Engineering

This section presents the requirements for programs in:

- **Aerospace Engineering - Bachelor of Engineering Stream A: Aerodynamics, Propulsion and Vehicle Performance**
- **Aerospace Engineering - Bachelor of Engineering Stream B: Aerospace Structures, Systems and Vehicle Design**
- **Aerospace Engineering - Bachelor of Engineering Stream C: Aerospace Electronics and Systems**
- **Aerospace Engineering - Bachelor of Engineering Stream Stream D: Space Systems Design**
- **Architectural Conservation and Sustainability Engineering Stream A: Structural**
- **Architectural Conservation and Sustainability Engineering Stream B: Environmental**
- **Biomedical and Electrical Engineering Bachelor of Engineering**
- **Biomedical and Mechanical Engineering Bachelor of Engineering**
- **Civil Engineering Bachelor of Engineering**
- **Communications Engineering Bachelor of Engineering**
- **Computer Systems Engineering Bachelor of Engineering**
- **Electrical Engineering Bachelor of Engineering**
- **Engineering Physics Bachelor of Engineering**
- **Environmental Engineering Bachelor of Engineering**
- **Mechanical Engineering Bachelor of Engineering**
- **Mechanical Engineering with Concentration in Integrated Manufacturing Bachelor of Engineering**
- **Software Engineering Bachelor of Engineering**
- **Sustainable and Renewable Energy Stream A: Smart Technologies for Power Generation and Distribution Bachelor of Engineering**
- **Sustainable and Renewable Energy Stream B: Efficient Energy Generation and Conversion Bachelor of Engineering**

Program Requirements

Course Categories for Engineering Programs

The following categories of courses are used in defining the programs.

Basic Science Electives

Courses in this classification must be chosen from among those listed as acceptable for the current academic year. The list is published annually on the engineering academic support website: carleton.ca/engineering/uas. The list will change from year to year and only courses on the list valid in the year the course is taken, or courses for which formal approval of the Faculty has been obtained can be used as credit toward an engineering degree. Courses not on the list may be used to fulfill a Basic Science elective requirement with the permission of the Faculty of Engineering and Design and provided all other specified course requirements are met. Note that access to courses on the list is not guaranteed and may depend on space availability and the satisfaction of other requirements including, for example, course prerequisites.

Complementary Studies Electives

Courses in this classification must be chosen from among those listed as acceptable for the current academic year. The list is published annually on the engineering academic support website: carleton.ca/engineering/uas. The list will change from year to year and only courses on the list valid in the year the course is taken, or courses for which formal approval of the Faculty has been obtained can be used as credit toward an engineering degree. English as a Second Language courses are not acceptable for use as Complementary Studies electives in any engineering program. Courses not on the list may be used to fulfill a Complementary Studies elective requirement with the permission of the Faculty of Engineering and Design and provided all other specified course requirements are met. Registration in CUTV sections is not acceptable. Note that access to courses on the list is not guaranteed and may depend on space availability and the satisfaction of other requirements including, for example, course prerequisites.

Communications Electives for Communications Engineering

ELEC 4503 [0.5]	Radio Frequency Lines and Antennas
ELEC 4505 [0.5]	Telecommunication Circuits
ELEC 4506 [0.5]	Computer-Aided Design of Circuits and Systems
ELEC 4509 [0.5]	Communication Links
ELEC 4702 [0.5]	Fiber Optic Communications
SYSC 4607 [0.5]	Wireless Communications

Aerospace Engineering Bachelor of Engineering

Students in Aerospace Engineering must satisfy the requirements for one of the following streams:

Aerospace Engineering - Bachelor of Engineering Stream A: Aerodynamics, Propulsion and Vehicle Performance (21.5 credits)

First Year		
1. 4.0 credits in:		4.0
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
2. 1.0 credit in Complementary Studies Electives		1.0
Second Year		
3. 5.0 credits in:		5.0

CCDP 2100 [0.5]	Communication Skills for Engineering Students	
ECOR 2606 [0.5]	Numerical Methods	
MAAE 2001 [0.5]	Engineering Graphical Design	
MAAE 2101 [0.5]	Engineering Dynamics	
MAAE 2202 [0.5]	Mechanics of Solids I	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MAAE 2700 [0.5]	Engineering Materials	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
4. 0.5 credit in Basic Science Electives		0.5
Third Year		
5. 5.5 credits in:		5.5
AERO 3002 [0.5]	Aerospace Design and Practice	
AERO 3700 [0.5]	Aerospace Materials	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 3605 [0.5]	Electrical Engineering	
MAAE 3004 [0.5]	Dynamics of Machinery	
MAAE 3202 [0.5]	Mechanics of Solids II	
MAAE 3300 [0.5]	Fluid Mechanics II	
MAAE 3400 [0.5]	Applied Thermodynamics	
MAAE 3500 [0.5]	Feedback Control Systems	
MAAE 3901 [0.5]	Mech and Aero Engineering Lab	
SYSC 3600 [0.5]	Systems and Simulation	
Fourth Year		
6. 4.0 credits from:		4.0
AERO 4003 [0.5]	Aerospace Systems Design	
AERO 4302 [0.5]	Aerodynamics and Heat Transfer	
AERO 4306 [0.5]	Aerospace Vehicle Performance	
AERO 4308 [0.5]	Aircraft Stability and Control	
MAAE 4907 [1.0]	Engineering Design Project	
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
7. 1.5 credits from:		1.5
ELEC 4504 [0.5]	Avionics Systems	
ELEC 4602 [0.5]	Electrical Power Engineering	
4000-level Mechanical and Aerospace Engineering (MAAE, AERO or MECH)		
Total Credits		21.5

Aerospace Engineering - Bachelor of Engineering Stream B: Aerospace Structures, Systems and Vehicle Design (21.5 credits)

First year		
1. 4.0 credits in:		4.0
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
2. 1.0 credit in Complementary Studies Electives		1.0
Second year		
3. 5.0 credits in:		5.0
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
ECOR 2606 [0.5]	Numerical Methods	
MAAE 2001 [0.5]	Engineering Graphical Design	
MAAE 2101 [0.5]	Engineering Dynamics	
MAAE 2202 [0.5]	Mechanics of Solids I	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MAAE 2700 [0.5]	Engineering Materials	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
4. 0.5 credit in Basic Science Electives		0.5
Third year		
5. 5.5 credits in:		5.5
AERO 3002 [0.5]	Aerospace Design and Practice	
AERO 3101 [0.5]	Lightweight Structures	
AERO 3700 [0.5]	Aerospace Materials	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 3605 [0.5]	Electrical Engineering	
MAAE 3004 [0.5]	Dynamics of Machinery	
MAAE 3202 [0.5]	Mechanics of Solids II	
MAAE 3300 [0.5]	Fluid Mechanics II	
MAAE 3500 [0.5]	Feedback Control Systems	
MAAE 3901 [0.5]	Mech and Aero Engineering Lab	
SYSC 3600 [0.5]	Systems and Simulation	
Fourth year		
6. 4.0 credits in:		4.0
AERO 4003 [0.5]	Aerospace Systems Design	
AERO 4602 [0.5]	Introductory Aeroelasticity	
AERO 4608 [0.5]	Composite Materials	
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
MAAE 4102 [0.5]	Materials: Strength and Fracture	
MAAE 4907 [1.0]	Engineering Design Project	
7. 1.5 credits from		1.5
ELEC 4504 [0.5]	Avionics Systems	
ELEC 4602 [0.5]	Electrical Power Engineering	
4000-level Mechanical and Aerospace Engineering (MAAE, AERO or MECH)		
Total Credits		21.5

Aerospace Engineering - Bachelor of Engineering Stream C: Aerospace Electronics and Systems (21.5 credits)

First year		
1. 4.0 credits in:		4.0
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	

MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
2. 1.0 credit in Complementary Studies Electives		1.0
Second year		
3. 5.5 credits in:		5.5
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
ECOR 2606 [0.5]	Numerical Methods	
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	
ELEC 2607 [0.5]	Switching Circuits	
MAAE 2001 [0.5]	Engineering Graphical Design	
MAAE 2101 [0.5]	Engineering Dynamics	
MAAE 2202 [0.5]	Mechanics of Solids I	
MAAE 2700 [0.5]	Engineering Materials	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
Third year		
4. 5.5 credits in:		5.5
AERO 3002 [0.5]	Aerospace Design and Practice	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 3105 [0.5]	Basic EM and Power Engineering	
ELEC 3500 [0.5]	Digital Electronics	
ELEC 3509 [0.5]	Electronics II	
ELEC 3909 [0.5]	Electromagnetic Waves	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MAAE 3500 [0.5]	Feedback Control Systems	
SYSC 3501 [0.5]	Communication Theory	
SYSC 3600 [0.5]	Systems and Simulation	
Fourth year		
5. 2.5 credits in:		2.5
AERO 4003 [0.5]	Aerospace Systems Design	
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
MAAE 4907 [1.0]	Engineering Design Project	
6. 2.5 credits from:		2.5
AERO 3240 [0.5]	Orbital Mechanics	
AERO 3841 [0.5]	Spacecraft Design I	
AERO 4009 [0.5]	Aviation Management and Certification	
AERO 4842 [0.5]	Spacecraft Design II	
ELEC 4502 [0.5]	Microwave Circuits	
ELEC 4503 [0.5]	Radio Frequency Lines and Antennas	
ELEC 4505 [0.5]	Telecommunication Circuits	
ELEC 4509 [0.5]	Communication Links	
ELEC 4600 [0.5]	Radar and Navigation	
ELEC 4602 [0.5]	Electrical Power Engineering	
ELEC 4706 [0.5]	Digital Integrated Electronics	
SYSC 4405 [0.5]	Digital Signal Processing	
SYSC 4600 [0.5]	Digital Communications	
SYSC 4607 [0.5]	Wireless Communications	
7. 0.5 credit in Basic Science Elective		0.5
Total Credits		21.5

Aerospace Engineering - Bachelor of Engineering Stream
Stream D: Space Systems Design (21.5 credits)

First year		
1. 4.0 credits in:		4.0
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
2. 1.0 credit in Complementary Studies Electives		1.0
Second year		
3. 5.0 credits in:		5.0
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
ECOR 2606 [0.5]	Numerical Methods	
MAAE 2001 [0.5]	Engineering Graphical Design	
MAAE 2101 [0.5]	Engineering Dynamics	
MAAE 2202 [0.5]	Mechanics of Solids I	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MAAE 2700 [0.5]	Engineering Materials	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
4. 0.5 credit in Basic Science Electives		0.5
Third year		
5. 5.0 credits in:		5.0
AERO 3002 [0.5]	Aerospace Design and Practice	
AERO 3240 [0.5]	Orbital Mechanics	
AERO 3841 [0.5]	Spacecraft Design I	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 3909 [0.5]	Electromagnetic Waves	
MAAE 3004 [0.5]	Dynamics of Machinery	
MAAE 3300 [0.5]	Fluid Mechanics II	
MAAE 3500 [0.5]	Feedback Control Systems	
MAAE 3901 [0.5]	Mech and Aero Engineering Lab	
SYSC 3600 [0.5]	Systems and Simulation	
Fourth year		
6. 4.5 credits in:		4.5
AERO 4442 [0.5]	Transatmospheric and Spacecraft Propulsion	
AERO 4446 [0.5]	Heat Transfer for Aerospace Applications	

AERO 4540 [0.5]	Spacecraft Attitude Dynamics and Control	
AERO 4842 [0.5]	Spacecraft Design II	
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
ELEC 4509 [0.5]	Communication Links	
MAAE 4907 [1.0]	Engineering Design Project	
7. 1.5 credits from 4000-level MAAE, AERO or MECH, or AERO 3101, AERO 3700, ELEC 4503, ELEC 4600, ELEC 4709		1.5
Total Credits		21.5

Architectural Conservation and Sustainability Engineering
Bachelor of Engineering

Students must satisfy the requirements for one of the following streams:

Architectural Conservation and Sustainability Engineering
Stream A: Structural (22.0 credits)

First year		
1. 5.5 credits in:		5.5
ARCH 1000 [0.5]	Introduction to Architecture	
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
ENVE 1001 [0.5]	Architecture and the Environment	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
Second year		
2. 5.5 credits in:		5.5
ARCC 2202 [0.5]	Architectural Technology 1	
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
CDNS 2400 [0.5]	Heritage Conservation in Canada	
CIVE 2004 [0.5]	GIS, Surveying, CAD and BIM	
CIVE 2200 [0.5]	Mechanics of Solids I	
CIVE 2700 [0.5]	Civil Engineering Materials	
ECOR 2606 [0.5]	Numerical Methods	
ENVE 2001 [0.5]	Process Analysis for Environmental Engineering	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
Third year		
3. 5.5 credits in:		5.5
ARCC 2203 [0.5]	Architectural Technology 3	
ARCC 3202 [0.5]	Architectural Technology 4	
CIVE 3202 [0.5]	Mechanics of Solids II	
CIVE 3203 [0.5]	Introduction to Structural Analysis	
CIVE 3204 [0.5]	Introduction to Structural Design	
CIVE 3205 [0.5]	Design of Structural Steel Components	
CIVE 3206 [0.5]	Design of Reinforced Concrete Components	
CIVE 3207 [0.5]	Historic Site Recording and Assessment	
CIVE 3209 [0.5]	Building Science	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ECOR 3800 [0.5]	Engineering Economics	
Fourth year		
4. 4.0 credits in:		4.0
ARCH 4200 [0.5]	Architectural Conservation Philosophy and Ethics	
CIVE 4202 [0.5]	Wood Engineering	
CIVE 4601 [0.5]	Building Pathology and Rehabilitation	
CIVE 4918 [1.0]	Design Project	
ECOR 4995 [0.5]	Professional Practice	
ENVE 4105 [0.5]	Green Building Design	
ENVE 4106 [0.5]	Indoor Environmental Quality	
5. 1.5 credits from:		1.5
CIVE 4200 [0.5]	Matrix Analysis of Framed Structures	
CIVE 4201 [0.5]	Finite Element Methods in Civil Engineering	
CIVE 4302 [0.5]	Reinforced and Prestressed Concrete Design	
CIVE 4303 [0.5]	Urban Planning	
CIVE 4308 [0.5]	Behaviour and Design of Steel Structures	
CIVE 4400 [0.5]	Construction/Project Management	
CIVE 4403 [0.5]	Masonry Design	
CIVE 4500 [0.5]	Computer Methods in Civil Engineering	
CIVE 4614 [0.5]	Building Fire Safety	
CIVE 4917 [0.5]	Undergraduate Directed Study	
ENVE 4003 [0.5]	Air Pollution and Emissions Control	
MECH 4407 [0.5]	Heating and Air Conditioning	
SREE 4002 [0.5]	The Energy Economy, Reliability and Risk	
(See Note 2, below)		
Total Credits		22.0

Notes:

1. For **Item 1** and students transferring into Architectural Conservation and Sustainability Engineering (Structural or Environmental Stream), students in good standing and who have successfully completed CHEM 1101 while registered in another engineering program may replace CHEM 1001 and CHEM 1002 with CHEM 1101 plus one 0.5 credit course from the Basic Science Electives list.
2. For Item 5 in the Structural Stream, CIVE 4907 may replace 1.0 credit.

Architectural Conservation and Sustainability Engineering
Stream B: Environmental (22.0 credits)

First year		
1. 5.5 credits in:		5.5
ARCH 1000 [0.5]	Introduction to Architecture	
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
ENVE 1001 [0.5]	Architecture and the Environment	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
Second year		
2. 5.5 credits in:		5.5
ARCC 2202 [0.5]	Architectural Technology 1	
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
CDNS 2400 [0.5]	Heritage Conservation in Canada	
CIVE 2004 [0.5]	GIS, Surveying, CAD and BIM	
CIVE 2200 [0.5]	Mechanics of Solids I	
CIVE 2700 [0.5]	Civil Engineering Materials	
ECOR 2606 [0.5]	Numerical Methods	
ENVE 2001 [0.5]	Process Analysis for Environmental Engineering	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
Third year		
3. 5.5 credits in:		5.5
ARCC 2203 [0.5]	Architectural Technology 3	
ARCC 3202 [0.5]	Architectural Technology 4	
CIVE 3204 [0.5]	Introduction to Structural Design	
CIVE 3207 [0.5]	Historic Site Recording and Assessment	
CIVE 3209 [0.5]	Building Science	
CIVE 4307 [0.5]	Municipal Hydraulics	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ECOR 3800 [0.5]	Engineering Economics	
ENVE 3001 [0.5]	Water Treatment Principles and Design	
ENVE 3002 [0.5]	Environmental Engineering Systems Modeling	
ENVE 3004 [0.5]	Contaminant and Pollutant Transport in the Environment	
Fourth year		
4. 5.0 credits in:		5.0
ARCH 4200 [0.5]	Architectural Conservation Philosophy and Ethics	
CIVE 4601 [0.5]	Building Pathology and Rehabilitation	
ECOR 4995 [0.5]	Professional Practice	
ENVE 4005 [0.5]	Wastewater Treatment Principles and Design	
ENVE 4101 [0.5]	Waste Management	
ENVE 4104 [0.5]	Environmental Planning and Impact Assessment	
ENVE 4105 [0.5]	Green Building Design	
ENVE 4106 [0.5]	Indoor Environmental Quality	
ENVE 4918 [1.0]	Design Project	
5. 0.5 credit from:		0.5
CIVE 4201 [0.5]	Finite Element Methods in Civil Engineering	
CIVE 4303 [0.5]	Urban Planning	
CIVE 4400 [0.5]	Construction/Project Management	
CIVE 4500 [0.5]	Computer Methods in Civil Engineering	
ENVE 3003 [0.5]	Water Resources Engineering	
ENVE 4003 [0.5]	Air Pollution and Emissions Control	
ENVE 4917 [0.5]	Undergraduate Directed Study	
MECH 4401 [0.5]	Power Plant Analysis	
MECH 4403 [0.5]	Power Generation Systems	
MECH 4406 [0.5]	Heat Transfer	
MECH 4407 [0.5]	Heating and Air Conditioning	
SREE 4002 [0.5]	The Energy Economy, Reliability and Risk	
Total Credits		22.0

Notes:

1. For **Item 1** and students transferring into Architectural Conservation and Sustainability Engineering (Structural or Environmental Stream), students in good standing and who have successfully completed CHEM 1101 while registered in another engineering program may replace CHEM 1001 and CHEM 1002 with CHEM 1101 plus one 0.5 credit course from the Basic Science Electives list.

Biomedical and Electrical Engineering
Bachelor of Engineering (21.0 credits)

First year		
1. 5.0 credits in:		5.0
BIOL 1103 [0.5]	Foundations of Biology I	
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
Second year		
2. 4.5 credits in:		4.5

CCDP 2100 [0.5]	Communication Skills for Engineering Students	
ECOR 2606 [0.5]	Numerical Methods	
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	
ELEC 2607 [0.5]	Switching Circuits	
ELEC 3105 [0.5]	Basic EM and Power Engineering	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
SYSC 2006 [0.5]	Foundations of Imperative Programming	
3. 0.5 credit from:		0.5
BIOL 2005 [0.5]	Human Physiology	
BIOL 2201 [0.5]	Cell Biology and Biochemistry	
CHEM 2203 [0.5]	Organic Chemistry I	
Third year		
4. 4.0 credits in:		4.0
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 3500 [0.5]	Digital Electronics	
ELEC 3909 [0.5]	Electromagnetic Waves	
SYSC 3006 [0.5]	Computer Organization	
SYSC 3203 [0.5]	Bioelectrical Systems	
SYSC 3501 [0.5]	Communication Theory	
SYSC 3610 [0.5]	Biomedical Systems, Modeling, and Control	
SYSC 4201 [0.5]	Ethics, Research Methods and Standards for Biomedical Engineering	
5. 0.5 credit from:		0.5
BIOL 2005 [0.5]	Human Physiology	
BIOL 2201 [0.5]	Cell Biology and Biochemistry	
CHEM 2203 [0.5]	Organic Chemistry I	
6. 0.5 credit from:		0.5
ELEC 3908 [0.5]	Physical Electronics	
SYSC 2004 [0.5]	Object-Oriented Software Development	
Fourth year		
7. 2.5 credits in:		2.5
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
ELEC 4601 [0.5]	Microprocessor Systems	
SYSC 4203 [0.5]	Bioinstrumentation and Signals	
SYSC 4405 [0.5]	Digital Signal Processing	
8. 1.0 credit in:		1.0
SYSC 4907 [1.0]	Engineering Project	
9. 1.0 credit from:		1.0
ELEC 4709 [0.5]	Integrated Sensors	
SYSC 4202 [0.5]	Clinical Engineering	
SYSC 4205 [0.5]	Image Processing for Medical Applications	
10. 0.5 credit from SYSC or ELEC at the 3000-level or above.		0.5
11. 1.0 credit in Complementary Studies Electives.		1.0
Total Credits		21.0

Notes:

1. For **Item 3** above, with the permission of their department, students may replace this requirement with an alternate 0.5 credit course in BIOL, BIOC or CHEM.
2. For **Item 5** above, with the permission of their department, students may replace this requirement with an alternate 0.5 credit course in BIOL, BIOC or CHEM.
3. For **Item 9** above, with the permission of their department, students may replace 0.5 credit from this requirement with a 0.5 credit course in BIOM at the 5000-level.
4. For **Item 10** above, with the permission of their department, students may replace this requirement with a 0.5 credit course in BIOM at the 5000-level.

