ECE Handbook 2022 - 2023

University of Manitoba

Engineering Society

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Electrical and Computer Engineering

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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 four focus areas for interested students. These include the study of Embedded Systems, Software Engineering, Communication Networks and Biomedical.

Electrical and electronic systems are present in every aspect of life, from the power that lights a house at night to various medical equipment. 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, Communication Devices, Biomedical, and Engineering Physics. Students interested in any of these programs should consult with the Electrical and Computer Department Office to select an appropriate set of elective courses.

What are the 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. Information on both technical elective structures and a full list of available courses can be found on the Electrical Engineering Documents page.

Students wishing to pursue more focused studies in a Computer Engineering subject/research area can do so by choosing one of the approved focus areas. The Computer Engineering program offers four focus areas; Computer Networks and Communications, Embedded Systems, Biomedical, 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 Computer Engineering Documents page.

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 complementary electives in the evenings during the summer. They are less demanding, and you 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. 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.
7. The concepts covered in Engineering Math 1-3 are extremely important for a lot of your electrical courses, so make sure you understand these topics very well.
8. 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 color codes.
9. If you need to pick up components for your projects or labs, visit the Tech Shop (E3-550). 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.

10. 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.
11. 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.
12. Buy a pair of wire strippers. They are available at the bookstore and will be very useful in the labs and for your design projects.

Course List: Electrical Engineering

For the program checklist, visit:
https://umanitoba.ca/engineering/sites/engineering/files/2021-02/Electrical-engineering-program-checklist.pdf

For the 2022-2023 course timetable, visit:
https://umanitoba.ca/engineering/sites/engineering/files/2021-07/ECE%20Course%20Timetable.pdf

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
Contemporary Statistics for Engineers	(STAT 2220)	3CR
Modern Physics for Engineers	(PHYS 2152)	3CR
Numerical Methods for Electrical Engineers	(ECE 2240)	4CR
Electronics 2E	(ECE 2160)	5CR

Third Year Courses		
Foundations of Electromagnetics	(ECE 3580)	4CR
Microprocessing Systems	(ECE 3610)	4CR
Engineering Mathematical Analysis 3	(MATH 3132)	3CR
Engineering Economics	(ENG 3000)	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
Communications Systems	(ECE 4260)	4CR

Technical Elective Courses

7 technical electives are required. A minimum of 3 electives are required from Group A; the other 4 electives may be taken from either Group A or B unless the student completes a Focus Area.

It is not guaranteed that all elective courses will be offered every session.

GROUP A - Qualified Engineering Design Elective Courses

Microwave Engineering	(ECE 4290)	4CR
Power Electronics	(ECE 4370)	4CR
Control Engineering	(ECE 4160)	4CR
Digital Communications	(ECE 4250)	4CR
Signal Processing 2	(ECE 4830)	4CR

GROUP B - Technical Elective Courses

Microprocessor Interfacing	(ECE 4240)	4CR
Antennas	(ECE 4270)	4CR
Electrical Energy Systems 1	(ECE 4300)	4CR
Engineering Computation 4E	(ECE 4390)	4CR
Design of RF Devices and Wireless Systems	(ECE 4430)	4CR
Applied Computational Intelligence	(ECE 4450)	4CR
Simulation and Modeling	(ECE 4520)	4CR
Parallel Processing	(ECE 4530)	4CR

Modern Computing Systems	(ECE 4560)	4CR
Wireless Networks	(ECE 4540)	4CR
Optoelectronics	(ECE 4580)	4CR
Biomedical Instrumentation and Signal Processing	(ECE 4610)	4CR
Digital System Implementation	(ECE 4740)	4CR
Computer Science 2	(COMP 1020)	3CR
Data Structures and Algorithms	(COMP 2140)	3CR
Introduction to Artificial Intelligence	(COMP 3190)	3CR
Applied Discrete Mathematics	(MATH 3120)	3CR
Optics	(PHYS 2260)	3CR
Electro and Magnetodynamics and Special Relativity	(PHYS 4646)	3CR
Electric Machines	(ECE 3650)	5CR
Telecommunication Networks Engineering	(ECE 3700)	4CR
Introduction to Microelectronic Fabrication	(ECE 4100)	4CR
Introduction to Robotics	(ECE 4180)	4CR
Electrical Energy Systems 2	(ECE 4310)	4CR
High Voltage Engineering	(ECE 4360)	4CR
Computer Vision	(ECE 4440)	4CR
Machine Learning	(COMP 4360)	3CR
Partial Differential Equations	(MATH 3460)	3CR
Medical Physics and Physiological Measurement	(PHYS 3220)	3CR
Advanced Optics	(PHYS 4590)	3CR
Digital Systems Design 2	(ECE 3770)	4CR
Engineering Electromagnetics	(ECE 4280)	4CR
Digital Control	(ECE 4420)	4CR

