# 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 D: Space Systems Design**
- **Architectural Conservation and Sustainability Engineering - Bachelor of Engineering**
- **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**
- **Mechatronics Engineering Bachelor of Engineering**
- **Software Engineering Bachelor of Engineering**
- **Software Engineering Stream A: Artificial Intelligence 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 CUOL or online course 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.

### Computer Science Electives for Software Engineering

The list of computer science (COMP) electives for software engineering degree 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 the Software Engineering degree.

## 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 (21.0 credits)**

**First Year**

| | | |
|---|---|---|
| **1. a) 4.0 credits in:** | | **4.0** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |

**b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:**

| | | |
|---|---|---|
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **3. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Second Year** | | |
| **4. a) 5.0 credits in:** | | **5.0** |
| AERO 2001 [0.5] | Aerospace Engineering Graphical Design | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ELEC 3605 [0.5] | Electrical Engineering | |
| 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 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third Year** | | |
| **5. 5.5 credits in:** | | 5.5 |
| AERO 3002 [0.5] | Aerospace Design and Practice | |
| AERO 3700 [0.5] | Aerospace Materials | |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 3800 [0.5] | Engineering Economics | |
| 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 | |
| MATH 3705 [0.5] | Mathematical Methods I | |
| SYSC 3600 [0.5] | Systems and Simulation | |
| **Fourth Year** | | |
| **6. 2.5 credits from:** | | 2.5 |
| 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 | |
| ECOR 4995 [0.5] | Professional Practice | |
| **7. 1.0 credit from** | | 1.0 |
| MAAE 4907 [1.0] | Engineering Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **8. 1.0 credit in** 4000-level Mechanical and Aerospace Engineering (MAAE, AERO, or MECH) | | 1.0 |
| **9. 0.5 credit from:** | | 0.5 |
| AERO 4402 [0.5] | Aerospace Propulsion | |
| AERO 4442 [0.5] | Transatmospheric and Spacecraft Propulsion | |
| AERO 4607 [0.5] | Rotorcraft Aerodynamics and Performance | |
| **10. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

### Aerospace Engineering - Bachelor of Engineering Stream B: Aerospace Structures, Systems and Vehicle Design (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.0 credits in:** | | **4.0** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **3. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Second year** | | |
| **4. a) 5.0 credits in:** | | **5.0** |
| AERO 2001 [0.5] | Aerospace Engineering Graphical Design | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ELEC 3605 [0.5] | Electrical Engineering | |
| 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 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **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 | |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 3800 [0.5] | Engineering Economics | |
| 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 | |
| MATH 3705 [0.5] | Mathematical Methods I | |
| SYSC 3600 [0.5] | Systems and Simulation | |
| **Fourth year** | | |
| **6. 2.5 credits in:** | | 2.5 |
| AERO 4003 [0.5] | Aerospace Systems Design | |
| AERO 4602 [0.5] | Introductory Aeroelasticity | |
| AERO 4608 [0.5] | Composite Materials | |
| ECOR 4995 [0.5] | Professional Practice | |
| MAAE 4102 [0.5] | Materials: Strength and Fracture | |
| **7. 1.0 credit from:** | | 1.0 |
| MAAE 4907 [1.0] | Engineering Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **8. 1.0 credits in** 4000-level Mechanical and Aerospace Engineering (MAAE, AERO, or MECH) | | 1.0 |
| **9. 0.5 credits from:** | | 0.5 |
| AERO 4609 [0.5] | Joining of Materials | |
| MECH 4103 [0.5] | Fatigue and Fracture Analysis | |
| MECH 4104 [0.5] | Vibration Analysis | |
| MECH 4604 [0.5] | Finite Element Methods | |
| **10. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

