduction to Polymer Chemistry**
(3.0 cr; =[CHEN 8221, MATS 5221, MATS 8221, CHEN 5221, CHEM 8221]; Prereq-[2302, 3501] or #; fall, every year)
Condensation, radical, ionic, emulsion, ring-opening, metal-catalyzed polymerizations. Chain conformation, solution thermodynamics, molecular weight characterization, physical properties.

CHEN 5531 **- Electrochemical Engineering and Renewable Energy**
(3.0 cr; =[MATS 5531]; Prereq-[MATS 3011 or #], [upper div CSE or grad student]; A-F only)
Fundamentals of electrochemical engineering. Electrochemical mass transfer electrokinetics, thermodynamics of electrochemical cells, modern sensors. Formation of thin films and microstructured materials. Computer-based problems.

CHEN 5551 **- Survey of Renewable Energy Technologies**
(3.0 cr; Prereq-[Upper div or #], basic knowledge of chemistry, thermodynamics; A-F or Aud)
Technologies to generate renewable energy/chemicals. Biomass, solar, wind, hydroelectric. Emphasizes biomass processing using chemical/biological methods. Renewable technologies compared with fossil fuel technologies.

CHEN 5751 **- Biochemical Engineering**
(3.0 cr; Prereq-[3005 or 4005], [&3006 or &4006], [&3102 or &4102]; A-F or Aud)
Chemical engineering principles applied to analysis/design of complex cellular/enzyme processes. Quantitative framework for design of cells for production of proteins, synthesis of antibodies with mammalian cells, or degradation of toxic compounds in contaminated soil.

CHEN 5752 **- Quantitative Biology for Engineers**
(3.0 cr; =[CHEN 8752]; Prereq-Engineering background, #; A-F or Aud)
Biological fundamentals of biotechnology. Structural basis of biological systems. Communication between cells/environment. Gene expression. Proteins and their functional classes. Metabolic pathways and their reactions. From gene/genome to physiology. Genomics/proteomics as technologies. Biotechnology and society: ethics, law, public policy. Biotechnology-based commercial enterprises.

CHEN 5771 **- Colloids and Dispersions**
(3.0 cr; =[01472]; Prereq-Physical chemistry; A-F or Aud)
Preparation, stability, coagulation kinetics or colloidal solutions. DLVO theory, electrokinetic phenomena. Properties of micelles, other microstructures.

MATS 4212 **- Ceramics**
(3.0 cr; Prereq-[3011, [4001 or CHEN 3101], [MatS or ChEn upper div]] or #; A-F or Aud)
Crystal structures, non-crystalline (glass) structures, microstructure. Ceramic phase relationships: binary/ternary diagrams. Ceramic properties: thermal, mechanical, electrical, magnetic, optical. Computer applications.

ME 5113 **- Aerosol/Particle Engineering**
(4.0 cr; Prereq-CSE upper div or grad student; A-F or Aud)
Kinetic theory, definition, theory and measurement of particle properties, elementary particle mechanics, particle statistics; Brownian motion and diffusion, coagulation, evaporation and condensation, sampling and transport.

Industrial Engineering – Caretta

You must take into consideration the four points on page 9.

EE 3015 **- Signals and Systems**
(3.0 cr; Prereq-[2011, CSE] or %)
Basic techniques for analysis/design of signal processing, communications, and control systems. Time/frequency models, Fourier-domain representations, modulation. Discrete-time/digital signal/system analysis. Z transform. State models, stability, feedback.

EE 4231 **- Linear Control Systems: Designed by Input/Output Methods**
(3.0 cr; Prereq-[3015, [upper div CSE or grad student in CSE major]] or #)
Modeling, characteristics, and performance of feedback control systems. Stability, root locus, and frequency response methods. Digital implementation, hardware considerations.

IE 4521 **- Statistics, Quality, and Reliability**
(4.0 cr; Prereq-Upper div or grad student or CNR)
Random variables/probability distributions, statistical sampling/measurement, statistical inferencing, confidence intervals, hypothesis testing, single/multivariate regression, design of experiments, statistical quality control, quality management, reliability, maintainability, availability.

IE 5441 **- Financial Decision Making**
((4.0 cr; Prereq-CSE upper div or grad student; A-F only)
Evaluating investment options, capital budgeting. Accounting for inflation, depreciation, and taxes. Evaluating financing options, cost of capital. Financial reporting, analysis of statements. Cost analysis. Financial markets/securities. Accounting for uncertainty, risk-return.

IE 5513 **- Engineering Safety**
(4.0 cr; Prereq-Upper div CSE or grad student; A-F or Aud)
Occupational, health, and product safety. Standards, laws, and regulations. Hazards and their engineering control, including general principles, tools and machines, mechanics and structures, electrical safety, materials handling, fire safety, and chemicals. Human behavior and safety, procedures and training, warnings and instructions.

IE 5522 **- Quality Engineering and Reliability**
(4.0 cr; Prereq-[4521 or equiv], [upper div or grad student or CNR])
Quality engineering/management, economics of quality, statistical process control design of experiments, reliability, maintainability, availability.
MGMT 4080W **- Applied Technology Entrepreneurship (WI)**
(4.0 cr; =[01591)
Team projects based on commercializable technologies or innovations. Teams present their ideas to investors and industry professionals. Students are encouraged to submit their business plans to Minnesota Cup.

ME 5223 **- Materials in Design**
(4.0 cr; Prereq-3221)
Fundamental properties of engineering materials. Fabrication, treatment. Physical and corrosive properties. Failure mechanism, cost and value analysis as related to material selection and specification.

Materials Science – Leighton

You must take into consideration the four points on page 9.

BP 4405/5405 **Bio-Based Composites Engineering Materials Science & Polymers**
(3.0 cr; =[BBE 5404]; Prereq-[4303, [5303 or AEM 3031]] or #; A-F or Aud)
Structure/properties of biopolymers and the engineering of composites from these biopolymers and/or plant-based materials.

CHEM 4223W **- Polymer Laboratory (WI)**
(2.0 cr; =[MATS 4223W, CHEN 4223W]; Prereq-4221 or 4214 or CHEN 4214 or MATS 4214 or #)
Synthesis, characterization, and physical properties of polymers. Free radical, condensation, emulsion, anionic polymerization. Infrared spectroscopy/gel permeation chromatography. Viscoelasticity, rubber elasticity, crystallization.

CHEN 4214 **- Polymers** (preferred)
(3.0 cr; Prereq-[[MATS 3011, [3101 or 4101 or MATS 4001], [upper div MatS or ChEn]]] or #; A-F or Aud)
Polymer structure-property relations: structure/morphology of crystalline/amorphous states. Crystallization kinetics. Vitrification and the glass transition. Mechanical properties, failure, permeability, optical/electrical properties, polymer composites, effect of processing on properties.

MATS 4013 **- Electrical and Magnetic Properties of Materials**
(3.0 cr; Prereq-[3011, [CHEM 3502 or PHYS 2303], upper div [MatS or ChEn]] or #; A-F or Aud)
Electronic/magnetic properties of solids. Simple band theory of solids. Free electron theory of conductivity/transport. Optical/dielectric response functions. Elementary theory of magnetism. Electronic devices. Superconductivity. Computer-based problems to illustrate applications.