Biomedical and Mechanical Engineering Bachelor of Engineering (21.5 credits)

First year		
1. 5.0 credits in:		5.0
BIOL 1103 [0.5]	Foundations of Biology I	
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
Second year		
2. 4.5 credits in:		4.5
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
MAAE 2001 [0.5]	Engineering Graphical Design	
MAAE 2101 [0.5]	Engineering Dynamics	
MAAE 2202 [0.5]	Mechanics of Solids I	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MAAE 2700 [0.5]	Engineering Materials	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
3. 0.5 credit from:		0.5
BIOL 2005 [0.5]	Human Physiology	
BIOL 2201 [0.5]	Cell Biology and Biochemistry	
CHEM 2203 [0.5]	Organic Chemistry I	
Third year		
4. 5.5 credits in:		5.5
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ECOR 2606 [0.5]	Numerical Methods	
ELEC 3605 [0.5]	Electrical Engineering	
MAAE 3004 [0.5]	Dynamics of Machinery	
MAAE 3202 [0.5]	Mechanics of Solids II	

MAAE 3500 [0.5]	Feedback Control Systems	
MECH 3002 [0.5]	Machine Design and Practice	
MECH 3310 [0.5]	Biofluid Mechanics	
MECH 3710 [0.5]	Biomaterials	
SYSC 3610 [0.5]	Biomedical Systems, Modeling, and Control	
SYSC 4201 [0.5]	Ethics, Research Methods and Standards for Biomedical Engineering	
5. 0.5 credit from:		0.5
BIOL 2005 [0.5]	Human Physiology	
BIOL 2201 [0.5]	Cell Biology and Biochemistry	
CHEM 2203 [0.5]	Organic Chemistry I	
Fourth year		
6. 3.0 credits in:		3.0
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
MAAE 3400 [0.5]	Applied Thermodynamics	
MECH 4013 [0.5]	Biomedical Device Design	
MECH 4210 [0.5]	Biomechanics	
MECH 4406 [0.5]	Heat Transfer	
7. 1.0 credit in:		1.0
MAAE 4907 [1.0]	Engineering Design Project	
8. 0.5 credit in MAAE, MECH or AERO at the 4000-level, SYSC 4202 [0.5], SYSC 4203 [0.5]		0.5
9. 1.0 credit in Complementary Studies Electives		1.0
Total Credits		21.5

Notes:

1. For **Item 3** above, with the permission of their department, students may replace this requirement with an alternate 0.5 credit course in BIOL, BIOC or CHEM.
2. For **Item 5** above, with the permission of their department, students may replace this requirement with an alternate 0.5 credit course in BIOL, BIOC or CHEM.

Civil Engineering
Bachelor of Engineering (21.5 credits)

First year		
1. 4.5 credits in:		4.5
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
2. 0.5 credit in Complementary Studies Electives		0.5
Second year		
3. 5.0 credits in:		5.0
CIVE 2004 [0.5]	GIS, Surveying, CAD and BIM	
CIVE 2101 [0.5]	Mechanics II	
CIVE 2200 [0.5]	Mechanics of Solids I	
CIVE 2700 [0.5]	Civil Engineering Materials	
ECOR 2606 [0.5]	Numerical Methods	
ERTH 2404 [0.5]	Engineering Geoscience	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
4. 0.5 credit in Complementary Studies Electives		0.5
Third year		
5. 5.5 credits in:		5.5
CIVE 3202 [0.5]	Mechanics of Solids II	
CIVE 3203 [0.5]	Introduction to Structural Analysis	
CIVE 3204 [0.5]	Introduction to Structural Design	
CIVE 3205 [0.5]	Design of Structural Steel Components	
CIVE 3206 [0.5]	Design of Reinforced Concrete Components	
CIVE 3208 [0.5]	Geotechnical Mechanics	
CIVE 3209 [0.5]	Building Science	
CIVE 3304 [0.5]	Transportation Engineering and Planning	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ECOR 3800 [0.5]	Engineering Economics	
ELEC 3605 [0.5]	Electrical Engineering	
Fourth year		
6. 3.0 credits in:		3.0
CIVE 4208 [0.5]	Geotechnical Engineering	
CIVE 4209 [0.5]	Highway Engineering	
CIVE 4407 [0.5]	Municipal Engineering	
CIVE 4918 [1.0]	Design Project	
ECOR 4995 [0.5]	Professional Practice	
7. 2.0 credits from:		2.0
CIVE 4200 [0.5]	Matrix Analysis of Framed Structures	
CIVE 4201 [0.5]	Finite Element Methods in Civil Engineering	
CIVE 4202 [0.5]	Wood Engineering	
CIVE 4301 [0.5]	Foundation Engineering	
CIVE 4302 [0.5]	Reinforced and Prestressed Concrete Design	
CIVE 4303 [0.5]	Urban Planning	
CIVE 4307 [0.5]	Municipal Hydraulics	
CIVE 4308 [0.5]	Behaviour and Design of Steel Structures	
CIVE 4400 [0.5]	Construction/Project Management	
CIVE 4403 [0.5]	Masonry Design	
CIVE 4500 [0.5]	Computer Methods in Civil Engineering	
CIVE 4614 [0.5]	Building Fire Safety	
CIVE 4907 [1.0]	Engineering Research Project	
CIVE 4917 [0.5]	Undergraduate Directed Study	
ENVE 3003 [0.5]	Water Resources Engineering	
ENVE 4105 [0.5]	Green Building Design	

8. 0.5 credit in Complementary Studies Electives		0.5
Total Credits		21.5

Communications Engineering Bachelor of Engineering (21.5 credits)

First year		
1. 4.5 credits in:		4.5
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
SYSC 1005 [0.5]	Introduction to Software Development	
SYSC 2006 [0.5]	Foundations of Imperative Programming	
2. 0.5 credit in Complementary Studies Electives		0.5
Second year		
3. 5.0 credits in:		5.0
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
ECOR 2606 [0.5]	Numerical Methods	
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
SYSC 2004 [0.5]	Object-Oriented Software Development	
SYSC 2310 [0.5]	Introduction to Digital Systems	
SYSC 2320 [0.5]	Introduction to Computer Organization and Architecture	
SYSC 2510 [0.5]	Probability, Statistics and Random Processes for Engineers	
4. 0.5 credit in Basic Science Electives		0.5
Third year		
5. 4.5 credits in:		4.5
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ECOR 3800 [0.5]	Engineering Economics	
ELEC 3509 [0.5]	Electronics II	
ELEC 3909 [0.5]	Electromagnetic Waves	
SYSC 3310 [0.5]	Introduction to Real-Time Systems	
SYSC 3500 [0.5]	Signals and Systems	
SYSC 3503 [0.5]	Communication Theory II	
SYSC 4502 [0.5]	Communications Software	
SYSC 4602 [0.5]	Computer Communications	
6. 0.5 credit in Complementary Studies Electives		0.5
Fourth year		
7. 3.5 credits in:		3.5
ECOR 4995 [0.5]	Professional Practice	
SYSC 4405 [0.5]	Digital Signal Processing	
SYSC 4504 [0.5]	Fundamentals of Web Development	
SYSC 4604 [0.5]	Digital Communication Theory	
SYSC 4700 [0.5]	Telecommunications Engineering	
SYSC 4701 [0.5]	Communications Systems Lab	
SYSC 4810 [0.5]	Introduction to Network and Software Security	
8. 1.0 credit from:		1.0
SYSC 4907 [1.0]	Engineering Project	
ELEC 4907 [1.0]	Engineering Project	
9. 1.0 credit in Communications Electives for Communications Engineering		1.0
10. 0.5 credit in SYSC or ELEC at the 3000- or 4000-level		0.5
Total Credits		21.5

Notes:

1. For **Item 8** above, students should register in SYSC 4907 if their supervisor is in Systems and Computer Engineering, or in ELEC 4907 if their supervisor is in Electronics.
2. For **Item 9** above, with the permission of their department, students may replace 0.5 credit from this requirement with 0.5 credit in SYSC at the 5000 level.
3. For **Item 10** above, with the permission of their department, students may replace 0.5 credit from this requirement with 0.5 credit in SYSC at the 5000 level.

Computer Systems Engineering Bachelor of Engineering (21.5 credits)

First year		
1. 5.0 credits in:		5.0
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1003 [0.5]	Introductory Mechanics and Thermodynamics	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
SYSC 1005 [0.5]	Introduction to Software Development	
SYSC 2006 [0.5]	Foundations of Imperative Programming	
Second year		
2. 5.0 credits in:		5.0
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
ECOR 2606 [0.5]	Numerical Methods	
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
SYSC 2004 [0.5]	Object-Oriented Software Development	
SYSC 2100 [0.5]	Algorithms and Data Structures	

SYSC 2310 [0.5]	Introduction to Digital Systems	
SYSC 2320 [0.5]	Introduction to Computer Organization and Architecture	
3. 0.5 credit in Complementary Studies Electives		0.5
Third year		
4. 5.0 credits in:		5.0
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ECOR 3800 [0.5]	Engineering Economics	
SYSC 3010 [0.5]	Computer Systems Development Project	
SYSC 3020 [0.5]	Introduction to Software Engineering	
SYSC 3303 [0.5]	Real-Time Concurrent Systems	
SYSC 3310 [0.5]	Introduction to Real-Time Systems	
SYSC 3320 [0.5]	Computer Systems Design	
SYSC 3501 [0.5]	Communication Theory	
SYSC 3600 [0.5]	Systems and Simulation	
SYSC 4001 [0.5]	Operating Systems	
Fourth year		
5. 3.0 credits in:		3.0
ECOR 4995 [0.5]	Professional Practice	
ELEC 4705 [0.5]	Electronic Materials, Devices and Transmission Media	
SYSC 4310 [0.5]	Computer Systems Architecture	
SYSC 4602 [0.5]	Computer Communications	
SYSC 4805 [0.5]	Computer Systems Design Lab	
SYSC 4810 [0.5]	Introduction to Network and Software Security	
6. 1.0 credit from:		1.0
SYSC 4907 [1.0]	Engineering Project	
ELEC 4907 [1.0]	Engineering Project	
7. 1.5 credits from:		1.5
MECH 4503 [0.5]	An Introduction to Robotics	
or SYSC or ELEC at the 3000-level or above		
8. 0.5 credit in Complementary Studies Electives		0.5
Total Credits		21.5

Notes:

1. For **Item 6** above, students should register in SYSC 4907 if their supervisor is in Systems and Computer Engineering, or in ELEC 4907 if their supervisor is in Electronics.
2. For **Item 7** above, with the permission of their department, students may replace 1.0 credit from this requirement with 1.0 credit in SYSC courses at the 5000 level.

Electrical Engineering
Bachelor of Engineering (21.5 credits)

First year		
1. 4.0 credits in:		4.0
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
2. 1.0 credit in Complementary Studies Electives		1.0
Second year		
3. 4.5 credits in:		4.5
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
ECOR 2606 [0.5]	Numerical Methods	
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	
ELEC 2607 [0.5]	Switching Circuits	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
SYSC 2004 [0.5]	Object-Oriented Software Development	
SYSC 2006 [0.5]	Foundations of Imperative Programming	
4. 0.5 credit in Complementary Studies		0.5
5. 0.5 credit in Basic Science Electives		0.5
Third year		
6. 5.0 credits in:		5.0
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 3105 [0.5]	Basic EM and Power Engineering	
ELEC 3500 [0.5]	Digital Electronics	
ELEC 3509 [0.5]	Electronics II	
ELEC 3907 [0.5]	Engineering Project	
ELEC 3908 [0.5]	Physical Electronics	
ELEC 3909 [0.5]	Electromagnetic Waves	
SYSC 3006 [0.5]	Computer Organization	
SYSC 3501 [0.5]	Communication Theory	
SYSC 3600 [0.5]	Systems and Simulation	
Fourth year		
7. 1.5 credits in:		1.5
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
ELEC 4601 [0.5]	Microprocessor Systems	
8. 1.0 credit from:		1.0
ELEC 4907 [1.0]	Engineering Project	
SYSC 4907 [1.0]	Engineering Project	
9. 3.0 credits from:		3.0
MECH 4503 [0.5]	An Introduction to Robotics	
SYSC 3020 [0.5]	Introduction to Software Engineering	
SYSC 3200 [0.5]	Industrial Engineering	
ELEC 3508 [0.5]	Power Electronics	
or ELEC OR SYSC at the 4000-level		
10. 0.5 credit from:		0.5
Basic Science Electives, or		
ENVE, CIVE, IDES, MAAE, AERO, MECH at the 2000-level or above, or		
ELEC 3508 [0.5]	Power Electronics	
MECH 4503 [0.5]	An Introduction to Robotics	
SYSC 3020 [0.5]	Introduction to Software Engineering	

SYSC 3200 [0.5]	Industrial Engineering	
or any ELEC or SYSC at the 4000-level		
Total Credits		21.5

Note: For **Item 8** above, students should register in ELEC 4907 if their supervisor is in Electronics, and in SYSC 4907 if their supervisor is in Systems and Computer Engineering.

Engineering Physics
Bachelor of Engineering (21.5 credits)

First year		
1. 4.5 credits in:		4.5
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1606 [0.5]	Problem Solving and Computers	
ELEC 1908 [0.5]	First Year Project	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1001 [0.5]	Foundations of Physics I	
PHYS 1002 [0.5]	Foundations of Physics II	
2. 0.5 credit in Complementary Studies Electives		0.5
Second year		
3. 5.0 credits in:		5.0
ECOR 2606 [0.5]	Numerical Methods	
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	
ELEC 2607 [0.5]	Switching Circuits	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
PHYS 2202 [0.5]	Wave Motion and Optics	
PHYS 2604 [0.5]	Modern Physics I	
SYSC 2004 [0.5]	Object-Oriented Software Development	
SYSC 2006 [0.5]	Foundations of Imperative Programming	
Third year		
4. 5.5 credits in:		5.5
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 3105 [0.5]	Basic EM and Power Engineering	
ELEC 3500 [0.5]	Digital Electronics	
ELEC 3509 [0.5]	Electronics II	
ELEC 3908 [0.5]	Physical Electronics	
ELEC 3909 [0.5]	Electromagnetic Waves	
PHYS 3606 [0.5]	Modern Physics II	
PHYS 3701 [0.5]	Elements of Quantum Mechanics	
PHYS 3807 [0.5]	Mathematical Physics I	
SYSC 3501 [0.5]	Communication Theory	
SYSC 3600 [0.5]	Systems and Simulation	
Fourth year		
5. 3.0 credits in:		3.0
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
ELEC 4908 [1.0]	Engineering Physics Project	
PHYS 4007 [0.5]	Fourth-Year Physics Laboratory: Selected Experiments and Seminars	
PHYS 4707 [0.5]	Introduction to Quantum Mechanics I	
6. 1.0 credit in PHYS at the 4000-level, which must include one of:		1.0
PHYS 4203 [0.5]	Physical Applications of Fourier Analysis	
PHYS 4208 [0.5]	Modern Optics	
PHYS 4409 [0.5]	Thermodynamics and Statistical Physics	
PHYS 4508 [0.5]	Solid State Physics	
PHYS 4807 [0.5]	Computational Physics	
7. 1.0 credit in ELEC at the 4000-level excluding: ELEC 4504, ELEC 4600, ELEC 4703, and ELEC 4705		1.0
8. 1.0 credit in Complementary Studies Electives		1.0
Total Credits		21.5

Environmental Engineering
Bachelor of Engineering (21.0 credits)

First year		
1. 5.0 credits in:		5.0
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
CHEM 1001 [0.5]	General Chemistry I	
CHEM 1002 [0.5]	General Chemistry II	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
Second year		
2. 5.0 credits in:		5.0
BIOL 1103 [0.5]	Foundations of Biology I	
BIOL 1104 [0.5]	Foundations of Biology II	
CHEM 2800 [0.5]	Foundations for Environmental Chemistry	
CIVE 2200 [0.5]	Mechanics of Solids I	
ECOR 2606 [0.5]	Numerical Methods	
ENVE 2001 [0.5]	Process Analysis for Environmental Engineering	
ERTH 2404 [0.5]	Engineering Geoscience	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
Third year		
3. 5.0 credits in:		5.0
CHEM 3800 [0.5]	The Chemistry of Environmental Pollutants	
CIVE 2700 [0.5]	Civil Engineering Materials	

CIVE 3208 [0.5]	Geotechnical Mechanics	
CIVE 4307 [0.5]	Municipal Hydraulics	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ECOR 3800 [0.5]	Engineering Economics	
ENVE 3001 [0.5]	Water Treatment Principles and Design	
ENVE 3002 [0.5]	Environmental Engineering Systems Modeling	
ENVE 3003 [0.5]	Water Resources Engineering	
ENVE 3004 [0.5]	Contaminant and Pollutant Transport in the Environment	
Fourth year		
4. 4.0 credits in:		4.0
ECOR 4995 [0.5]	Professional Practice	
ENVE 4003 [0.5]	Air Pollution and Emissions Control	
ENVE 4005 [0.5]	Wastewater Treatment Principles and Design	
ENVE 4006 [0.5]	Contaminant Hydrogeology	
ENVE 4101 [0.5]	Waste Management	
ENVE 4104 [0.5]	Environmental Planning and Impact Assessment	
ENVE 4918 [1.0]	Design Project	
5. 1.0 credit from:		1.0
CIVE 3304 [0.5]	Transportation Engineering and Planning	
CIVE 4208 [0.5]	Geotechnical Engineering	
CIVE 4301 [0.5]	Foundation Engineering	
CIVE 4303 [0.5]	Urban Planning	
CIVE 4400 [0.5]	Construction/Project Management	
ENVE 4002 [0.5]	Environmental Geotechnical Engineering	
ENVE 4105 [0.5]	Green Building Design	
ENVE 4106 [0.5]	Indoor Environmental Quality	
ENVE 4907 [1.0]	Engineering Research Project	
ENVE 4917 [0.5]	Undergraduate Directed Study	
MECH 4401 [0.5]	Power Plant Analysis	
MECH 4403 [0.5]	Power Generation Systems	
MECH 4406 [0.5]	Heat Transfer	
MECH 4407 [0.5]	Heating and Air Conditioning	
SYSC 3200 [0.5]	Industrial Engineering	
SREE 3001 [0.5]	Sustainable and Renewable Energy Sources	
SREE 4002 [0.5]	The Energy Economy, Reliability and Risk	
6. 1.0 credit in Complementary Studies Electives		1.0
Total Credits		21.0

Note: For **Item 1** above and students transferring into Environmental Engineering, students in good standing and who have successfully completed CHEM 1101 while registered in another engineering program may replace CHEM 1001 and CHEM 1002 with CHEM 1101 plus one 0.5 credit from the Basic Science Electives for Engineering.