### Aerospace Engineering - Bachelor of Engineering Stream C: Aerospace Electronics and Systems (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.0 credits in:** | | **4.0** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **3. 0.5 credit in** Basic Science Elective | | 0.5 |
| **Second year** | | |
| **4. a) 5.0 credits in:** | | **5.0** |
| AERO 2001 [0.5] | Aerospace Engineering Graphical Design | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ELEC 2501 [0.5] | Circuits and Signals | |
| ELEC 2507 [0.5] | Electronics I | |
| ELEC 2607 [0.5] | Switching Circuits | |
| MAAE 2101 [0.5] | Engineering Dynamics | |
| MAAE 2202 [0.5] | Mechanics of Solids I | |
| MAAE 2700 [0.5] | Engineering Materials | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **5. 5.5 credits in:** | | 5.5 |
| AERO 3002 [0.5] | Aerospace Design and Practice | |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 3800 [0.5] | Engineering Economics | |
| ELEC 3105 [0.5] | Electromagnetic Fields | |
| 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 3500 [0.5] | Feedback Control Systems | |
| MATH 3705 [0.5] | Mathematical Methods I | |
| SYSC 3600 [0.5] | Systems and Simulation | |
| **Fourth year** | | |
| **6. 2.5 credits in:** | | 2.5 |
| AERO 4003 [0.5] | Aerospace Systems Design | |
| AERO 4504 [0.5] | Avionics Systems | |
| ECOR 4995 [0.5] | Professional Practice | |
| MAAE 2400 [0.5] | Thermodynamics and Heat Transfer | |
| SYSC 3501 [0.5] | Communication Theory | |
| **7. 1.0 credit from:** | | 1.0 |
| MAAE 4907 [1.0] | Engineering Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **8. 1.5 credits from:** 4000-level AERO, MAAE or MECH, or | | 1.5 |
| AERO 3240 [0.5] | Orbital Mechanics | |
| AERO 3841 [0.5] | Spacecraft Design I | |
| ELEC 4502 [0.5] | Microwave Circuits | |
| 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 4600 [0.5] | Radar and Navigation | |
| ELEC 4609 [0.5] | Integrated Circuit Design and Fabrication | |
| ELEC 4703 [0.5] | Solar Cells | |
| ELEC 4706 [0.5] | High-Speed Electronics: Circuits and Systems | |
| ELEC 4707 [0.5] | Analog Integrated Electronics | |

| | | |
|---|---|---|
| ELEC 4708 [0.5] | Advanced Digital Integrated Circuit Design | |
| ELEC 4709 [0.5] | Integrated Sensors | |
| SYSC 4205 [0.5] | Image Processing for Medical Applications | |
| SYSC 4600 [0.5] | Digital Communications | |
| SYSC 4607 [0.5] | Wireless Communications | |
| **9. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

### Aerospace Engineering - Bachelor of Engineering Stream D: Space Systems Design (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.0 credits in:** | | **4.0** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **3. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Second year** | | |
| **4. a) 4.5 credits in:** | | **4.5** |
| AERO 2001 [0.5] | Aerospace Engineering Graphical Design | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| 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 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| SYSC 3600 [0.5] | Systems and Simulation | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **5. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Third year** | | |
| **6. 5.5 credits in:** | | 5.5 |
| AERO 3002 [0.5] | Aerospace Design and Practice | |
| AERO 3240 [0.5] | Orbital Mechanics | |
| AERO 3841 [0.5] | Spacecraft Design I | |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 3800 [0.5] | Engineering Economics | |
| ELEC 3909 [0.5] | Electromagnetic Waves | |
| MAAE 2700 [0.5] | Engineering Materials | |
| MAAE 3004 [0.5] | Dynamics of Machinery | |
| MAAE 3300 [0.5] | Fluid Mechanics II | |
| MAAE 3500 [0.5] | Feedback Control Systems | |
| MATH 3705 [0.5] | Mathematical Methods I | |
| **Fourth year** | | |
| **7. 3.0 credits in:** | | 3.0 |
| 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 4995 [0.5] | Professional Practice | |
| ELEC 4509 [0.5] | Communication Links | |
| **8. 1.0 credit from:** | | 1.0 |
| MAAE 4907 [1.0] | Engineering Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **9. 1.5 credits from** 4000-level MAAE, AERO or MECH, or | | 1.5 |
| AERO 3101 [0.5] | Lightweight Structures | |
| AERO 3700 [0.5] | Aerospace Materials | |
| ELEC 4503 [0.5] | Radio Frequency Lines and Antennas | |
| ELEC 4600 [0.5] | Radar and Navigation | |
| ELEC 4709 [0.5] | Integrated Sensors | |
| **Total Credits** | | **21.0** |