MATS 4212 **- Ceramics**
(3.0 cr; Prereq-[3011, [4001 or CHEN 3101], [MatS or ChEn upper div]] or #; A-F or Aud)
Crystal structures, non-crystalline (glass) structures, microstructure. Ceramic phase relationships: binary/ternary diagrams. Ceramic properties: thermal, mechanical, electrical, magnetic, optical. Computer applications.

MATS 4301W **- Materials Processing (WI)**
(4.0 cr; Prereq-4212, [4214 or &4214]; A-F only)
Casting, solidification and plastic forming of metals. Powder processing, forming operations, sintering of ceramics. Processing of thermoplastic/thermoset polymers. Computer applications of data collection/reduction.

MATS 4511W **- Corrosion and Electrochemistry of Corrosion (WI)**
(4.0 cr; Prereq-MatS 3011 or #, upper div CSE or grad; A-F or Aud)
Electrochemical thermodynamics, electrochemical kinetics, theory of aqueous corrosion, theory of high temperature oxidation; specific topics include general corrosion, passivation, pitting, galvanic protection/corrosion, environmental degradation of mechanical properties, corrosion of electronic components, growth of oxide scales by diffusion, materials selection and design. Computers used to collect lab data.

MATS 5531 **- Electrochemical Engineering**
(3.0 cr; =[CHEN 5531]; Prereq-MatS 3011 or #, upper div CSE or grad; fall, offered periodically)
Fundamentals of electrochemical engineering. Topics include electrochemical mass transfer electrokinetics, thermodynamics of cells, modern sensors, formation of thin films and microstructured materials. Computer-based problems will be assigned.

Mathematics and Statistics – Daoutidis or Kumar

You must take into consideration the four points on page 9.

MATH 2283 **- Sequences, Series, and Foundations**
(3.0 cr; =[MATH 3283W]; Prereq-[&2243 or &2263 or &2373 or &2374] w/grade of at least C-)
Mathematical reasoning. Elements of logic. Mathematical induction. Real number system. General, monotone, recursively defined sequences. Convergence of infinite series/sequences. Taylor's series. Power series with applications to differential equations. Newton's method.

MATH 3283W **- Sequences, Series, and Foundations: Writing Intensive (WI)**
(4.0 cr; =[MATH 2283]; Prereq-[&2243 or &2263 or &2373 or &2374] w/grade of at least C-)
Introduction to reasoning used in advanced mathematics courses. Logic, mathematical induction, real number system, general/monotone/recursively defined sequences, convergence of infinite series/sequences, Taylor's series, power series with applications to differential equations, Newton's method. Writing-intensive component.

MATH 4065 **- Theory of Interest**
(3.0 cr; Prereq-1272 or 1372 or 1572; primarily for [mathematics, business] majors interested in actuarial science
Time value of money. Annuities, sinking funds, bonds, similar items.

MATH 4242 **- Applied Linear Algebra**
(4.0 cr; =[MATH 4457]; Prereq-2243 or 2373 or 2573)
Systems of linear equations, vector spaces, subspaces, bases, linear transformations, matrices, determinants, eigenvalues, canonical forms, quadratic forms, applications.

MATH 4512 **- Differential Equations with Applications**
(3.0 cr; Prereq-2243 or 2373 or 2573)
Laplace transforms, series solutions, systems, numerical methods, plane autonomous systems, stability.

MATH 4567 **- Applied Fourier Analysis**
(4.0 cr; Prereq-2243 or 2373 or 2573)
Fourier series, integral/transform. Convergence. Fourier series, transform in complex form. Solution of wave, heat, Laplace equations by separation of variables. Sturm-Liouville systems, finite Fourier, fast Fourier transform. Applications. Other topics as time permits.

MATH 4603 **- Advanced Calculus I**
(4.0 cr; =[01072]; Prereq-[[2243 or 2373], [2263 or 2374]] or 2574 or #)
Axioms for the real numbers. Techniques of proof for limits, continuity, uniform convergence. Rigorous treatment of differential/integral calculus for single-variable functions.

MATH 5251 **- Error-Correcting Codes, Finite Fields, Algebraic Curves**
(4.0 cr; Prereq-2 sems soph math)
Information theory: channel models, transmission errors. Hamming weight/distance. Linear codes/fields, check bits. Error processing: linear codes, Hamming codes, binary Golay codes. Euclidean algorithm. Finite fields, Bose-Chaudhuri-Hocquenghem codes, polynomial codes, Goppa codes, codes from algebraic curves.

MATH 5378 **- Differential Geometry**
(4.0 cr; Prereq-[2263 or 2374 or 2573], [2243 or 2373 or 2574]; [2283 or 3283] recommended])
Basic geometry of curves in plane and in space, including Frenet formula, theory of surfaces, differential forms, Riemannian geometry.

MATH 5445 **- Mathematical Analysis of Biological Networks**
(4.0 cr; Prereq-Linear algebra, differential equations)
Development/analysis of models for complex biological networks. Examples taken from signal transduction networks, metabolic networks, gene control networks, and ecological networks.

MATH 5525 **- Introduction to Ordinary Differential Equations**
(4.0 cr; Prereq-[2243 or 2373 or 2573], [2283 or 2574 or 3283])
Ordinary differential equations, solution of linear systems, qualitative/numerical methods for nonlinear systems. Linear algebra background, fundamental matrix solutions, variation of parameters, existence/uniqueness theorems, phase space. Rest points, their stability. Periodic orbits, Poincare-Bendixson theory, strange attractors.

MATH 5535 **- Dynamical Systems and Chaos**
(4.0 cr; Prereq-[2243 or 2373 or 2573], [2263 or 2374 or 2574])
Dynamical systems theory. Emphasizes iteration of one-dimensional mappings. Fixed points, periodic points, stability, bifurcations, symbolic dynamics, chaos, fractals, Julia/Mandelbrot sets.

MATH 5587 **- Elementary Partial Differential Equations I**
(4.0 cr; Prereq-[2243 or 2373 or 2573], [2263 or 2374 or 2574])
Emphasizes partial differential equations w/physical applications, including heat, wave, Laplace's equations. Interpretations of boundary conditions. Characteristics, Fourier series, transforms, Green's functions, images, computational methods. Applications include wave propagation, diffusions, electrostatics, shocks.

MATH 5616H **- Honors: Introduction to Analysis II**
(4.0 cr; Prereq-5615)
Rigorous treatment of Riemann-Stieltjes integration. Sequences/series of functions, uniform convergence, equicontinuous families, Stone-Weierstrass Theorem, power series. Rigorous treatment of differentiation/integration of multivariable functions, Implicit Function Theorem, Stokes' Theorem. Additional topics as time permits.

MATH 5651 **- Basic Theory of Probability and Statistics**
(4.0 cr; Prereq-[2263 or 2374 or 2573], [2243 or 2373]; [2283 or 2574 or 3283] recommended; Credit will not be granted if credit has been received for: Stat 4101, Stat 5101.)
Logical development of probability, basic issues in statistics. Probability spaces, random variables, their distributions/expected values. Law of large numbers, central limit theorem, generating functions, sampling, sufficiency, estimation.

Microelectronic materials – Caretta or Aydil

You must take into consideration the four points on page 9.