Mechanical Engineering
Bachelor of Engineering (21.5 credits)

First year		
1. 4.0 credits in:		4.0
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
2. 1.0 credit in Complementary Studies Electives		1.0
Second year		
3. 5.0 credits in:		5.0
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
ECOR 2606 [0.5]	Numerical Methods	
MAAE 2001 [0.5]	Engineering Graphical Design	
MAAE 2101 [0.5]	Engineering Dynamics	
MAAE 2202 [0.5]	Mechanics of Solids I	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MAAE 2700 [0.5]	Engineering Materials	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
4. 0.5 credit in Basic Science Electives		0.5
Third year		
5. 5.5 credits in:		5.5
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 3605 [0.5]	Electrical Engineering	
MAAE 3004 [0.5]	Dynamics of Machinery	
MAAE 3202 [0.5]	Mechanics of Solids II	
MAAE 3300 [0.5]	Fluid Mechanics II	
MAAE 3400 [0.5]	Applied Thermodynamics	
MAAE 3500 [0.5]	Feedback Control Systems	
MAAE 3901 [0.5]	Mech and Aero Engineering Lab	
MECH 3002 [0.5]	Machine Design and Practice	
MECH 3700 [0.5]	Principles of Manufacturing	
SYSC 3600 [0.5]	Systems and Simulation	
Fourth year		
6. 3.5 credits in:		3.5
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
MAAE 4102 [0.5]	Materials: Strength and Fracture	
MAAE 4907 [1.0]	Engineering Design Project	
MECH 4003 [0.5]	Mechanical Systems Design	
MECH 4406 [0.5]	Heat Transfer	
7. 2.0 credits from:		2.0
ELEC 4504 [0.5]	Avionics Systems	
ELEC 4602 [0.5]	Electrical Power Engineering	
4000-level Mechanical and Aerospace Engineering (MAAE, AERO or MECH)		
Total Credits		21.5

Mechanical Engineering with Concentration in Integrated Manufacturing
Bachelor of Engineering (22.0 credits)

First year		
1. 4.0 credits in:		4.0
CHEM 1101 [0.5]	Chemistry for Engineering Students	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
2. 1.0 credit in Complementary Studies Electives		1.0
Second year		
3. 5.0 credits in:		5.0
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
MAAE 2001 [0.5]	Engineering Graphical Design	
MAAE 2101 [0.5]	Engineering Dynamics	
MAAE 2202 [0.5]	Mechanics of Solids I	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MAAE 2700 [0.5]	Engineering Materials	
ECOR 2606 [0.5]	Numerical Methods	
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
4. 0.5 credit in Basic Science Electives		0.5
Third year		
5. 5.5 credits in:		5.5
MAAE 3004 [0.5]	Dynamics of Machinery	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
MAAE 3202 [0.5]	Mechanics of Solids II	
MAAE 3300 [0.5]	Fluid Mechanics II	
MAAE 3400 [0.5]	Applied Thermodynamics	
MAAE 3901 [0.5]	Mech and Aero Engineering Lab	
MECH 3002 [0.5]	Machine Design and Practice	
MECH 3700 [0.5]	Principles of Manufacturing	
SYSC 3600 [0.5]	Systems and Simulation	
ELEC 3605 [0.5]	Electrical Engineering	
MAAE 3500 [0.5]	Feedback Control Systems	
Fourth year		
6. 4.0 credits in:		4.0
MAAE 4102 [0.5]	Materials: Strength and Fracture	
MAAE 4907 [1.0]	Engineering Design Project	
ECOR 4995 [0.5]	Professional Practice	
MECH 4003 [0.5]	Mechanical Systems Design	
MECH 4406 [0.5]	Heat Transfer	
ECOR 3800 [0.5]	Engineering Economics	
SYSC 3200 [0.5]	Industrial Engineering	
7. 1.5 credits from:		1.5
MECH 4501 [0.5]	State Space Modeling and Control	
MECH 4503 [0.5]	An Introduction to Robotics	
MECH 4604 [0.5]	Finite Element Methods	
MECH 4704 [0.5]	Integrated Manufacturing - CIMS	
MECH 4705 [0.5]	CAD/CAM	
MECH 4805 [0.5]	Measurement and Data Systems	
MECH 4806 [0.5]	Mechatronics	
8. 0.5 credits from:		0.5
ELEC 4504 [0.5]	Avionics Systems	
ELEC 4602 [0.5]	Electrical Power Engineering	
4000-level Mechanical and Aerospace Engineering (MAAE, AERO or MECH)		
Total Credits		22.0

Software Engineering
Bachelor of Engineering (21.5 credits)

First year		
1. 5.0 credits in:		5.0
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1003 [0.5]	Introductory Mechanics and Thermodynamics	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
SYSC 1005 [0.5]	Introduction to Software Development	
SYSC 2006 [0.5]	Foundations of Imperative Programming	
Second year		
2. 4.5 credits in:		4.5
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
COMP 1805 [0.5]	Discrete Structures I	
ELEC 2501 [0.5]	Circuits and Signals	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
SYSC 2004 [0.5]	Object-Oriented Software Development	
SYSC 2100 [0.5]	Algorithms and Data Structures	
SYSC 2310 [0.5]	Introduction to Digital Systems	
SYSC 2320 [0.5]	Introduction to Computer Organization and Architecture	
SYSC 3101 [0.5]	Programming Languages	
3. 1.0 credit in Complementary Studies Electives		1.0
Third year		
4. 4.5 credits in:		4.5
COMP 3005 [0.5]	Database Management Systems	
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ECOR 3800 [0.5]	Engineering Economics	
SYSC 3110 [0.5]	Software Development Project	
SYSC 3120 [0.5]	Software Requirements Engineering	

SYSC 3303 [0.5]	Real-Time Concurrent Systems	
SYSC 3310 [0.5]	Introduction to Real-Time Systems	
SYSC 4001 [0.5]	Operating Systems	
SYSC 4106 [0.5]	Software Product Management	
5. 0.5 credit from:		0.5
ECOR 2606 [0.5]	Numerical Methods	
ELEC 2507 [0.5]	Electronics I	
SYSC or ELEC course at the 3000 level or above		
Fourth year		
6. 3.5 credits in:		3.5
ECOR 4995 [0.5]	Professional Practice	
ELEC 4705 [0.5]	Electronic Materials, Devices and Transmission Media	
SYSC 4005 [0.5]	Discrete Simulation/Modeling	
SYSC 4101 [0.5]	Software Validation	
SYSC 4120 [0.5]	Software Architecture and Design	
SYSC 4806 [0.5]	Software Engineering Lab	
SYSC 4810 [0.5]	Introduction to Network and Software Security	
7. 1.0 credit in:		1.0
SYSC 4907 [1.0]	Engineering Project	
8. 0.5 credit from the list in Item 5		0.5
9. 1.0 credit from the list in Item 5, or from:		1.0
COMP 2804 [0.5]	Discrete Structures II	
COMP 3002 [0.5]	Compiler Construction	
COMP 3008 [0.5]	Human-Computer Interaction	
COMP 3400 [0.5]	Computational Logic and Automated Reasoning	
COMP 3501 [0.5]	Foundations of Game Programming and Computer Graphics	
COMP 3801 [0.5]	Algorithms for Modern Data Sets	
COMP 3803 [0.5]	Introduction to Theory of Computation	
COMP 3804 [0.5]	Design and Analysis of Algorithms I	
COMP 4000 [0.5]	Distributed Operating Systems	
COMP 4002 [0.5]	Real-Time 3D Game Engines	
COMP 4003 [0.5]	Transaction Processing Systems	
COMP 4009 [0.5]	Programming for Clusters and Multi-Core Processors	
COMP 4102 [0.5]	Computer Vision	
COMP 4106 [0.5]	Artificial Intelligence	
COMP 4109 [0.5]	Applied Cryptography	
COMP 4111 [0.5]	Data Management for Business Intelligence	
Total Credits		21.5

Note: For **Item 9** above, with the permission of their department, students may replace 1.0 credit from this requirement with 1.0 credit in SYSC courses at the 5000 level.

Sustainable and Renewable Energy Stream A: Smart Technologies for Power Generation and Distribution
Bachelor of Engineering (21.5 credits)

First year		
1. 4.5 credits in:		4.5
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
2. 0.5 credit in Complementary Studies Electives		0.5
3. Successful completion of:		0.0
SREE 1000 [0.0]	Introduction to Sustainable Energy	
Second year		
4. 5.0 credits in:		5.0
ECOR 2606 [0.5]	Numerical Methods	
ELEC 2501 [0.5]	Circuits and Signals	
ELEC 2507 [0.5]	Electronics I	
ELEC 2607 [0.5]	Switching Circuits	
ENVE 2001 [0.5]	Process Analysis for Environmental Engineering	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
SYSC 2006 [0.5]	Foundations of Imperative Programming	
5. 0.5 credit in Basic Science Electives		0.5
Third year		
6. 5.0 credits in:		5.0
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 3508 [0.5]	Power Electronics	
ELEC 4602 [0.5]	Electrical Power Engineering	
MAAE 3400 [0.5]	Applied Thermodynamics	
SREE 3001 [0.5]	Sustainable and Renewable Energy Sources	
SREE 3002 [0.5]	Electricity: Use, Distribution, Integration of Distributed Generation	
SREE 3003 [0.5]	Sustainable and Renewable Electricity Generation	
SYSC 3006 [0.5]	Computer Organization	
SYSC 3200 [0.5]	Industrial Engineering	
SYSC 3600 [0.5]	Systems and Simulation	
Fourth year		
7. 4.0 credits in:		4.0
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
ELEC 4703 [0.5]	Solar Cells	
ENVE 4003 [0.5]	Air Pollution and Emissions Control	
SREE 4001 [0.5]	Efficient Energy Conversion	
SREE 4002 [0.5]	The Energy Economy, Reliability and Risk	

SYSC 4505 [0.5]	Automatic Control Systems I	
SYSC 4602 [0.5]	Computer Communications	
8. 1.0 credit in:		1.0
SREE 4907 [1.0]	Energy Engineering Project	
9. 0.5 credit in any 3000-level or 4000-level Engineering course for which prerequisites have been satisfied		0.5
10. 0.5 credit in any 4000-level Engineering course for which prerequisites have been satisfied		0.5
Total Credits		21.5

Sustainable and Renewable Energy Stream B: Efficient Energy Generation and Conversion Bachelor of Engineering (21.5 credits)

First year		
1. 4.5 credits in:		4.5
CCDP 2100 [0.5]	Communication Skills for Engineering Students	
CHEM 1101 [0.5]	Chemistry for Engineering Students	
ECOR 1010 [0.5]	Introduction to Engineering	
ECOR 1101 [0.5]	Mechanics I	
ECOR 1606 [0.5]	Problem Solving and Computers	
MATH 1004 [0.5]	Calculus for Engineering or Physics	
MATH 1005 [0.5]	Differential Equations and Infinite Series for Engineering or Physics	
MATH 1104 [0.5]	Linear Algebra for Engineering or Science	
PHYS 1004 [0.5]	Introductory Electromagnetism and Wave Motion	
2. 0.5 credit in Complementary Studies Electives		0.5
3. Successful completion of:		0.0
SREE 1000 [0.0]	Introduction to Sustainable Energy	
Second year		
4. 5.0 credits in:		5.0
ECOR 2606 [0.5]	Numerical Methods	
ELEC 3605 [0.5]	Electrical Engineering	
ENVE 2001 [0.5]	Process Analysis for Environmental Engineering	
MAAE 2001 [0.5]	Engineering Graphical Design	
MAAE 2101 [0.5]	Engineering Dynamics	
MAAE 2202 [0.5]	Mechanics of Solids I	
MAAE 2300 [0.5]	Fluid Mechanics I	
MAAE 2400 [0.5]	Thermodynamics and Heat Transfer	
MATH 2004 [0.5]	Multivariable Calculus for Engineering or Physics	
MATH 3705 [0.5]	Mathematical Methods I	
5. 0.5 credit in Basic Science Electives		0.5
Third year		
6. 5.5 credits in:		5.5
ECOR 2050 [0.5]	Design and Analysis of Engineering Experiments	
ELEC 4602 [0.5]	Electrical Power Engineering	
MAAE 2700 [0.5]	Engineering Materials	
MAAE 3300 [0.5]	Fluid Mechanics II	
MAAE 3400 [0.5]	Applied Thermodynamics	
MAAE 3500 [0.5]	Feedback Control Systems	
SREE 3001 [0.5]	Sustainable and Renewable Energy Sources	
SREE 3002 [0.5]	Electricity: Use, Distribution, Integration of Distributed Generation	
SREE 3003 [0.5]	Sustainable and Renewable Electricity Generation	
SYSC 3200 [0.5]	Industrial Engineering	
SYSC 3600 [0.5]	Systems and Simulation	
Fourth year		
7. 3.5 credits in:		3.5
ECOR 3800 [0.5]	Engineering Economics	
ECOR 4995 [0.5]	Professional Practice	
ENVE 4003 [0.5]	Air Pollution and Emissions Control	
MECH 4406 [0.5]	Heat Transfer	
MECH 4408 [0.5]	Thermofluids and Energy Systems Design	
SREE 4001 [0.5]	Efficient Energy Conversion	
SREE 4002 [0.5]	The Energy Economy, Reliability and Risk	
8. 1.0 credit in:		1.0
SREE 4907 [1.0]	Energy Engineering Project	
9. 0.5 credit in any 3000-level or 4000-level Engineering course for which prerequisites have been satisfied		0.5
10. 0.5 credit in any 4000-level Engineering course for which prerequisites have been satisfied		0.5
Total Credits		21.5

Regulations

Regulations

The regulations presented in this section apply to all Bachelor of Engineering programs.

In addition to the requirements presented here, students must satisfy the University regulations common to all undergraduate students including the process of Academic Performance Evaluation (see the Academic Regulations of the University section of this Calendar), with the following additions and amendments:

Academic Performance Evaluation for Engineering

1. In Engineering programs, all credits are included in the Major CGPA, making it identical to the Overall CGPA.
2. Students who are not assigned the status Good Standing or Academic Warning will be required to leave the degree with either the status Continue in Alternate (CA) or the status Dismissed from Program (DP).

Graduation

Students in Engineering programs are covered by the common University regulations regarding graduation, with the following additions and amendments.

1. Students entering an Engineering program with Advanced Standing will receive transfer credit for at most ten of the credits required for their program.
2. Students must take a minimum of 1.0 credit of complementary studies at Carleton University.

Course Load

Regulations regarding Course Load and Overload can be found in the *Academic Regulations of the University* section of this Calendar. The normal course load in

Engineering is defined as the number of credits required in the student's program for the current year status of the students. Since the programs in Engineering require more than 20.0 credits in total, the normal course load is more than 5.0 credits in some years of the program. Registration in more than this number of credits constitutes an overload.

Co-operative Education Programs

All Engineering programs are available with or without participation in the Co-operative Education option.

Year Status for Engineering

In the Bachelor of Engineering Degree program, Year Status is defined as follows.

1st year: Admission to the program.

2nd year: Successful completion of all Engineering, Science and Mathematics course requirements in the first year of the program, all English as a Second Language Requirements, and any additional requirements as determined in the admissions process.

3rd year: Successful completion of 4.0 credits from the second year requirements of the program.

4th year: Successful completion of all second year requirements and 3.5 credits from the third year requirements of the program.

Year Status Prerequisites

Year Status in Engineering is used in some course prerequisites to limit access to only those students who have sufficient preparation. In particular students will not have access to second, third or fourth year engineering, science or mathematics courses until they have achieved second year status. Similarly, to take some specific engineering, science and mathematics courses in third or fourth year, that year status must be achieved. For additional information on prerequisites, see the individual course descriptions.

Time Limit

The Bachelor of Engineering degree must be completed within eight calendar years of initial registration. Students who do not complete their program requirements within this limit will be given the status Continue in Alternate.

Academic Appeals

The Engineering Committee on Admission and Studies handles all academic appeals.

Co-operative Education

For more information about how to apply for the Co-op program and how the Co-op program works please visit the Co-op website.

All students participating in the Co-op program are governed by the Undergraduate Co-operative Education Policy.

Undergraduate Co-operative Education Policy

Admission Requirements

Students can apply to co-op in one of two ways; directly from high school or after beginning a degree program at Carleton.

If a student is admitted to co-op from high school, their grades will be reviewed two terms to one year prior to their first work term to ensure they continue to meet the academic requirements after their 1st or 2nd year of study. The time at which evaluation takes place depends on the program of study. Students will automatically be notified via their Carleton email account if they are permitted to continue.

Students not admitted to Carleton University with the co-op option on their degree can apply for admission via the co-operative education program website. To view application deadlines, visit carleton.ca/co-op.

Admission to the co-op option is based on the completion of 5.0 or more credits at Carleton University, the CGPA requirement for the students' academic program as well as any course prerequisites. The articulated CGPA for each program is the normal standard for assessment. Please see the specific degree program sections for the unique admission and continuation requirements for each academic program.

English Language Proficiency

Students admitted to Carleton based on CAEL, IELTS or TOEFL assessments and who are required to take an ESL course must take and pass the Oral Proficiency in Communicative Settings (OPECS) Test. The test must be taken before being permitted to register in COOP 1000. Admission to the co-op program can be confirmed with a minimum score of 4+.

Participation Requirements

COOP 1000

Once a student has been given admission or continuation confirmation to the co-op option s/he must complete and pass COOP 1000 (a mandatory online 0.0 credit course). Students will have access to this course a minimum of two terms prior to their first work term and will be notified when to register.

Communication with the Co-op Office

Students must maintain contact with the co-op office during their job search and while on a work term. All email communication will be conducted via the students' Carleton email account.

Employment

Although every effort is made to ensure a sufficient number of job postings for all students enrolled in the co-op option of their degree program, no guarantee of employment can be made. Carleton's co-op program operates a competitive job search process and is dependent upon current market conditions. Academic performance, skills, motivation, maturity, attitude and potential will determine whether a student is offered a job. It is the student's responsibility to actively conduct a job search in addition to participation in the job search process

operated by the co-op office. Once a student accepts a co-op job offer (verbally or written), his/her job search will end and access to co-op jobs will be removed for that term. Students that do not successfully obtain a co-op work term are expected to continue with their academic studies. The summer term is the exception to this rule. Students should also note that hiring priority is given to Canadian citizens for co-op positions in the Federal Government of Canada.

Registering in Co-op Courses

Students will be registered in a Co-op Work Term course while at work. The number of Co-op Work Term courses that a student is registered in is dependent upon the number of four-month work terms that a student accepts.

While on a co-op work term students may take a maximum of 0.5 credit throughout each four-month co-op work term. Courses must be scheduled outside of regular working hours.

Students must be registered as full-time before they begin their co-op job search (2.0 credits). All co-op work terms must be completed before the beginning of the final academic term. Students may not finish their degree on a co-op work term.

Work Term Assessment and Evaluation

To obtain a Satisfactory grade for the co-op work term students must have:

1. A satisfactory work term evaluation by the co-op employer;
2. A satisfactory grade on the work term report.

Students must submit a work term report at the completion of each four-month work term. Reports are due on the 16th of April, August, and December and students are notified of due dates through their Carleton email account.

Workplace performance will be assessed by the workplace supervisor. Should a student receive an unsatisfactory rating from their co-op employer, an investigation by the co-op program manager will be undertaken. An unsatisfactory employer evaluation does not preclude a student from achieving an overall satisfactory rating for the work term.

Graduation with the Co-op Designation

In order to graduate with the co-op designation, students must satisfy all requirements for their degree program in addition to the requirements according to each co-op program (i.e. successful completion of three or four work terms).

Note: Participation in the co-op option will add up to one additional year for a student to complete their degree program.

Voluntary Withdrawal from the Co-op Option

Students may withdraw from the co-op option of their degree program during a study term ONLY. Students at work may not withdraw from the work term or the co-op option until s/he has completed the requirements of the work term.

Students are eligible to continue in their regular academic program provided that they meet the academic standards required for continuation.

Involuntary or Required Withdrawal from the Co-op Option

Students may be required to withdraw from the co-op option of their degree program for one or any of the following reasons:

1. Failure to achieve a grade of SAT in COOP 1000
2. Failure to pay all co-op related fees
3. Failure to actively participate in the job search process
4. Failure to attend all interviews for positions to which the student has applied
5. Declining more than one job offer during the job search process
6. Continuing a job search after accepting a co-op position
7. Dismissal from a work term by the co-op employer
8. Leaving a work term without approval by the Co-op manager
9. Receipt of an unsatisfactory work term evaluation
10. Submission of an unsatisfactory work term report

Standing and Appeals

The Co-op and Career Services office administers the regulations and procedures that are applicable to all co-op program options. All instances of a student's failure during a work term or other issues directly related to their participation in the co-op option will be reported to the academic department.

Any decision made by the Co-op and Career Services office can be appealed via the normal appeal process within the University.

International Students

All International Students are required to possess a Co-op Work Permit issued by Citizenship and Immigration Canada before they can begin working. It is illegal to work in Canada without the proper authorization. Students will be provided with a letter of support to accompany their application. Students must submit their application for their permit before being permitted to view and apply for jobs on the Co-op Services database. Confirmation of a position will not be approved until a student can confirm they have received their permit. Students are advised to discuss the application process and requirements with the International Student Services Office.

Bachelor of Engineering: Co-op Admission and Continuation Requirements

- Maintain full-time status in each study term (2.0 credits);
- Be eligible to work in Canada (for off-campus work)
- Have successfully completed COOP 1000 [0.0]

In addition to the following:

1. Registered as a full-time student in the Engineering program
2. An overall CGPA of 8.00 or higher;

3. Successfully completed all required first year courses including CCDP 2100 before beginning the first work term;
4. Students must be eligible for third-year standing when they return for a study term after their first work placement.

Students in all Bachelor of Engineering concentrations must successfully complete four (4) work terms to obtain the co-op designation.

Work Term Courses:

Aerospace Engineering and Mechanical Engineering, Biomedical and Mechanical Engineering:	
MAAE 3999 [0.0]	Co-operative Work Term
Architectural Conservation and Sustainability Engineering:	
CIVE 3999 [0.0]	Co-operative Work Term
or ENVE 3999 [0.	Co-operative Work Term
Civil Engineering	
CIVE 3999 [0.0]	Co-operative Work Term
Communications Engineering, Computer Systems Engineering and Software Engineering:	
SYSC 3999 [0.0]	Co-operative Work Term
Biomedical and Electrical Engineering, Electrical Engineering and Engineering Physics:	
ELEC 3999 [0.0]	Co-operative Work Term
Environmental Engineering	
ENVE 3999 [0.0]	Co-operative Work Term
Sustainable and Renewable Energy Engineering	
ELEC 3999 [0.0]	Co-operative Work Term
MAAE 3999 [0.0]	Co-operative Work Term
(depending on student's stream)	

Work/Study Patterns

Aerospace Engineering, Architectural Conservation and Sustainability Engineering, Biomedical and Mechanical Engineering, Civil Engineering, Communications Engineering, Environmental Engineering, Mechanical Engineering, Sustainable and Renewable Energy Engineering

Year 1		Year 2		Year 3		Year 4		Year 5	
Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern
Fall	S	Fall	S	Fall	S	Fall	W	Fall	S
Winter	S	Winter	S	Winter	S	Winter	W	Winter	S
Summer	**O	Summer	O/W	Summer	W	Summer	W		

Electrical Engineering, Engineering Physics

Year 1		Year 2		Year 3		Year 4		Year 5	
Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern
Fall	S	Fall	S	Fall	W	Fall	W	Fall	S
Winter	S	Winter	S	Winter	S	Winter	W	Winter	S
Summer	**O	Summer	W	Summer	S	Summer	W		

Biomedical and Electrical Engineering, Computer Systems Engineering, Software Engineering

Year 1		Year 2		Year 3		Year 4		Year 5	
Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern	Term	Pattern
Fall	S	Fall	S	Fall	S	Fall	W	Fall	S
Winter	S	Winter	S	Winter	W	Winter	S	Winter	S
Summer		Summer	W	Summer	W	Summer	W		

Legend
S: Study
W: Work
O: Optional
***** indicates recommended work study pattern
****** student finds own employer for this work-term.

