Table of Contents

University of Manitoba
Engineering Society
204-474-6362 • EITC E2-292 • 75A Chancellors Circle • Winnipeg, MB R32 5V6

Electrical and Computer Engineering

Department Contacts

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Department Descriptions

The work of Computer Engineers is sometimes hidden and embedded into everyday objects such as cars, bank machines and smartphones. Computer Engineering students receive a broad education which encompasses both the hardware and software aspects of any application. In addition to the standard Computer Engineering program, the department offers three focus areas for interested students. These include the study of Embedded Systems, Communication Networks and Machine Vision.

Electrical and electronic systems are present in every aspect of life, from the power that lights a house at night to the toaster that prepares breakfast in the morning. Life would be very different without the benefits of these and other devices designed chiefly by electrical engineers. In addition to the traditional fields of electric power systems and telecommunications, today's electrical engineers are also expanding their work into fields such as biomedical devices and micro-electronics. In addition to the standard Electrical Engineering program, the department offers four focus areas for interested students. These include the study of Power and Energy Systems, Wireless Communication Devices, Biomedical Engineering and Engineering Physics. Students interested any of these programs should consult with the Electrical and Computer Department Office to select an appropriate set of elective courses.

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Engineering Society
204-474-6362 • EITC E2-292 • 75A Chancellors Circle • Winnipeg, MB R32 5V6

Tips for Incoming ECE Students

These tips are from current electrical and computer students.

1. If they are available, old midterms and finals are one of the best ways to prepare for your exams. Pay attention to the style of questions your professor has given in the past and to the concepts that were emphasized in previous years' exams.
2. Make friends, you will have several group projects for which you get to choose your partners.
3. Don't leave all of your tech electives for your last year, they conflict with each other and you will not be able to get into the courses you want.
4. Consider taking your complimentary electives in the evenings during the summer. They are less demanding and you can can lighten your course load during the school year.
5. In your circuits labs you will be taught how to use an oscilloscope and function generator. Make sure you fully understand how to use them, as they will be necessary for many subsequent courses.
6. You can buy a student version of multisim (a circuit simulator) for $60. This is a great investment, as it will help you complete design projects, labs and assignments more efficiently.
7. You can buy a student version of matlab for $100. Matlab will be used in labs for several different courses, so it is important to become proficient at matlab programming. There are lots of free tutorials available online.
8. Design projects are an important part of many of the courses in electrical engineering. Get started as early as possible on all design projects and keep in mind that the physical circuit will not behave exactly like the simulation. The Engineers in Residence are a great source of information about design, so make sure to ask lots of questions about the design process and your projects.
9. The concepts covered in Math 1-3 are extremely important for a lot of your electrical courses, so make sure you understand these topics very well.
10. Always use a multimeter to check the values of your resistors and capacitors. The components often get mixed up and this will save you a lot of time in the lab. You can also memorize the resistor colour codes.
11. If you need to pick up components for your projects or labs, visit the tech shop (E3-541). There are resistors, capacitors and wires available for students in drawers at the front of the tech shop. You need to ask one of the technicians for op amps, inductors and transistors.

12. Many of your courses will have weekly quizzes or assignments. Even though they aren't worth a large percentage of your grade, put in as much effort as you can. Your marks in these sections of the course can help boost your overall grade.
13. Always complete the prelabs before your lab section. This will help to ensure you are able to finish the lab on time. The prelabs and lab reports are also a good chance to practice applying some of the topics you are covering in class.
14. Buy a pair of wire strippers. They are available at the book store and will be very useful in the labs and for your design projects.

University of Manitoba
Engineering Society
204-474-6362 • EITC E2-292 • 75A Chancellors Circle • Winnipeg, MB R32 5V6

Conferences and Competitions

WESST Executive Meeting (WESST EM) - http://em.wesst.ca

Participation Available To: *UMES Executives only*
2015/2016 Conference Dates: *May 7th – 10th, 2015*
2015/2016 Conference Location: *Edmonton, AB*

WESST EM brings together student representatives from 10 engineering schools in Western Canada. The conference includes a number of sessions, presentations, meetings and discussions centered around the development of student leadership skills.

WESST Retreat - http://wesst.ca/retreat/

Participation Available To: *All Engineering students*
2015/2016 Retreat Dates: *Early October*
2015/2016 Retreat Location: *Regina, SK*

This retreat offers students from the 10 WESST schools an opportunity to interact in a camp setting. In addition to WESST's AGM, retreat activities include sessions on building leadership skills and a number of social and team-building activities.

Conference on Diversity in Engineering (CDE) - http://2015.cde.cfes.ca/index.html

Participation Available To: *All Engineering students*
2015/2016 Conference Dates: *November 13th – 15th, 2015*
2015/2016 Conference Location: *Waterloo, ON*

This conference focuses on the importance of diversity in Engineering, specifically examining the role of students in achieving the industry's related goals. CDE attracts approximately 150 engineering students from across Canada.

University of Manitoba Engineering Competition (UMEC) - http://umes.mb.ca/node/56

Participation Available To: *All Engineering students*
2015/2016 Competition Dates: *End of November*
2015/2016 Competition Location: *U of M Engineering*

This competition is run annually by UMES and is held here at the U of M. All students are encouraged to participate, and those who qualify will be sponsored by UMES to subsequently attend WEC (see below).

University of Manitoba
Engineering Society
204-474-6362 • EITC E2-292 • 75A Chancellors Circle • Winnipeg, MB R32 5V6

CFES Congress - http://congress.cfes.ca

Participation Available To: *All Engineering students*
2015/2016 Conference Dates: *January 3rd – 9th, 2016*
2015/2016 Conference Location: *Calgary, AB*

Congress is an annual, student-run conference hosted by a different CFES school each year. The conference serves not only as CFES' Annual General Meeting (AGM), but also as a platform for students to interact with both engineering students and professionals from across the country. Each year CFES Congress attracts 150 to 200 student delegates from over 40 Canadian engineering schools.

Western Engineering Competition (WEC) - http://wec2015.ca

Participation Available To: *Winners of UMEC*
2015/2016 Competition Dates: *January 22nd – 26th, 2016*
2015/2016 Competition Location: *Kelowna, BC*

Run annually by WESST, this competition provides students from 10 Western Canadian engineering schools the opportunity to engage in competition. The competition also includes a series of industry tours and networking activities. Those who place first or second in their category qualify for CEC.

Canadian Engineering Competition (CEC) - http://cec2016.com

Participation Available To: *Winners of WEC*
2015/2016 Competition Dates: *March 3rd – 6th, 2016*
2015/2016 Competition Location: *Montreal, QC*

This competition is run annually by CFES and brings together 150 of the most innovative and creative Canadian engineering undergraduate students. In addition to gaining competition experience, participants will have the opportunity to engage with engineering students and professionals from across the country.

International Engineering Competition (IEC) - http://cfes.ca/events-and-services/iec/

Participation Available To: *Winners of CEC*
2015/2016 Competition Dates: *TBA*
2015/2016 Competition Location: *TBA*

Also organized annually by CFES, the International Engineering Competition engages students from across Canada, the United States and Europe in consulting and design engineering challenges. Much like CEC, participants are also provided the opportunity to interact with a diverse group of engineering students and professionals.

University of Manitoba
Engineering Society
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Summer Session and Minors

Summer Sessions

Extended Education

188 Continued Education Complex
summer@umanitoba.ca
474-8008
http://umanitoba.ca/summer/

Taking summer session courses is a good way to reduce your workload during the year. However, do not rely on taking a given course during the summer as the course offerings at this time are very irregular. Those courses offered during the summer are targeted primarily at students who couldn't fit a course into their regular session or who failed/dropped a course during the regular session. If interested, you may petition a faculty to make a course available during the summer. Contact the Vice Stick Academic for help with putting a petition together.

Some courses which *are* typically offered in the summer include the engineering math courses (Calc I & II, Linear Algebra, Math 1 & 2), some preliminary year engineering courses (such as Intro. to Thermal Sciences and Statics), CHEM 1300 and many Arts and Management courses suitable for your complementary electives. Note that the Summer Session calendar is released in March. The term is generally divided into Spring and Summer "terms" of 2 months each, with some courses spanning both terms.

Minors

Engineering Student Affairs Office

EITC E1-284
Judy.Schroen-Galinaitis@umanitoba.ca
474-9808

Minors in Business, Arts, Music, Math, and Computer Science are offered to Engineering students. These programs help to broaden your education and increase your prospects for future employment. In order to obtain a minor you must complete 18 credit hours of courses from the given faculty.

Requirements for pursuing a minor include the completion of at least 30 credit hours toward your engineering degree, as well as a CGPA of at least 3.00. There are a limited number of spaces available in the minor programs therefore preference is given to students who are closest to completing their degree.

Visit the Engineering Undergraduate Student Affairs Office for more details on pursuing a minor. Applications for minors must be submitted to this office before the end of May.

*With the approval of the Faculty of Engineering, courses taken to complete minors may also be used to fulfill engineering course requirements.

University of Manitoba
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Summer Research Opportunities

The following is a list of research topics shared in the Fall 2016 term for potential summer research student positions. For more information about specific opportunities we have provided the contact information for the professors.

For more information on…

U of M URA: Google University of Manitoba URA and visit the U of M website.

NSERC USRA: Google NSERC USRA and visit the NSERC website.