EE 3161 **- Semiconductor Devices**
(3.0 cr; Prereq-Upper div CSE, 2011, Phys 1302, Phys 2303 or Chem 1022)
Elementary semiconductor physics; physical description of pn junction diodes, bipolar junction transistors, field-effect transistors.

EE 5171 **- Microelectronic Fabrication**
(4.0 cr; Prereq-CSE grad student or %)
Fabrication of microelectronic devices. Silicon integrated circuits, GaAs devices. Lithography, oxidation, diffusion. Process integration of various technologies, including CMOS, double poly bipolar, and GaAs MESFET.

EE 5173 **- Basic Microelectronics Laboratory**
(1.0 cr; Prereq-[[5171 or &5171], CSE grad student] or %)
Students fabricate a polysilicon gate, single-layer metal, NMOS chip, performing 80 percent of processing, including photolithography, diffusion, oxidation, and etching. In-process measurement results are compared with final electrical test results. Simple circuits are used to estimate technology performance.

EE 5653 **- Physical Principles of Magnetic Materials**
(3.0 cr; Prereq-CSE grad student or %)
Physics of diamagnetism, paramagnetism, ferromagnetism, antiferromagnetism, ferrimagnetism. Ferromagnetic phenomena. Static/dynamic theory of micromagnetics, magneto-optics, and magnetization dynamics. Magnetic material applications.

EE 5655 **- Magnetic Recording**
(3.0 cr; Prereq-CSE grad student or %)
Magnetic fundamentals, recording materials, idealized models of magnetic records/reproduction, analytic models of magnetic record heads, sinusoidal magnetic recording, digital magnetic recording, magnetic recording heads/media, digital recording systems.

Polymers – Macosko

You must take into consideration the four points on page 9.

BP 4405/5405 **Bio-Based Composites Engineering Materials Science & Polymers**
(3.0 cr; =[BBE 5404]; Prereq-[4303, [5303 or AEM 3031]] or #; A-F or Aud)
Structure/properties of biopolymers and the engineering of composites from these biopolymers and/or plant-based materials.

CHEM 4223W **- Polymer Laboratory (WI)**
(2.0 cr; =[MATS 4223W, CHEN 4223W]; Prereq-4221 or 4214 or CHEN 4214 or MATS 4214 or #)
Synthesis, characterization, and physical properties of polymers. Free radical, condensation, emulsion, anionic polymerization. Infrared spectroscopy/gel permeation chromatography. Viscoelasticity, rubber elasticity, crystallization.

CHEN 4214 **- Polymers** (preferred)

(3.0 cr; Prereq-[[MATS 3011, [3101 or 4101 or MATS 4001], [upper div MatS or ChEn]]] or #; A-F or Aud)
Polymer structure-property relations: structure/morphology of crystalline/amorphous states. Crystallization kinetics. Vitrification and the glass transition. Mechanical properties, failure, permeability, optical/electrical properties, polymer composites, effect of processing on properties.

CHEN 4702 **- Advanced Undergraduate Rheology**
(2.0 cr; Prereq-[3005 or 4005], #; A-F only)
Deformation/flow of non-Newtonian/viscoelastic fluids, plastic materials, perfectly elastic solids. Phenomenological/molecular interpretation of rheology of elastomers, polymer melts, polymer solutions. Application of rheology to polymer processing. Undergraduate version of 8102.

CHEM 4221 **- Introduction to Polymer Chemistry**
(3.0 cr; =[CHEN 8221, MATS 5221, MATS 8221, CHEN 5221, CHEM 8221]; Prereq-[2302, 3501] or #; fall, every year)
Condensation, radical, ionic, emulsion, ring-opening, metal-catalyzed polymerizations. Chain conformation, solution thermodynamics, molecular weight characterization, physical properties.

CHEN 5771 **- Colloids and Dispersions**
(3.0 cr; =[01472]; Prereq-Physical chemistry; A-F or Aud)
Preparation, stability, coagulation kinetics or colloidal solutions. DLVO theory, electrokinetic phenomena. Properties of micelles, other microstructures.

PHYS 4911 **- Introduction to Biopolymer Physics**
(3.0 cr; =[PHYS 5081]; Prereq-[2303, 2403H, 2503] or Chem 3501 or #)
Introduction to biological and soft condensed matter physics. Emphasizes physical ideas necessary to understand behavior of macromolecules and other biological materials. Elements of thermodynamics and statistical mechanics are presented as needed.

Pre-Medical – Tranquillo

You must take into consideration the four points on page 9.

NOTE: Some credits from Biol 2xxx and 3xxx e.g. [BIOL 2005, 3211 and BIOC 3021] below can be approved if required for Medical School applications. Must petition Professor Tranquillo.

[BIOL 2005 **- Animal Diversity Laboratory**]
(1.0 cr; =[BIOL 2012])
Dissection, direct observation of representatives of major animal groups.

BIOL 3211 **- Physiology of Humans and Other Animals**
(3.0 cr; Prereq-[1002 or 1009 or 2003 or equiv], CHEM 1021; concurrent registration in 2005 is strongly recommended)
Ways different animals solve similar physiological problems.

[BIOC 3021 **- Biochemistry**]
(3.0 cr; =[BIOC 6021]; Prereq-[[BIOL 2003 or BiOL 1002 or BIOL 1009], CHEM 2301], or #;)
Fundamentals of biochemistry including structure and function of proteins, nucleic acids, lipids and carbohydrates; metabolism and regulation of metabolism; quantitative treatments of chemical equilibria, enzyme catalysis and bioenergetics; the chemical basis of genetic information flow.

Prof. Tranquillo will also approve 4xxx or higher level courses in the life sciences or bioengineering, preferably biomedical engineering. He recommends that you also contact the Health Careers Center
to enroll in the “First Step” program for pre-med students.

Health Careers Center
Website: www.healthcareers.umn.edu
Email: HCC@umn.edu
Phone: (612) 624-6767 Fax: (612) 624-4415
2-565 Moos Tower
Open Monday through Friday from 8:00 a.m. to 4:30 p.m. and closed on University holidays.

Renewable and Process Chemistry – Schmidt

You must take into consideration the four points on page 9.

Prof. Schmidt can approve other courses by petition, sometimes with only partial technical elective credit.

Note: See Prof. Kumar and Prof. Tschirner if interested in BBE minor and further BBE courses.

BBE 4301 **- Surface and Colloid Science in Bio-based Products Manufacturing**
(3.0 cr; =[BBE 5301]; Prereq-Chem 3501, [jr or sr or #])
Principles of surface/colloid science, their application to understanding manufacturing/performance of bio-based products.

BBE 4733 **- Renewable Energy Technologies**
3.0 cr; =[BBE 5733]; Prereq-Upper div CSE or grad student or #; A-F or Aud)
Fundamentals of current/emerging technologies for renewable energy production/use. Issues regarding national energy security. Environmental, economic, and societal impacts of renewable energy. Current/future developments in renewable energy technologies. Impact of renewable energy on sustainable development.

CHEM 4001 **- Chemistry of Plant Materials**
(4.0 cr; =[01147]; Prereq-2302, [jr or sr or #]; A-F or Aud)
Chemical principles underlying structure, properties, processing, and performance of plant materials.

CHEM 4066 **- Chemistry of Industry**
(3.0 cr; Prereq-Chem sr or grad student or #)
Industrial and polymer chemistry technology. Relation of basic properties to industrial utility. Economics, social problems, industrial environment.