Natural Science Electives

Introduction to Astronomy: The Magnificent Universe	(ASTR 1810)	3CR
Stars	(ASTR 3180)	3CR
Biology 1: Principles and Themes	(BIOL 1020)	3CR
Economic Plants	(BIOL 1300)	3CR
Anatomy of the Human Body	(BIOL 1410)	3CR
Introduction to Physical Chemistry	(CHEM 1110)	3CR
Introduction to Organic Chemistry	(CHEM 1130)	3CR
Introduction to Entomology	(ENTM 2050)	3CR
The Dynamic Earth	(GEOL 1340)	3CR
Essentials of Microbiology	(MBIO 1220)	3CR
Optics	(PHYS 2260)	3CR
Introduction to Quantum Mechanics and Special Relativity	(PHYS 2386)	3CR
Classical Mechanics 1	(PHYS 2650)	3CR
Medical Physics and Physiological Measurements	(PHYS 3220)	3CR

Course List: Computer Engineering

For the program checklist, visit:
https://umanitoba.ca/engineering/sites/engineering/files/2021-02/Computer-engineering-program-checklist.pdf

For the 2022-2023 course timetable, visit:
https://umanitoba.ca/engineering/sites/engineering/files/2021-07/ECE%20Course%20Timetable.pdf

Second Year Courses (2000 Level)		
Engineering Communication	(ENG 2030 **or** ENG 2040)	3CR
Engineering Mathematical Analysis 1	(MATH 2130)	3CR
Engineering Mathematical Analysis 2	(MATH 2132)	3CR
Ecology, Technology and Society	(ANTH 2430)	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
Contemporary Statistics for Engineers	(STAT 2220)	3CR
Electronics 2E	(ECE 2160)	5CR
Data Structures and Algorithms	(COMP 2140)	3CR

Third Year Courses (3000 Level)		
Applied Discrete Mathematics	(MATH 3120)	3CR
Engineering Mathematical Analysis 3	(MATH 3132)	3CR
Engineering Economics	(ENG 3000)	3CR
Signal Processing 1	(ECE 3780)	4CR
Microprocessing Systems	(ECE 3610)	4CR
Engineering Algorithms	(ECE 3790)	4CR
Systems Engineering Principles 1	(ECE 3740)	4CR
Digital Systems Design 1	(ECE 3760)	4CR

Introduction to Operating Systems	(COMP 3430)	3CR
Telecommunication Network Engineering	(ECE 3700)	4CR

Fourth Year Courses (4000 Level)		
Control Systems **or** Communications Systems	(ECE 4150) **or** (ECE 4260)	4CR
Group Design Project	(ECE 4600)	6CR
Microprocessor Interfacing	(ECE 4240)	4CR
Signal Processing 2	(ECE 4830)	4CR

Technical Elective Courses

Students may select their five technical electives from the following list, with the only limitations that no more than two may come from the list of Approved Electrical Engineering Electives (*).

It is not guaranteed that all elective courses will be offered every session.

*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
*Communication Systems	(ECE 4260)	4CR
*Engineering Computation 4E	(ECE 4390)	4CR
*Biomedical Instrumentation and Signal Processing	(ECE 4610)	4CR
Applied Computational Intelligence	(ECE 4450)	*4CR*
Parallel Processing	(ECE 4530)	4CR
Modern Computing Systems	(ECE 4560)	*4CR*
Wireless Networks	(ECE 4540)	4CR
Digital System Implementation	(ECE 4740)	4CR
Simulation and Modeling	(ECE 4520)	4CR