Either Award: Contact Kristy McGregor in E1-284 or at kristy.mcgregor@umanitoba.ca

- Dr. Carl Ho: RIGA Lab, Carl.Ho@umanitoba.ca, E1-456.
    - One student for implementation of a DSP controller for Solar Inverters: To develop algorithms and program in a TI DSP/MCU to control Solar inverters, including MPP Tracking, gird current control.
    - One student for implementation of a Solar Inverter: To design a converter and route PCBs to implement an Solar inverter prototype.

- Dr. Derek Oliver, Nano-Scale Systems, Derek.Oliver@umanitoba.ca, E2-390G.
    - I collaborate with an interdisciplinary and international team to develop a device that will use energy from the sun to “split” water into hydrogen and oxygen. A key part of the proposed device are silicon microwires that will absorb the sunlight. The electrical characterization of these wires and their interface with other system components is our speciality - a summer student will work in partnership with graduate students on this.

- Dr. Zahra Moussavi, Biomedical Instrumentation, Zahra.Moussavi@umanitoba.ca, E3-517.
    - My research is focused in three clusters:
        - medical devices instrumentation and signal analysis,
        - immersive virtual reality design for diagnosis and rehabilitation of Alzheimer’s disease, and
        - electrovestibulography for diagnosis of neurological and mental disorders, e.g. depression, concussion, Alzheimer’s, etc.
- Dr. Joe LoVetri, Electromagnetic Imaging Lab, Joe.LoVetri@umanitoba.ca, E2-390C.
    - Dr. LoVetri is the director of the University of Manitoba Electromagnetic Imaging Lab, focused on the development of microwave and ultrasound imaging algorithms and hardware systems. Summer research positions will focus on the development, maintenance

or testing of hardware systems and/or algorithms for various imaging applications. Matlab/C/C++ programming, RF hardware, and/or embedded system experience will be advantageous.

- Dr. Arkady Major, Biomedical & Laser Photonics Lab, A.Major@umanitoba.ca, E3-559.
    - Develop (design, build and test) a (1) CCD camera based laser beam profiler; (2) temperature controlled cooling system for LED; (3) electrical pulse generator with MHz repetition rate; (4) laser based microscope.
- Dr. Cyrus Shafai, Nano-Systems Fabrication Lab, Cyrus.Shafai@umanitoba.ca, E1-534.
    - Development of micro-fabricated (in cleanroom) micro-sensors for electric field and magnetic field measurement. Integration of sensors with electronics, with Arduino and Raspberry Pi for interfacing and data logging. Application for remote, non-contact, voltage and current measurement of electric cabling and high voltage power lines.
- Dr. Dustin Isleifson, Applied Electromagnetics & Remote Sensing, Dustin.Isleifson@umanitoba.ca, E3-513.
    - Undergraduate student research position in the development of electromagnetic simulation tools for remote sensing problems. Tasks would include running simulations, code development (MATLAB, C), validation, and verification.
- Ahmad Byagowi, Ahmad.Byagowi@umanitoba.ca
- Dr. Greg Bridges, Advanced RF Systems Laboratory, Gregory.Bridges@umanitoba.ca, E3-465.
    - The ARFSL specializes in the design and test of microwave and millimeter wave integrated circuits and RF microfluidic devices. Summer research positions are available in two areas.
        - Development of an RF microfluidic fabrication process that integrates RF electronics with fluid channels on a single chip.
        - Development of a microwave chipless RFID sensor for remote chemical monitoring.
- Dr. Ian Jeffrey, Electromagnetic Imaging Lab, Ian.Jeffrey@umanitoba.ca, E3-546.
    - This summer one project focuses on the development of computational electromagnetics codes in Matlab and/or C++ for microwave imaging algorithms. A second project is the development of a mobile game platform for determining users' abilities to detect and maintain strategies in short-duration simple games.

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What are Focus Areas?

Students wishing to pursue more focused studies in an Electrical Engineering subject/research area can do so by choosing one of the approved focus areas. The Electrical Engineering program offers four focus areas; Power and Energy Systems, Communication Devices, Biomedical and Engineering Physics. More information about the focus areas can be found here.

The Electrical Engineering Program requires students to take 7 Technical Electives and 1 Natural Science Elective. The technical elective structure has recently changed, effective September 2016. Students who were enrolled in the Electrical Engineering degree program prior to this change may choose to follow the new structure, or may complete their degree using the previous technical elective structure. Information on both technical elective structures and a full list of available courses can be found on the Technical and Science Electives page.

Students wishing to pursue more focused studies a Computer Engineering subject/research area can do so by choosing one of the approved focus areas. The Computer Engineering program offers three focus areas; Computer Networks and Communications, Embedded Systems, and Software Engineering. More information about the focus areas can be found here.

The Computer Engineering Program requires students to take 2 Natural Science Electives and 5 Technical Electives, with a maximum of 2 Electrical Engineering technical electives. The full list of available courses can be found on the Technical and Science Electives page.

University of Manitoba
Engineering Society
204-474-6362 • EITC E2-292 • 75A Chancellors Circle • Winnipeg, MB R32 5V6

Course List

Electrical Engineering

Second Year Courses
Engineering Communication (ENG 2030 or ENG 2040) 3CR
Engineering Mathematical Analysis 1 (MATH 2130) 3CR
Engineering Mathematical Analysis 2 (MATH 2132) 3CR
Electric Circuits (ECE 2262) 4CR
Digital Logic Systems (ECE 2220) 5CR
Ecology, Technology and Society (ANTH 2430) 3CR
Modern Physics for Engineers (PHYS 2152) 3CR
Numerical Methods for Electrical Engineers (ECE 2240) 4CR
Electronics 2E (ECE 2160)
Microprocessing Systems (ECE 3610) 4CR

Third Year Courses
Foundations of Electromagnetics (ECE 3580) 4CR
Contemporary Statistics for Engineers (STAT 2220) 3CR
Signal Processing 1 (ECE 3780) 4CR
Electric Power and Machines (ECE 3720) 4CR
Electronics 3E (ECE 3670) 4CR
Electromagnetic Theory (ECE 3590) 4CR
Physical Electronics (ECE 3600) 4CR
Communications Systems (ECE 4260) 4CR
Advanced Circuit Analysis and Design (ECE 3540) 4CR
Principles of Embedded System Design (ECE 3730) 4CR

Fourth Year Courses
Control Systems (ECE 4150) 4CR
Group Design Project (ECE 4600) 6CR
Engineering Economics (CIVL 4050) 3CR

Technical Elective Courses
Group A
Control Engineering (ECE 4160) 4CR
Digital Communications (ECE 4240) 4CR
Microwave Engineering (ECE 4290) 4CR

Power Electronics (ECE 4370) 4CR
Signal Processing 2 (ECE 4830) 4CR
Group B
Electric Machines (ECE 3650) 5CR
Telecommunication Networks Engineering (ECE 3700) 4CR
Introduction to Microelectronic Fabrication (ECE 4100) 4CR
Introduction to Robotics (ECE 4180) 4CR
Antennas (ECE 4270) 4CR
High Voltage Engineering (ECE 4360) 4CR
Engineering Computation 4E (ECE 4390) 4CR
Computer Vision (ECE 4440) 4CR
Parallel Processing (ECE 4530) 4CR
Wireless Networks (ECE 4540) 4CR
Optoelectronics (ECE 4580) 4CR
Biomedical Instrumentation and Signal Processing (ECE 4610) 4CR
Digital System Implementation (ECE 4740) 4CR
(T01) Modern Computing Systems (ECE 4850) 4CR
(T02) Applied Computational Intelligence (ECE 4850) 4CR
(T01) Random Signals and Processes (ECE 4860) 4CR
(T02) Biomedical Signal Processes (ECE 4860) 4CR
(T03) Design of RF Devices and Wireless Systems (ECE 4860) 4CR
(T05) Materials Characterizations (ECE 4860) 4CR
Computer Science 2 (COMP 1020) 3CR
Data Structures and Algorithms (COMP 2140) 3CR
Introduction to Artificial Intelligence (COMP 3190) 3CR
Machine Learning (COMP 4360) 3CR
Applied Discrete Mathematics (MATH 3120) 3CR
Complex Analysis 1 (MATH 3340) 3CR
Partial Differential Equations (MATH 3460) 3CR
Optics (PHYS 2260) 3CR
Medical Physics and Physiological Measurement (PHYS 3220) 3CR
Electro- and Magnetodynamics and Special Relativity (PHYS 3640) 3CR
Advanced Optics (PHYS 4590) 3CR

Elective Courses Not Offered in 2016-2017
Please consult the ECE department website or your undergraduate advisor for more information about the following courses and when they are offered
Digital Systems Design 2 (ECE 3770) 4CR
Power Transmission Lines (ECE 4140) 4CR
Electronic Filter Design (ECE 4200) 4CR

Engineering Electromagnetics (ECE 4280) 4CR
Electric Energy Systems 2 (ECE 4310) 4CR
Digital Control (ECE 4420) 4CR
Simulation and Modelling (ECE 4520) 4CR

Computer Engineering

Second Year Courses
Engineering Communications (ENG 2030) 3CR
Engineering Communications (ENG 2040) 3CR
Engineering Mathematical Analysis 1 (Math 2130) 3CR
Engineering Mathematical Analysis 2 (MATH 2132) 3CR
Electric Circuits (ECE 2262) 4CR
Digital Logic Systems (ECE 2220) 5CR
Computer Science 2 (COMP 1020) 3CR
Modern Physics for Engineers (PHYS 2152) 3CR
Engineering Mathematical Analysis 3 (MATH 3132) 3CR
Electronics 2E (ECE 2160) 5CR
Microprocessing Systems (ECE 3610) 4CR
Data Structures and Algorithms (COMP 2140) 3CR
Engineering Algorithms (ECE 3790) 4CR