CHEM 4301 **- Surface and Colloid Science in Bio-based Products Manufacturing**
(3.0 cr; =[01193]; Prereq-3501, [jr or sr or #])
Principles of surface/colloid science, their application to understanding manufacturing/performance of bio-based products.

CHEN 4708 **- Advanced Undergraduate Chemical Rate Processes: Analysis of Chemical Reactors**
(3.0 cr; Prereq-[3102 or 4102], ChEn major upper div; A-F only)
Design of reactors for heat management, with catalytic processes. Analysis of steady state, transient behavior. Polymerization, combustion, solids processing, environmental modeling. Design of multiphase reactors.

CHEM 4221 **- Introduction to Polymer Chemistry**
(3.0 cr; =[CHEN 8221, MATS 5221, MATS 8221, CHEN 5221, CHEM 8221]; Prereq-[2302, 3501] or #; fall, every year)
Condensation, radical, ionic, emulsion, ring-opening, metal-catalyzed polymerizations. Chain conformation, solution thermodynamics, molecular weight characterization, physical properties.

CHEN 5531 **- Electrochemical Engineering and Renewable Energy**
(3.0 cr; =[MATS 5531]; Prereq-[MATS 3011 or #], [upper div CSE or grad student]; A-F only)
Fundamentals of electrochemical engineering. Electrochemical mass transfer electrokinetics, thermodynamics of electrochemical cells, modern sensors. Formation of thin films and microstructured materials. Computer-based problems.

CHEN 5551 **- Survey of Renewable Energy Technologies**
(3.0 cr; Prereq-[Upper div or #], basic knowledge of chemistry, thermodynamics; A-F or Aud)
Technologies to generate renewable energy/chemicals. Biomass, solar, wind, hydroelectric. Emphasizes biomass processing using chemical/biological methods. Renewable technologies compared with fossil fuel technologies.

MATS 4511W **- Corrosion and Electrochemistry of Corrosion (WI)**
(4.0 cr; Prereq-MatS 3011 or #, upper div CSE or grad; A-F or Aud)
Electrochemical thermodynamics, electrochemical kinetics, theory of aqueous corrosion, theory of high temperature oxidation; specific topics include general corrosion, passivation, pitting, galvanic protection/corrosion, environmental degradation of

mechanical properties, corrosion of electronic components, growth of oxide scales by diffusion, materials selection and design. Computers used to collect lab data.

ME 4431W **- Energy Conversion Systems Laboratory (WI)**
(4.0 cr; Prereq-3333, 4031W, [CSE upper div or grad student]; A-F or Aud)
Material from courses is applied to analyze operation/control of engines, power plants, and heating/ventilation systems. Emphasizes principles underlying performance characteristics of devices, measurement techniques, interpretation of experimental data, and presentation of results.

ME 5113 **- Aerosol/Particle Engineering**
(4.0 cr; Prereq-CSE upper div or grad student; A-F or Aud)
Kinetic theory, definition, theory and measurement of particle properties, elementary particle mechanics, particle statistics; Brownian motion and diffusion, coagulation, evaporation and condensation, sampling and transport.

ME 5446 **- Introduction to Combustion**
(4.0 cr; Prereq-3331, 3332, 3333, CSE upper div or grad student; A-F or Aud, fall, every year)
Thermodynamics, kinetics, energy and mass transport, pollutants in reacting systems. Reactors, laminar and turbulent flames. Ignition, quenching, and flame stability. Diffusion flames. Combustion in reciprocating engines, furnaces, and turbines, with emphasis on internal combustion engine performance and emissions.

Science, Technology, and Society Technical Elective Emphasis - Kumar

You must take into consideration the four points on page 9.

Understanding the role that science and technology play in the modern world is an integral component of an engineering education. This intent of this technical elective emphasis is to broaden students' perspectives of the intersections between science, technology, and society. The courses listed below are simply examples; many other courses would be appropriate. Note that other courses not explicitly involving science and technology may be appropriate if they fit into a coherent set or subset of courses related to science, technology, and society (e.g., a political science course on foreign policy would be appropriate as part of a set of courses focusing on international aspects of science, technology, and society).

NOTE: In order to use the courses below (or other courses approved to be part of this emphasis) as technical electives, at least 6 credits of your technical electives must come from courses covering engineering topics (e.g., If you take the polymers course and another 3 credit course from one of the other technical elective emphasis areas, then you may use up to 6 credits of courses from the Science, Technology, and Society emphasis as technical electives.)

APEC 5721 - **Economics of Science and Technology Policy**
(3.0 cr; Prereq-[[5151 or &5151], PA 5022] or #)
Economics of innovation, technical change, and research/development. Productivity measurement. Knowledge stocks, research lags/spillovers. Econometric/welfare surplus methods for evaluating economic consequences of R&D. Economics of intellectual property rights.

CSCL 3331 **- Science and Culture (AH)**
(3.0 cr)
Science and technology engaged through historical and cultural manifestations from film, literature, and YouTube to scientific and philosophical essays. Relations among humanities, science, economics, politics, philosophy and history. Psychiatry and drugs, food and agriculture, sexuality, religion and science, climate change.

ESPM 4609 - **Air Pollution Impacts, Management, and Ethical Challenges (CIV)**
(3.0 cr; =[ESPM 5609]; Prereq-[BIOL 1001 or BIOL 1009], [CHEM 1011 or CHEM 1015 or CHEM 1021], CHEM 1017; A-F or Aud)
Air pollutants, sources, and impacts on humans, plants, animals, soil, water, atmosphere, and planet. Emission rates, measurement, control technologies, air pollution laws/regulations. Personal erspectives/ethics related to air pollution, how they impact professional/civic life.

HMED 3075 **- Technology and Medicine in Modern America (HIS, TS)**
(3.0 - 5.0 cr [max 5.0 cr])
How technology came to medicine's center-stage. Impact on production of medical knowledge, professionalization, development of institutions/industry, health policy, and gender/race disparities in health care.

HSCI 3332 **- Science and American Culture (HIS, DSJ)**
(3.0 cr; =[HSCI 5332])

American science since 1600, including transfer of science to America; development of indigenous traditions for pursuit of science; infrastructure for education and research; public response to scientific development.

HUMF 5722 **- Human Factors Psychology**
(3.0 cr; Prereq-Grad student or #; A-F or Aud)
Psychological principles that underlie human interactions with technological systems. Techniques/methodologies to assess faulty/incorrect system design. Emphasizes human-centered approaches. Rigorous evaluation of human-machine interaction.

PA 5711 **- Science and Technology Policy**
(3.0 cr; Prereq-Grad student or #)
Effect of science/technology on relations among nations in such matters as autonomy, national security, economic strength, environment, cultural identity, and international cooperation. Negotiating international agreements with S&T implications.

PHIL 3602 **- Science, Technology, and Society**
(3.0 cr; A-F or Aud)
Philosophical issues that arise out of interaction between science, technology, society (e.g., religion and science, genetics and society, science and the environment).

SOC 4305 **- Society and the Environment: A Growing Conflict**
(3.0 cr; Prereq-1001 or environmental course recommended; soc majors/minors must register A-F; A-F or Aud)
Societal causes/cures of ecological problems such as global warming, species extinction, and resource exhaustion.