Introduction to Data Mining	(COMP 4710)	3CR
Systems Engineering Principles 2	(ECE 3750)	4CR
Digital Systems Design 2	(ECE 3770)	4CR
Digital Control	(ECE 4420)	4CR
Programming Practices	(COMP 2160)	3CR
Human-Computer Interaction 1	(COMP 3020)	3CR
Introduction to Artificial Intelligence	(COMP 3190)	3CR
Database Concepts and Usage	(COMP 3380)	3CR
Computer Graphics 1	(COMP 3490)	3CR
Introduction to Robotics	(ECE 4180)	4CR
Digital Communications	(ECE 4250)	4CR
Computer Vision	(ECE 4440)	4CR
Object Orientation	(COMP 2150)	3CR
Distributed Computing	(COMP 3010)	3CR
Software Engineering 1	(COMP 3350)	3CR
Introduction to Compiler Construction	(COMP 3290)	3CR
Databases Concepts and Usage	(COMP 3380)	3CR
Human-Computer Interaction 2	(COMP 4020)	3CR
Artificial Intelligence	(COMP 4190)	3CR
Expert Systems	(COMP 4200)	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

Natural Science Electives

*Computer Engineering students are required to complete two (2) Natural Science Electives as part of their program. These courses may be taken anytime during the student's program.

Introduction to Astronomy: The Magnificent Universe	(ASTR 1810)	3CR
Stars	(ASTR 3180)	3CR
Biology 1: Principles and Themes	(BIOL 1020)	3CR
Economic Plants	(BIOL 1300)	3CR
Anatomy of the Human Body	(BIOL 1410)	3CR
Introduction to Physical Chemistry	(CHEM 1110)	3CR
Introduction to Organic Chemistry	(CHEM 1130)	3CR
Introduction to Entomology	(ENTM 2050)	3CR
The Dynamic Earth	(GEOL 1340)	3CR
Essentials of Microbiology	(MBIO 1220)	3CR
Optics	(PHYS 2260)	3CR
Introduction to Quantum Mechanics and Special Relativity	(PHYS 2386)	3CR
Electromagnetic Field Theory	(PHYS 2650)	3CR
Classical Mechanics 1	(PHYS 2650)	3CR
Medical Physics and Physiological Measurements	(PHYS 3220)	3CR
Electro - and Magnetostatic Theory	(PHYS 3630)	3CR

Course Descriptions: ELECTRICAL ENGINEERING

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.

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 Co-requisite: 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.

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.

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 from 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.

THIRD YEAR COURSE DESCRIPTIONS

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.

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.

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.

Engineering Economics (ENG 3000) 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**

Tips: Not Available

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.

FOURTH YEAR COURSE DESCRIPTIONS

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

Tips: Not Available

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

Tips: Not Available

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: N/A **Workload:** N/A

Tips: Not Available

TECHNICAL ELECTIVE COURSE DESCRIPTIONS

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 the 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.

Difficulty: 3.5 **Workload:** 3.5

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: 3 **Workload:** 3.5

Tips: Not Available

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

Tips: Not Available

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**

Tips: Not Available

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

Tips: Not Available

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

Tips: Not Available

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

Tips: Not Available

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

Tips: Not Available

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.

Difficulty: 3.5 **Workload:** 3.5

Tips: Not Available

Antennas (ECE 4270) 4CR

Radiation fundamentals, linear antennas, point source arrays, aperture antennas, antenna impedance, antenna systems. Prerequisite: ECE 3590.

Difficulty: 3 **Workload:** 3.5

Tips: Not Available

Electrical Energy Systems 1 (ECE 4300) 4CR

Power system component modeling and computational methods for system problems such as load flow, faults, and stability. Prerequisite: ECE 3650.

Difficulty: N/A **Workload:** N/A

Tips: Not Available

Electrical 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. Prerequisites: ECE 4150 and ECE 4300.

Difficulty: N/A **Workload:** N/A

Tips: Not Available

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

Tips: Not Available

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.