### Architectural Conservation and Sustainability Engineering - Bachelor of Engineering (21.5 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5 credits in:** | | **4.5** |
| ARCH 1000 [0.5] | Introduction to Architecture | |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Basic Science Electives | | 0.5 |

| | | |
|---|---|---|
| **Second year** | | |
| **3. a) 5.5 credits in:** | | **5.5** |
| ACSE 2001 [0.5] | Architecture and the Environment | |
| ARCC 2202 [0.5] | Architectural Technology 1 | |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| CDNS 2400 [0.5] | Heritage Places and Practices in Canada | |
| CIVE 2200 [0.5] | Mechanics of Solids I | |
| CIVE 2700 [0.5] | Civil Engineering Materials | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| MAAE 2300 [0.5] | Fluid Mechanics I | |
| MAAE 2400 [0.5] | Thermodynamics and Heat Transfer | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| **b) Successful completion of** | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **4. 5.5 credits in:** | | 5.5 |
| ACSE 3105 [0.5] | Green Building Design | |
| ACSE 3201 [0.5] | Introduction to Building Performance Simulation | |
| ACSE 3207 [0.5] | Historic Site Recording and Assessment | |
| ACSE 3209 [0.5] | Building Science | |
| ARCC 2203 [0.5] | Architectural Technology 3 | |
| 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 4202 [0.5] | Wood Engineering | |
| ECOR 3800 [0.5] | Engineering Economics | |
| **Fourth year** | | |
| **5. 3.0 credits in:** | | 3.0 |
| ACSE 4101 [0.5] | Introduction to Structural Assessment of Historic Masonry Buildings | |
| ACSE 4106 [0.5] | Indoor Environmental Quality | |
| ACSE 4107 [0.5] | Building Services Engineering | |
| ACSE 4601 [0.5] | Building Pathology and Rehabilitation | |
| ARCH 4200 [0.5] | Architectural Conservation Philosophy and Ethics | |
| ECOR 4995 [0.5] | Professional Practice | |
| **6. 1.0 credit from** | | 1.0 |
| ACSE 4918 [1.0] | Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **7. 1.5 credits from:** | | 1.5 |
| CIVE 3202 [0.5] | Mechanics of Solids II | |
| CIVE 3208 [0.5] | Geotechnical Mechanics | |
| 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 Systems | |
| 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 4407 [0.5] | Municipal Engineering | |
| 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 4003 [0.5] | Air Pollution and Emissions Control | |
| ENVE 4200 [0.5] | Climate Change and Engineering | |
| MECH 4407 [0.5] | Heating and Air Conditioning | |
| SREE 4002 [0.5] | Modelling and Analysis of Energy Systems: Risk, Reliability, and Economics | |
| **Total Credits** | | **21.5** |

**Note:** Students admitted starting from fall 2019 are not eligible to select either the Structural or Environmental stream of the program.

## Biomedical and Electrical Engineering Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5 credits in:** | | **4.5** |
| CHEM 1001 [0.5] | General Chemistry I | |
| CHEM 1002 [0.5] | General Chemistry II | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives. | | 0.5 |
| **Second year** | | |
| 3. a) 5.0 credits in: | | 5.0 |
| BIOL 1103 [0.5] | Foundations of Biology I | |