SUST 3003 **- Sustainable People, Sustainable Planet (ENV)**
(3.0 cr; =[GLOS 3304]; Prereq-Soph or jr or sr)
Introduction to interdisciplinary Sustainability Studies minor. Scientific, cultural, ethical, and economic concepts that affect environmental sustainability and global economic justice. Key texts. Participatory classroom environment.

SUST 3480 **- Topics in Sustainability**
(1.0 - 4.0 cr [max 24.0 cr]; A-F only)
Topics in sustainability encompass special courses related to issues such as renewable energy, food and waste systems, sustainable planning, water and climate change.

SUST 4004 **- Sustainable Communities**
(3.0 cr; Prereq-[3003 or GLOS 3304, [jr or sr] in sustainability studies minor] or #; A-F only)
Students synthesize multiple disciplinary perspectives and integrate insights gained from various approaches/methods. Concepts/scholarship related to sustainability. Applying knowledge/experience to real sustainability problems.

WRIT 4431 **- Intersections of Scientific and Technical Communication and Law**
(3.0 cr; Prereq-Jr or sr or grad student or #; A-F only)
How issues in science/technology are affecting 21st century practice of law. Ownership, access, ethics, information, and technology used to frame topics. Intellectual Property, privacy, health law, research practice.

VIII. Conduct

"The College of Science and Engineering assumes that all students who enroll in its programs are serious about their education and expects them to be responsible individuals who demand of themselves high standards of honesty and good personal conduct." "Any act of scholastic dishonesty is regarded as a serious offense that will result in a sanction being imposed, and may result in expulsion." <http://cse.umn.edu/services/advising/CSE_CONTENT_188716.php>

All students in the Department of Chemical Engineering and Materials Science are expected to abide by the highest professional ethical standards. For links to more regulations regarding academic integrity and disruptive behavior, see <http://cse.umn.edu/services/advising/CSE_CONTENT_188716.php>. The Office for Student Conduct and Academic Integrity (OSCAI) <http://www1.umn.edu/oscai/> covers Student Conduct and Academic Integrity.

IX. College of Science and Engineering and University of Minnesota Policies

The College of Science and Engineering website is a valuable source of official information on all aspects of academic and student life. Rules and procedures about changing majors, Honor Points, GPA requirements, Liberal Education Requirements, dropping and adding classes, entrance to upper division, college forms, Dean's List, probation, repeating course, etc., are contained on the CSE website <http://cse.umn.edu/services/advising/CSE_CONTENT_188611.php>. The Undergraduate Catalog also has course descriptions of all CSE courses, which can be - particularly useful when you are considering technical electives, this, can be found at <http://www.catalogs.umn.edu/ug/index.html>.

X. Double Majors

If you wish to pursue a second major in CSE you must file a petition and seek CSE advising in 130 Lind. It usually requires five or more years to complete a double major program. Two double majors that are possible in four years, particularly if you have advanced placement credits, are Chemistry and Chemical Engineering; and Materials Science and Chemical Engineering.

Chemistry/Chemical Engineering*(adapted from < http://www.chem.umn.edu/undergrad/UGCur.html >)

In order to avoid class-time conflicts with the necessary Chemistry courses, this recommended sequence of courses differs from the typical course plan. Please see the Chemistry Department website for details.

This program is designed for CSE students who wish to obtain a double major in Chemistry and Chemical Engineering. This plan fulfills the ChEn technical requirements. Talk to an advisor in Chemistry about the options for Advanced Chem Lecture and Lab Electives.

NOTE: Program varies depending on which term you begin. See advisors for updates.

Freshman Year

Fall Semester	Spring Semester
Chem 1021 Chemical Principles I (4 cr)	Chem 1022 Chemical Principles II (4 cr)
Math 1271 Calculus I (4 cr) +	Math 1272 Calculus II (4 cr) +
Phys 1301 Introductory Physics I (4 cr)	Phys 1302 Introductory Physics II (4 cr)
WRIT 1301 Univ Writing & Critical Reading (4 cr)	Biol 1009 General Biology (4 cr)

Sophomore Year

Fall Semester	Spring Semester
Chem 2301 Organic Chemistry I (3 cr)	Chem 2302 Organic Chemistry II (3 cr)
Chem 3502 Physical Chemistry II (3 cr)	Chem 3501 Physical Chemistry I (3 cr)
Math 2263 Multivariable Calculus (4 cr) +	Chem 2121 Analytical Chemistry (3 cr)
ChEn 2001 Material & Energy Balances (4 cr)	Math 2243 Linear Algebra & Differential Equations (4 cr) +
	MatS 3011 Intro to the Science of Materials (3 cr)

Junior Year

Fall Semester	Spring Semester
Chem 2311 Organic Chemistry Lab I (4 cr)	ChEn 3006 Mass Transfer and Separations (4 cr)
Chem 4701 Inorganic Chemistry Lect (3 cr)	ChEn 3102 Reaction Kin & Reactor Eng (4 cr)
ChEn 3101 Chem Eng Thermodynamics (4 cr)	ChEn 3201 Computational Methods in ChEn (3 cr)
ChEn 3005 Momentum & Heat Transfer (4 cr)	ChEn 3401W Junior Chemical Engineering Laboratory (2)
Advanced Chemistry Lab (2 cr)	Chem 4121 Process Analytical Chemistry Lab (3 cr)

Senior Year

Fall Semester	Spring Semester

ChEn 3701 Intro to Biomolecular Eng (3 cr) #
ChEn 4601 Process Control (3 cr)
ChEn 4401 Chemical Engineering Lab I (3 cr)
ChEn 4501 Chem Eng Process Design I (3 cr)
Advanced Chemistry Lecture Elective (3 cr)

ChEn 4502 Chem Eng Process Design II (2 cr)
Chem 4214 Polymers (3 cr)
Advanced Chemistry Lab (2 cr)
Advanced Chemistry Lab (2 cr)

+ Math 1371, 1372, 2373, 2374 sequence is preferred by Chemical Engineering.
* Program layout does not contain all college or liberal education requirements.
# ChEn 3701 gets moved to Sr. year to accommodate Chem 4701. See Prof. Kumar if you need to make a substitution.
You can take Chem 4221 instead and it will cover the Adv. Chemistry Lecture Elective for the Chemistry requirements. If you do that, you need to make up 2 elective credits at some point.

Materials Science and Engineering and Chemical Engineering

The program combines the Chemical Engineering and Materials Science and Engineering upper division courses and is designed to satisfy the requirements for a Bachelor's degree for both majors. Normally, substitutions from the listed courses are not recommended. Students wishing to enter this program should apply via petition at the end of their second year, or no later than the end of their third year. You must meet the GPA admission requirements of both programs.