Difficulty: 4 **Workload:** 5

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

Design of RF Devices and Wireless Systems (ECE 4430) 4CR

Techniques for the system level design, simulation, fabrication,and testing of RF devices and microwave circuits, including the basics of radar and RFID technology. Prerequisite: ECE 3590.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Applied Computational Intelligence (ECE 4450) 4CR

Computational intelligence and machine learning algorithms and their application in solving complex engineering problems. Prerequisite: MATH 3132.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Simulation and Modeling (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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: 4 **Workload:** 3

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Modern Computing Systems (ECE 4560) 4CR

Advanced topics in computer architecture and organization, such as instruction set architecture, performance measures, pipeline processor design, data and instruction cache, data dependencies, branch prediction and penalties, superscalar architecture, multithreading, out-of-order execution, speculative execution, overlapping register windowing, and multiprocessor system design. Prerequisite: ECE 3610.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Optoelectronics (ECE 4580) 4CR

Basic theory of quantum mechanics; solution of Schrödinger 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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Machine Learning (COMP 4360) 3CR

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

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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)].

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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 Co-requisite: 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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Electro - and Magnetodynamics and Special Relativity (PHYS 4646) 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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Note: The course prerequisite, PHYS 3630, is a Natural Science Elective for Computer Engineering (Group A)

Advanced Optics (PHYS 4590) 3CR

Light as a classical electromagnetic wave, optical fields in media, interference by wave front 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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Course Descriptions: 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.

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.

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 Co-requisite: 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.

Difficulty: 4 **Workload:** 2

Tips: Not Available

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.

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.

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 from 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.

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.

Difficulty: 2.5 **Workload:** 2.5

Tips: Not Available

THIRD YEAR COURSE DESCRIPTIONS

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).

Difficulty: 2 **Workload:** 3

Tips: Not Available

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.

Engineering Economics (ENG 3000) 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**

Tips: Not Available

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.

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.

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 Co-requisite: Comp 2140 and Math 3132.

Difficulty: 2 **Workload:** 3

Tips: Not Available

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.

Difficulty: 3 **Workload:** 2

Tips: Not Available

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.

Difficulty: 2 **Workload:** 2

Tips: Not Available

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.

Difficulty: 3 **Workload:** 3.5

Tips: Not Available

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

Tips: Not Available

FOURTH YEAR COURSE DESCRIPTIONS

Control Systems (ECE 4150) 4CR

Principal methods of analysis and design for feedback control systems. Prerequisite: ECE 2160 and ECE 3780.

Difficulty: 3.5 **Workload:** 4

Tips: Not Available

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.

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: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: 3.5 **Workload:** 3.5

Tips: Not Available

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

Tips: Not Available

TECHNICAL ELECTIVE COURSE DESCRIPTIONS

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

Tips: Not Available

*Control Systems (ECE 4150) 4CR

Principal methods of analysis and design for feedback control systems. Prerequisite: ECE 2160 and ECE 3780.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

*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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

*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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

*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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Systems Engineering Principles 2 (ECE 3750) 4CR

Reliability measures and analysis, software system architectures, system metrics, system verification for embedded systems. Coding practices for large scale embedded system development. Real- time systems, graphical user interfaces, and computational models. Prerequisite: ECE 3740.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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

Tips: Not Available

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

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Applied Computational Intelligence (ECE 4450) 4CR

Computational intelligence and machine learning algorithms and their application in solving complex engineering problems. Prerequisite: MATH 3132.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Wireless Networks (ECE 4540) 4CR

Advanced topics in computer architecture and organization, such as instruction set architecture, performance measures, pipeline processor design, data and instruction cache, data dependencies, branch prediction and penalties, superscalar architecture, multithreading, out-of-order execution, speculative execution, overlapping register windowing, and multiprocessor system design. Prerequisite: ECE 3610.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Modern Computing Systems (ECE 4560) 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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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 or ECE 3740.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Artificial Intelligence (COMP 4190) 3CR

Reasoning with temporal knowledge; causal reasoning; plausible reasoning; non-monotonic reasoning; abductive reasoning. Prerequisite: COMP 3190 (C).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Expert Systems (COMP 4200) 3CR

Organization of expert systems; knowledge representation in expert systems; inference; knowledge engineering; tools for building expert systems; limitations of expert systems. Prerequisite: COMP 3190.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Machine Learning (COMP 4360) 3CR

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

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Database Implementation (COMP 4380) 3CR

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

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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).

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Introduction to Data Mining (COMP 4710) 3CR

Introduction to data mining concepts and their applications. Prerequisite: COMP 3380 or consent of department.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

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.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Simulation and Modelling (ECE 4520) 4CR

Monte Carlo Methods, random processes, simulation of complex systems in the design of computer systems. Use of statistical inference and measures of performance in hardware and software systems. Prerequisites: STAT 2220 and COMP 2140.