Admissions Information

Admission Requirements are for the 2018-2019 year only, and are based on the Ontario High School System. Holding the minimum admission requirements only establishes eligibility for consideration. The cut-off averages for admission may be considerably higher than the minimum. See also the **General Admission and Procedures** section of this Calendar. An overall average of at least 70% is normally required to be considered for admission. Some programs may also require specific course prerequisites and prerequisite averages and/or supplementary admission portfolios. Higher averages are required for admission to programs for which the demand for places by qualified applicants exceeds the number of places available. The overall average required for admission is determined each year on a program by program basis. Consult admissions.carleton.ca for further details.

Note: Courses listed as *recommended* are not mandatory for admission. Students who do not follow the recommendations will not be disadvantaged in the admission process.

Degree

- B. Eng.

Admission Requirements

First Year

The Ontario Secondary School Diploma (OSSD) or equivalent including a minimum of six 4U or M courses. The six 4U or M courses must include four prerequisite courses (4U courses in Advanced Functions, Chemistry, Physics, and one of Calculus and Vectors (recommended) or Biology or Earth and Space Science). Although it is not an admission requirement, at least one 4U course in either English or français is recommended.

The overall admission cut-off average and/or the prerequisite course average may be considerably higher than the stated minimum requirements for some Engineering programs.

Advanced Standing

Applications for admission with advanced standing to the program leading to the Bachelor of Engineering degree will be evaluated on an individual basis. Successful applicants will have individual academic subjects, completed with grades of C- or higher, evaluated for academic standing, provided the academic work has been completed at another university or degree-granting college or in another degree program at Carleton University. Students must take a minimum of 1.0 credit of complementary studies at Carleton University.

Co-op Option

Direct Admission to the First Year of the Co-op Option

Applicants must:

1. meet the required overall admission cut-off average and prerequisite course average. These averages may be higher than the stated minimum requirements;
2. be registered as a full-time student in the Engineering degree;
3. be eligible for work in Canada (for off-campus work placements).

Note that meeting the above entrance requirements only establishes eligibility for admission to the program. Enrolment in the co-op option may be limited at the discretion of the department.

Note: continuation requirements for students previously admitted to the co-op option and admission requirements for the co-op option after beginning the program are described in the Co-operative Education Regulations section of this Calendar.

Aerospace Engineering (AERO) Courses

AERO 3002 [0.5 credit]
Aerospace Design and Practice
Design approach and phases. Design integration. Influence of mission and other requirements on vehicle configuration. Trade-off studies, sizing and configuration layout. Flight vehicle loads, velocity-load factor diagram. Structural design: overall philosophy, role in design process, methods.
Prerequisite(s): MAAE 2001 and third-year status in Engineering.
Lectures three hours a week, problem analysis three hours a week.

AERO 3101 [0.5 credit]
Lightweight Structures
Structural concepts; theory of elasticity; bending, torsion and shear in thin-walled beams having single or multi-cell sections; work and energy principles; deformation and force analysis of advanced structures, including stiffened thin-wall panels; finite element methods. Stability and buckling of thin-walled structures.
Prerequisite(s): MAAE 3202.
Lectures three hours a week; problem analysis and laboratories one hour a week.

AERO 3240 [0.5 credit]
Orbital Mechanics
Review of translational kinematics and dynamics. Keplerian two-body problem: Kepler's laws, orbital elements, orbit determination. Orbital perturbations: oblateness of the Earth, atmospheric drag. Orbital maneuvers and interplanetary flights. Advanced topics.
Prerequisite(s): MAAE 2101.
Lectures three hours per week, tutorial one hour per week.

AERO 3700 [0.5 credit]
Aerospace Materials
Properties, behaviour and manufacturing methods for metals, polymers and ceramics used in aerospace applications. Specialty alloys for gas turbines. Properties and manufacture of aerospace composites. Behaviour of materials in space.
Prerequisite(s): MAAE 2700.
Lectures three hours a week; problem analysis and laboratories one hour a week.

AERO 3841 [0.5 credit]
Spacecraft Design I
Design of spacecraft and spacecraft subsystems with emphasis on mission requirements and current design methods: spacecraft configuration, payload, structural, attitude control, thermal, power, and other related subsystems. Spacecraft integration and testing.
Prerequisite(s): AERO 3240.
Lectures three hours a week, tutorials or laboratories three hours per week.

AERO 4003 [0.5 credit]
Aerospace Systems Design
Stress and deflection analysis; fatigue, safe life, damage tolerant design. Propulsion systems integration; landing gear; control and other subsystems. Mechanical component design. Airworthiness regulations and certification procedures. Weight and cost estimation and control. System reliability. Design studies of aircraft or spacecraft components.
Prerequisite(s): MAAE 2202 and AERO 3002.
Lectures three hours a week, problem analysis three hours a week.

AERO 4009 [0.5 credit]
Aviation Management and Certification
Product development, quality control. Strategic organizational analysis and design. Airworthiness, type certification and planning, delegation of authority, airplane flight manual. Aerospace system design and safety.
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours per week.

AERO 4300 [0.5 credit]
Acoustics and Noise Control
Behaviour of compressible fluids, sound waves and properties of sound sources; measurement of sound; human perception of sound; prediction methods based on energy considerations; sound propagation in realistic environments: outdoors, rooms, ducts; absorption and transmission loss, noise control; case studies.
Prerequisite(s): MATH 3705 and fourth-year status in Engineering.
Lectures three hours a week.

AERO 4302 [0.5 credit]
Aerodynamics and Heat Transfer
Differential equations of motion. Viscous and inviscid regions. Potential flow: superposition; thin airfoils; finite wings; compressibility corrections. Viscous flow: thin shear layer approximation; laminar layers; transition; turbulence modeling. Convective heat transfer: free versus forced convection; energy and energy integral equations; turbulent diffusion.
Prerequisite(s): MAAE 3300.
Also offered at the graduate level, with different requirements, as MECH 5000., for which additional credit is precluded.
Lectures three hours a week.

AERO 4304 [0.5 credit]
Computational Fluid Dynamics
Differential equations of motion. Numerical integration of ordinary differential equations. Potential flows: panel methods; direct solution; vortex-lattice methods. Finite-difference formulations: explicit versus implicit methods; stability. Parabolized and full Navier-Stokes equations; conservation form. Transonic and supersonic flows: upwind differencing. Grid transformations. Computer-based assignments.
Prerequisite(s): MAAE 3300 or MECH 3310.
Lectures three hours a week.

AERO 4306 [0.5 credit]
Aerospace Vehicle Performance
Morphology of aircraft and spacecraft. Performance analysis of fixed wing aircraft: drag estimation, propulsion, take-off, climb and landing, endurance, payload/range, manoeuvres; operational economics. Performance analysis of rotor craft: rotor-blade motion, hovering and vertical ascent, forward flight, and autorotation. Rocket propulsion; escape velocity; orbital dynamics.
Prerequisite(s): MAAE 3300.
Lectures three hours a week.

AERO 4308 [0.5 credit]
Aircraft Stability and Control
Static stability and control: equilibrium requirements; longitudinal stability requirements; neutral points; manoeuvring flight; control forces and control requirements; lateral static stability certification requirements. Dynamic stability: axis systems; governing equations; phugoid and short period modes; lateral dynamic modes. Closed-loop control.
Prerequisite(s): MAAE 3300. Additional recommended background: MAAE 4500.
Also offered at the graduate level, with different requirements, as MECH 5101., for which additional credit is precluded.
Lectures three hours a week.

AERO 4402 [0.5 credit]
Aerospace Propulsion
Propulsion requirements, effects of Mach Number, altitude, and application; basic propeller theory; propeller, turboshaft, turbojet, turbofan and rocket; cycle analysis and optimization for gas turbine power plant; inter-relations between thermodynamic, aerodynamic and mechanical designs; rocket propulsion; selection of aeroengines.
Precludes additional credit for MECH 4401.
Prerequisite(s): MAAE 2400 and MAAE 3300.
Lectures three hours a week.

AERO 4442 [0.5 credit]
Transatmospheric and Spacecraft Propulsion
Planetary/interplanetary environments and effects. Launch and spacecraft propulsion: liquid/solid/hybrid rockets, ram/scramjets, combined cycle engines, electrothermal, electromagnetic, electrostatic, nuclear, and propellantless propulsion. Trajectory analysis, multi-staging, separation dynamics. Advanced engine concepts.
Prerequisite(s): AERO 4302 or AERO 4446 or MECH 4406.
Lectures three hours a week.

AERO 4446 [0.5 credit]
Heat Transfer for Aerospace Applications
Fundamentals of heat transfer with emphasis on aerospace systems design. Conduction, convection and radiation modes of heat transfer. Radiation exchange between surfaces and view factors. Radiation in spacecraft thermal control. High speed flight and reentry heating.
Precludes additional credit for MECH 4406.
Prerequisite(s): MAAE 2400, MAAE 3300.
Lectures three hours a week.

AERO 4540 [0.5 credit]
Spacecraft Attitude Dynamics and Control
Rigid body dynamics. The dynamic behavior of spacecraft. Environmental torques. The design of attitude control systems. Gravity gradient, spin, and dual spin stabilization. Attitude manoeuvres. The design of automatic control systems. Impacts of attitude stabilization techniques on mission performance.
Prerequisite(s): MATH 3705, AERO 3240, MAAE 3500 and SYSC 3600.
Lectures three hours a week.

AERO 4602 [0.5 credit]
Introductory Aeroelasticity
Review of structural behaviour of lifting surface elements; structural dynamics, Laplace Transforms, dynamic stability; modal analysis; flutter, Theodorsen's theory; flutter of a typical section; wing flutter, T-tail flutter, propeller whirl flutter; gust response; buffeting, limit cycle flutter.
Prerequisite(s): MAAE 3300 and SYSC 3600.
Lectures three hours a week.

AERO 4607 [0.5 credit]
Rotorcraft Aerodynamics and Performance
Rotorcraft history and fundamentals. Momentum theory: hover, axial climb and descent, autorotation, forward flight, momentum theory for coaxial and tandem rotors. Blade element analysis. Rotor airfoil aerodynamics. Rotor blade dynamics and trim. Helicopter performance, height-velocity curves, conceptual design. High-speed rotorcraft.
Prerequisite(s): MAAE 3300 and MAAE 3004.
Lectures three hours per week.

AERO 4608 [0.5 credit]
Composite Materials
Reinforcing mechanisms in composite materials; material properties. Strength and elastic constants of unidirectional composites; failure criteria. Analysis of laminated plates; bending and eigenvalue problems. Environmental effects and durability. Damage tolerance. Design of composite structures.
Prerequisite(s): MAAE 3202.
Lectures three hours a week.

AERO 4609 [0.5 credit]
Joining of Materials
Design for joining: base material and component geometry. Selection of joining method and filler material; Adhesive bonding; Soldering; Brazing; Diffusion bonding; Resistance welding; Fusion welding (GTAW, EB, laser and plasma arc); Friction welding; NDE. Emphasis on Aerospace materials and applications.
Prerequisite(s): AERO 3700 or MECH 3700.
Lectures three hours per week.

AERO 4842 [0.5 credit]
Spacecraft Design II
System view of spacecraft. Requirements definition. Spacecraft payloads (remote sensing, imaging systems, astronomy instrumentation etc.). Exploration missions. Implications for systems and missions. Space system design case studies.
Precludes additional credit for AERO 4802 (no longer offered).
Prerequisite(s): AERO 3841.
Lectures three hours a week, tutorials or laboratories one hour per week.

Civil Engineering (CIVE) Courses

CIVE 2004 [0.5 credit]
GIS, Surveying, CAD and BIM
Engineering geometry and spatial graphics. Fundamentals of surveys. Digital surveying tools; total station, GPS. Computer-Aided Drafting (CAD). Geographic Information Systems (GIS). Spatial referencing. Building Information Modelling (BIM). Integrated design using digital tools. Field exercises using software to process and evaluate spatial data.
Prerequisite(s): ECOR 1010.
Lectures three hours a week, problem analysis and laboratories three hours a week.

CIVE 2005 [0.5 credit]
Architectural Technology 2
Technical issues involved in architectural design of buildings from ancient times to the present. Technological innovation and materials related to structural developments, and the organization and design of structures. Basic concepts of calculus, equilibrium, and mechanics of materials. Not eligible for use for Bachelor of Engineering degree requirements.
Prerequisite(s): ARCC 2202.
Lectures three hours a week, laboratory three hours a week.

CIVE 2101 [0.5 credit]
Mechanics II
Plane trusses. Virtual work. Friction. Relative motion of particles. Kinematics of a rigid body: translation, rotation; general plane motion; absolute and relative motion. Kinetics of a rigid body: equations of motion; work-energy; impulse-momentum; conservation of momentum and energy. Conservative forces and potential energy.
Precludes additional credit for MAAE 2101 and ECOR 2101.
Prerequisite(s): ECOR 1101 and MATH 1004 and MATH 1104.
Lectures three hours a week, problem analysis three hours a week.

CIVE 2200 [0.5 credit]
Mechanics of Solids I
Stress and strain. Stress-strain relationship: Hooke's law. Torsion of circular shafts. Bending moment and shear force distribution. Flexural stresses. Deflection. Shear stress in beams. Stresses in thin- walled cylinders. Transformation of 2D stress and strain: Mohr's circle. Buckling of columns.
Precludes additional credit for MAAE 2202.
Prerequisite(s): ECOR 1101 for B.Eng. students or CIVE 2005 for B.A.S. with Concentration in Conservation and Sustainability.
Lectures three hours a week, problem analysis and laboratory three hours a week.

CIVE 2700 [0.5 credit]
Civil Engineering Materials
Introduction to material science. Structure of atoms. Crystallography. Crystal Imperfections. Characteristics, behaviour and use of Civil Engineering materials: steel, concrete, asphalt, wood, polymers, composites. Specifications. Physical, chemical and mechanical properties. Quality control and material tests. Fatigue. Corrosion. Applications in construction and rehabilitation of structures.
Prerequisite(s): second year status for students in an Engineering program or second year standing in a B.A.S. major in Conservation and Sustainability.
Lectures three hours a week, problem analysis and laboratory three hours a week.

CIVE 3202 [0.5 credit]
Mechanics of Solids II
Shear flow. Definition of shear centre, Saint Venant and warping torsional constants. Behaviour, governing differential equations and solutions for torsion, beam-columns, lateral torsional buckling of doubly symmetric beams, axially loaded doubly symmetric, singly symmetric and asymmetric columns. Failure criterion, fatigue and fracture.
Precludes additional credit for MAAE 3202.
Prerequisite(s): CIVE 2200.
Lectures three hours a week, laboratory/problem analysis three hours alternate weeks.

CIVE 3203 [0.5 credit]
Introduction to Structural Analysis
Concepts and assumptions for structural analysis: framed structures; joints; supports; compatibility and equilibrium; stability and determinacy; generalized forces and displacements. Principle of Virtual Work: unknown force calculations; influence lines. Complementary Virtual Work: displacement calculations, indeterminate analysis. Introduction to the Stiffness Method of Analysis.
Prerequisite(s): CIVE 2200 and MATH 1004.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 3204 [0.5 credit]
Introduction to Structural Design
Building systems and structural form. Design Philosophy and design process. Limit states design. National Building Code of Canada. Determination of dead, live, snow, wind, and earthquake loads.
Prerequisite(s): CIVE 2200.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 3205 [0.5 credit]
Design of Structural Steel Components
Introduction to CAN/CSA - S16, design and behaviour concepts; shear lag, block shear, local plate buckling, lateral torsional buckling, instantaneous centre, inelastic strength and stability. Design of tension members, axially loaded columns, beams, beam-columns, simple bolted and welded connections.
Prerequisite(s): CIVE 2200 and CIVE 2700.
Recommended prerequisite: CIVE 3204.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 3206 [0.5 credit]
Design of Reinforced Concrete Components
Introduction to CAN/CSA - A23.3; design and behaviour concepts; flexural analysis at service loads; shear, bond, Whitney stress block, under, over reinforced behaviour, ultimate strength. Flexural design of singly reinforced, doubly reinforced T-beams, one-way slabs. Shear design for beams. One-way, two-way slab systems, columns.
Prerequisite(s): CIVE 2200 and CIVE 2700.
Recommended prerequisite: CIVE 3204.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 3207 [0.5 credit]
Historic Site Recording and Assessment
Methods of heritage documentation including hand recording, photography, rectified photography, total station, gps, photogrammetry, and laser scanning. Non-destructive testing techniques; environmental assessment tools for determining air quality and energy efficiency. Multidisciplinary teams for all project work.
Also listed as ARCN 4100.
Prerequisite(s): third-year status in B.Eng. in Architectural Conservation and Sustainability Engineering.
Lectures three hours a week, lab or field work two hours a week.

CIVE 3208 [0.5 credit]
Geotechnical Mechanics
Soil composition and soil classification. Soil properties, compaction, seepage and permeability. Concepts of pore water pressure, capillary pressure and hydraulic head. Principle of effective stress, stress-deformation and strength characteristics of soils, consolidation, stress distribution with soils, and settlement. Laboratory testing.
Also listed as ERTH 4107.
Prerequisite(s): third-year status in Engineering, or permission of the department. Additional recommended background: ERTH 2404 or equivalent.
Lectures three hours a week, laboratory three hours alternate weeks.

CIVE 3209 [0.5 credit]
Building Science
Building envelope design and analysis; applied heat transfer and moisture transport; solar radiation; hygrothermal modelling; control of rain, air, vapour, and heat; materials for wall, window, curtain wall, roof, and foundation systems; building envelope retrofit case studies; building code; envelope construction.
Prerequisite(s): MAAE2400 and third-year status in B.Eng. Architectural Conservation and Sustainability Engineering or in Civil Engineering.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 3304 [0.5 credit]
Transportation Engineering and Planning
Transportation and the socio-economic environment; modal and intermodal systems and components; vehicle motion, human factors, system and facility design; traffic flow; capacity analysis; planning methodology; environmental impacts; evaluation methods.
Also listed as GEOG 4304.
Prerequisite(s): third-year status in Engineering, or permission of the Department.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 3999 [0.0 credit]
Co-operative Work Term

CIVE 4200 [0.5 credit]
Matrix Analysis of Framed Structures
Review of basic structural concepts. Betti's law and applications. Matrix flexibility method, flexibility influence coefficients. Development of stiffness influence coefficients. Stiffness method of analysis: beams; plane trusses and frames; space trusses and frames. Introduction to the finite element method.
Prerequisite(s): CIVE 3203.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4201 [0.5 credit]
Finite Element Methods in Civil Engineering
Introduction to the theory and application of finite element methods. The relationship with virtual work, Rayleigh-Ritz, system of linear equations, polynomial interpolation, numerical integration, and theory of elasticity is explored. Isoparametric formulations of structural and plane elements are examined. Geotechnical and nonlinear problems are introduced.
Prerequisite(s): CIVE 2200 and fourth year status in engineering.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4202 [0.5 credit]
Wood Engineering
Structural design in timber. Properties, anatomy of wood, wood products, factors affecting strength and behaviour, strength evaluation and testing. Design of columns, beams and beam-columns. Design of trusses, frames, glulam structures, plywood components, formwork, foundations, connections and connectors. Inspection, maintenance and repair.
Also listed as ARCC 4202.
Prerequisite(s): CIVE 2200, CIVE 3204.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4208 [0.5 credit]
Geotechnical Engineering
Strength of soils, steady state seepage, flownets and piping. Stress distribution in soils. Earth pressures: at rest, active and passive. Design of flexible and rigid retaining structures. Stability of excavations, slopes and embankments. Settlement of foundations. Bearing capacity of footings.
Prerequisite(s): CIVE 3208.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4209 [0.5 credit]
Highway Engineering
Highway planning; highway location and geometric design; traffic engineering; highway capacity; soil classifications; subgrade and base materials; highway drainage; frost action; structural design of rigid and flexible pavements; highway economics and finance; maintenance and rehabilitation.
Prerequisite(s): Fourth year status in engineering.
Recommended prerequisites: CIVE 2004, CIVE 3304 and CIVE 3208.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4301 [0.5 credit]
Foundation Engineering
A critical study of the theories in soil mechanics and their application to the solution of geotechnical engineering problems. Field investigations, laboratory and field testing, shallow foundations, special footings, mat foundations, pile foundations and excavations. Discussion of new methods and current research.
Prerequisite(s): CIVE 4208.
Lectures three hours a week, laboratory three hours alternate weeks.