The following course plan is designed for students declaring a double major:

ChEn and MatS double major, lower division	
Math 1371, 1372, 2373, 2374	16 credits
Physics 1301, 1302	8 credits
Chem 1021, 1022, 2301, 2302, 2121, 3501	20 credits
AEM 2011	3 credits
CSci 1107	3 credits
WRIT 1301 (or equivalent)	4 credits
Biol 1009 (or equivalent)	4 credits
ChEn 2001	4 credits
MatS 3011	3 credits
ChEn and MatS double major, upper division	
AEM 3031, 4511	6 credits
Chem 2311, 3502	6 credits
ChEn 3701, 3005, 3006, 3101, 3102, 3201, 3401, 4401, 4501, 4601 (not 4502)	35 credits
MatS 3012, 3801, 3851, 4013, 4212, 4214 4221, 4301, 4400	27 credits
Liberal Education Requirements (6 courses)	15 credits
Total credits	154 credits

XI. Research, Internship, and Co-op Experiences

Many opportunities exist on campus and in the department for undergraduates to participate in a research project, usually with a graduate student or postdoctoral associate under the supervision of a faculty member. Participating in a research project is a very good way to develop the skills research requires. It also provides an excellent opportunity for getting to know professors so they can write more extensive letters of recommendation for employment or graduate studies. For students considering graduate school, this is the best way to sample graduate student life. Use the department research brochure on the department website <http://www.cems.umn.edu/resrch/areas/> to identify professors doing research in chemical engineering that interests you.

Getting Technical Elective Credit for Unpaid Academic Research
A student may earn academic credit for research in faculty laboratories, under a faculty advisor, which may apply toward the Chemical Engineering technical elective requirements. The upper limit of credits so applied is two. To apply for technical elective credit, the following conditions must pertain: 1) the student is not paid for the research; 2) the student is registered for the undergraduate Chemical Engineering Directed Research course (ChEn 4594); 3) student has a project report or presentation graded by the supervising faculty member, who then assigns the course grade. Use the Form 2010 Research as Technical Elective Approval Form found on page 34. Turn it into Ms. Laura Ericksen, 151BB Amundson.

The number of credits you may register for in ChEn 4594 is determined by your faculty advisor. In general, each credit entails 3-4 hours of work related to the lab each week over the course of the semester. Besides the work actually done in the lab, related work outside the lab, such as literature searches, calculations, and report preparation should also be taken into account.

Co-op Program
The Department of Chemical Engineering and Materials Science supports both Industrial Internships and Co-op Industrial Assignments for undergraduates. Please see the program description and procedures at: <http://www.cems.umn.edu/downloads/ug/intern_coop.pdf>. If you have questions about the Co-op program please contact Prof. David Shores (108 Amundson, 612-625-0014, dshores@umn.edu).

Finding opportunities for paid summer internships
Excellent industrial or research experience can be gained without interfering with your studies through the many summer internship positions announced and posted at the CSE Career Services office (390 Shepaherd Labs (2011-2012); <http://ccse.umn.edu/index.php>; (612) 624-4090; ccse@umn.edu) and on the CEMS Undergraduate Bulletin Board, located on the first floor of Amundson Hall, over the course of the year. Interviewing for industrial summer positions is generally conducted at the CSE Career Services Office well in advance of the summer – often in the preceding *fall*. Be sure to sign up early! Industrial summer internship opportunities become almost equivalent to coop experiences when the guidelines are followed to receive academic credit: see <http://www.cems.umn.edu/downloads/ug/intern_coop.pdf>.

There are also opportunities to get paid for research work on campus (but in most cases no academic credit can be obtained – see guidelines below). When such opportunities arise, they are arranged directly by the faculty member who is hiring. Many faculty members inform Prof. Daoutidis about positions in relation to the Honors Program. If you qualify for work-study, be sure to tell your supervising professor so that they might be able to arrange coordination with your financial aid package.

Moreover, several centers on campus (e.g., the Minnesota Supercomputing Institute) conduct summer internship programs. Notices about these are posted as available on the Undergraduate Bulletin Board. Finally, the University provides Undergraduate Research Opportunity Program (UROP) awards; applications are available in 196 Shepherd Labs (2010-2011). Awards are normally made twice a year for limited stipend and research expenses.

XII. Scholarships (Department and CSE)

In the spring some scholarships are awarded by the College of Science and Engineering. Students must apply for the CSE scholarships (applications available early in the Spring semester and at the CSE Academic Advising Office in 196 Shepherd Labs (2011-2012).

Applications for department scholarships are solicited by email in the Spring semester for the following year. The department has a variety of scholarships which are available to both citizens and international students. Depending on the wishes of the donor most scholarships are merit based and/or need based.

Many CSE and department scholarships cannot be awarded if you have not applied for financial aid. Be sure to apply for financial aid at the Office of Student Finance (333 Science Teaching & Student Services; 612-624-1111) or, if appropriate, at the International Students and Scholar Services office (190 HHH; 612-626-7100; <http://www.isss.umn.edu>. These offices are also an excellent source of other scholarship announcements.

XIII. Caution Against Working While Studying

Beware the danger of getting behind in your coursework, especially in upper division. You should expect that course work will be very demanding. Even without part-time work many students find themselves having to adjust their study habits and manage their time more carefully when entering upper division. Working part-time is challenging for anyone carrying a full course load, and it is rare that anyone working fifteen hours a week or more during the semester can learn and perform up to their potential and still graduate in four years. If you opt for a lower course load, be sure to schedule courses carefully.

Many U of MN students hold part-time jobs while pursuing their degrees, and though some jobs provide educational technical experiences as well as financial benefits, you should remain aware that pursuing a full course load is itself a full time job.

Excellent industrial and research experience can be gained without interfering with your studies through the many summer internships announced and posted on the Undergraduate Bulletin Board throughout the year.

XIV. Study Abroad

Students who are interested in exploring foreign cultures may be able to arrange up to one year of study in a university in a foreign country. Many courses taken in a university abroad can be transferred for credits. However, it is likely that the graduation date will be delayed beyond the normal four-year period. Students who are interested in studying abroad are urged to consult with the Learning Abroad office (<http://www.umabroad.umn.edu/>; 230 Heller Hall; 612-626-9000) and with the Director of Undergraduate Studies (201 Amundson; <kumar030@umn.edu>; 612-625-2558) as early as your Freshman year. It may be easiest to study abroad in the Sophomore year or after the ChEn core courses are completed.

Adam Pagel (196 Shepherd Labs (2011-2012); pagel@umn.edu; 612-624-8013) is the CSE advisor for issues related to study abroad programs and international students. Be sure to consult him when making plans.

XV. Honors Degrees and the Upper Division ChEn Honors Program

Chemical Engineering students may graduate with Latin honors (/cum laude/, /magna cum laude/, /summa cum laude/). Students must be enrolled in the University Honors Program to graduate with Latin Honors. For further information on the University Honors Program visit the UHP website at <http://www.honors.umn.edu/>.

You will also want to make an appointment with the Honors Program advisor, Prof. Daoutidis at, daout001@umn.edu, to discuss proposed honors experiences. Bring a copy of your transcript to your appointment. When the two of you agree on an individual honors program, you should file the "Graduation with Honors-Preliminary" form with the University Honors Program office (available in 20 Nicholson Hall). At the beginning of your graduation semester you should again make an appointment with Prof. Daoutidis to verify the satisfactory completion of all honors experiences. You should then work with University Honors Program office closely your last semester to file all the appropriate paperwork on time.

XVI. Requirements for Chemistry Minor

The Chemistry courses required for the BChE degree automatically qualify you for a Chemistry minor. You do not need to apply to the Chemistry Department for the Chemistry minor – it should appear on your record automatically with your BChE degree.