| | | |
|---|---|---|
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ELEC 2501 [0.5] | Circuits and Signals | |
| ELEC 2507 [0.5] | Electronics I | |
| ELEC 2607 [0.5] | Switching Circuits | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| SYSC 2006 [0.5] | Foundations of Imperative Programming | |
| SYSC 2510 [0.5] | Probability, Statistics and Random Processes for Engineers | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **4. 4.5 credits in:** | | 4.5 |
| ELEC 3105 [0.5] | Electromagnetic Fields | |
| 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 | |
| ECOR 3800 [0.5] | Engineering Economics | |
| **5. 0.5 credit from:** | | 0.5 |
| BIOL 1104 [0.5] | Foundations of Biology II | |
| BIOL 2005 [0.5] | Human Biology | |
| BIOL 2201 [0.5] | Cell Biology and Biochemistry | |
| BIOL 2303 [0.5] | Microbiology | |
| BIOL 3306 [0.5] | Human Anatomy and Physiology | |
| BIOL 4309 [0.5] | Studies in Human Performance | |
| BIOL 4319 [0.5] | Studies in Exercise Physiology | |
| CHEM 2203 [0.5] | Organic Chemistry I | |
| CHEM 2204 [0.5] | Organic Chemistry II | |
| **OR (with permission of the department)** | | |
| 0.5 credit in BIOL, BIOC or CHEM | | |
| **6. 0.5 credit from:** | | 0.5 |
| ELEC 3908 [0.5] | Physical Electronics | |
| SYSC 2010 [0.5] | Programming Project | |
| **Fourth year** | | |
| **7. 2.0 credits in:** | | 2.0 |
| 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 | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **9. 0.5 credit from** the list in Item 5 | | 0.5 |
| **10. 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 | |
| SYSC 4206 [0.5] | Surgical Robotics | |
| **OR** | | |
| 0.5 credit in BIOM at the 5000 level | | |
| **11. 0.5 credit from** SYSC or ELEC course at the 3000 level or above | | 0.5 |
| **OR** | | |
| 0.5 credit in BIOM or SYSC at the 5000 level | | |
| **12. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

## Biomedical and Mechanical Engineering Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5. credits in:** | | **4.5** |
| CHEM 1001 [0.5] | General Chemistry I | |
| CHEM 1002 [0.5] | General Chemistry II | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Second year** | | |
| 3. a) 4.5 credits in: | | 4.5 |
| BIOL 1103 [0.5] | Foundations of Biology 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 | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **4. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Third year** | | |
| **5. 6.0 credits in:** | | 6.0 |

| | | |
|---|---|---|
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ECOR 3800 [0.5] | Engineering Economics | |
| 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 | |
| MATH 3705 [0.5] | Mathematical Methods I | |
| 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 | |
| **Fourth year** | | |
| **6. 2.5 credits in:** | | 2.5 |
| ECOR 4995 [0.5] | Professional Practice | |
| MECH 4013 [0.5] | Biomedical Device Design | |
| MECH 4210 [0.5] | Biomechanics | |
| MECH 4406 [0.5] | Heat Transfer | |
| SYSC 4201 [0.5] | Ethics, Research Methods and Standards for Biomedical Engineering | |
| **7. 1.0 credit from** | | 1.0 |
| MAAE 4907 [1.0] | Engineering Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering 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 credits from:** | | 1.0 |
| BIOL 2005 [0.5] | Human Biology | |
| BIOL 2201 [0.5] | Cell Biology and Biochemistry | |
| CHEM 2203 [0.5] | Organic Chemistry I | |
| **OR (with permission of the department)** | | |
| 1.0 credit in BIOL, BIOC or CHEM | | |
| **Total Credits** | | **21.0** |

## Civil Engineering
## Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5 credits in:** | | **4.5** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| ERTH 2404 [0.5] | Engineering Geoscience | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Elective | | 0.5 |
| **Second year** | | |
| **3. a) 5.0 credits in:** | | **5.0** |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| CIVE 2004 [0.5] | GIS, Surveying, CAD and BIM | |
| CIVE 2101 [0.5] | Engineering Mechanics | |
| CIVE 2200 [0.5] | Mechanics of Solids I | |
| CIVE 2700 [0.5] | Civil Engineering Materials | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| MAAE 2300 [0.5] | Fluid Mechanics I | |
| MAAE 2400 [0.5] | Thermodynamics and Heat Transfer | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| **b) Successful completion of** | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **4. 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 3210 [0.5] | Geotechnical Engineering | |
| CIVE 3304 [0.5] | Transportation Engineering and Planning | |
| CIVE 3305 [0.5] | Highway Engineering | |
| CIVE 3407 [0.5] | Municipal Engineering | |
| ECOR 3800 [0.5] | Engineering Economics | |
| **Fourth year** | | |
| **5. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **6. 0.5 credit in:** | | 0.5 |
| ECOR 4995 [0.5] | Professional Practice | |
| **7. 1.0 credit from** | | 1.0 |
| CIVE 4918 [1.0] | Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **8. 0.5 credit from:** | | 0.5 |
| CIVE 4202 [0.5] | Wood Engineering | |
| CIVE 4301 [0.5] | Foundation Engineering | |
| CIVE 4204 [0.5] | Pavement Design | |
| **9. 3.0 credits from:** | | 3.0 |
| ACSE 3105 [0.5] | Green Building Design | |
| ACSE 4101 [0.5] | Introduction to Structural Assessment of Historic Masonry Buildings | |