Third Year courses
Statistics for Engineerings (STAT 2220) 3CR
Applied Discrete Mathematics (MATH 3120) 3CR
Signal Processing 1 (ECE 3780) 4CR
Microprocessor Interfacing (ECE 4240) 4CR
Systems Engineering Principles 1 (ECE 3740) 4CR
Communication Systems (ECE 4260) 4CR
Signal Processing 2 (ECE 4830) 4CR
Ecology, Technology and Society (ANTH 2430) 3CR
Digital Systems Design 1 (ECE 3760) 4CR
Introduction to Operating Systems (COMP 3430) 3CR
Telecommunication Network Engineering (ECE 3700) 4CR

Fourth Year Courses
Control Systems (ECE 4150) 4CR
Group Design Project (ECE 4600) 6CR
Engineering Economics (CIVL 4050) 3CR

University of Manitoba
Engineering Society
204-474-6362 • EITC E2-292 • 75A Chancellors Circle • Winnipeg, MB R32 5V6

Technical Elective Courses

*Advanced Circuit Analysis and Design (ECE 3540) 4CR
*Foundations of Electromagnetics (ECE 3580) 4CR
*Physical Electronics (ECE 3600) 4CR
*Electronics 3E (ECE 3670) 4CR
*Electric Power and Machines (ECE 3720) 4CR
*Introduction to Microelectronic Fabrication (ECE 4100) 4CR
*Control Systems (ECE 4150) 4CR
*Control Engineering (ECE 4160) 4CR
Introduction to Robotics (ECE 4180) 4CR
Digital Communications (ECE 4250) 4CR
*Communication Systems (ECE 4260) 4CR
*Engineering Computation 4E (ECE 4390) 4CR
Computer Vision (ECE 4440) 4CR
Parallel Processing (ECE 4530) 4CR
Wireless Networks (ECE 4540) 4CR
*Biomedical Instrumentation and Signal Processing (ECE 4610) 4CR
Digital System Implementation (ECE 4740) 4CR
(T01) Modern Computing Systems (ECE 4850) 4CR
(T02) Applied Computational Intelligence (ECE 4850) 4CR
(T01) Random Signals and Processes (ECE 4860) 4CR
(T02) Biomedical Signal Processing (ECE 4860) 4CR
Object Orientation (COMP 2150) 3CR
Programming Practices (COMP 2160) 3CR
Distributed COmputing (COMP 3010) 3CR
Human-Computer Interaction 1 (COMP 3020) 3CR
Introduction to Artificial Intelligence (COMP 3190) 3CR
Introduction to Compiler Construction (COMP 3290) 3CR
Software Engineering 1 (COMP 3350) 3CR
Database Concepts and Usage (COMP 3380) 3CR
Computer Graphics 1 (COMP 3490) 3CR
Human-Computer Interaction 2 (COMP 4020) 3CR
Introduction to Cryptography and Cryptosystems (COMP 4140) 3CR
Artificial Intelligence (COMP 4190) 3CR
Software Engineering 2 (COMP 4350) 3CR
Machine Learning (COMP 4360) 3CR
Database Implementation (COMP 4380) 3CR
Operating Systems 2 (COMP 4430) 3CR
Computer Graphics 2 (COMP 4490) 3CR

Computer Security (COMP 4580) 3CR
Introduction to Data Mining (COMP 4710) 3CR

Elective Courses Not Offered in 2016-2017
Digital Systems Design 2 (ECE 3770) 4CR
Power Transmission Lines (ECE 4140) 4CR
Electronic Filter Design (ECE 4200) 4CR
Engineering Electromagnetics (ECE 4280) 4CR
Electric Energy Systems 2 (ECE 4310) 4CR
Digital Control (ECE 4420) 4CR
Simulation and Modelling (ECE 4520) 4CR

University of Manitoba
Engineering Society
204-474-6362 • EITC E2-292 • 75A Chancellors Circle • Winnipeg, MB R32 5V6

Course Descriptions

SECOND YEAR COURSE DESCRIPTIONS

Engineering Communication (ENG 2030 or ENG 2040) 3CR
Take only one of **ENG 2030**: Students work in a team-based environment to produce deliverables comparable to the engineering workplace. In-class tutorials focus on the sharpening of individual students' writing skills through an analytical, problem-solving and critical thinking approach. Students are exposed to a variety of communicative scenarios and emphasis is placed on development of a repertoire of skills necessary for effective communication in the engineering profession. **OR ENG 2040**: This team-based course focuses on a rhetorical approach, communication strategies and guided practice in the design of engineering communications. ENGL 1400/1310, ENG 1430 (or former ENG 2010) prerequisite.

Difficulty: 3 **Workload:** 5

Tips: Make sure to get started on your final report early to allow lots of time for editing. Wear business clothes for all presentations. Try to keep up with entries in your journal.

Engineering Mathematical Analysis 1 (MATH 2130) 3CR
Multivariable differential and integral calculus up to and including multiple integrals in cylindrical and spherical coordinates. For Engineering and Geophysics students only. Prerequisites: MATH 1210 or MATH 1211 and MATH 1710.

Difficulty: 3 **Workload:** 3

Tips: Make sure to review your notes from Calculus 2 before starting this class. The textbook has lots of practice problems, which are a great way to prepare for the tests. Make an effort to attend the tutorials, as the professors will go through practice problems.

Engineering Mathematical Analysis 2 (MATH 2132) 3CR
Infinite series, Taylor and Maclaurin Series; ordinary differential equations including Laplace transforms. For Engineering and Geophysics students only. MATH 1210 and MATH 1710 are prerequisites.

Difficulty: 4 **Workload:** 3

Tips: The best way to prepare for your midterms and final is to do lots of practice problems in the textbook. The tutorials are taught by the professor, so they are a great opportunity to go through additional practice problems and ask your questions.

Engineering Mathematical Analysis 3 (MATH 3132) 3CR
Vector integral calculus; series of ordinary differential equations; Fourier series and Partial differential equations. MATH 2130 and MATH 2132 are prerequisites.

Difficulty: 4 **Workload:** 3

Tips: Review your notes from Math 1 and 2 before starting this course. The textbook is an excellent source of practice problems for the midterm and final. The topics covered in Math 3 will be used in many of the third year electrical engineering courses, so it is important to understand all the concepts covered in the class.

Electric Circuits (ECE 2262) 4CR
The application of circuit concepts; network theorems and formal methods, steady state analysis, frequency and transient response, application of the Laplace transform in the analysis of linear time-invariant networks. Prerequisite: ENG 1450. Pre- or Corequisite: MATH 2132.

Difficulty: 3.5 **Workload:** 3.5

Tips: Review your notes from ENG 1450. The concepts and analysis techniques you learn in the labs (such as the use of an oscilloscope and function generator) will be used throughout your degree. Practicing old exams and doing textbook problems are excellent ways to prepare for the midterm.

Digital Logic Systems (ECE 2220) 5CR
Boolean algebra and logic primitives, net-work simplification techniques, physical realizations, number systems and codes; analysis and design of asynchronous and synchronous sequential circuits; applications to computation, measurements, and control. Prerequisite ENG 1450

Difficulty: 3 **Workload:** 4

Tips: This course includes an open ended design project. Get started on it early to allow plenty of time for debugging. The TA's and Professors like to see creativity on the design project. The textbook for this course is very expensive but is an excellent source of practice problems, so it is worth the investment.

Ecology, Technology and Society (ANTH 2430) 3CR
Ecological analysis of the interplay of socio-political and technological processes in different types of societies. Focus upon the ecological side-effects and selected technologies, economic mechanisms and political institutions.

Difficulty: 2 **Workload:** 2

Tips: This course requires students to write several essays. If you send a draft of your essay to the TA, they will be able to give you comments and feedback before the final paper is due.

Modern Physics for Engineers (PHYS 2152) 3CR
An overview of topics in modern physics including wave particle duality, atomic structure and quantum mechanics. Elementary classical electromagnetic theory and wave theory are reviewed as an introduction to the modern physics concepts. For Engineering students only. Not to be held with PHYS 1070 or PHYS 1071. Prerequisites: a "C" or better in one of PHYS 1050, and a "C" or better in MATH 1510; and a "C" or better in MATH 1710, or MATH 1690. Prerequisite or concurrent requirement: MATH 2130.

Difficulty: 3 **Workload:** 2

Tips: The midterm and final are both multiple choice. Practicing old exams (which are available in your lab manual) is an excellent way to prepare. Lab reports have to be handed in by the end of the lab section, so make sure to come prepared.

Numerical Methods for Electrical Engineers (ECE 2240) 4CR
Numerical methods applied to Electrical Engineering problems; mathematical models of physical systems, solutions of linear and non-linear equations, numerical differentiation and integration methods and associated errors, introduction to solution analysis. Prerequisites ECE 2262, COMP 1012, MATH 2132.

Difficulty: 3.5 **Workload:** 3.5

Tips: You are not provided with a formula sheet for the exams, so make sure to memorize all the necessary equations. All labs are completed on Matlab, so spend some time at the beginning of the semester learning basic Matlab syntax.

Electronics 2E (ECE 2160) 5CR
Characteristics of integrated circuits and transistors; design of DC and AC amplifiers in the steady state. Prerequisite: ECE 2262.