XVII. AIChE Student Chapter

The American Institute of Chemical Engineers (AIChE) <http://www.tc.umn.edu/~aiche/mainIndex.html> student chapter has an office in Room 132B, and Prof. Caretta is the advisor. The AIChE is the primary professional organization for chemical engineers, and you can join as a student. The student chapter sponsors informational, educational, and social meetings, which include visits from corporate representatives and recruiters.

XVIII. Selected Facilities and Organizations of Interest

CSE Academic Advising/Lower Division

Most of the college business you will need to deal with is taken care of in 196 Shepherd Labs – CSE Academic Advising – (612) 624-2890. See advisors there about petitions, probation, transfer admissions, your degree clearance, and college policies.

Before you are admitted to the upper division Chemical Engineering program you should get your advising from CSE Academic Advising.

Computer Facilities

The Department of Chemical Engineering and Materials Science has an undergraduate study room in Amundson 132. There are computers for the exclusive use of CEMS undergraduates. In addition there are CSE computer labs in several locations exclusively for CSE students. Finally, even more University facilities (ADCS – Academic Distributed Computed Services) are available to you around campus.

To learn more about the departmental computing resources to include, printing, and the Acceptable Use Policy visit: <https://wiki.umn.edu/view/CEMSUndergrads/WebHome>.

Counseling
University Counseling Services <http://uccs.umn.edu/> in 340 Appleby Hall offers a wide variety of services and provides help with problems ranging from improving study skills, making career decisions, and improving communication skills to controlling anxiety, and stress and time management.

Libraries
There are many library collections at the University. For a complete list see the library website at: <http://www.lib.umn.edu/>. All of the libraries have study areas. The libraries closest and most useful to you are:

Science and Engineering Library	Walter Library
Mathematics Library	310 Vincent Hall
Bio-Medical Library	Diehl Hall
Wilson Library (main library)	Wilson Library (on the West Bank)

Placement – summer and permanent
The Career Center for Science and Engineering is located in 390 Shepherd Labs (2011-2012); (<http://ccse.umn.edu/index.php>; (612) 624-4090; ccse@umn.edu). Every year, particularly in the Fall Semester, companies seeking to hire engineers set up interview schedules through the Career Center Office. You should register to browse through their collection of company brochures, and sign up for GoldPASS and interviews both for summer internships and for permanent employment.

Study Areas
Amundson 132 is the principal study room for Chemical Engineering undergrads in Amundson Hall. Other locations include various locations in the college's classroom building, also Walter Library and other libraries have large study areas as well.

Student Organizations
There are student organizations for virtually every interest – sports, hobbies, politics, religion, arts, student government, professions, music, travel, ethnic culture, and many, many others. The Coffman Memorial Union website is a good resource for research what groups exist. Go to the <http://www.coffman.umn.edu/> website and click on "Get Involved". Some engineering student groups include: the Society of Women Engineers, the CSE Student Board, the CSE Board of Publications, Tau Beta Pi, and Plumb Bob. See the University of Minnesota website for contact information for all of these groups.

Tutoring
Students in the College of Science and Engineering can visit the SMART Learning Commons in **220** Walter Library (612-624-1071**)** for workshops, individual consultations, exam reviews, and an old test bank.

Student Writing Support, 15 Nicholson Hall (612-625-1893), < http://writing.umn.edu/sws/> provides free writing instruction for all University of Minnesota students at all stages of the writing process. In face-to-face and online collaborative consultations, we help students develop productive writing habits and revision strategies.

XIX. Graduation

You should review your Academic Progress Audit System report (APAS, available through your OneStop account on the Web <http://onestop.umn.edu/>, click on APAS report under "Student records tools") at least two semesters before you plan to graduate. The APAS report should be an exact statement of the courses you must successfully complete in order to finish your BChE degree. WARNING: The Registrar's software is known to make errors. If corrections are needed in your lower division coursework, Liberal Education electives, Writing Intensive requirements, or Residency requirements, see CSE Academic Advising.

You must complete and submit an online *Degree Application* form no later than the beginning of the semester you plan to graduation. Deadlines are usually very early in the semester. The application is available at the OneStop website: <http://onestop.umn.edu/degree_planning/graduation/index.html>. The *Degree Application* form is used by the Office of the Registrar to begin the degree clearance process.

Application deadlines for each graduation term, along with a complete academic calendar is published on the web at: <http://onestop.umn.edu/calendars/index.html>.

Form 1014 Technical Elective Approval Form

Directions: This form is for students who would like to get approval to use as a technical elective a course that is not on the pre-approved tech electives list.

Fill out the blanks below, attach the course syllabus, your current plan to graduate, your APAS and unofficial transcript then return the form to Laura Ericksen in 151BB Amundson. She will have the director of undergraduate studies indicate their approval by signing and dating the form on the bottom. Your adviser can sign the form prior to you turning it into 151BB Amundson.

NOTE: Permission must be obtained before registering for the course. Retroactive permission is unlikely to be granted.

Student name:_____ Student ID: _____

Email:_____ Phone: _____

****

Course name: _____

Course Number: _____ Number of credits: _____

Instructor's name: _____

Explain why this class is a particularly good fit for you: (Use the back of the page if necessary.)

List your other tech electives:

1. 2.
3. 4.
5. 6.

_____ _____

Approved by (Advisor or DUS signature here.) Date

Form 2010 Research as Technical Elective Approval Form

Directions: This form is for students who would like to get approval to use Upper Division directed research as a technical elective.

You may apply for 1 credit of directed research toward your technical electives if approved as such by your advisor. (On rare occasion 2 credits might be considered).

Fill out the blanks below, attach your current plan to graduate, your APAS and unofficial transcript then return the form to Laura Ericksen in 151BB Amundson. She will have the director of undergraduate studies (DUGS) indicate his approval by signing and dating the form on the bottom.

You will need the following:

1) agreement from a faculty member or to act as co-instructor with the DUS in the ChEn Directed Research (ChEn 4594) course,
2) a written report to be graded by the supervisor and the DUS
3) course grade to be assigned by a faculty member on an A/F basis.

NOTE: 1) By submitting this form you are acknowledging that you are aware that *you must submit a written report* to Laura Ericksen at the end of the semester reflecting the work you completed to receive credit.
2) Permission must be obtained before registering for the course. Retroactive permission is unlikely to be granted.

Student name:_____ Student ID: _____

Student email:_____ Phone: _____

Research title: _____

Research advisor's name: _____

List your other tech electives (course designation and name):

1. 2.

3. 4.

5. 6.

_____ _____

Approved by (DUS signature here.) Date

Form 3000 Substitution Approval Form for ChEn/MatS 4214

Who should use this form:

This form is for students (typically students with a double major in the biosciences or chemistry, if a very crowded schedule) who would like to get approval to substitute a different course for ChEn/MatS 4214 (polymers).

Directions Attach a course syllabus from the proposed course (if from another college or university), your APAS, current plan to graduate and unofficial transcript to this form. Return the completed form and all attachments to Laura Ericksen in 151BB Amundson. She will have the director of undergraduate studies indicate their approval by signing and dating the form on the bottom.

NOTE: Permission must be obtained before registering for the course. Retroactive permission is unlikely to be granted.