| | | |
|---|---|---|
| CIVE 3209 [0.5] | Building Science | |
| 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 4204 [0.5] | Pavement Design | |
| CIVE 4205 [0.5] | Traffic Engineering | |
| CIVE 4301 [0.5] | Foundation Engineering | |
| CIVE 4302 [0.5] | Reinforced and Prestressed Concrete Design | |
| CIVE 4303 [0.5] | Urban Systems | |
| 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 4200 [0.5] | Climate Change and Engineering | |
| MATH 3705 [0.5] | Mathematical Methods I | |
| **Total Credits** | | **21.0** |

## Communications Engineering Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5 credits in:** | | **4.5** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| SYSC 1006 [0.5] | Foundations of Imperative Programming | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Second year** | | |
| **3. a) 5.5 credits in:** | | **5.5** |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ELEC 2501 [0.5] | Circuits and Signals | |
| ELEC 2507 [0.5] | Electronics I | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| SYSC 2010 [0.5] | Programming Project | |
| 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 2510 [0.5] | Probability, Statistics and Random Processes for Engineers | |
| **b) Successful completion of** | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **4. 4.5 credits in:** | | 4.5 |
| ECOR 3800 [0.5] | Engineering Economics | |
| ELEC 3105 [0.5] | Electromagnetic Fields | |
| ELEC 3509 [0.5] | Electronics II | |
| ELEC 3909 [0.5] | Electromagnetic Waves | |
| SYSC 3310 [0.5] | Introduction to Real-Time Systems | |
| SYSC 3501 [0.5] | Communication Theory | |
| SYSC 3512 [0.5] | Computer Communications | |
| SYSC 3522 [0.5] | Communications Software Laboratory | |
| SYSC 3600 [0.5] | Systems and Simulation | |
| **5. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **6. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Fourth year** | | |
| **7. 3.0 credits in:** | | 3.0 |
| ECOR 4995 [0.5] | Professional Practice | |
| SYSC 4405 [0.5] | Digital Signal Processing | |
| SYSC 4505 [0.5] | Automatic Control Systems I | |
| SYSC 4511 [0.5] | Digital Wireless Communication | |
| SYSC 4700 [0.5] | Topics in Communications Networks | |
| SYSC 4810 [0.5] | Introduction to Network and Software Security | |
| **8. 0.5 credit from:** | | 0.5 |
| SYSC 4415 [0.5] | Introduction to Machine Learning | |
| SYSC 4416 [0.5] | Artificial Intelligence in Engineering | |
| **9. 1.0 credit from:** | | 1.0 |
| SYSC 4907 [1.0] | Engineering Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **10. 0.5 credit from:** | | 0.5 |
| SYSC or ELEC at the 3000 level or above (may include 0.5 credit in SYSC at the 5000 level) | | |
| **Total Credits** | | **21.0** |

## Computer Systems Engineering Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5 credits in:** | | **4.5** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |

| | | |
|---|---|---|
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| SYSC 1006 [0.5] | Foundations of Imperative Programming | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Second year** | | |
| 3. a) 5.0 credits in: | | 5.0 |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ELEC 2501 [0.5] | Circuits and Signals | |
| ELEC 2507 [0.5] | Electronics I | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| 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 2510 [0.5] | Probability, Statistics and Random Processes for Engineers | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **4. 0.5 credit from:** | | 0.5 |
| BIOL 1103 [0.5] | Foundations of Biology I | |
| BIOL 1104 [0.5] | Foundations of Biology II | |
| CHEM 2302 [0.5] | Analytical Chemistry I | |
| CHEM 2800 [0.5] | Foundations for Environmental Chemistry | |
| PHYS 1001 [0.5] | Foundations of Physics I | |
| PHYS 1003 [0.5] | Introductory Mechanics and Thermodynamics | |
| **Third year** | | |
| **5. 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 3310 [0.5] | Introduction to Real-Time Systems | |
| SYSC 3313 [0.5] | Real-Time Embedded 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 | |
| **6. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Fourth year** | | |
| **7. 2.5 credits in:** | | 2.5 |
| ECOR 4995 [0.5] | Professional Practice | |
| 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 | |
| **8. 1.0 credit from:** | | 1.0 |
| SYSC 4907 [1.0] | Engineering Project (if supervisor is in Systems and Computer Engineering) | |
| ELEC 4907 [1.0] | Engineering Project (if supervisor is in Electronics) | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **9. 1.5 credits from:** | | 1.5 |
| MECH 4503 [0.5] | An Introduction to Robotics | |
| or SYSC or ELEC at the 3000 level or above (may include 1.0 credit in SYSC at the 5000 level) | | |
| **Total Credits** | | **21.0** |