CIVE 4302 [0.5 credit]
Reinforced and Prestressed Concrete Design
Reinforced concrete shear and torsion design. Two-way slab design by Direct Design and Equivalent Frame Method. Behaviour and design of slender reinforced concrete columns. Prestressed concrete concepts; flexural analysis and design; shear design; anchorage zone design; deflection and prestress loss determination.
Prerequisite(s): CIVE 3202, CIVE 3203 and CIVE 3206.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4303 [0.5 credit]
Urban Planning
A systematic approach to urban planning; urban sprawl; data collection; forecasting; standards; space requirements; land use; zoning; transportation; land development; site selection; land capability; layout; evaluation; housing; urban renewal and new towns.
Also listed as GEOG 4303.
Prerequisite(s): fourth-year status in Engineering, or permission of the Department.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4307 [0.5 credit]
Municipal Hydraulics
Fluid flow fundamentals. Hydraulics of pipe systems. Open channel flow. Prediction of sanitary and storm sewage, flow rates. Design of water distribution systems, culverts, sanitary and storm sewers. Pumps and measuring devices. Hydraulic and flow control structures.
Prerequisite(s): MAAE 2300.
Lectures three hours a week, problem analysis 1.

CIVE 4308 [0.5 credit]
Behaviour and Design of Steel Structures
Behaviour and design of open web steel joists, steel and composite decks, composite beams and columns, stud girders, and plate girders. Design of moment connections, base plates and anchor bolts, and bracing connections. Stability of rigid and braced frames. Design for lateral load effects.
Prerequisite(s): CIVE 3205 and fourth-year status in Engineering.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4400 [0.5 credit]
Construction/Project Management
Systems approach to project planning and control. Analysis of alternative network planning methods: CPM, precedence and PERT; planning procedure; computer techniques and estimating; physical, economic and financial feasibility; implementation feedback and control; case studies.
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4403 [0.5 credit]
Masonry Design
Introduction to structural design in masonry. Properties of masonry materials and assemblages. Behaviour and design of beams, walls and columns. Selected topics including veneer wall systems, differential movement, workmanship, specifications, inspection, maintenance and repair. Lowrise and highrise building design.
Prerequisite(s): CIVE 3204, CIVE 3206 and fourth-year status in Engineering or permission of the Department.
Also offered at the graduate level, with different requirements, as CIVE 5200, for which additional credit is precluded.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4407 [0.5 credit]
Municipal Engineering
Introduction to fundamentals of municipal engineering. Water quality: physical, chemical and biological parameters. Water treatment: softening mixing, flocculation, sedimentation, filtration, disinfection, fluoridation. Biological processes. Wastewater treatment: primary, secondary and tertiary treatment. Sludge disposal and wastewater reuse. Solid waste management.
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours a week, problem analysis 1.

CIVE 4500 [0.5 credit]
Computer Methods in Civil Engineering
Advanced software development for Civil Engineering applications. Examples may be chosen from surveying, transportation, geotechnical and/or structural engineering. Software technologies include object-oriented programming, data base management, Internet-based applications and graphical user interfaces.
Prerequisite(s): ECOR 2606 and fourth-year status in Engineering.
Also offered at the graduate level, with different requirements, as CIVE 5602, for which additional credit is precluded.
Lectures three hours a week, problem analysis three hours alternate weeks.

CIVE 4601 [0.5 credit]
Building Pathology and Rehabilitation
Deterioration mechanisms for concrete, timber, steel and masonry structures. Identification of design deficiencies; criteria for selection and design of rehabilitation systems. Design techniques to reduce deterioration in new construction and historical structures.
Also listed as ARCN 4200.
Prerequisite(s): CIVE 3207 and fourth-year status in B.Eng. in Architectural Conservation and Sustainability Engineering.
Lectures three hours a week, lab/field work two hours a week.

CIVE 4614 [0.5 credit]
Building Fire Safety
Understanding fire-structure interaction and the concepts of fire severity and resistance; behaviour of steel, concrete, and timber buildings exposed to fires; compartment fire dynamics; correlations and computer models to predict fire dynamics; fire retardants; laboratory-scale fire experiments; performance-based approach for building fire safety design.
Prerequisite(s): MAAE 2400 and fourth-year status in Engineering, or permission of the Department.
Lectures three hours a week, problem analysis and laboratories one and one-half hours per week.

CIVE 4907 [1.0 credit]
Engineering Research Project
A research project in engineering analysis, design or development carried out by individual students or small teams, for an opportunity to develop initiative, self-reliance, creative ability and engineering judgment and is normally intended for students with high CGPAs and an interest in graduate studies.
Precludes additional credit for CIVE 4917.
Prerequisite(s): fourth-year status in Engineering and permission of the department.

CIVE 4917 [0.5 credit]
Undergraduate Directed Study
Student carries out a study, analysis, and solution of an engineering problem which results in a written final report. Carried out under close supervision of a faculty member. Intended for students interested in pursuing graduate studies. Requires supervising faculty member and proposal from student.
Precludes additional credit for CIVE 4907.
Prerequisite(s): permission of the Department and completion of, or concurrent registration in, CIVE 4918.
Self study.

CIVE 4918 [1.0 credit]
Design Project
Teams of students develop professional level experience through a design project that incorporates fundamentals acquired in previous mathematics, science, engineering, and complementary studies courses. A final report and oral presentations are required.
Prerequisite(s): ECOR 3800 and fourth-year status in Engineering. Certain projects may have additional requirements.
Lectures two hours alternate weeks, problem analysis three hours a week.

Electronics (ELEC) Courses

ELEC 1908 [0.5 credit]
First Year Project
A practical introduction to engineering design. Students work in small teams to specify, design and implement a system, formally managing the project progress and submitting oral and written reports. Professionalism: engineering ethics; health and safety. Technology, society and the environment.
Prerequisite(s): registration in the Engineering Physics program.
Lectures and tutorials three hours a week, laboratory four hours a week.

ELEC 2501 [0.5 credit]
Circuits and Signals
Properties of signals. Basic circuit elements: voltage and current sources. Kirchhoff's laws, linearity, superposition. Thevenin and Norton's theorems. Circuit simplification. AC steady-state analysis: impedance, admittance, phasors, frequency response. Transient response of RL and RC circuits: form of response, initial and final conditions. RLC circuits: resonance.
Prerequisite(s): MATH 1005 and (PHYS 1004 or PHYS 1002).
Lectures three hours a week, laboratory and problem analysis three hours a week.

ELEC 2507 [0.5 credit]
Electronics I
Qualitative semiconductor physics, leading to the diode equation. Diode applications. Operational amplifiers and their application in feedback configurations including active filters. Introduction to bipolar transistors and MOSFETs, analysis of biasing circuits. Transistor applications including small signal amplifiers.
Precludes additional credit for PLT 2006.
Prerequisite(s): ELEC 2501.
Lectures three hours a week, laboratory and problem analysis three hours a week.

ELEC 2607 [0.5 credit]
Switching Circuits
Boolean algebra, gate, combinatorial circuits. DeMorgan notation, sum-of-product and product-of-sum forms. Logic arrays, PLAs and PALs. Flip-flops, latches, sequential circuits, state graphs and state minimization. Counters and controllers. Hazards. Asynchronous sequential circuits, race free assignment, realization.
Precludes additional credit for SYSC 2310.
Prerequisite(s): PHYS 1004 or PHYS 1002.
Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 3105 [0.5 credit]
Basic EM and Power Engineering
Electrostatics and magnetostatics. Solution of Poisson's and Laplace's equations. The Lorenz equation and force. Time varying fields. Magnetic circuits and transformers. DC and AC machines. Basic three-phase power.
Prerequisite(s): MATH 2004 and (PHYS 1004 or PHYS 1002).
Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 3500 [0.5 credit]
Digital Electronics
Digital circuit design using verilog and logic synthesis, the electronic properties of logic gates, electrical interfacing between logic families, asynchronous to synchronous interfacing, clock distribution and timing, VLSI design options. Students implement substantial circuits with field-programmable gate arrays.
Prerequisite(s): ELEC 2507 and ELEC 2607.
Lectures three hours a week, laboratory three hours a week.

ELEC 3508 [0.5 credit]
Power Electronics
Power transformers. DC and AC motors. Power semiconductor devices: Thyristors, Triacs, MCTs, IGBTs). Converter circuits: controlled AC to DC rectifiers, choppers, DC to AC inverters, AC voltage controllers, cycloconverters. Protection of conversion circuits. Applications to high-efficiency control of electric machines and electromechanical energy conversion devices.
Prerequisite(s): ELEC 2501 and ELEC 2507.
Lectures three hours per week, laboratories/problem analysis three hours per week.

ELEC 3509 [0.5 credit]
Electronics II
Introduction to semiconductor devices and ICs. DC, AC and switching properties of BJTs. Linear amplifiers; bandwidth considerations; two-port analysis. Large signal amplifiers; power amplifiers; transformerless circuits. Feedback and operational amplifiers; gain, sensitivity, distortion and stability. Filter design. Oscillators.
Precludes additional credit for : ELEC 3509 may not be taken for credit by students in the Biomedical and Electrical Engineering or Biomedical and Mechanical Engineering programs.
Prerequisite(s): ELEC 2507.
Lectures three hours a week, laboratory three hours a week.

ELEC 3605 [0.5 credit]
Electrical Engineering
DC circuits: elements, sources, analysis. Single phase AC circuits: phasors, RLC circuits, real and reactive power, impedance, network analysis, three phase systems. Power transformers. DC motors: operation and characteristics. AC motors: single phase and three phase.
Precludes additional credit for ELEC 2501.
Prerequisite(s): MATH 1005 and (PHYS 1004 or PHYS 1002).
Lectures three hours a week, problem analysis 1.5 hours a week.

ELEC 3907 [0.5 credit]
Engineering Project
Student teams work on open-ended projects based on previously acquired knowledge. Lectures are devoted to discussing project-related issues and student presentations. A project proposal, a series of project reports, and oral presentations, and a comprehensive final report are required.
Prerequisite(s): ELEC 2607, ELEC 2507, and ECOR 2606, and enrolment in the Electrical Engineering program.
Lecture two hours per week, laboratory six hours per week.

ELEC 3908 [0.5 credit]
Physical Electronics
Fundamentals of device physics and operation of the pn junction, bipolar transistor and MOSFET. Basic integrated circuit processing and application to diodes, BJTs and MOSFETs. Correlation between processing, structure, operation and modeling. Consideration of parasitic and small-geometry effects, reliability and process variation.
Precludes additional credit for ELEC 4705.
Prerequisite(s): ELEC 2507.
Lectures three hours a week, problem analysis two hours a week.

ELEC 3909 [0.5 credit]
Electromagnetic Waves
Maxwell's equations and EM wave solutions. Polarization. Poyntingvector. EM waves in dielectrics and conductors; skin depth. Reflection and refraction. Standing waves. Fresnel relations, Brewster angle. Transmission lines. Line termination, basic impedance matching and transformation. Smith charts. Introduction to guided waves; slab waveguide.
Precludes additional credit for PHYS 3308.
Prerequisite(s): ELEC 3105 or permission of the Department.
Lectures three hours a week, problem analysis three hours alternate weeks.

ELEC 3999 [0.0 credit]
Co-operative Work Term

ELEC 4502 [0.5 credit]
Microwave Circuits
Introduction to microwave semiconductor devices, microwave passive components, microwave integrated circuit technology, and microwave circuit measurements. Basic network theory and scattering matrix description of circuits. Design of matching networks, filters, amplifiers and oscillators at microwave frequencies.
Prerequisite(s): ELEC 4503; may be taken concurrently.
Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4503 [0.5 credit]
Radio Frequency Lines and Antennas
Introduction to distributed circuits, travelling and standing waves, reflection coefficient, SWR, impedance transformation, Smith charts. Introduction to transmission lines; coaxial, rectangular waveguide, resonators, optical fibers. Introduction to antennas; gain, directivity, effective area. Introduction to linear arrays.
Prerequisite(s): ELEC 3909.
Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4504 [0.5 credit]
Avionics Systems
Electromagnetic spectrum. Air data sensing, display. Communications systems. Navigation and landing systems; ground-based, inertial and satellite systems. Airborne radar. Guidance, control for aircraft, autopilots; stability augmentation; active control; sensor requirements; display techniques. Aircraft power systems. Safety systems. Vehicle/systems integration, certification.
Precludes additional credit for AERO 4504.
Prerequisite(s): fourth-year status in Engineering. Not open to students in Electrical Engineering, Computer Systems Engineering, Aerospace Stream C Engineering, Engineering Physics or Communications Engineering.
Lecture three hours a week.

ELEC 4505 [0.5 credit]
Telecommunication Circuits
A course of study of the commonly used circuit components in modern telecommunication systems. Both analog and digital systems are included. The design of the hardware is emphasized. Examples are drawn from broadcasting, telephony and satellite systems.
Prerequisite(s): ELEC 3509 and (SYSC 3501 or SYSC 3503).
Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4506 [0.5 credit]
Computer-Aided Design of Circuits and Systems
Basic principles of Computer-Aided Design tools used for analysis and design of communication circuits and systems. Frequency and time-domain analysis. Noise and distortion analysis. Transmission line effects. Sensitivity analysis, and circuit performance optimization. Digital simulation.
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4509 [0.5 credit]
Communication Links
Fundamentals; decibel, intermodulation, 1dB compression, dynamic range, SNR, noise figure, noise temperature, antenna gain, EIRP, G/T. Line-of-sight links; receiver, diversity, fade margin. Satellite links; link calculations, multiple accessing, earth stations. Fiber links, fiber types, sources, detectors, systems.
Prerequisite(s): fourth-year status in Engineering or permission of the Department.
Lectures three hours a week, problem analysis three hours alternate weeks.

ELEC 4600 [0.5 credit]
Radar and Navigation
Radar: operation, minimum detectable signal, propagation effects. Surveillance Radars: Moving Target indicator and Pulse Doppler operation. Radio Navigation: pulsed and CW operation. Operational systems: Loran C., VOR/DME, TACAN, Global Positioning system. Inertial Navigation. Navigation Co-ordinate Systems. Techniques for determining best estimates of position.
Prerequisite(s): fourth-year status in Engineering or permission of the Department.
Lectures three hours a week, problem analysis 3 hours alternate weeks.

ELEC 4601 [0.5 credit]
Microprocessor Systems
Interfacing aspects in microprocessor systems. Microprocessors and bus structures, internal architecture, instruction set and pin functions. Memory interfacing, input-output, interrupts, direct memory accesses, special processors and multiprocessor systems.
Precludes additional credit for COMP 3006, SYSC 3320, SYSC 3601.
Prerequisite(s): ELEC 2607 and one of SYSC 2003 or SYSC 3003 or SYSC 3006 or permission of the Department.
Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4602 [0.5 credit]
Electrical Power Engineering
The electric power system. Major components: induction and synchronous machines, power transformers and connections, transmission. Analysis: balanced and unbalanced three-phase systems, symmetrical components, load flow. Operation: frequency control, steady state and transient generator stability, voltage collapse, thermal constraints. Variable speed drives, power quality.
Prerequisite(s): ELEC 2501 or ELEC 3605.
Lectures three hours a week, problem analysis two hours every week.

ELEC 4609 [0.5 credit]
Integrated Circuit Design and Fabrication
Introduction to nMOS IC design: static logic gates, noise margin, transmission gates, factors influencing switching speed, dynamic logic, input protection, output buffers, circuit simulation with SPICE. Laboratory work includes design and layout of a simple nMOS IC that is fabricated and returned for testing.
Prerequisite(s): ELEC 3500 or ELEC 3908.
Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4700 [0.5 credit]
The Physics and Modeling of Advanced Devices and Technologies
Fabrication, operation and modeling of advanced devices for information technology. Topics: physics of materials, quantum mechanics of solids, optical transitions, physical analysis and models for state-of-the-art electronic/optical technologies and materials. Technologies: MOS and III-V based transistors, solid-state optical devices, MEMS and nano-technology based devices.
Prerequisite(s): ELEC 3908.
Lectures three hours a week, problem analysis two hours alternate weeks.

ELEC 4702 [0.5 credit]
Fiber Optic Communications
Fundamentals of optoelectronics with application to fiber optic communications. Optical fibre: modes, losses, dispersion, splices and coupling to sources. Optical sources: LEDs and laser diodes. Optical detectors: photoconductor, pin and avalanche photodiodes. Optical receiver design. Fiber optic communications systems: intensity modulation/direct detection; coherent homodyne or heterodyne detection.
Prerequisite(s): ELEC 3908 and ELEC 3909.
Lectures three hours a week, laboratory three hours alternate weeks.

ELEC 4703 [0.5 credit]
Solar Cells
Semiconductor band structure, photogeneration, the solar spectrum. Detailed analysis of monocrystalline silicon solar cells. Solar cells based on thin film materials: amorphous silicon, III-V materials, organics, titania-dye cells. Cells for concentrator systems. Photovoltaic power systems. Solar cells for building envelopes.
Prerequisite(s): ELEC 2501 and ELEC 2507 and fourth-year status in Sustainable and Renewable Energy Engineering, or ELEC 2501 and ELEC 2507 and fourth-year status in Engineering with permission of the instructor.
Lectures three hours per week, laboratories/problem analysis three hours alternate weeks.

ELEC 4704 [0.5 credit]
Nanoscale Technology and Devices
Engineering at the nanoscale. Quantum confinement and the effect of scale. Analysis tools: microscopy, spectroscopy. Fabrication: thin films, nanoparticles, nanotubes, graphene, organics. Structures and properties: quantum wells, nanocrystals, nanostructuring. Applications and devices: electronics, optoelectronics, photonics.
Prerequisite(s): ELEC 3908.
Lectures three hours a week, problem analysis 1.5 hours a week.

ELEC 4705 [0.5 credit]
Electronic Materials, Devices and Transmission Media
Review of solid-state theory, conductors, semiconductors, superconductors, insulators, and optical and magnetic properties. Devices used in modern high speed electronic and communication systems: transistors, lasers, photodiodes, fiber optics, Josephson junctions. Implications of material properties on fabrication and operation of devices and circuits.
Precludes additional credit for ELEC 3908.
Prerequisite(s): fourth-year status in Engineering. Not available for credit to students in Electrical Engineering or Engineering Physics.
Lectures three hours a week.

ELEC 4706 [0.5 credit]
Digital Integrated Electronics
Lectures and hands-on experience introduce advanced concepts in digital interfacing and hardware simulation. Industry standard programmable ASIC design tools, interfacing techniques and System on a Chip are introduced along with hardware modeling and design flow. A modern laboratory includes software and hardware digital design tools.
Prerequisite(s): ELEC 3500.
Lectures two hours a week, laboratory three hours a week.

ELEC 4707 [0.5 credit]
Analog Integrated Electronics
Emphasis on integration of analog signal processing techniques in monolithic IC technology. Continuous active filter design. MOS IC technology. OP amp design. Basic sampled data concepts; Z-transform analysis, switched capacitor filters. Noise aspects. Bipolar technology: radio frequency IC design.
Prerequisite(s): ELEC 3509.
Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4708 [0.5 credit]
Advanced Digital Integrated Circuit Design
Advanced Verilog, test benches. VLSI design based on CMOS technology, characteristics of CMOS logic circuits, cell libraries, building blocks, structured design, testing, Computer-Aided Design tools. Laboratory emphasis on design synthesis from Verilog.
Prerequisite(s): fourth-year status in Engineering and ELEC 3500) or permission of the department.
Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4709 [0.5 credit]
Integrated Sensors
Overview of sensor technologies with emphasis on devices suitable for integration with silicon integrated circuits. Sensor design and fabrication principles including signal conditioning; discussion of automotive, biomedical, and other instrumentation applications.
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4906 [0.5 credit]
Special Topics
At the discretion of the Engineering Faculty Board, a course dealing with selected advanced topics of interest to students in Biomedical and Electrical, Communications, Computer Systems, Electrical and Software Engineering and Engineering Physics may be offered.
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

ELEC 4907 [1.0 credit]
Engineering Project
Student teams develop professional-level experience by applying, honing, integrating, and extending previously acquired knowledge in a major design project. Lectures are devoted to discussing project-related issues and student presentations. A project proposal, interim report, oral presentations, and a comprehensive final report are required.
Prerequisite(s): ELEC 3907, ECOR 4995 (may be taken concurrently) and fourth-year status in Engineering.
Lecture one hour a week, laboratory seven hours a week.

ELEC 4908 [1.0 credit]
Engineering Physics Project
Student teams develop professional-level experience by applying, honing, integrating, and extending previously acquired knowledge in a major design project approved for Engineering Physics. Lectures devoted to discussing project-related issues and student presentations. A project proposal, interim report, oral presentations, and comprehensive final report are required.
Prerequisite(s): fourth-year status in Engineering and ECOR 4995 (may be taken concurrently). Certain projects may have additional prerequisites or corequisites.
Lecture one hour a week, laboratory seven hours a week.