Difficulty: 3.5 **Workload:** 3.5

Tips: This course includes a design project. It is important to get started early to allow yourself plenty of time to work on your simulation, and then perform physical testing. Keep in mind that the actual behaviour of your circuit will be different than the simulation. Each semester an engineer in residence will be assisting with the design project. Ask lots of questions and consult them if you encounter problems with the design process.

Microprocessing Systems (ECE 3610) 4CR
Fundamentals of microprocessors and microcomputers; data flow; machine programming; architectures and instructions sets; stacks, subroutines, I/0, and interrupts; interfacing fundamentals; designing with microprocessors. Prerequisite: ECE 2220.

Difficulty: 3 **Workload:** 4

Tips: The labs for this course require students to code in assembly language. Make sure to prepare before the labs so that you are able to finish on time. Old midterms should be available on the course website and are an excellent way to prepare for the term tests.

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THIRD YEAR COURSE DESCRIPTIONS

Electrical Engineering

Foundations of Electromagnetics (ECE 3580) 4CR
Fundamental laws of field theory; Maxwell's equations in integral and point form. This course introduces students to electrostatics, magnetostatics and basics of electromagnetics. Prerequisite: ECE 2240, PHYS 2152, and MATH 3132.

Difficulty: 5 **Workload:** 4

Tips: The labs in this course are completed on Matlab. Make sure to review Matlab before the first lab, to ensure that you will be able to finish on time. In the past, this course has included 5 quizzes. Spend some time practicing the old quizzes and reviewing the concepts covered in class to prepare for them. There may also be a tutorial session each week. The tutorial is an excellent chance to practice additional problems and to get your questions answered. Old midterms are a good tool to prepare for the midterm and final, but make sure to review the course notes as well, as it is likely that your exams will include types of questions that are not on any of the old tests.

Contemporary Statistics for Engineers (STAT 2220) 3CR
Descriptive statistics, basic probability concepts, special statistical distributions, statistical inference-estimation and hypothesis testing, regression, reliability, statistical process control. Prerequisite: MATH 1710.

Difficulty: 2.5 **Workload:** 2

Tips: Make sure to memorize all the equations you will need for the tests, as you will not be given a formula sheet. Practicing old exams is a great way to prepare for the midterm and final.

Signal Processing 1 (ECE 3780) 4CR
Introduction to signals and systems; spectral analysis (Fourier Series) of continuous-time periodic signals; spectral analysis of aperiodic signals (Fourier Transform); the impulse response and convolution operator; frequency analysis of linear time-invariant systems; applications to filtering, communications systems, and biological systems; A/D conversion; sampling. Laboratory periods will be used to give students hands-on experience in programming many of the techniques covered in the theoretical parts of the course. Prerequisites: ECE 2262 or ECE 2260 and MATH 3132 or MATH 3100.

Difficulty: 5 **Workload:** 3

Tips: Ensure that you are comfortable with the concepts covered in math 2 and 3 before starting ECE 3780. The textbook has a lot of sample problems, which are a good way to prepare for the tests and quizzes. The labs are a great way to deepen your understanding of the concepts covered in class.

Electric Power and Machines (ECE 3720) 4CR
Principles and applications of electric power, energy conversion and machines. Prerequisite: ECE 2262 or ENG 1180.

Difficulty: 3 **Workload:** 3

Tips: The textbook is an excellent source of sample problems that will help you prepare for the midterm and final. Try to complete the calculation portion of the labs before your lab section. This will allow you to compare your measured values to the theoretical values to ensure that you are building your circuits and taking the measurements properly.

Electronics 3E (ECE 3670) 4CR
Continuation of ECE 2160, including device models, feedback, regulators, frequency effects, oscillators, and bistability and gates. This course is design based. Prerequisite: ECE 2160.

Difficulty: 4 **Workload:** 5

Tips: The majority of the exam problems in this class are design based. When you are preparing for exams, you can test your solutions by building your design on multisim and comparing the simulated output to the design requirements.

Electromagnetic Theory (ECE 3590) 4CR
Maxwell's equations; plane electromagnetic waves; transmission line theory; electromagnetic radiation and introduction to antennas. Prerequisite: ECE 3580.

Difficulty: 3 **Workload:** 3

Tips: Review your notes from ECE 3580 (particularly plane waves) before starting this course. The old tests posted on the course website are an excellent way to prepare for the exams. Make sure to complete the prelabs to ensure that you are prepared for the in-lab quizzes.

Physical Electronics (ECE 3600) 4CR
Basic solid state theory; properties of semi-conductors; principles of metal-semiconductor junctions, p-n junctions and transistors; optoelectronic processes. Prerequisites: PHYS 2152, MATH 3132, ECE 3670.

Difficulty: 5 **Workload:** 4

Tips: This course introduces a lot of new and complex concepts. Make sure to keep up with your studying and practice problems throughout the semester.

Communications Systems (ECE 4260) 4CR

Development and applications of random processes. Analysis and comparison of modulation schemes: AM, FM, PM, PCM. Prerequisites: ECE 3780, and STAT 2220.

Difficulty: 3 **Workload:** 2

Tips: Review your notes from Signal Processing before starting this course. The labs are very long so come prepared. The labs also introduce you to a lot of new equipment (such as the spectrum analyzer) so make sure to ask the TA's if you are struggling with using the equipment.

Advanced Circuit Analysis and Design (ECE 3540) 4CR
Application of the Laplace Transform in the analysis of linear time-invariant networks, poles, zeros and frequency response; natural frequencies; general network theorems; two ports; energy and passivity; transmission lines; time and frequency domain. Prerequisite: ECE 2262, MATH 3132.

Difficulty: 4 **Workload:** 4

Tips: Review the concepts from the first circuits course before starting this class. The assignments for this course are very lengthy. Try to use matlab to help you complete the assignments more efficiently.

Principles of Embedded System Design (ECE 3730) 4CR
This course will introduce students to the design and implementation of embedded systems. Topics include introduction to UML and data structures, A-to-D, D-to-A, serial bus architectures, embedded computing, bus-based computer systems, program design and analysis, networks, and hardware-software co-design. Prerequisites: ECE 2160, ECE 3610 and COMP 1012.

Difficulty: 4 **Workload:** 5

Tips: The assignments and labs for this course are very extensive. Make sure to start on your assignments as early as possible, and get started on the lab before your scheduled lab period. In the past, the assignments have been submitted through the U of M email. Make sure to follow all submission procedures exactly to avoid losing points.

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FOURTH YEAR COURSE DESCRIPTIONS

Electrical Engineering

Control Systems (ECE 4150) 4CR
Principal methods of analysis and design for feedback control systems. Prerequisite: ECE 2160 and ECE 3780.

Difficulty: 3 **Workload:** 3.5

Group Design Project (ECE 4600) 6CR
The engineering curriculum must culminate in a significant design experience which is based on the knowledge and skills acquired in earlier course work and which gives students an exposure to the concepts of teamwork and project management. Prerequisites: [ENG 2030 or ENG 2040] and ECE 3780 and [(ECE 3580, ECE 3720, ECE 3670 and ECE 3610) or (ECE 3700, ECE 3760 and ECE 3740)].

Difficulty: 5 **Workload:** 5

Engineering Economics (CIVL 4050) 3CR
Introduction to engineering economics. Time value of money and discounted cash flow calculations. Comparing alternatives. Replacement analysis and life-cycle costing. Public sector engineering economy studies. Private sector engineering economy studies. Before and after-tax analysis. Applications in cost-estimating. Applications in asset management systems. Basic accounting. Accommodating capital limitations. Dealing with inflation. Dealing with risk and uncertainty. STAT 2220 is a prerequisite.

Difficulty: 3 **Workload: 3**

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TECHNICAL ELECTIVE COURSE DESCRIPTIONS

Electrical Engineering

Seven (7) technical electives are required, at least three (3) must be from Group A.
***This requirement applies to students admitted September 2016 and later, consult ECE department website for more detailed information.**

GROUP A QUALIFIED ENGINEERING DESIGN ELECTIVE COURSES

Control Engineering (ECE 4160) 4CR
Design of control systems by frequency domain and root locus method; state equations; introduction to nonlinear analysis. Prerequisite: ECE 4150.

Digital Communications (ECE 4250) 4CR
Transmission of digital data; error rates, interference. Information measures, information rate and channel capacity. Coding. Prerequisite: ECE 4260 and ECE 3780.

Microwave Engineering (ECE 4290) 4CR
Microwave circuit analysis; passive and active devices; communication system power budget and signal-to-noise ratio calculations. Prerequisite: ECE 3590.

Power Electronics (ECE 4370) 4CR
Thyristor device theory and operation, controlled rectifiers and line-commuted inverters, and forced commutation as applied to d/c choppers and a/c variable frequency and voltage inverters. Prerequisites: ECE 3720 and ECE 2160.

Difficulty: 4 **Workload:** 3.5

Signal Processing 2 (ECE 4830) 4CR
Representation of discrete-time signals and systems in the time and frequency domains; the z-transform; application to various discrete-time linear time-invariant systems; design of digital filters. Laboratory periods will be used to give students hands-on experience in programming many of the techniques covered in the theoretical parts of the course. Prerequisite: ECE 3780.

Difficulty: 4 **Workload: 3**

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GROUP B TECHNICAL ELECTIVE COURSES

Electric Machines (ECE 3650) 5CR
Continuation of ECE 3270 (Electric Power and Machines), including steady state and transient performance and introductory power systems theory. Prerequisite: ECE 3720.

Difficulty: 3.5 **Workload:** 3.5

Telecommunication Networks Engineering (ECE 3700) 4CR
This course will introduce modem concepts in telecommunications, including LANs, WANs, telephone networks, wireless and mobile networks, and Internet networks. Focus will be on design engineering, and management of networks, and on network programming for client server architectures. Prerequisite: COMP 2140.