Difficulty: Not Available **Workload:** Not Available

Tips: Not Available

Academic/Counselling Student Resources

If you're ever stuck on a class, need help on a certain section, or just want clarity, UMES offers a paid tutoring service! This service offers students a chance to learn from real students who have taken the class already and received a high grade in the class.

Mobile Application name: Nimbus
Available on Google play, Apple store, and web browser.

Please contact vsa@umes.mb.ca for any inquiries or concerns.

Additionally, if you would like to sign up as a tutor and get **paid**, you can do so on the application as well! Just go to the link from the following QR code to sign up.

Nimbus Learning

As university students, we know that times can be stressful, that is why UMES alongside UMSU has outlined and provided the following resources that students can use to help support the mental and physical strain long academic terms can cause to an individual. If you ever feel the need to use one of these resources follow the respective link or QR code below.

Student Counselling Center	https://umanitoba.ca/student-supports/counselling-resources-students
Health and Wellness Services	https://umanitoba.ca/student-supports/student-health-and-wellness
Province of Manitoba Virtual Therapy Program	https://www.gov.mb.ca/covid19/bewell/virtualtherapy.html

For 24/7 Help:

Empower Me (free for U of M students)	https://studentcare.ca/rte/en/IHaveAPlan_UniversityofManitoba_EmpowerMe_EmpowerMe 1-833-628-5589	
Klinic Crisis Support	http://klinic.mb.ca/crisis-support/ (204) 786-8686	
Manitoba Suicide Prevention & Support Line	Student Counselling Centre (SCC) | University of Manitoba (umanitoba.ca) 1-877-435-7170	

For any other inquiries related to the department, feel free to contact:

- Vice Stick Academic: email:vsa@umes.mb.ca
  - Kassem Harb

- Academic Advocacy Directorship: email: advocacy@umes.mb.ca
  - Rhyz Abella (Director)
  - Ashly Shalu
  - Smit Shah
  - Pankitjot Singh

- UMES Office: **E2-292 EITC**

Summer Research Opportunities

Each summer, students have the opportunity to work alongside professors in their research labs. For the Electrical and Computer Engineering Department, there are a total of nine (9) research facilities.

For general information about research in the Electrical and Computer Engineering Department, please visit:
https://umanitoba.ca/engineering/electrical-and-computer-engineering#:~:text=into%20the%20program.-,Research,-Faculty%20and%20students

For general information about the faculty involved with each branch of research, please visit:
https://umanitoba.ca/engineering/faculty-staff/electrical-and-computer-engineering

For general information about the University of Manitoba Undergraduate Research Awards (URA) and NSERC Undergraduate Student Research Awards (USRA), please visit:
https://umanitoba.ca/engineering/student-experience/scholarships-and-awards#undergraduate-awards-and-funding

For more information, please contact the Electrical and Computer Engineering Department:
Email: umece@umanitoba.ca

Glossary

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

- **EGM:** (Formerly APEGM) Engineers and Geoscientists 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.

Helpful Links

UMES Website: http://umes.mb.ca/

Important Dates and Deadlines: http://umanitoba.ca/student/records/deadlines/

Department Academic Calendar:
https://catalog.umanitoba.ca/undergraduate-studies/engineering/electrical-computer-engineering/

ECE Course Timetable:
https://umanitoba.ca/engineering/sites/engineering/files/2021-07/ECE%20Course%20Timetable.pdf

ECE Department Homepage:
http://umanitoba.ca/faculties/engineering/departments/ece/index.html

Electrical Program

Checklist:
https://umanitoba.ca/engineering/sites/engineering/files/2021-02/Electrical-engineering-program-checklist.pdf

4-Year Flowchart:
https://umanitoba.ca/engineering/sites/engineering/files/2022-05/electrical-engineering-flowchart-4-year-plan.pdf

Computer Program

Checklist:
https://umanitoba.ca/engineering/sites/engineering/files/2021-02/Computer-engineering-program-checklist.pdf

4-Year Flowchart:
https://umanitoba.ca/engineering/sites/engineering/files/2022-05/computer-engineering-flowchart-4-year-plan.pdf