Engineering Core (ECOR) Courses

ECOR 1010 [0.5 credit]
Introduction to Engineering
Technology, society and the environment. Graphical design communication: sketching, graphical projections; CAD. Managing data: statistical methods; spreadsheets. Design analysis: matrix programming software; symbolic computer algebra systems. Design process: proposals; reports; presentations; reporting software.
Precludes additional credit for ECOR 1000.
Lectures four hours per week, laboratories two hours per week.

ECOR 1101 [0.5 credit]
Mechanics I
Introduction to mechanics. Scalars and vectors. Concurrent forces: resultant and components. Statics of particles. Moments and couples. Force system resultants. Rigid body equilibrium. Frames and machines. Internal forces. Kinematics and kinetics of particles. Conservation theorems: work-energy; impulse-momentum. Centroids and centres of gravity.
Prerequisite(s): MATH 1004 and MATH 1104.
Lectures three hours a week, tutorials and problem analysis three hours a week.

ECOR 1606 [0.5 credit]
Problem Solving and Computers
Introduction to engineering problem solving. Defining and modeling problems, designing algorithmic solutions, using procedural programming, selection and iteration constructs, functions, arrays, converting algorithms to a program, testing and debugging. Program style, documentation, reliability. Applications to engineering problems; may include numerical methods, sorting and searching.
Precludes additional credit for SYSC 1005, SYSC 1100(no longer offered), SYSC 1102(no longer offered), COMP 1005, COMP 1405.
Lectures three hours a week, laboratory three hours a week.

ECOR 2050 [0.5 credit]
Design and Analysis of Engineering Experiments
Statistics and the design of engineering experiments. Basic exploratory data analysis. Central limit theorem. Hypothesis testing: t-test, chi-square test, type-I and type-II errors, multiple-comparison problem. Statistical bias. Design of experiments: randomization, blocking and replication, randomized blocking designs, factorial design. Statistical software packages.
Prerequisite(s): 2nd Year Status in Engineering.
Lectures three hours a week, problem analysis and laboratory three hours a week.

ECOR 2606 [0.5 credit]
Numerical Methods
Numerical algorithms and tools for engineering and problem solving. Sources of error and error propagation, solution of systems of linear equations, curve fitting, polynomial interpolation and splines, numerical differentiation and integration, root finding, solution of differential equations. Software tools.
Precludes additional credit for SYSC 2606.
Prerequisite(s): MATH 1005 and (ECOR 1606 or SYSC 1005) and (ECOR 1010 or ELEC 1908).
Lectures three hours a week, laboratory 1.

ECOR 3800 [0.5 credit]
Engineering Economics
Introduction to engineering economics; cash flow calculations; methods of comparison of alternatives; structural analysis; replacement analysis; public projects; depreciation and income tax; effects of inflation; sensitivity analysis; break-even analysis; decision making under risk and uncertainty.
Prerequisite(s): third-year status in Engineering.
Lectures three hours a week.

ECOR 4995 [0.5 credit]
Professional Practice
Presentations by faculty and external lecturers on the Professional Engineers Act, professional ethics and responsibilities, practice within the discipline and its relationship with other disciplines and to society, health and safety, environmental stewardship, principles and practice of sustainable development. Communication skills are emphasized.
Precludes additional credit for MAAE 4905, CIVE 4905, SYSC 3905 or ELEC 3905.
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours a week.

Environmental Engineering (ENVE) Courses

ENVE 1001 [0.5 credit]
Architecture and the Environment
Impacts of the environment on architecture; deterioration, freeze/thaw, solar heat, air pollution, moisture; Impacts of architecture on the environment; ecologic footprint, energy consumption, air quality, waste generation; designing with the environment; renewable energy, effective siting and landscape, passive solar energy, natural lighting, energy efficiency.
Lectures three hours a week.

ENVE 2001 [0.5 credit]
Process Analysis for Environmental Engineering
Material and energy balances for reacting and non-reacting systems. Applications in mining, metallurgy, pulp and paper, power generation, energy utilization. Emissions to the environment per unit product or service generated. Introduction to life cycle analysis, comparative products and processes.
Prerequisite(s): CHEM 1002 or CHEM 1101 or equivalent, and MAAE 2400 (may be taken concurrently).
Lectures two hours a week, problem analysis three hours a week.

ENVE 2002 [0.5 credit]
Microbiology
The biology of the Bacteria, Archaea, Viruses and Protozoans, from the fundamentals of cell chemistry, molecular biology, structure and function, to their involvement in ecological and industrial processes and human disease.
Also listed as BIOL 2303.
Prerequisite(s): BIOL 1103 or CHEM 1002 or CHEM 1101 or equivalent.
Lectures three hours a week.

ENVE 3001 [0.5 credit]
Water Treatment Principles and Design
Theoretical aspects of unit operations for water treatment with design applications. Topics include water characteristics and contaminants, coagulation, flocculation, sedimentation, filtration, adsorption, ion exchange, membrane processes, disinfection and disinfection by-products, and management of water treatment residuals. Laboratory procedures: settling operations, filtration, aeration, and adsorption.
Prerequisite(s): ENVE 3002.
Lectures three hours a week, problem analysis one hour a week, laboratory three hours alternate weeks.

ENVE 3002 [0.5 credit]
Environmental Engineering Systems Modeling
Engineered systems for pollution abatement; chemical reaction engineering; reaction kinetics and rate data analysis; design and modeling of reactors; single and multiple reactions; ideal and nonideal reactors; single and multi-parameter models; biochemical reaction engineering; process control. Laboratory procedures: reactor systems performance: Batch, CSTR and PFR.
Prerequisite(s): CHEM 1002 or CHEM 1101 or equivalent and MATH 2004. Additional recommended background: ENVE 2001.
Lectures three hours a week, problem analysis one hour a week, laboratory three hours alternate weeks.

ENVE 3003 [0.5 credit]
Water Resources Engineering
A quantitative analysis of natural water systems and the development of these systems as a resource. Components of the hydrologic cycle. Quantitative analysis of stream flow. Probability concepts in water resources. Reservoir design and operation. Hydraulic properties and availability of groundwater. Storm water management.
Also listed as GEOG 4103.
Prerequisite(s): recommended background: MAAE 2300.
Lectures three hours a week, problem analysis one hour a week.

ENVE 3004 [0.5 credit]
Contaminant and Pollutant Transport in the Environment
Physical phenomenon governing the transport of contaminants in the environment: diffusion, advection, dispersion, sorption, interphase transfer. Derivation and application of transport equations in air, surface and groundwater pollution; analytical and numerical solutions. Equilibrium partitioning of contaminants among air, water, sediment, and biota.
Prerequisite(s): CHEM 1002 or CHEM 1101 or equivalent; ENVE 3002.
Lectures three hours a week, problem analysis one hour a week.

ENVE 3909 [0.5 credit]
Work Term 3

ENVE 3999 [0.0 credit]
Co-operative Work Term

ENVE 4002 [0.5 credit]
Environmental Geotechnical Engineering
Landfill design; hydrogeologic principles, water budget, landfill liners, geosynthetics, landfill covers, quality control/quality assurance, clay leachate interaction, composite liner design and leak detection. Landfill operation, maintenance and monitoring. Case studies of landfill design and performance. Geotechnical design of environmental control and containment systems.
Prerequisite(s): ENVE 3004, CIVE 3208.
Also offered at the graduate level, with different requirements, as ENVE 5201/EVG 7201, for which additional credit is precluded.
Lectures three hours a week, problem analysis one hour a week.

ENVE 4003 [0.5 credit]
Air Pollution and Emissions Control
Air pollutants, classification, sources, and effects. Ambient air quality objectives and monitoring. Pollutant formation mechanisms in combustion. Major pollutant categories and control methods. Indoor air quality. Laboratory procedures: emissions from boilers and IC engines, particulate size distribution and control, IAQ parameters.
Prerequisite(s): ENVE 2001 and fourth-year status in Engineering or permission of the department.
Also offered at the graduate level, with different requirements, as ENVE 5101/EVG 5101, for which additional credit is precluded.
Lectures three hours a week, problem analysis one hour a week, laboratory three hours alternate weeks.

ENVE 4005 [0.5 credit]
Wastewater Treatment Principles and Design
Theoretical aspects of unit operations and processes for wastewater treatment with design applications. Topics include wastewater characteristics, flow rates, primary treatment, chemical unit processes, biological treatment processes, advanced wastewater treatment, disinfection, biosolids treatment and disposal. Laboratory procedures: activated sludge, anaerobic growth, chemical precipitation, disinfection.
Prerequisite(s): ENVE 3001, ENVE 3002.
Lectures three hours a week, problem analysis one hour a week, laboratory three hours alternate weeks.

ENVE 4006 [0.5 credit]
Contaminant Hydrogeology
Theory of flow through porous media. Site investigation: geology, hydrology and chemistry. Contaminant transport. Unsaturated and multiphase flow. Numerical modeling. Site remediation and remediation technologies.
Prerequisite(s): ENVE 3004 and MAAE 2300. Additional recommended background: ENVE 3003.
Also offered at the graduate level, with different requirements, as ENVE 5301/EVG 7301, for which additional credit is precluded.
Lectures three hours a week, problem analysis three hours alternate weeks.

ENVE 4101 [0.5 credit]
Waste Management
Municipal, hazardous, and mine waste management. Waste composition and potential impacts, collection and transport, recycling and reuse, biological and thermal treatments, isolation. Integrated waste management planning.
Prerequisite(s): ENVE 3001, ENVE 3002 and ENVE 3004.
Also offered at the graduate level, with different requirements, as ENVE 5203/EVG 5203, for which additional credit is precluded.
Lectures three hours a week, problem analysis one hour a week.

ENVE 4104 [0.5 credit]
Environmental Planning and Impact Assessment
Canada and U.S. environmental regulations. Framework for Environmental Impact Assessment, survey techniques for impact assessment and EIA review process. Case studies of selected engineering projects. Environmental planning, management of residuals and environmental standards. Risk assessment, policy development and decision-making. Fault-tree analysis.
Prerequisite(s): ENVE 3004 and fourth-year status in Engineering.
Lectures three hours a week, problem analysis three hours alternate weeks.

ENVE 4105 [0.5 credit]
Green Building Design
Concepts, calculations, modeling; design of green buildings and their components; sustainable sites and landscaping; passive design; building envelope; building materials; daylighting; heating, cooling, and ventilation; building-integrated renewable energy systems; indoor environmental quality; overview of building standards and codes.
Prerequisite(s): fourth-year status in B.Eng. Architectural Conservation and Sustainability Engineering, Environmental Engineering or Civil Engineering or fourth-year standing in B.A.S. concentration in Conservation and Sustainability.
Lectures three hours a week, problem analysis one hour per week.

ENVE 4106 [0.5 credit]
Indoor Environmental Quality
Indoor environmental quality (air quality, thermal, visual, and acoustic comfort); physical and chemical parameters for characterization. Types and sources of indoor air pollution and discomfort; measurement techniques. Heating, ventilation, air conditioning, lighting practices and issues. Modelling of and design for indoor environmental quality.
Prerequisite(s): fourth year status in B.Eng. Architectural Conservation and Sustainability Engineering or B.Eng. Environmental Engineering or fourth year standing in B.A.S. concentration in Conservation and Sustainability. Also offered at the graduate level, with different requirements, as ENVE 5104, for which additional credit is precluded.
Lectures three hours a week, problem analysis and laboratory three hours alternate weeks.

ENVE 4907 [1.0 credit]
Engineering Research Project
A research project in engineering analysis, design or development carried out by individual students or small teams, for an opportunity to develop initiative, self-reliance, creative ability and engineering judgment and is normally intended for students with high CGPAs and an interest in graduate studies.
Precludes additional credit for ENVE 4917.
Prerequisite(s): fourth-year status in Engineering and permission of the department.

ENVE 4917 [0.5 credit]
Undergraduate Directed Study
Student carries out a study, analysis, and solution of an engineering problem which results in a written final report. Carried out under close supervision of a faculty member. Intended for students interested in pursuing graduate studies. Requires supervising faculty member and proposal from student.
Precludes additional credit for ENVE 4907.
Prerequisite(s): permission of the Department and completion of, or concurrent registration in, ENVE 4918.
Self study.

ENVE 4918 [1.0 credit]
Design Project
Teams of students develop professional level experience through a design project that incorporates fundamentals acquired in previous mathematics, science, engineering, and complementary studies courses. A final report and oral presentations are required.
Prerequisite(s): ECOR 3800 and fourth-year Status in Engineering. Certain projects may have additional requirements.
Lectures two hours alternate weeks, problem analysis three hours a week.

Mechanical Engineering (MECH) Courses

MECH 3002 [0.5 credit]
Machine Design and Practice
The design of mechanical machine elements is studied from theoretical and practical points of view. Topics covered include: design factors, fatigue, and discrete machine elements. Problem analysis emphasizes the application to practical mechanical engineering problems.
Prerequisite(s): MAAE 2001 and MAAE 3202.
Lectures three hours a week, problem analysis three hours a week.

MECH 3310 [0.5 credit]
Biofluid Mechanics
Applications of fundamental fluid mechanics to human circulatory and respiratory systems. Basic viscous flow theory including: blood flow in the heart and large arteries, air flow in extra-thoracic (nose-mouth throat) airways and lungs.
Prerequisite(s): MATH 2004 and MAAE 2300.
Lectures three hours per week, laboratories or tutorials three hours per week.

MECH 3700 [0.5 credit]
Principles of Manufacturing
Manufacturing processes, materials. Casting: solidification and heat flow theory, defect formation, casting design. Metal forming: elementary plasticity theory, plastic failure criteria, force and work calculations. Bulk and sheet forming. Joining: heat flow and defect formation theory, residual stresses. Machining theory and methods. Hardening: diffusion, wear resistance.
Prerequisite(s): MAAE 2700.
Lectures three hours a week, problem analysis and laboratories one hour a week.

MECH 3710 [0.5 credit]
Biomaterials
Materials used in biomedical applications: metals, polymers, ceramics and composites. Material response and degradation. Properties of biologic materials; bone, cartilage, soft tissue. Materials selection for biocompatibility.
Prerequisite(s): MAAE 2700.
Lectures three hours per week, laboratories and problem analysis three hours per week.

MECH 4003 [0.5 credit]
Mechanical Systems Design
Design of mechanical systems: establishing design criteria, conceptual design, design economics, value analysis, synthesis and optimization. Mechanical elements/systems: gear and flexible drive systems, fluid power systems. These elements are utilized in group design projects.
Prerequisite(s): MECH 3002.
Lectures three hours a week, problem analysis three hours a week.

MECH 4006 [0.5 credit]
Vehicle Engineering I
The course emphasizes the engineering and design principles of road transport vehicles. Topics to be covered include: performance characteristics, handling behaviour and ride quality of road vehicles.
Prerequisite(s): MAAE 2101, MAAE 3004 (Dynamics of Machinery) and third- or fourth-year status in Engineering.
Lectures three hours a week.

MECH 4007 [0.5 credit]
Vehicle Engineering II
Engineering and design principles of off-road vehicles and air cushion technology. Topics include: mechanics of vehicle-terrain interaction - terramechanics, performance characteristics of off-road vehicles, steering of tracked vehicles, air cushion systems and their performance, applications of air cushion technology to transportation.
Prerequisite(s): MAAE 2101, MAAE 3004 (Dynamics of Machinery) and third-or fourth-year status in Engineering.
Lectures three hours a week.

MECH 4013 [0.5 credit]
Biomedical Device Design
Medical Devices: the industry and its regulation. Design methodologies. Examination of specific medical devices: surgical equipment, orthopedic devices, rehabilitation engineering, life support, artificial organs. Case studies.
Prerequisite(s): MECH 4210.
Lectures three hours per week, laboratories or tutorial three hours per week.

MECH 4101 [0.5 credit]
Mechanics of Deformable Solids
Course extends the student's ability in design and stress analysis. Topics include: introductory continuum mechanics, theory of elasticity, stress function approach, Lamé and Mitchell problems, stress concentrations, thermoelasticity and plasticity.
Prerequisite(s): MAAE 3202.
Lectures three hours a week.

MECH 4103 [0.5 credit]
Fatigue and Fracture Analysis
Elastic and elasto-plastic fracture mechanics. Fatigue design methods, fatigue crack initiation and growth Paris law and strain-life methods. Fatigue testing, scatter, mean stress effects and notches. Welded and built up structures, real load histories and corrosion fatigue. Damage tolerant design and fracture control plans.
Prerequisite(s): MAAE 3202.
Lectures three hours a week.

MECH 4104 [0.5 credit]
Vibration Analysis
Free and forced vibrations of one and two degree-of-freedom systems. Vibration measurement and isolation. Numerical methods for multi-degree-of-freedom systems. Modal analysis techniques. Dynamic vibration absorbers. Shaft whirling. Vibration of continuous systems: bars, plates, beams and shafts. Energy methods. Holzer method.
Prerequisite(s): MAAE 3004.
Lectures three hours per week.

MECH 4210 [0.5 credit]
Biomechanics
The biomechanics of biological systems; muscles and movement, nerves and motor control. Measurements of motion, strain and neural signals. The hand and manipulation; locomotion and the leg.
Prerequisite(s): MAAE 3202 and MECH 3710. Additional recommended background: MECH 3310.
Lectures three hours per week, laboratories or tutorials three hours per week.

MECH 4305 [0.5 credit]
Fluid Machinery
Types of machines. Similarity: performance parameters; characteristics; cavitation. Velocity triangles. Euler equation: impulse and reaction. Radial pumps and compressors: analysis, design and operation. Axial pumps and compressors: cascade and blade-element methods; staging; off-design performance; stall and surge. Axial turbines. Current design practice.
Prerequisite(s): MAAE 3300.
Lectures three hours a week.

MECH 4401 [0.5 credit]
Power Plant Analysis
Criteria of merit; selection of power plant for transportation and power generation applications; interrelation among mechanical, thermodynamic and aerodynamic design processes; jet propulsion, turbojets and turbofans; alternative proposals for vehicular power plant; combined cycle applications.
Precludes additional credit for Engineering AERO 4402.
Prerequisite(s): MAAE 2400.
Lectures three hours a week.

MECH 4403 [0.5 credit]
Power Generation Systems
Steam generators, solid, liquid, gaseous and biofuels and cycles. Geothermal, solar powerplants. Energy storage. Environmental aspects of power generation. Industrial use and auto-generation of energy. Energy intensity and efficiency of industrial processes and products. Comparative analysis of raw material, energy, or product transport. Life-cycle analysis.
Precludes additional credit for SREE 4001.
Prerequisite(s): MAAE 2300, MAAE 2400 and fourth year status in Mechanical, Aerospace, or Biomedical and Mechanical Engineering.
Lectures three hours a week. Problem analysis three hours per week.

MECH 4406 [0.5 credit]
Heat Transfer
Mechanisms of heat transfer: fundamentals and solutions. Steady and transient conduction: solution and numerical and electrical analog techniques. Convective heat transfer: free and forced convection for laminar and turbulent flows; heat exchangers. Heat transfer between black and grey surfaces, radiation shields, gas radiation, radiation interchange.
Precludes additional credit for AERO 4446.
Prerequisite(s): MAAE 2400, MAAE 3300 or MECH 3310, or ENVE 3001 and permission of the Department of Mechanical and Aerospace Engineering.
Lectures three hours a week.

MECH 4407 [0.5 credit]
Heating and Air Conditioning
Environmental demands for residential, commercial and industrial systems. Methods of altering and controlling environment. Air distribution. Refrigeration methods, equipment and controls. Integrated year-round air-conditioning and heating systems; heat pumps. Cooling load and air-conditioning calculations. Thermal radiation control. Component matching. System analysis and design.
Prerequisite(s): MAAE 2400 and third-year status in Engineering.
Lectures three hours a week.

MECH 4408 [0.5 credit]
Thermofluids and Energy Systems Design
Integration of fluid mechanics, thermodynamics, and heat transfer for design of energy conversion systems. Chemical kinetics and mass transfer. Efficient combustion, fuel cells and batteries. Efficient operation and design of engines, power generators, boilers, furnaces, incinerators, and co-generation systems. Emerging energy systems.
Prerequisite(s): MAAE 3400 and MECH 4406.
Lectures three hours per week.

MECH 4501 [0.5 credit]
State Space Modeling and Control
Review of matrices. Geometric structure and dynamics of linear systems. Controllability and observability. Pole placement design of controllers and observers. Design of regulator and servo systems. Transmission zeros. Eigenstructure assignment. Relationship to frequency or classical control techniques. Computer solutions using MATLAB. Applications.
Precludes additional credit for SYSC 5502.
Prerequisite(s): MAAE 4500 or AERO 4540 or SYSC 4505.
Lectures three hours a week.

MECH 4503 [0.5 credit]
An Introduction to Robotics
History of robotics and typical applications. Robotic actuators and sensors. Kinematics of manipulators, inverse kinematics, differential relationships and the Jacobian. Manipulator dynamics. Trajectory generation and path planning. Robot control and performance evaluation. Force control and compliance. Applications in manufacturing and other industries.
Prerequisite(s): MATH 3705 and SYSC 3600 or SYSC 3610.
Lectures three hours a week.