Difficulty: 3.5 Workload: 3.5

Introduction to Microelectronic Fabrication (ECE 4100) 4CR
Introduction to the fabrication of integrated circuits (ICs). Emphasis is on silicon based devices. Topics include water preparation, oxidation, thin film deposition, diffusion and ion implantation, lithography, wet and dry etching and metallization. An introduction to MEMS and micromachining technology is given. Prerequisite: ECE 3670.

Difficulty: 3 Workload: 3

Introduction to Robotics (ECE 4180) 4CR
This course provides fundamental concepts of robotics, including robot classification and applications, robot kinematics, sensor and actuators, sensor interfacing, motor control, trajectory planning, and robot programming. Prerequisites: ECE 4150 and (ECE 4240 or ECE 3730).

Difficulty: 3 Workload: 2.5

Antennas (ECE 4270) 4CR
Radiation fundamentals, linear antennas, point source arrays, aperture antennas, antenna impedance, antenna systems. Prerequisite: ECE 3590.

High Voltage Engineering (ECE 4360) 4CR
The course serves as an introduction to high voltage engineering, including basics of electrical breakdown, high voltage generation, high voltage test systems, measurement and analysis techniques as applied to power system apparatus, such as cables, insulators, transformers, and generators. Prerequisite: ECE 3580, ECE 3720.

Difficulty: 4 Workload: 4

Engineering Computation 4E (ECE 4390) 4CR
Development and application of numerical methods for the solution of electrical and computer engineering problems. Optimization techniques. Finite difference, finite element and boundary element methods. Solution of large systems of linear and non-linear equations. Prerequisite: MATH 3132, ECE 2240.

Tips: There is a lot of information in this course and the labs and assignments require a lot of time. However, the quizzes, test and exam are open book. It is suggested to get ahold of Joe Lovetri's notes from the old website for these tests.

Difficulty: 4 **Workload:** 5

Computer Vision (ECE 4440) 4CR
Image formation and sensing, image compression degradation and restoration, geometrical and topological properties, pattern classification, segmentation procedures, line-drawing images, texture analysis, 3-D image processing. Prerequisite: ECE 3780.

Parallel Processing (ECE 4530) 4CR
Classification of parallel processors, SIMD vs. MIMD, multiprocessing Vs parallel processing, interconnection topology, communications, and node complexity, pipelining and vector processors, array algorithmic machines. Prerequisites: COMP 2140 and ECE 3760.

Wireless Networks (ECE 4540) 4CR
Introduction to wireless communications systems, network architectures, protocols and applications. Topics include mobile computing systems, signals propagation, channel modelling, modulation, and networking standards. Prerequisite: ECE 3700 and ECE 3780.

Optoelectronics (ECE 4580) 4CR
Basic theory of quantum mechanics; solution of Shrodinger equations; interaction of radiation with matter; masers and lasers; propagation, modulation, excitation and detection in optical waveguides; introduction to fiber and integrated optics. Prerequisite: ECE 3600.

Biomedical Instrumentation and Signal Processing (ECE 4610) 4CR
Introduction to biological systems and application of engineering principles to medical problems. Students design systems to acquire and analyze biological signals in the laboratory. Content includes introduction to relevant physiology and anatomy of cells, skeletal muscles, heart and cardiovascular systems, human balance and biomechanics, recording and analyzing amplifiers for signal conditioning, medical instrumentation safety and health hazards. Prerequisites: ECE 2160 and ECE 3780.

Digital System Implementation (ECE 4740) 4CR

Implementation methodologies and technologies for digital systems, including VLSI implementations, PCB implementations, and rapid prototyping (FPGA). Prerequisite: ECE 4240. Not to be held with ECE 4500.

(T01) Modern Computing Systems (ECE 4850) 4CR
Prerequisite: ECE 3610.

(T02) Applied Computational Intelligence (ECE 4850) 4CR
Prerequisite: MATH 3132.

(T01) Random Signals and Processes (ECE 4860) 4CR
Prerequisite: STAT 2220, ECE 3780.

(T02) Biomedical Signal Processing (ECE 4860) 4CR
Prerequisite: Permission of the Instructor (S. Sherif).

(T03) Design of RF Devices and Wireless Systems (ECE 4860) 4CR
Prerequisite: ECE 3590.

(T05) Materials Characterizations (ECE 4860) 4CR
Prerequisite: Permission of the Instructor (D. Oliver).

Computer Science 2 (COMP 1020) 3CR
More features of a procedural language, elements of programming. Not to be held with COMP 1021. Prerequisite: COMP 1010 or COMP 1011; or COMP 1012, COMP 1013 (C) or High School Computer Science 40S (75%) and any grade 12 or 40S Mathematics, or equivalent.

Data Structures and Algorithms (COMP 2140) 3CR
Introduction to the representation and manipulation of data structures. Topics will include lists, stacks, queues, trees, and graphs. Not to be held with COMP 2061. Prerequisites: one of COMP 1020, COMP 1021.

Introduction to Artificial Intelligence (COMP 3190) 3CR
Principles of artificial intelligence: problem solving, knowledge representation and manipulation; the application of these principles to the solution of 'hard' problems. Prerequisite: one of COMP 2140, or COMP 2061(C).

Machine Learning (COMP 4360) 3CR
Learning strategies; evaluation of learning; learning in symbolic systems; neural networks, genetic algorithms. Prerequisite: COMP 3190(C).

Applied Discrete Mathematics (MATH 3120) 3CR

Sets, groups, graphs, and Boolean algebra. For Engineering students only. Not to be held with COMP 2130. Prerequisites: ECE 2220 (C) and MATH 2130 (C).

Complex Analysis 1 (MATH 3340) 3CR
Analytic functions, Cauchy's theorem and integral formula, series representation of analytic functions, calculus of residues, Rouche's theorem and the principle of the argument. Not to be held with the former MATH 3710. Prerequisites: [MATH 2180 (C) or the former MATH 3230 (C)] and [MATH 2150 (C) or MATH 2720 (B) or MATH 2721 (B) or the former MATH 2750 (C)].

Partial Differential Equations (Math 3460) 3CR
Method of characteristics for first order PDEs, wave, beam, heat and Laplace equations, derivation of PDEs, existence and uniqueness, energy estimates, well-posedness, maximum principles, separation of variables. Not to be held with the former MATH 3810. Prerequisites: [MATH 2150 (C) or ((MATH 2720 (B) or MATH 2721 (B)) and (the former MATH 2730 (B) or MATH 2731 (B)))] and [MATH 3440 (C)].

Optics (PHYS 2260) 3CR
A survey of refraction, reflection, simple lens systems and optical systems, dispersion, achromatism and an elementary treatment of diffraction, interference, and polarization. Not to be held with PHYS 2261. Prerequisites: A “C” or better in PHYS 1050 or PHYS 1051, or a “C+” or better in PHYS 1020 or PHYS 1021; and a "C" or better in one of MATH 1230, MATH 1500, MATH 1501, MATH 1510, MATH 1520, or MATH 1690. Prerequisite or Corequisite: one of PHYS 1070, PHYS 1071, PHYS 1030, PHYS 1031 or PHYS 2152; and one of MATH 1220, MATH 1300, MATH 1301, or MATH 1310; and one of MATH 1232, MATH 1690, MATH 1700, MATH 1701, MATH 1710.

Medical Physics and Physiological Measurement (PHYS 3220) 3CR
This course will introduce the core subject areas of Medical Physics, in particular the physics of physiology and of radiology. The mechanics of body systems and the theory, medical applications and safety issues relating to the production, use, detection and measurements of electromagnetic radiation (both ionizing and non-ionizing) will be included. It will also cover Medical imaging (Ultrasound, CT and MRI) and will provide the student with an understanding of the physics underlying neurological, audiological, respiratory and vascular function and measurements. Prerequisite: one of PHYS 2600 (016.260) (C) or PHYS 2210 (or the former PHYS 2200)(C), or ECE 3580, or consent of the department.

Electro- and Magnetodynamics and Special Relativity (PHYS 3640) 3CR
Topics covered will include time dependent Maxwell's equations, Ohm's and Faraday's Law, electromagnetic waves, potential and fields, radiation, and special relativity including the Lorentz transformations. Prerequisite: PHYS 3630 or ECE 3590(C).

Advanced Optics (PHYS 4590) 3CR

Light as a classical electromagnetic wave, optical fields in media, interference by wavefront and amplitude splitting, diffraction, diffraction theory of image formation, spatial filtering and image processing, coherence theory. Not to be held with the former 016.458. Prerequisites: PHYS 2260 (C); and PHYS 3640 (C).

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ELECTIVE COURSES NOT OFFERED IN 2016-2017

Digital Systems Design 2 (ECE 3770) 4CR
Executable system specification and a methodology for system partitioning and refinement into system-level components. Models and architectures, specification languages, translation to an HDL, system partitioning, design quality estimation, specification refinement into synthesizable models. Prerequisite: ECE 4240 and MATH 3120.

Power Transmission Lines (ECE 4140) 4CR
AC and DC transmission line corona and its environmental effects. Electric field calculations; design methods to reduce electric field. Electrostatic and electromagnetic effects. Insulation design for power frequency, switching and lightning induced surges. Insulation coordination - conventional and probabilistic methods. Power apparatus testing - criteria and significance. Prerequisite: ECE 3720.