Student name:_____ Student ID: _____

Student email:_____ Telephone: _____

****

Course name(s): _____

Course Number(s): _____ Number of credits: _____

Instructor's name: _____

Explain why this class is a particularly good fit for you:

List your tech electives:

1. 2.
3. 4.
5. 6.

_____ _____

Approved by (Advisor or DUS signature here.) Date

Form 3020 Getting Credit (NOT for technical elective) for a Paid Industrial Internship or Paid Academic Research Position

Directions:

These requirements have been put in place to ensure that academic credit reflects a learning experience that complements your Chemical Engineering degree; they are similar in rigor to the requirements of the CEMS Coop program; a major difference, though, is that you may not use these credits toward your technical elective requirements and you may only be graded on an S/N basis. If you receive a salary or stipend for your research or intern work, whether on campus or off campus (e.g., at a company), you can receive academic credit only if the following requirements are met:

1) agreement from a faculty member or company supervisor to act as co-instructor with the DUS in the ChEn Directed Studies (ChEn 4593) course,
2) a written report to be graded by a the supervisor and the DUS, (this report must be nonproprietary, and the supervisor must ensure that)
3) written evaluation of the student's work performance by the supervisor,
4) course grade to be assigned by a faculty member on an S/N basis (and so may NOT be used toward technical electives).

Most students do NOT choose to pursue credit in this way, but on occasion this procedure is useful for the Curricular Practical Training (CPT) program of international students. If you need CPT credit you must attach your current plan to graduate, your APAS and unofficial transcript then return the form and all attachments to Laura Ericksen in 151BB Amundson.

NOTE:

1) By submitting this form you are acknowledging that you are aware that <u>you must submit a written report</u> to Laura Ericksen 151BB Amundson at the end of the semester reflecting the work you completed to receive credit.
2) Permission must be obtained before registering for the course. Retroactive permission is unlikely to be granted.

Student name:_____ Student ID: _____

Student email: _____ Student phone #: _____

Research title: _____

Research advisor's name: _____

Research advisor's phone #_____

_____ _____

Approved by (DUS signature here.) Date

Form 6010 CPT Approval Form

Getting Credit (NOT for technical elective) for a Paid Industrial Internship or Paid Academic Research Position

These requirements have been put in place to ensure that academic credit reflects a learning experience that complements your Chemical Engineering degree; they are similar in rigor to the requirements of the CEMS Coop program; a major difference, though, is that you may not use these credits toward your technical elective requirements and you may only be graded on an S/N basis. If you receive a salary or stipend for your research or intern work, whether on campus or off campus (e.g., at a company), you can receive academic credit only if the following requirements are met:

1) agreement from a faculty member or company supervisor to act as co-instructor with the DUS in the ChEn Directed Studies (ChEn 4593) course,
2) a written report to be graded by a the supervisor and the DUS, (this report must be nonproprietary, and the supervisor must ensure that)
3) written evaluation of the student's work performance by the supervisor,
4) course grade to be assigned by a faculty member on an S/N basis (and so may NOT be used toward technical electives).

Most students do NOT choose to pursue credit in this way, but on occasion this procedure is useful for the Curricular Practical Training program of international students.

DIRECTIONS: Fill out the blanks below, attach the course syllabus, your current plan to graduate, your APAS and unofficial transcript then return the form to Laura Ericksen in 151BB Amundson. She will have the director of undergraduate studies indicate their approval by signing and dating the form on the bottom.

NOTE: 1) By submitting this form you are acknowledging that you are aware that *you must submit a written report* to Laura Ericksen at the end of the semester reflecting the work you completed.
2) Permission must be obtained before registering. Retroactive permission is unlikely to be granted.

Student name:_____ Student ID: _____

Student email: _____ Student phone #: _____

Research title: _____

Research advisor's name and Company name: _____

_____ _____

Approved by (faculty advisor signature here.) Date

_____ _____

Approved by (Director of Undergrad Studies signature here.) Date

XX. Faculty Addresses and Phone Numbers

AYDIL, Eray, Professor and Executive Officer, 235c AmH, **5-8593,** aydil@umn.edu
BATES, Frank S., Distinguished McKnight University Professor, Regents Professor and Head, 391 AmH, **4-0839**, bates001@.umn.edu
BHAN, Aditya, Assistant Professor, 437 AmH, **6-3981**, abhan@umn.edu
CARETTA, Raul A., Professor, 151b AmH, **5-8066**, caretta@umn.edu, Unit Ops Lab 350a AmH 6-2019, Undergrad AIChE Advisor
COCOCCIONI, Matteo, Assistant Professor, 204 AmH, **4-9056**, matteo@umn.edu
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DERBY, Jeffrey J., Distinguished McKnight University Professor, 283 AmH, **5-8881**, derby@umn.edu

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FRISBIE, C. Daniel, Professor, and Director of Graduate Studies, Materials Science and Engineering,493 AmH, **5-0779**, frisbie@umn.edu
GERBERICH, William W., Professor, 395 AmH, **5-8548**, wgerb@umn.edu
HACKEL, Benjamin, Assistant Professor, 356 Am H, **4-7102**, hacke076@umn.edu
HOLMES, Russell J., Assistant Professor, 404 AmH, **4-9058**, rholmes@umn.edu
HU, **Wei-Shou,** Distinguished McKnight University Professor, 257c AmH, **5-0546**, wshu@umn.edu
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KAZNESSIS, Yiannis N., Professor, and Director of Graduate Studies, Chemical Engineering, 253 AmH, **4-4197**, yiannis@umn.edu
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KUMAR, Satish, Professor and Director of Undergraduate Studies, Chemical Engineering,, 201 AmH, **5-2558**, kumar030@umn.edu,
LEIGHTON, Christopher, Professor and Director of Undergraduate Studies, Materials Science and Engineering**,** 48 AmH, **5-4018**, leighton@umn.edu
LODGE, Timothy P., Distinguished McKnight University Professor, IT Distinguished Professor, and Director of MRSEC, 235 SmithH, **5-0877** and 491 AmH, **5-8856**, lodge@umn.edu
MACOSKO, Christopher W., Professor, 304 AmH, **5-0092**, macosko@umn.edu,
McCORMICK, Alon V.,
34 AmH, **5-2059,** mkhoyan@umn.edu

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SCHOTT, Jeffrey H., Professor,112b AmH, **5-1420,** jschott@umn.edu, Materials Sci. Lab B-30 5-3823
SEIDEL, Robert W., Professor, 101 AmH, **4-8003,** rws@umn.edu
SHORES, David A., Professor and Director, Corrosion Research Center, 108 AmH, **5-0014**, dshores@umn.edu
SMYRL, **William H.,** Professor, 112d AmH, **5-0717**, smyrl001@umn.edu
SNOWDEN, Frank, Professor, 401 AmH, **6-2207,** snowd001@umn.edu
SRIENC, Friedrich, Professor, 257a AmH, **5-6362**, BPTI, 240 Gortner Lab (St. Paul) **4-9776**, srienc@umn.edu

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TSAPATSIS, Michael, Professor, 445 AmH, **6-0920**, tsapa001@umn.edu
WENTZCOVITCH, Renata M.M., Professor, 293 AmH, **5-6345**, wentz002@umn.edu
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ZHANG, Kechun, Assistant Professor, 263 AmH, **6-0635**, kzhang@umn.edu