MECH 4604 [0.5 credit]
Finite Element Methods
Finite element methodology with emphasis on applications to stress analysis, heat transfer and fluid flow using the simplest one- and two-dimensional elements. Direct equilibrium, variational and Galerkin formulations. Computer programs and practical applications. Higher order elements.
Prerequisite(s): MAAE 3202 and (MAAE 3300 or MECH 3310).
Lectures three hours a week.

MECH 4704 [0.5 credit]
Integrated Manufacturing - CIMS
Overview of the topics essential to CIMS including integration of design and assembly techniques, numerical analysis, statistical process control and related production technologies within the manufacturing enterprise.
Prerequisite(s): AERO 3700 or MECH 3700.
Also offered at the graduate level, with different requirements, as MECH 5704, for which additional credit is precluded.
Lectures three hours a week.

MECH 4705 [0.5 credit]
CAD/CAM
Introduction to contemporary computer aided design and manufacturing (CAD/CAM) Topics covered include mathematical representation, solid modeling, drafting, mechanical assembly mechanism design, (CNC) machining. Current issues such as CAD data exchange standards, rapid prototyping, concurrent engineering, and design for X (DFX) are also discussed.
Prerequisite(s): MAAE 2001 (Engineering Graphics and Design) and fourth-year status in Engineering. Lectures three hours a week.
Lectures three hours a week.

MECH 4805 [0.5 credit]
Measurement and Data Systems
Experimental data, accuracy and uncertainty analysis. Analog systems. Sensors. Signal conditioning. Op-Amps, instrumentation amplifiers, charge amplifiers, filters. Digital techniques. Encoders, A/D D/A converters. Data acquisition using microcomputers. Hardware and software considerations. Interfacing. Applications to measurement of motion, strain, force/torque, pressure, fluid flow, temperature.
Precludes additional credit for Engineering ELEC 4805.
Prerequisite(s): STAT 3502, SYSC 3600 or SYSC 3610, and ELEC 3605 or ELEC 2501 or SYSC 3203.
Lectures three hours a week.

MECH 4806 [0.5 credit]
Mechatronics
Introduction to the integration of mechanical, electronic and software components to build mechatronic devices. Mechanical and electrical systems modeling, simulation and implementation. Basic automation and computer requirements. Design tools and examples of mechatronic applications.
Prerequisite(s): MAAE 4500 or AERO 4540 or SYSC 4505.
Lectures three hours per week.

Mechanical and Aerospace Engineering (MAAE) Courses

MAAE 2001 [0.5 credit]
Engineering Graphical Design
Engineering drawing techniques; fits and tolerances; working drawings; fasteners. Elementary descriptive geometry; true length, true view, and intersection of geometric entities; developments. Assignments will make extensive use of Computer-Aided Design (CAD) and will include the production of detail and assembly drawings from actual physical models.
Prerequisite(s): ECOR 1010.
Lectures and tutorials two hours a week, laboratory four hours a week.

MAAE 2101 [0.5 credit]
Engineering Dynamics
Review of kinematics and kinetics of particles: rectilinear and curvilinear motions; Newton's second law; energy and momentum methods. Kinematics and kinetics of rigid bodies: plane motion of rigid bodies; forces and accelerations; energy and momentum methods.
Precludes additional credit for CIVE 2101.
Prerequisite(s): ECOR 1101 and MATH 1005 and MATH 1104.
Lectures three hours a week, problem analysis three hours a week.

MAAE 2202 [0.5 credit]
Mechanics of Solids I
Review of Principles of Statics; friction problems; Concepts of stress and strain at a point; statically determinate and indeterminate stress systems; torsion of circular sections; bending moment and shear force diagrams; stresses and deflections in bending; buckling instability.
Precludes additional credit for CIVE 2200.
Prerequisite(s): ECOR 1101, MATH 1005 and MATH 1104.
Lectures three hours a week, problem analysis and laboratory three hours a week.

MAAE 2300 [0.5 credit]
Fluid Mechanics I
Fluid properties. Units. Kinematics, dynamics of fluid motion: concepts of streamline, control volume, steady and one-dimensional flows; continuity, Euler, Bernouilli, steady flow energy, momentum, moment of momentum equations; applications. Fluid statics; pressure distribution in fluid at rest; hydrostatic forces on plane and curved surfaces; buoyancy.
Prerequisite(s): MATH 1005, MATH 1104 and ECOR 1101.
Lectures three hours a week, laboratory and problem analysis three hours a week.

MAAE 2400 [0.5 credit]
Thermodynamics and Heat Transfer
Basic concepts of thermodynamics: temperature, work, heat, internal energy and enthalpy. First law of thermodynamics for closed and steady-flow open systems. Thermodynamic properties of pure substances; changes of phase; equation of state. Second law of thermodynamics: concept of entropy. Simple power and refrigeration cycles. Introduction to heat transfer: conduction, convection and radiation.
Prerequisite(s): CHEM 1101 or CHEM 1001 and CHEM 1002, MATH 1005 and MATH 1104.
Lectures three hours a week, laboratory and problem analysis three hours a week.

MAAE 2700 [0.5 credit]
Engineering Materials
Materials (metals, alloys, polymers) in engineering service; relationship of interatomic bonding, crystal structure and defect structure (vacancies, dislocations) to material properties; polymers, phase diagrams and alloys; microstructure control (heat treatment) and mechanical properties; material failure; corrosion.
Precludes additional credit for CIVE 2700.
Prerequisite(s): CHEM 1101 or CHEM 1001 and CHEM 1002 and ECOR 1101.
Lectures three hours a week, problem analysis and laboratory three hours a week.

MAAE 3004 [0.5 credit]
Dynamics of Machinery
Kinematic and dynamic analysis of mechanisms and machines. Mechanism force analysis. Static and dynamic balancing. Kinematic and dynamic analysis of cams. Free and forced vibration of single-degree-of-freedom systems. Introduction to multibody dynamics.
Prerequisite(s): MAAE 2101.
Lectures three hours a week, problem analysis and laboratories two hours a week.

MAAE 3202 [0.5 credit]
Mechanics of Solids II
Stress and strain transformations: torsion of non-circular sections; unsymmetric bending and shear centre; energy methods; complex stresses and criteria of yielding; elementary theory of elasticity; axisymmetric deformations.
Precludes additional credit for CIVE 3202.
Prerequisite(s): MAAE 2202.
Lectures three hours a week, problem analysis and laboratory three hours a week.

MAAE 3300 [0.5 credit]
Fluid Mechanics II
Review of control volume analysis. Dimensional analysis and similitude. Compressible flow: isentropic flow relations, flow in ducts and nozzles, effects of friction and heat transfer, normal and oblique shocks, two-dimensional isentropic expansion. Viscous flow theory: hydrodynamic lubrication and introduction to boundary layers.
Prerequisite(s): MATH 2004 and MAAE 2300.
Lectures three hours a week, problem analysis and laboratory three hours a week.

MAAE 3400 [0.5 credit]
Applied Thermodynamics
Gas and vapour power cycles: reheat, regeneration, combined gas/vapour cycles, cogeneration. Heat pump and refrigeration cycles: vapour compression cycles, absorption refrigeration and gas refrigeration. Mixtures of perfect gases and vapours: psychometry and combustion. Principles of turbomachinery.
Prerequisite(s): MAAE 2400.
Lectures three hours a week, problem analysis and laboratories one hour a week.

MAAE 3500 [0.5 credit]
Feedback Control Systems
Introduction to the linear feedback control. Analysis and design of classical control systems. Stability and the Routh-Hurwitz criteria. Time and frequency domain performance criteria, robustness and sensitivity. Root locus, Bode and Nyquist design techniques. Control system components and industrial process automation.
Precludes additional credit for MAAE 4500 (no longer offered), SYSC 4505.
Prerequisite(s): MATH 3705 and SYSC 3600 or SYSC 3610.
Lectures three hours a week, problem analysis one and a half hours a week.

MAAE 3901 [0.5 credit]
Mech and Aero Engineering Lab
Students perform a series of laboratory exercises dealing with a wide range of mechanical engineering topics. Included in this course is a group design project. Students relate theory and practice and develop experience with modern engineering equipment, measurement techniques and design methodology. Good reporting practice is emphasized.
Prerequisite(s): third-year status in Engineering.
Lectures and tutorials one hour a week, laboratory five hours a week.

MAAE 3999 [0.0 credit]
Co-operative Work Term

MAAE 4102 [0.5 credit]
Materials: Strength and Fracture
Analysis and prevention of failures in metals; plasticity analysis and plastic collapse; micro-mechanisms of fracture, conditions leading to crack growth and transition temperature effects, fracture mechanics, fatigue, environmentally assisted cracking, non-destructive evaluation and testing.
Prerequisite(s): MAAE 2700 and MAAE 3202.
Lectures three hours a week.

MAAE 4903 [0.5 credit]
Special Topics: Mech & Aero Eng.
At the discretion of the Faculty, a course may be offered that deals with selected advanced topics of interest to Aerospace and Mechanical Engineering students.
Prerequisite(s): permission of the Department.
Lecture three hours a week.

MAAE 4906 [0.5 credit]
Special Topics: Mech and Aero Eng.
At the discretion of the Faculty, a course may be offered that deals with selected advanced topics of interest to Aerospace and Mechanical Engineering students.
Prerequisite(s): permission of the Department.

MAAE 4907 [1.0 credit]
Engineering Design Project
Team project in the design of an aerospace, biomedical, mechanical, or sustainable energy system. Opportunity to develop initiative, engineering judgement, self-reliance, and creativity in a team environment. Results submitted in a comprehensive report as well as through formal oral presentations.
Prerequisite(s): fourth-year status in engineering. Completion of or concurrent registration in AERO 4003, AERO 4842, MECH 4003, MECH 4013, or SREE 4001, or permission of Department. Certain projects may have additional prerequisites.

MAAE 4917 [0.5 credit]
Undergraduate Directed Study
Student carries out a study, analysis, and solution of an engineering problem. Results presented in the form of a written report. Carried out under the close supervision of a faculty member. Intended for students interested in pursuing graduate studies. Requires supervising faculty member and proposal from student.
Prerequisite(s): permission of the Department and completion of, or concurrent registration in, AERO 4907 or MECH 4907.

Sustainable and Renewable Energy (SREE) Courses

SREE 1000 [0.0 credit]
Introduction to Sustainable Energy
The concept of energy sustainability. Energy-economy system. Global energy trends, the next 100 years. Energy reserves and resources. Primary and secondary clean energy. Energy use, efficiency and renewables. Energy and the environment/climate change. Sustainable energy choices and policies.
Prerequisite(s): registration in Sustainable and Renewable Energy Engineering.
Lectures one hour per week.

SREE 3001 [0.5 credit]
Sustainable and Renewable Energy Sources
Primary energy sources and the pathways to use. Renewables: photovoltaic, solar-thermal, hydropower, geothermal, tidal. Fossil fuels and nuclear. Terrestial, thermodynamic and electrical limitations.
Prerequisite(s): ENVE 2001 and MAAE 2300 and (ELEC 3605 or ELEC 2501 or fourth-year status in Environmental Engineering).
Lectures three hours per week, laboratories/problem analysis one hour per week.

SREE 3002 [0.5 credit]
Electricity: Use, Distribution, Integration of Distributed Generation
Electricity use in Ontario: rates, government incentives, smart use. Electricity Distribution: topology, reliability, load characteristics, voltage regulation, power loss, capacitors, economics of optimum choice, system protection. Distributed Generation: guides and regulations, case study.
Prerequisite(s): SREE 3001, ELEC 4602 and (ELEC 2501 or ELEC 3605).
Lectures three hours per week, laboratories three hours per week alternate weeks.

SREE 3003 [0.5 credit]
Sustainable and Renewable Electricity Generation
Power system structures; photovoltaic (PV) cell model, PV current-voltage curves, maximum power point tracking, grid-connected PV systems; power flow of wind generation, grid connection of wind generator; energy storage classification, battery equivalent circuit model, battery charging and discharging; renewable generation; feed-in tariff program.
Prerequisite(s): SREE 3001, ELEC 4602 and (ELEC 2501 or ELEC 3605).
Lectures three hours per week, laboratories three hours per week alternate weeks.

SREE 4001 [0.5 credit]
Efficient Energy Conversion
Steam generators, solid, liquid, gaseous and biofuels and cycles. Geothermal, solar powerplants. Energy storage. Environmental aspects of power generation. Industrial use and auto-generation of energy. Energy intensity and efficiency of industrial processes and products. Comparative analysis of raw material, energy, or product transport. Life-cycle analysis.
Precludes additional credit for MECH 4403.
Prerequisite(s): MAAE 2300, MAAE 2400 and fourth year status in Sustainable & Renewable Energy Engineering.
Lectures three hours per week, laboratories/problem analysis three hours per week.

SREE 4002 [0.5 credit]
The Energy Economy, Reliability and Risk
Interrelationship between energy and economic policy and regulations. Reliability of energy supply systems. Risk analysis and its application to the generation, distribution and environmental impacts of energy. Risks analysis and management associated with natural and human and regulatory influences. Environmental and public health risk analysis.
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours per week.

SREE 4907 [1.0 credit]
Energy Engineering Project
Student teams develop professional-level experience by applying, honing, integrating and extending previously acquired knowledge in a major design project. Lectures are devoted to discussing project-related issues and student presentations. A project proposal, interim report, oral presentations, and a comprehensive final report are required.
Prerequisite(s): SREE 3002 and SREE 3003, fourth-year status in Sustainable and Renewable Energy Engineering and ECOR 4995 (may be taken concurrently). Certain projects may have additional prerequisites or corequisites.
Lecture one hour a week, laboratory seven hours a week.

Systems and Computer Engineering (SYSC) Courses

Note: the Departments of Systems and Computer Engineering and Electronics offer courses in: Biomedical and Electrical Engineering, Communications Engineering,

Computer Systems Engineering, Electrical Engineering, Software Engineering and Engineering Physics.

SYSC 1005 [0.5 credit]
Introduction to Software Development
Software development as an engineering discipline, using a modern programming language, Language syntax. Algorithm design. Tracing and visualizing program execution. Testing and debugging. Program style, documentation, reliability. Lab projects are drawn from a variety of application domains: digital image manipulation, computer games, robotics.
Precludes additional credit for ECOR 1606, SYSC 1100(no longer offered), COMP 1005 and COMP 1405.
Lectures three hours a week, laboratory three hours a week.

SYSC 2001 [0.5 credit]
Computer Systems Foundations
Computer architecture and organization: CPU, cache, memory, input/output, bus structures, interrupts; computer arithmetic: integer and floating point; CPU: instruction sets, addressing modes, instruction encoding. Input/output: programmed, interrupt-driven, block-oriented. Examples from several modern processor families.
Precludes additional credit for SYSC 2320, SYSC 3006.
Prerequisite(s): ECOR 1606 or SYSC 1005. Additional recommended background: SYSC 2006.
Lectures three hours a week, laboratory two hours a week.

SYSC 2003 [0.5 credit]
Introductory Real-Time Systems
Principles of event-driven systems. Review of computer organization. Assemblers and linkers. Development of embedded applications. Programming external interfaces, programmable timer. Input/output methods: polling, interrupts. Real-time issues: concurrency, mutual exclusion, buffering. Introduction to concurrent processes.
Precludes additional credit for SYSC 3006 and SYSC 3310.
Prerequisite(s): SYSC 2001 and SYSC 2006.
Lectures three hours a week, laboratory two hours a week.

SYSC 2004 [0.5 credit]
Object-Oriented Software Development
Designing and implementing small-scale programs as communities of collaborating objects, using a dynamically-typed or statically-typed programming language. Fundamental concepts: classes, objects, encapsulation, information hiding, inheritance, polymorphism. Iterative, incremental development and test-driven development.
Precludes additional credit for SYSC 1101, COMP 1006 and COMP 1406.
Prerequisite(s): SYSC 2006 or permission of the department.
Lectures three hours a week, laboratory two hours a week.

SYSC 2006 [0.5 credit]
Foundations of Imperative Programming
Modular programming with a procedural language. Compilation and linking, libraries. Memory management and object lifetimes: static allocation, automatic allocation in stack frames, dynamic allocation from the heap. Introduction to data structures: dynamic arrays, linked lists. Collections: lists, stacks, queues. Introduction to recursion.
Precludes additional credit for SYSC 1102, SYSC 2002 and COMP 2401.
Prerequisite(s): ECOR 1606 or SYSC 1005.
Lectures three hours a week, laboratory two hours a week.

SYSC 2100 [0.5 credit]
Algorithms and Data Structures
Thorough coverage of fundamental abstract collections: stacks, queues, lists, priority queues, dictionaries, sets, graphs. Data structures: review of arrays and linked lists; trees, heaps, hash tables. Specification, design, implementation of collections, complexity analysis of operations. Sorting algorithms.
Precludes additional credit for SYSC 2002 and COMP 2402.
Prerequisite(s): SYSC 2006 and SYSC 2004.
Lectures three hours a week, laboratory two hours a week.

SYSC 2310 [0.5 credit]
Introduction to Digital Systems
Number systems: binary, decimal, hexadecimal. Digital representation of information. Computer arithmetic: integer, floating point, fixed point. Boolean logic, realization as basic digital circuits. Applications: simple memory circuits, synchronous sequential circuits for computer systems. Finite state machines, state graphs, counters, adders. Asynchronous sequential circuits. Races.
Precludes additional credit for ELEC 2607.
Prerequisite(s): SYSC 1005 or ECOR 1606, and enrolment in Computer Systems Engineering, Communications Engineering, or Software engineering.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 2320 [0.5 credit]
Introduction to Computer Organization and Architecture
Computer organization: processor, memory, input/output, system bus. Microarchitecture. Instruction set architecture. Assembly language programming: addressing modes, instruction encoding, execution. Assembler. Simple digital I/O, programmable timer. Input/output methods: polling, hardware interrupts.
Precludes additional credit for SYSC 2001 and SYSC 3006.
Prerequisite(s): SYSC 2006 and SYSC 2310.
Lectures three hours a week, laboratory three hours a week.

SYSC 2510 [0.5 credit]
Probability, Statistics and Random Processes for Engineers
Discrete and continuous random variables. Joint and conditional probabilities, independence, sums of random variables. Expectation, moments, laws of large numbers. Introduction to statistics. Stochastic processes, stationarity, additive white Gaussian noise, Poisson processes. Markov processes, transition probabilities and rates, birth death processes, introduction to queueing theory.
Prerequisite(s): MATH 1004 and MATH 1104.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 3006 [0.5 credit]
Computer Organization
Computer organization: processor, memory, input/output, system bus. Number systems: binary, decimal, hexadecimal. Assembly language programming: representation of data, instruction encoding, execution. Devices: keyboard, programmable timer, parallel interface. Input/output methods: polling, hardware/software interrupts.
Precludes additional credit for SYSC 2001, SYSC 2003, SYSC 2320 and SYSC 3310. May not be taken for credit by students in Computer Systems Engineering, Communications Engineering, or Software Engineering.
Prerequisite(s): SYSC 2006 and ELEC 2607.
Lectures three hours a week, laboratory two hours a week.

SYSC 3010 [0.5 credit]
Computer Systems Development Project
Development of expertise in designing, implementing and testing maintainable, reusable software through team projects. Applying modern programming languages, design patterns, frameworks, UML and modern development processes (refactoring, iterative and incremental development, version control techniques) to medium-scale projects; for example, embedded or mobile applications.
Precludes additional credit for SYSC 2101, SYSC 3110 and COMP 2404.
Prerequisite(s): SYSC 2100, and third-year status in Computer Systems Engineering.
Lectures two hours a week, laboratory three hours a week.

SYSC 3020 [0.5 credit]
Introduction to Software Engineering
Introduction to software engineering principles, software development life-cycles. Modelling in software engineering. Current techniques, notations, methods, processes and tools used in software engineering. UML modelling. Introduction to software quality, software verification and validation, software testing.
Precludes additional credit for SYSC 3100, SYSC 3120, SYSC 4120 and COMP 3004.
Prerequisite(s): SYSC 2004 and (SYSC 2006 or SYSC 2002).
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 3101 [0.5 credit]
Programming Languages
Principles underlying different kinds of programming languages (procedural, functional, logic programming) and their semantics. Overview of machinery needed for language support (compilers, interpreters and run-time systems).
Precludes additional credit for COMP 3007.
Prerequisite(s): SYSC 2004.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 3110 [0.5 credit]
Software Development Project
Development of expertise in designing, implementing and testing maintainable, reusable software through team projects. Applying modern programming languages, design patterns, frameworks, UML and modern development processes (detection of olfactible source code defects, refactoring, iterative and incremental development, version control techniques) to medium-scale projects.
Precludes additional credit for SYSC 2101, SYSC 3010 and COMP 2404.
Prerequisite(s): SYSC 2100, and third-year status in Software Engineering.
Lectures two hours a week, laboratory three hours a week.