Electronic Filter Design (ECE 4200) 4CR
Realizability theory, approximation of filtering characteristics, ladder networks and transmission zeros, active RC filter design with regard to sensitivity minimization, phase-shifting and time-delay filters, impulse response of filters, rudiments of digital filters. Prerequisite: ECE 3540 (or ECE 3530).

Engineering Electromagnetics (ECE 4280) 4CR
Plane, cylindrical and spherical waves, introduction to scattering and diffraction, waveguides, transmission line applications. Prerequisite: ECE 3590.

Difficulty: 4 Workload: 3.5

Electric Energy Systems 2 (ECE 4310) 4CR
Generating stations. Power system stability and optimal operation. EHV-ac and HVDC power transmission. Power system protective relaying and reliability evaluation. Prerequisite: ECE 4300.

Difficulty: 3 Workload: 3

Digital Control (ECE 4420) 4CR
Mathematical modelling of sampling switches. Z-transforms. Response and stability of systems involving sampling. Design of digital compensators. Prerequisites: ECE 4830 and ECE 4150.

Simulation and Modelling (ECE 4520) 4CR
Monte Carlo Methods, random processes, simulation of complex systems in the design of computer systems. Use of statistical interference and measures of performance in hardware and software systems. Prerequisites: STAT 2220 and COMP 2140.

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COMPUTER ENGINEERING

SECOND YEAR COURSE DESCRIPTIONS

Engineering Communications (ENG 2030) 3CR
Students work in a team-based environment to produce deliverables comparable to the engineering workplace. In-class tutorials focus on the sharpening of individual students' writing skills through an analytical, problem-solving and critical thinking approach. Students are exposed to a variety of communicative scenarios and emphasis is placed on development of a repertoire of skills necessary for effective communication in the engineering profession. Prerequisites: (ENGL 1200 or ENGL 1300 or ENGL 1310 or ENGL 1340 or ENGL 1400) and ENG 1430.

Difficulty: 3 **Workload:** 5

Tips: Make sure to get started on your final report early to allow lots of time for editing. Wear business clothes for all presentations. Try to keep up with entries in your journal.

Engineering Communications (ENG 2040) 3CR
This team-based course focuses on a rhetorical approach, communication strategies and guided practice in the design of engineering communications. Prerequisites: (ENGL 1200 or ENGL 1300 or ENGL 1310 or ENGL 1340 or ENGL 1400) and ENG 1430.

Difficulty: 3 **Workload:** 5

Tips: Make sure to get started on your final report early to allow lots of time for editing. Wear business clothes for all presentations. Try to keep up with entries in your journal.

Engineering Mathematical Analysis 1 (MATH 2130) 3CR
Multivariable differential and integral calculus up to and including multiple integrals in cylindrical and spherical coordinates. For Engineering and Geophysics students only.Prerequisites: MATH 1210 or MATH 1211 and MATH 1710.

Difficulty: 3 **Workload:** 3

Tips: Make sure to review your notes from Calculus 2 before starting this class. The textbook has lots of practice problems, which are a great way to prepare for the tests. Make an effort to attend the tutorials, as the professors will go through practice problems.

Engineering Mathematical Analysis 2 (MATH 2132) 3CR
(Lab required) Infinite series, Taylor and Maclaurin Series; ordinary differential equations including Laplace transforms. For Engineering and Geophysics students only. MATH 1210 and MATH 1710 are prerequisites.

Difficulty: 4 **Workload:** 3

Tips: The best way to prepare for your midterms and final is to do lots of practice problems in the textbook. The tutorials are taught by the professor, so they are a great opportunity to go through additional practice problems and ask your questions.

Electric Circuits (ECE 2262) 4CR
The application of circuit concepts; network theorems and formal methods, steady state analysis, frequency and transient response, application of the Laplace transform in the analysis of linear time-invariant networks. Prerequisite: ENG 1450. Pre- or Corequisite: MATH 2132

Difficulty: 3.5 **Workload:** 3.5

Tips: Review your notes from ENG 1450. Practicing old exams and doing textbook problems are excellent ways to prepare for the midterm.

Digital Logic Systems (ECE 2220) 5CR
Boolean algebra and logic primitives, net-work simplification techniques, physical realizations, number systems and codes; analysis and design of asynchronous and synchronous sequential circuits; applications to computation, measurements, and control. Prerequisite ENG 1450

Difficulty: 3 **Workload:** 4

Tips: This course includes an open ended design project. Get started on it early to allow plenty of time for debugging. The TA's and Professors like to see creativity on the design project. The textbook for this course is very expensive but is an excellent source of practice problems, so it is worth the investment.

Computer Science 2 (COMP 1020) 3CR
More features of a procedural language, elements of programming. Not to be held with COMP 1021. Prerequisite: COMP 1010 or COMP 1011; or COMP 1012, COMP 1013 (C) or High School Computer Science 40S (75%) and any grade 12 or 40S Mathematics, or equivalent.

Modern Physics for Engineers (PHYS 2152) 3CR
(Lab Required) An overview of topics in modern physics including wave particle duality, atomic structure and quantum mechanics. Elementary classical electromagnetic theory and wave theory are reviewed as an introduction to the modern physics concepts. For Engineering students only.

Not to be held with PHYS 1070 or PHYS 1071. Prerequisites: a "C" or better in one of PHYS 1050, and a "C" or better in MATH 1510; and a "C" or better in MATH 1710, or MATH 1690.

Prerequisite or concurrent requirement: MATH 2130.

Difficulty: 3 **Workload:** 2

Tips: The midterm and final are both multiple choice. Practicing old exams (which are available in your lab manual) is an excellent way to prepare. Lab reports have to be handed in by the end of the lab section, so make sure to come prepared.

Engineering Mathematical Analysis 3 (MATH 3132) 3CR
Vector integral calculus; series of ordinary differential equations; Fourier series and Partial differential equations. MATH 2130 and MATH 2132 are prerequisites.

Difficulty: 4 **Workload:** 3

Tips: Review your notes from Math 1 and 2 before starting this course. The textbook is an excellent source of practice problems for the midterm and final.

Electronics 2E (ECE 2160) 5CR
Characteristics of integrated circuits and transistors; design of DC and AC amplifiers in the steady state. Prerequisite: ECE 2262.

Difficulty: 3.5 **Workload:** 3.5

Tips: This course includes a design project. It is important to get started early to allow yourself plenty of time to work on your simulation, and then perform physical testing. Keep in mind that the actual behaviour of your circuit will be different than the simulation. Each semester an engineer in residence will be assisting with the design project. Ask lots of questions and consult them if you encounter problems with the design process.

Microprocessing Systems (ECE 3610) 4CR
Fundamentals of microprocessors and microcomputers; data flow; machine programming; architectures and instructions sets; stacks, subroutines, I/0, and interrupts; interfacing fundamentals; designing with microprocessors. Prerequisite: ECE 2220

Difficulty: 3 **Workload:** 4

Tips: The labs for this course require students to code in assembly language. Make sure to prepare before the labs so that you are able to finish on time. Old midterms should be available on the course website and are an excellent way to prepare for the term tests.

Data Structures and Algorithms (COMP 2140) 3CR
Introduction to the representation and manipulation of data structures. Topics will include lists, stacks, queues, trees, and graphs. Not to be held with COMP 2061. Prerequisites: one of COMP 1020, COMP 1021.

Engineering Algorithms (ECE 3790) 4CR
Numerical algorithms, optimization, statistical description of data random number generation, string processing, geometric algorithms, algorithm machines, dynamic programming and NP complete problems. Pre- or Corequisite: Comp 2140 and Math 3132.

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THIRD YEAR COURSE DESCRIPTIONS

Computer Engineering

Statistics for Engineers (STAT 2220) 3CR
Descriptive statistics, basic probability concepts, special statistical distributions, statistical inference-estimation and hypothesis testing, regression, reliability, statistical process control. Prerequisite: MATH 1710.

Difficulty: 2 **Workload:** 2

Tips: Make sure to memorize all the equations you will need for the tests, as you will not be given a formula sheet. Practicing old exams is a great way to prepare for the midterm and final.

Applied Discrete Mathematics (MATH 3120) 3CR
Sets, groups, graphs, and Boolean algebra. For Engineering students only. Not to be held with COMP 2130. Prerequisites: ECE 2220 (C) and MATH 2130 (C).

Signal Processing 1 (ECE 3780) 4CR
Introduction to signals and systems; spectral analysis (Fourier Series) of continuous-time periodic signals; spectral analysis of aperiodic signals (Fourier Transform); the impulse response and convolution operator; frequency analysis of linear time-invariant systems; applications to filtering, communications systems, and biological systems; A/D conversion; sampling. Laboratory periods will be used to give students hands-on experience in programming many of the techniques covered in the theoretical parts of the course. Prerequisites: ECE 2262 or ECE 2260 and MATH 3132 or MATH 3100.

Difficulty: 5 **Workload:** 3

Tips: Ensure that you are comfortable with the concepts covered in math 2 and 3 before starting ECE 3780. The textbook has a lot of sample problems, which are a good way to prepare for the tests and quizzes. The labs are a great way to deepen your understanding of the concepts covered in class.

Microprocessor Interfacing (ECE 4240) 4CR
Interfacing of microcomputers to the external world: interfacing of I/0 devices with minimum hardware and software; data acquisition with and without microprocessors; data communication, transmission and logging with small computers. Prerequisite: ECE 2160 and ECE 3610.