SYSC 3120 [0.5 credit]
Software Requirements Engineering
Current techniques, notations, methods, processes and tools used in Requirements Engineering. Requirements elicitation, negotiation, modeling requirements, management, validation. Skills needed for Requirements Engineering and the many disciplines on which it draws. Requirements analysis: domain modeling, modeling object interactions; UML modeling. Introduction to software development processes.
Precludes additional credit for SYSC 3020 and COMP 3004.
Prerequisite(s): SYSC 2100 and third-year status in Software Engineering.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 3200 [0.5 credit]
Industrial Engineering
Techniques of operations research for decision-making in complex engineering systems. Linear programming, network models, PERT, integer programming, dynamic programming, queuing systems and inventory models. Problem solving is emphasized.
Precludes additional credit for BUSI 2300, ECON 4004, or MATH 3801.
Prerequisite(s): MATH 1004 and MATH 1104 and (ECOR 1606 or SYSC 1005).
Lectures three hours a week, laboratory/problem analysis one and a half hours per week.

SYSC 3203 [0.5 credit]
Bioelectrical Systems
Biomedical transducers, sensors, and biomedical actuators. Biomaterials and biocompatibility. Amplifier designs: inverting, noninverting, differential, and bioinstrumentation. Amplifier analysis: gain, sensitivity, distortion and stability. Filter design. Sampling and quantization. Electrical machines. Biomedical electrical safety and standards.
Prerequisite(s): MATH 3705 and PHYS 1004 and enrolment in Biomedical and Electrical Engineering or Biomedical and Mechanical Engineering programs.
Lectures three hours a week, laboratory three hours a week.

SYSC 3303 [0.5 credit]
Real-Time Concurrent Systems
Principles and practice of a systems engineering approach to the development of software for real-time, concurrent, distributed systems. Designing to achieve concurrency, performance, and robustness, using visual notations. Converting designs into programs. Introduction to hard real-time systems. Team project.
Prerequisite(s): for students in the Faculty of Engineering and Design: (SYSC 2003 or SYSC 3310) and SYSC 2004. For students in Computer Science: COMP 2401 and COMP 2402.
Lectures three hours a week, laboratory two hours a week.

SYSC 3310 [0.5 credit]
Introduction to Real-Time Systems
Principles of event-driven systems. Microcontroller organization. Development of embedded applications. Programming external interfaces, programmable timer. Input/output methods: polling, interrupts. Real-time issues: concurrency, mutual exclusion, buffering. Introduction to concurrent processes.
Precludes additional credit for SYSC 2003, SYSC 3006.
Prerequisite(s): SYSC 2320.
Lectures three hours a week, laboratory two hours a week.

SYSC 3320 [0.5 credit]
Computer Systems Design
System on Chip (SoC)-based computer system design. SoC internal organization. Cache memory. Interfacing: external memory, hardware subsystems. Direct memory access. Floating point units. Introduction to field programmable gate arrays.
Precludes additional credit for SYSC 3601 and ELEC 4601.
Prerequisite(s): SYSC 3310 and third year status in Computer Systems Engineering, or permission of the Department.
Lectures three hours a week, laboratory three house alternate weeks.

SYSC 3500 [0.5 credit]
Signals and Systems
Signals: energy and power signals, discrete-time and continuous. Linear systems and convolution. Fourier Transform; complex Fourier series; signal spectral properties and bandwidth. Laplace transform and transient analysis. Transfer functions, block diagrams. Baseband and passband signals, with applications to communications systems.
Precludes additional credit for SYSC 3600, SYSC 2500 (no longer offered) and SYSC 3610.
Prerequisite(s): MATH 2004 and enrolment in Communications Engineering.
Lectures three hours a week, problem analysis three hours alternate weeks.

SYSC 3501 [0.5 credit]
Communication Theory
Review of signals, linear systems and Fourier theory; signal bandwidth and spectra; digital waveform coding; introduction to analog and digital modulation systems; synchronization; characterization and effects of noise; link budgets; communications media and circuits; applications to current communications systems.
Precludes additional credit for SYSC 3503.
Prerequisite(s): MATH 3705 and (SYSC 3600 or SYSC 3610).
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 3503 [0.5 credit]
Communication Theory II
Amplitude Modulation. Frequency Modulation. Performance of AM and FM in noise. Communication channels, channel models, noise sources, noise models. Digital modulation: ASK, FSK, PSK. Optimal reception, probability of error on the AWGN channel.
Precludes additional credit for SYSC 3501 or SYSC 4600.
Prerequisite(s): SYSC 3500 and (STAT 2605 or SYSC 2510).
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 3600 [0.5 credit]
Systems and Simulation
Properties of linear systems. Linear dynamic models of engineering systems. Applications of the Laplace transform. Transfer functions. Block diagrams. Frequency and time response. System simulation with digital computers.
Precludes additional credit for SYSC 2500 (no longer offered), SYSC 3500 or SYSC 3610.
Prerequisite(s): MATH 1005, and (ECOR 1101 or PHYS 1001).
Lectures three hours a week, laboratory three hours a week.

SYSC 3601 [0.5 credit]
Microprocessor Systems
Microprocessor-based system design for different microprocessor families. Microprocessors: internal organization, instruction sets, address generation, pin-outs, bus cycles, signalling waveforms. Interfacing memory and I/O devices. Interrupt structures, direct memory access. Floating point coprocessors. System bus standards. Introduction to DSPs.
Precludes additional credit for SYSC 3320 or ELEC 4601.
Prerequisite(s): ELEC 2607, and SYSC 2003 or permission of the department.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 3610 [0.5 credit]
Biomedical Systems, Modeling, and Control
Properties of linear systems. Linear dynamic models of biomedical systems. Biomedical application of the Laplace transforms. Transfer functions. Block diagram. Frequency and time response. Feedback, control, and stability. Biomedical systems modeling and control.
Precludes additional credit for SYSC 3500 or SYSC 3600.
Prerequisite(s): MATH 3705 and ECOR 1101 and enrolment in Biomedical and Electrical Engineering program or in Biomedical and Mechanical Engineering programs.
Lectures three hours a week, laboratory three hours a week.

SYSC 3999 [0.0 credit]
Co-operative Work Term

SYSC 4001 [0.5 credit]
Operating Systems
Introduction to operating system principles. Processes and threads. CPU scheduling. Managing concurrency: mutual exclusion and synchronization, deadlock and starvation. Managing memory and input/output. Concurrent programming, including interprocess communication in distributed systems.
Precludes additional credit for SYSC 3001 and COMP 3000.
Prerequisite(s): SYSC 2006 and (SYSC 2003 or SYSC 3006 or SYSC 3310).
Lectures three hours a week, laboratory three hours a week.

SYSC 4005 [0.5 credit]
Discrete Simulation/Modeling
Simulation as a problem solving tool. Random variable generation, general discrete simulation procedure: event table and statistical gathering. Analyses of simulation data: point and interval estimation. Confidence intervals. Overview of modeling, simulation, and problem solving using SIMSCRIPT, MODSIM, and other languages.
Prerequisite(s): (SYSC 2510 or STAT 2605 or STAT 3502) and fourth-year status in Engineering, or permission of the Department.
Also offered at the graduate level, with different requirements, as SYSC 5001, for which additional credit is precluded.
Lectures three hours a week, laboratory one hour a week.

SYSC 4101 [0.5 credit]
Software Validation
Techniques for the systematic testing of software systems. Software validation and verification, software debugging, quality assurance, measurement and prediction of software reliability. Emphasis on the treatment of these topics in the context of real-time and distributed systems.
Precludes additional credit for COMP 4004.
Prerequisite(s): SYSC 3120 or SYSC 3020.
Lectures three hours a week, laboratory/problem analysis three hours alternate weeks.

SYSC 4102 [0.5 credit]
Performance Engineering
Techniques based on measurements and models, for predicting and evaluating the performance of computer systems. Instrumentation. Simple queueing models and approximations. Techniques for modifying software designs to improve performance.
Prerequisite(s): STAT 3502 and SYSC 4001.
Also offered at the graduate level, with different requirements, as SYSC 5101, for which additional credit is precluded.
Lectures three hours a week, laboratory/problem analysis three hours alternate weeks.

SYSC 4105 [0.5 credit]
Engineering Management
Introduction to engineering management: management of new products, management of manufacturing processes, management of the linkages between new products and manufacturing processes. Current theories, concepts and techniques are stressed, using a combination of readings, cases and guest speakers.
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours a week.

SYSC 4106 [0.5 credit]
Software Product Management
Stages of the life cycle of software products and their implications for architecture definition, requirements specification, variety, target market segmentation, adoption, roll-out plans, documentation, maintenance, skills, building prototypes, testing, feature prioritization, quality and tools infrastructures.
Prerequisite(s): SYSC 3020 or SYSC 3120 (may be taken concurrently) or COMP 3004.
Lectures three hours a week.

SYSC 4107 [0.5 credit]
Software Business
Establishing and growing businesses anchored on software design and development. Models for software business; partnerships with suppliers and customers; distribution; raising money; intellectual property protection; evolving core products and sources of competitive advantage; alignment among the business model, infrastructures, and software development.
Prerequisite(s): fourth-year status in Engineering or Computer Science.
Lectures three hours a week.

SYSC 4120 [0.5 credit]
Software Architecture and Design
Introduction and importance of software architectures and software system design in software engineering. Current techniques, modeling notations, method processes and tolls used in software architecture and system design. Software architectures, architectural patterns, design patterns, software qualities, software reuse.
Precludes additional credit for SYSC 3020, SYSC 4800 and COMP 3004.
Prerequisite(s): SYSC 3120.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 4201 [0.5 credit]
Ethics, Research Methods and Standards for Biomedical Engineering
Ethical theories, ethical decision-making, biomedical research ethics: informed consent, confidentiality, privacy, research ethics boards; research methods: hypothesis formulation, data collection, sampling bias, experimental design, statistical literacy; regulations for design, manufacture, certification of medical devices; impact of technology and research (social, political, financial).
Prerequisite(s): ELEC 3605 or SYSC 3203.
Lectures three hours a week, problem analysis three hours alternate weeks.

SYSC 4202 [0.5 credit]
Clinical Engineering
Overview of the Canadian health care system; brief examples of other countries; clinical engineering and the management of technologies in industrialized and in developing countries; safety, reliability, quality assurance; introduction to biomedical sensor technologies; applications of telemedicine; impact of technology on health care.
Prerequisite(s): fourth-year status in Biomedical and Electrical or Biomedical and Mechanical Engineering.
Also offered at the graduate level, with different requirements, as BIOM 5406, for which additional credit is precluded.
Lectures three hours a week, problem analysis three hours alternate weeks.

SYSC 4203 [0.5 credit]
Bioinstrumentation and Signals
Bioinstrumentation and biological signals; instrumentation systems, noise, electrical safety, and biocompatibility; bioelectric signals; biopotential electrodes: material properties, selection, and fabrication; measurement of flow and pressure; data acquisition; signal processing; biomedical imaging technologies; performance and characteristics of bioamplifier systems; major physiological systems and associated measurements.
Prerequisite(s): (SYSC 3600 or SYSC 3500 or SYSC 3610) and (ELEC 2507 or ELEC 3605 or SYSC 3203) and fourth-year status in Biomedical and Electrical Engineering or fourth-year status in Biomedical and Mechanical Engineering.
Lectures three hours a week, laboratory/problem analysis three hours a week.

SYSC 4205 [0.5 credit]
Image Processing for Medical Applications
Two-dimensional signals, filters, and Fourier transforms. Image acquisition, sampling, quantization and representation. Image perception. Digital and film cameras. Medical imaging technologies. Image processing operations: histogram, convolution, morphological, segmentation, registration. Image compression and formats.
Prerequisite(s): MATH 3705 and fourth-year status in Engineering.
Lectures three hours a week, laboratory/problem analysis three hours alternate weeks.

SYSC 4310 [0.5 credit]
Computer Systems Architecture
Evolution of computer systems architecture to improve performance. Memory hierarchy, hardware accelerators. Instruction level parallelism, pipelining, vector processing, superscalar, out-of-order execution, speculative execution. Thread level parallelism, multi-core, many-core, heterogeneous systems. Processor-level interconnect bus, non-uniform memory access. Application-oriented architectures. Virtualization.
Precludes additional credit for SYSC 4507.
Prerequisite(s): SYSC 3320 and fourth year status in Computer Systems Engineering.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 4320 [0.5 credit]
Case Studies in Computer Systems
Examples of several modern computer systems are presented in a computer systems context: system objectives, software and hardware components, interactions. The case studies present computer systems trends emerging in practice.
Prerequisite(s): SYSC 4310 and fourth year status in Computer Systems Engineering.
Lectures three hours a week, problem analysis one hour a week.

SYSC 4405 [0.5 credit]
Digital Signal Processing
Discrete time signal and system representation: time domain, z-transform, frequency domain. Sampling theorem. Digital filters: design, response, implementation, computer-aided design. Spectral analysis: the discrete Fourier transform and the FFT. Applications of digital signal processing.
Prerequisite(s): SYSC 3500 or SYSC 3600 or SYSC 3610.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 4502 [0.5 credit]
Communications Software
Communications software architectures, protocols and operating systems. Application layer protocols, APIs and socket programming. P2P algorithms, network virtualization, SDN. Reliable data transfer algorithms, FSM, MSC. Network security. Multimedia applications, RTSP, CDN, DASH, RTP, RTCP. Packet scheduling algorithms, DiffServ, IntServ, RSVP. Traffic classification, cross-layer optimization.
Prerequisite(s): SYSC 4602 and SYSC 2004 and third-year status in Engineering.
Lectures three hours a week, problem analysis three hours alternate weeks.

SYSC 4504 [0.5 credit]
Fundamentals of Web Development
WWW architecture, web servers and browsers, core protocols. Web pages, their structure, interpretation and internal representation. Client-side and server-side programming. Data representation. Interfacing with databases and other server-side services. Cookies, state management, and privacy issues. Security. Web services.
Prerequisite(s): SYSC 2004. Additional recommended background: SYSC 4602 or SYSC 3303.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 4505 [0.5 credit]
Automatic Control Systems I
Review of Laplace transform techniques. Effects of feedback: frequency response, pole-zero positions. Compensation: root locus, Bode plots. State variables: formulation, solution of linear systems, examples of simple second-order non-linear systems. Discrete time systems: z-transforms. Signal reconstruction.
Precludes additional credit for MAAE 3500, MAAE 4500 (no longer offered).
Prerequisite(s): MATH 2004 and (SYSC 3500 or SYSC 3600 or SYSC 3610).
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 4507 [0.5 credit]
Computer Systems Architecture
Evolution of computer systems architecture, influences of changing technology, techniques to improve performance, memory hierarchy, hardware accelerators. Instruction level parallelism, pipelining, vector processing, superscalar, out of order execution, speculative execution. Thread level parallelism, multi-core, many-core, heterogeneous systems. Evolution of architectures for specific application domains.
Precludes additional credit for SYSC 4310.
Prerequisite(s): ELEC 2607 and (SYSC 2001 or SYSC 3006).
Lectures three hours a week, laboratory/problem analysis one hour a week.

SYSC 4600 [0.5 credit]
Digital Communications
Review of probability, random variables, signal representation. Baseband data transmission: Nyquist criterion, equalization, optimal receiver, error probability. Digital modulation, performance. Synchronization. Introduction to information theory. Error detection and correction. Spread spectrum. Applications to current digital wired and wireless communications systems.
Precludes additional credit for SYSC 3503 and SYSC 4604.
Prerequisite(s): SYSC 3501 and STAT 3502.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 4602 [0.5 credit]
Computer Communications
Layered network architectures, TCP/IP suite, circuit switching, packet switching. Physical media, data transmission, multiplexing. Data link controls, MAC protocols, random access, polling, IEEE 802 standards. Bridges, switched Ethernet, VLANs. Routing algorithms, Internet routing protocols, datagram networks, virtual circuit networks. Transport protocols.
Precludes additional credit for COMP 3203.
Prerequisite(s): SYSC 2510 or STAT 2605 or STAT 3502 (may be taken concurrently), and third-year status in Biomedical and Electrical, Electrical, Communications, Computer Systems, Software, or Sustainable and Renewable Energy Engineering.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 4604 [0.5 credit]
Digital Communication Theory
Introduction to information theory, source coding and data compression, Error control coding, Trellis coded modulation, advanced topics of current interest: spread spectrum; digital wireless communications.
Precludes additional credit for SYSC 4600.
Prerequisite(s): SYSC 3503.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 4607 [0.5 credit]
Wireless Communications
Wireless radio channel characterization, diversity, equalization; cellular architecture, multiple access principles, spread spectrum systems, radio resource management; examples from modern wireless systems, networks, and standards, including cellular networks, WLANs, ad hoc networks, and satellite systems.
Prerequisite(s): SYSC 3501 or SYSC 3503.
Lectures three hours a week, laboratory three hours alternate weeks.

SYSC 4700 [0.5 credit]
Telecommunications Engineering
Telecommunications as a national and international infrastructure. Systems view of network architecture: transmission, access, switching, multiplexing, signalling, and teletraffic. Network planning, management, security and control. Role of government, regulation and competition. Current telecommunications network evolution.
Prerequisite(s): fourth-year status in Electrical, Computer Systems or Communications Engineering, and (SYSC 3501 or SYSC 3503).
Lectures three hours a week, laboratory/problem analysis three hours alternate weeks.

SYSC 4701 [0.5 credit]
Communications Systems Lab
Project-oriented level experience in the design of communication systems to meet user requirements. Lectures on queuing theory and teletraffic analysis; system specification and design: requirements analysis, solution alternatives, evaluation of alternative technologies, design, costing, implementation, test.
Prerequisite(s): fourth-year status in Communications Engineering.
Lectures two hours a week, laboratory four hours a week.

SYSC 4805 [0.5 credit]
Computer Systems Design Lab
Developing professional-level expertise in selected, important areas of the field by applying, honing, integrating, and extending previously acquired knowledge in team projects in the laboratory. Lecture periods are devoted to new knowledge required for the selected areas, to project-related issues, and to student presentations.
Prerequisite(s): SYSC 3303 and SYSC 3020 and fourth year status in Computer Systems Engineering.
Lectures two hours a week, laboratory four hours a week.

SYSC 4806 [0.5 credit]
Software Engineering Lab
Applying the full spectrum of engineering and programming knowledge acquired in the program through team projects in the laboratory. Practice in doing presentations and reviews. Lectures will discuss software engineering issues as they relate to the projects, from a mature point of view.
Prerequisite(s): SYSC 4120 and fourth-year status in Software Engineering.
Lectures two hours a week, laboratory four hours a week.

SYSC 4810 [0.5 credit]
Introduction to Network and Software Security
Network security with coverage of computer security in support of networking concepts. Covers various security issues in data networks at different protocol layers. Routing security, worm attacks, and botnets. Security of new mobile networks and emerging networked paradigms such as social networks and cloud computing.
Prerequisite(s): fourth-year status in Engineering or permission of the Department.
Lectures three hours a week, problem analysis one and a half hours a week.

SYSC 4906 [0.5 credit]
Special Topics
At the discretion of the Department, a course dealing with selected advanced topics of interest to students in Biomedical and Electrical, Communications, Computer Systems, Electrical, Software Engineering, and Engineering Physics may be offered.
Prerequisite(s): permission of the Department.

SYSC 4907 [1.0 credit]
Engineering Project
Student teams develop professional-level experience by applying previously acquired knowledge to a major design project. Lectures discuss project-related issues and student presentations. A project proposal, interim report, oral presentations, and a comprehensive final report are required.
Prerequisite(s): fourth-year status in Engineering and ECOR 4995 (may be taken concurrently). Certain projects may have additional prerequisites.
Lecture one hour a week, laboratory seven hours a week.

SYSC 4917 [1.0 credit]
Biomedical Engineering Project
Student teams develop professional-level experience by applying previously acquired knowledge to a major design project in biomedical engineering. Lectures discuss project-related issues and student presentations. A project proposal, interim report, oral presentations, and a comprehensive final report are required.
Prerequisite(s): fourth-year standing in Biomedical and Electrical Engineering and ECOR 4995 (may be taken concurrently). Certain projects may have additional prerequisites.
Lecture one hour a week, laboratory seven hours a week.

SYSC 4927 [1.0 credit]
Software Engineering Project
Student teams gain professional-level experience by applying and extending previously acquired knowledge in a major design project in software engineering. Lectures discuss project-related issues and student presentations. A project proposal, interim report, oral presentations, and a comprehensive final report are required.
Prerequisite(s): fourth-year status in Software Engineering and ECOR 4995 (may be taken concurrently). Certain projects may have additional prerequisites.
Lecture one hour a week, laboratory seven hours a week.

SYSC 4937 [1.0 credit]
Communications Engineering Project
Student teams gain professional-level experience by applying and extending previously acquired knowledge in a major design project in communications engineering. Lectures discuss project-related issues and student presentations. A project proposal, interim report, oral presentations, and a comprehensive final report are required.
Prerequisite(s): fourth-year status in Communications Engineering and ECOR 4995 (may be taken concurrently). Certain projects may have additional prerequisites.
Lecture one hour a week, laboratory seven hours a week.

Summer session: some of the courses listed in this Calendar are offered during the summer. Hours and scheduling for summer session courses will differ significantly from those reported in the fall/winter Calendar. To determine the scheduling and hours for summer session classes, consult the class schedule at central.carleton.ca

Not all courses listed are offered in a given year. For an up-to-date statement of course offerings for the current session and to determine the term of offering, consult the class schedule at central.carleton.ca