Systems Engineering Principles 1 (ECE 3740) 4CR
Complexity and other system measures and analysis, system architectures and architectural elements for embedded systems, hardware and software, incremental design elaboration. Coding, testing, debugging, verification and validation. Project planning, cost analysis and maintenance.

Real-time systems, graphical user interfaces and computational models. Prerequisite: COMP 2140.

Communication Systems (ECE 4260) 4CR
Development and applications of random processes. Analysis and comparison of modulation schemes: AM, FM, PM, PCM. Prerequisites: ECE 3780, and STAT 2220

Difficulty: 3 **Workload:** 2

Tips: Review your notes from Signal Processing before starting this course. The labs are very long so come prepared. The labs also introduce you to a lot of new equipment (such as the spectrum analyzer) so make sure to ask the TA's if you are struggling with using the equipment.

Signal Processing 2 (ECE 4830) 4CR
Representation of discrete-time signals and systems in the time and frequency domains; the z-transform; application to various discrete-time linear time-invariant systems; design of digital filters. Laboratory periods will be used to give students hands-on experience in programming many of the techniques covered in the theoretical parts of the course. Prerequisite: ECE 3780.

Difficulty: 4 **Workload: 3**

Ecology, Technology and Society (ANTH 2430) 3CR
Ecological analysis of the interplay of socio-political and technological processes in different types of societies. Focus upon the ecological side-effects and selected technologies, economic mechanisms and political institutions.

Difficulty: 2 **Workload:** 2

Tips: This course requires students to write several essays. If you send a draft of your essay to the TA, they will be able to give you comments and feedback before the final paper is due.

Digital Systems Design 1 (ECE 3760) 4CR
Design methodologies for the development of digital hardware, including system specification, component allocation, functional partitioning, specification refinement, implementation, verification, and testing. Hardware-software co-design. Prerequisite: ECE 4240.

Introduction to Operating Systems (COMP 3430) 3CR
Operating systems, their design, implementation, and usage. Prerequisites: one of COMP 2140 (or COMP 2061)(C); and COMP 2280 (C) or ECE 3610 (C). COMP 2160 is recommended.

Telecomm. Network Engineering (ECE 3700) 4CR
This course will introduce modem concepts in telecommunications, including LANs, WANs, telephone networks, wireless and mobile networks, and Internet networks. Focus will be on design engineering, and management of networks, and on network programming for client server architectures. Prerequisite: COMP 2140.

Difficulty: 3.5 Workload: 3.5

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FOURTH YEAR COURSE DESCRIPTIONS

Computer Engineering

Control Systems (ECE 4150) 4CR
Principal methods of analysis and design for feedback control systems. Prerequisite: ECE 2160 and ECE 3780.

Group Design Project (ECE 4600) 6CR
The engineering curriculum must culminate in a significant design experience which is based on the knowledge and skills acquired in earlier course work and which gives students an exposure to the concepts of teamwork and project management. Prerequisites: [ENG 2030 or ENG 2040] and ECE 3780 and [(ECE 3580, ECE 3720, ECE 3670 and ECE 3610) or (ECE 3700, ECE 3760 and ECE 3740)].

Engineering Economics (CIVL 4050) 3CR
Introduction to engineering economics. Time value of money and discounted cash flow calculations. Comparing alternatives. Replacement analysis and life-cycle costing. Public sector engineering economy studies. Private sector engineering economy studies. Before and after-tax analysis. Applications in cost-estimating. Applications in asset management systems. Basic accounting. Accommodating capital limitations. Dealing with inflation. Dealing with risk and uncertainty. STAT 2220 is a prerequisite.

Difficulty: 3 **Workload: 3**

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TECHNICAL ELECTIVE COURSE DESCRIPTIONS

Computer Engineering

Five (5) technical electives are required.
*Note: A maximum of two (2) Electrical Engineering technical electives may be taken as part of the Computer Engineering Program.

***Advanced Circuit Analysis and Design (ECE 3540) 4CR**
Application of the Laplace Transform in the analysis of linear time-invariant networks, poles, zeros and frequency response; natural frequencies; general network theorems; two ports; energy and passivity; transmission lines; time and frequency domain. Prerequisite: ECE 2262, MATH 3132.

Difficulty: 4 **Workload:** 4

Tips: Review the concepts from the first circuits course before starting this class. The assignments for this course are very lengthy. Try to use matlab to help you complete the assignments more efficiently.

***Foundations of Electromagnetics (ECE 3580) 4CR**
Fundamental laws of field theory; Maxwell's equations in integral and point form. This course introduces students to electrostatics, magnetostatics and basics of electromagnetics. Prerequisite: ECE 2240, PHYS 2152, and MATH 3132.

Difficulty: 5 **Workload:** 4

Tips: The labs in this course are completed on Matlab. Make sure to review Matlab before the first lab, to ensure that you will be able to finish on time. In the past, this course has included 5 quizzes. Spend some time practicing the old quizzes and reviewing the concepts covered in class to prepare for them. There may also be a tutorial session each week. The tutorial is an excellent chance to practice additional problems and to get your questions answered. Old midterms are a good tool to prepare for the midterm and final, but make sure to review the course notes as well, as it is likely that your exams will include types of questions that are not on any of the old tests.

***Physical Electronics (ECE 3600) 4CR**
Basic solid state theory; properties of semi-conductors; principles of metal-semiconductor junctions, p-n junctions and transistors; optoelectronic processes. Prerequisites: PHYS 2152, MATH 3132, ECE 3670.

Difficulty: 5 **Workload:** 4

Tips: This course introduces a lot of new and complex concepts. Make sure to keep up with your studying and practice problems throughout the semester.

***Electronics 3E (ECE 3670) 4CR**
Continuation of ECE 2160, including device models, feedback, regulators, frequency effects, oscillators, and bistability and gates. This course is design based. Prerequisite: ECE 2160

Difficulty: 4 **Workload:** 5

Tips: The majority of the exam problems in this class are design based. When you are preparing for exams, you can test your solutions by building your design on multisim and comparing the simulated output to the design requirements.

***Electric Power and Machines (ECE 3720) 4CR**
Principles and applications of electric power, energy conversion and machines. Prerequisite: ECE 2262 or ENG 1180.

Difficulty: 3 **Workload:** 3

Tips: The textbook is an excellent source of sample problems that will help you prepare for the midterm and final. Try to complete the calculation portion of the labs before your lab section. This will allow you to compare your measured values to the theoretical values to ensure that you are building your circuits and taking the measurements properly.

***Introduction to Microelectronic Fabrication (ECE 4100) 4CR**
Introduction to the fabrication of integrated circuits (ICs). Emphasis is on silicon based devices. Topics include water preparation, oxidation, thin film deposition, diffusion and ion implantation, lithography, wet and dry etching and metallization. An introduction to MEMS and micromachining technology is given. Prerequisite: ECE 3670.

Difficulty: 3 Workload: 3

***Control Systems (ECE 4150) 4CR**
Principal methods of analysis and design for feedback control systems. Prerequisite: ECE 2160 and ECE 3780.

***Control Engineering (ECE 4160) 4CR**
Design of control systems by frequency domain and root locus method; state equations; introduction to nonlinear analysis. Prerequisite: ECE 4150.

Introduction to Robotics (ECE 4180) 4CR
This course provides fundamental concepts of robotics, including robot classification and applications, robot kinematics, sensor and actuators, sensor interfacing, motor control, trajectory planning, and robot programming. Prerequisites: ECE 4150 and (ECE 4240 or ECE 3730).

Difficulty: 3 Workload: 2.5

Digital Communications (ECE 4250) 4Cr
Transmission of digital data; error rates, interference. Information measures, information rate and channel capacity. Coding. Prerequisite: ECE 4260 and ECE 3780.

***Communication Systems (ECE 4260) 4CR**
Development and applications of random processes. Analysis and comparison of modulation schemes: AM, FM, PM, PCM. Prerequisites: ECE 3780, and STAT 2220

Difficulty: 3 **Workload:** 2

Tips: Review your notes from Signal Processing before starting this course. The labs are very long so come prepared. The labs also introduce you to a lot of new equipment (such as the spectrum analyzer) so make sure to ask the TA's if you are struggling with using the equipment.

***Engineering Computation 4E (ECE 4390) 4CR**
Development and application of numerical methods for the solution of electrical and computer engineering problems. Optimization techniques. Finite difference, finite element and boundary element methods. Solution of large systems of linear and non-linear equations. Prerequisite: MATH 3132, ECE 2240.

Computer Vision (ECE 4440) 4CR
Image formation and sensing, image compression degradation and restoration, geometrical and topological properties, pattern classification, segmentation procedures, line-drawing images, texture analysis, 3-D image processing. Prerequisite: ECE 3780.

Parallel Processing (ECE 4530) 4CR
Classification of parallel processors, SIMD vs. MIMD, multiprocessing Vs parallel processing, interconnection topology, communications, and node complexity, pipelining and vector processors, array algorithmic machines. Prerequisites: COMP 2140 and ECE 3760.

Wireless Networks (ECE 4540) 4CR
Introduction to wireless communications systems, network architectures, protocols and applications. Topics include mobile computing systems, signals propagation, channel modelling, modulation, and networking standards. Prerequisite: ECE 3700 and ECE 3780.

***Biomedical Instrumentation and Signal Processing (ECE 4610) 4CR**
Introduction to biological systems and application of engineering principles to medical problems. Students design systems to acquire and analyze biological signals in the laboratory. Content includes introduction to relevant physiology and anatomy of cells, skeletal muscles, heart and cardiovascular systems, human balance and biomechanics, recording and analyzing amplifiers for signal conditioning, medical instrumentation safety and health hazards. Prerequisites: ECE 2160 and ECE 3780.

Digital System Implementation (ECE 4740) 4CR
Implementation methodologies and technologies for digital systems, including VLSI implementations, PCB implementations, and rapid prototyping (FPGA). Prerequisite: ECE 4240. Not to be held with ECE 4500.

(T01) Modern Computing Systems (ECE 4850) 4CR
Prerequisite: ECE 3610.

(T02) Applied Computational Intelligence (ECE 4850) 4CR
Prerequisite: MATH 3132.

(T01) Random Signals and Processes (ECE 4860) 4CR
Prerequisite: STAT 2220, ECE 3780.

(T02) Biomedical Signal Processing (ECE 4860) 4CR
Prerequisite: Permission of the Instructor.

Object Orientation (COMP 2150) 3CR
Design and development of object-oriented software. Topics will include inheritance, polymorphism, data abstraction and encapsulation. Examples will be drawn from several programming languages. Prerequisite: COMP 2160; and one of COMP 2140, or COMP 2061(C).

Programming Practices (COMP 2160) 3CR
Introduction to issues involved in real-world computing. Topics will include memory management, debugging, compilation, performance, and good programming practices. Prerequisite: COMP 1020 or COMP 1021 (C).

Distributed Computing (COMP 3010) 3CR
An introduction to the development of client server and peer-to-peer systems through web applications, distributed programming models, and distributed algorithms. Prerequisite: COMP 2150 (C).

Human-Computer Interaction 1 (COMP 3020) 3CR
Human-computer interaction: human factors and usability, user-centered design, prototyping, usability evaluation. Prerequisite: one of COMP 2140, or COMP 2061 (C). A course in cognitive psychology, such as PSYC 2480, is recommended.

Introduction to Artificial Intelligence (COMP 3190) 3CR
Principles of artificial intelligence: problem solving, knowledge representation and manipulation; the application of these principles to the solution of 'hard' problems. Prerequisite: one of COMP 2140, or COMP 2061(C).

Introduction to Compiler Construction (COMP 3290) 3CR
Introduction to the standard compiler phases: scanning, parsing, symbol-table management, code generation, and code optimization. The emphasis is on the simpler techniques for compiler construction such as recursive descent. Prerequisites: COMP 2140 (or COMP 2061)(C) and COMP 2280 (or ECE 3610)(C). COMP 2160 is recommended.

Software Engineering 1 (COMP 3350) 3CR
Introduction to software engineering. Software life cycle models, system and software requirements analysis, specifications, software design, testing and maintenance, software quality. Prerequisites: COMP 2150 (C), or COMP 2061 (C).

Database Concepts and Usage (COMP 3380) 3CR
An introduction to database systems including the relational, hierarchical, network and entity-relationship models with emphasis on the relational model and SQL. Prerequisite: one of COMP 2140, or COMP 2061(C).

Computer Graphics 1 (COMP 3490) 3CR
An introductory course in computer graphics including topics such as raster graphics, two and three dimensional transforms, and simple rendering. Prerequisite: COMP 2140 (C); and either COMP 2190 (C), or a C in both: MATH 1300 (or MATH 1220, MATH 1310, MATH 1301, MATH 1210 or MATH 1211) and MATH 1500 (or MATH 1230, MATH 1501, MATH 1510 or MATH 1520).

Human-Computer Interaction 2 (COMP 4020) 3CR
Advanced issues in the field of human-computer interaction. Topics will be selected from current research and development issues in the field of HCI. Prerequisite: COMP 3020 (C). A course in cognitive psychology such as PSYC 2480 is recommended.

Introduction to Cryptography and Cryptosystems (COMP 4140) 3CR
Description and analysis of cryptographic methods used in the authentication and protection of data. Classical cryptosystems and cryptoanalysis, the Advanced Data Encryption Standard (ADES) and Public-key cryptosystems. Prerequisite: COMP 2130 (C). Students must be registered in fourth year of a Major or Honours programme in the Department of Computer Science.

Artificial Intelligence (COMP 4190) 3CR
Reasoning with temporal knowledge; causal reasoning; plausible reasoning; nonmonotonic reasoning; abductive reasoning. Prerequisite: COMP 3190 (C).

Software Engineering 2 (COMP 4350) 3CR
Advanced treatment of software development methods. Topics will be selected from requirements gathering, design methodologies, prototyping, software verification and validation. Prerequisite: COMP 3350(C).

Machine Learning (COMP 4360) 3CR

Learning strategies; evaluation of learning; learning in symbolic systems; neural networks, genetic algorithms. Prerequisite: COMP 3190(C).

Database Implementation (COMP 4380) 3CR
Implementation of modern database systems including query modification/optimization, recovery, concurrency, integrity, and distribution. Prerequisite: COMP 3380 (C).

Operating Systems 2 (COMP 4430) 3CR
Design and implementation of modern operating systems. Detailed analysis of an open source modern operating system and hands-on experience with its kernel and major components. Prerequisites: COMP 2160(C) and COMP 3430(C).

Computer Graphics 2 (COMP 4490) 3CR
Methods in computer graphics including topics such as representation of curves and surfaces, viewing in three dimensions, and colour models. Prerequisite: COMP 3490 (C).

Computer Security (COMP 4580) 3CR
Computer security and information management. This course will examine state-of-the-art knowledge about the issues relevant to data and computer security. Prerequisite: COMP 3430 (C) and COMP 3010 (C).

Introduction to Data Mining (COMP 4710) 3CR
Introduction to data mining concepts and their applications. Prerequisite: COMP 3380 or consent of department.

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ELECTIVE COURSES NOT OFFERED IN 2016-2017

Digital Systems Design 2 (ECE 3770) 4CR
Executable system specification and a methodology for system partitioning and refinement into system-level components. Models and architectures, specification languages, translation to an HDL, system partitioning, design quality estimation, specification refinement into synthesizable models. Prerequisite: ECE 4240 and MATH 3120.

Power Transmission Lines (ECE 4140) 4CR
AC and DC transmission line corona and its environmental effects. Electric field calculations; design methods to reduce electric field. Electrostatic and electromagnetic effects. Insulation design for power frequency, switching and lightning induced surges. Insulation coordination - conventional and probabilistic methods. Power apparatus testing - criteria and significance. Prerequisite: ECE 3720.

Electronic Filter Design (ECE 4200) 4CR
Realizability theory, approximation of filtering characteristics, ladder networks and transmission zeros, active RC filter design with regard to sensitivity minimization, phase-shifting and time-delay filters, impulse response of filters, rudiments of digital filters. Prerequisite: ECE 3540 (or ECE 3530).

Engineering Electromagnetics (ECE 4280) 4CR
Plane, cylindrical and spherical waves, introduction to scattering and diffraction, waveguides, transmission line applications. Prerequisite: ECE 3590.

Difficulty: 4 Workload: 3.5

Electric Energy Systems 2 (ECE 4310) 4CR
Generating stations. Power system stability and optimal operation. EHV-ac and HVDC power transmission. Power system protective relaying and reliability evaluation. Prerequisite: ECE 4300.

Difficulty: 3 Workload: 3

Digital Control (ECE 4420) 4CR
Mathematical modelling of sampling switches. Z-transforms. Response and stability of systems involving sampling. Design of digital compensators. Prerequisites: ECE 4830 and ECE 4150.

Simulation and Modelling (ECE 4520) 4CR
Monte Carlo Methods, random processes, simulation of complex systems in the design of computer systems. Use of statistical interference and measures of performance in hardware and software systems. Prerequisites: STAT 2220 and COMP 2140.

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Glossary

These are a few terms that may be helpful to know throughout your studies in our faculty.

- **APEGM:** The Association of Professional Engineers and Geoscientists of Manitoba. This organization governs the work of all Professional Engineers and Geoscientists in Manitoba.
- **CFES:** The Canadian Federation of Engineering Students (which includes U of M). This national organization provides a diverse range of services as they work to support a number of Canadian Engineering schools.
- **Co-Requisite:** Refers to a course which must be taken concurrently with another course.
- **EngO:** The U of M's Engineering Orientation, also known as the two funnest days of the year. Be sure to attend on September 8th and 9th!
- **Frosh:** Refers to a first-year student.
- **HIRED:** Helping Industry Reach Engineers Directly. These sessions are held every Monday evening and provide students the opportunity to interact with industry (there's free pizza!).
- **Lab:** Refers to the portion of a course involving hands-on experiments. Most labs also require the submission of an individual or group report.
- **Midterm:** Most courses include one or two midterm exams which cover a selected portion of the course content. Although they come up quickly, midterms serve as an effective tool to keep updated with course material.
- **Prerequisite:** Refers to a course which must be completed prior to registration for another course.
- **TA:** Teaching Assistant. TAs will usually be available to students during labs/tutorials and can be very helpful in answering questions.
- **Technical Societies:** Also called "Tech Socs", this term refers to the many engineering student groups associated with UMES. Tech Soc lounges are located on the fifth floor of E1.
- **The Window:** Opens onto the Engineering Atrium and is a great resource for all engineering students. Stop by The Window to purchase snacks, UMES merchandise and event tickets or to simply ask questions.
- **Tutorial:** Refers to the portion of a course involving practice problems. Some tutorials require these questions be submitted while others do not.
- **UMES:** The University of Manitoba Engineering Society. Refers to the faculty student council which coordinates many important events and services.
- **WESST:** The Western Engineering Students' Societies Team (which includes U of M). WESST provides a diverse range of services to its 10 Western Canadian member schools.