## Electrical Engineering
## Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.0 credits in:** | | **4.0** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **3. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Second year** | | |
| 4. a) 5.0 credits in: | | 5.0 |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ELEC 2501 [0.5] | Circuits and Signals | |
| ELEC 2507 [0.5] | Electronics I | |

| | | |
|---|---|---|
| ELEC 2602 [0.5] | Electric Machines and Power | |
| ELEC 2607 [0.5] | Switching Circuits | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| 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 | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **5. 5.5 credits in:** | | 5.5 |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ECOR 3800 [0.5] | Engineering Economics | |
| ELEC 3105 [0.5] | Electromagnetic Fields | |
| 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** | | |
| **6. 1.5 credits in:** | | 1.5 |
| ECOR 4995 [0.5] | Professional Practice | |
| ELEC 4601 [0.5] | Microprocessor Systems | |
| SYSC 4505 [0.5] | Automatic Control Systems I | |
| **7. 1.0 credit from:** | | 1.0 |
| ELEC 4907 [1.0] | Engineering Project (if supervisor is in Electronics) | |
| SYSC 4907 [1.0] | Engineering Project (if supervisor is in Systems and Computer Engineering) | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **8. 2.0 credits from:** | | 2.0 |
| 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 | | |
| **9. 0.5 credit from:** | | 0.5 |
| Basic Science Electives, or | | |
| ENVE, CIVE, IDES, MAAE, AERO, MECH at the 2000 level or above, or | | |
| 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 | | |
| **10. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

## Engineering Physics
## Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5 credits in:** | | **4.5** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus 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 | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Second year** | | |
| 3. a) 5.5 credits in: | | 5.5 |
| ELEC 2501 [0.5] | Circuits and Signals | |
| ELEC 2507 [0.5] | Electronics I | |
| MAAE 2400 [0.5] | Thermodynamics and Heat Transfer | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| MATH 3705 [0.5] | Mathematical Methods I | |
| PHYS 2007 [0.5] | Second Year Physics Laboratory: Selected Experiments and Seminars | |
| PHYS 2605 [0.5] | Modern Physics I | |
| SYSC 2004 [0.5] | Object-Oriented Software Development | |
| SYSC 2006 [0.5] | Foundations of Imperative Programming | |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **4. 5.5 credits in:** | | 5.5 |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ECOR 3800 [0.5] | Engineering Economics | |
| ELEC 2607 [0.5] | Switching Circuits | |
| ELEC 3105 [0.5] | Electromagnetic Fields | |
| ELEC 3907 [0.5] | Engineering Project | |
| 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 3600 [0.5] | Systems and Simulation | |
| **Fourth year** | | |
| **5. 2.5 credits in:** | | 2.5 |
| ECOR 4995 [0.5] | Professional Practice | |
| ELEC 3500 [0.5] | Digital Electronics | |
| ELEC 3509 [0.5] | Electronics II | |
| 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 from** | | 1.0 |
| ELEC 4908 [1.0] | Engineering Physics Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **6. 0.5 credit from:** | | 0.5 |
| 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 4708 [0.5] | Introduction to Quantum Mechanics II | |
| PHYS 4807 [0.5] | Statistical Data Analysis Techniques for Physics | |
| **7. 0.5 credit in** ELEC at the 4000 level excluding: ELEC 4504, ELEC 4600, ELEC 4703, and ELEC 4705 | | 0.5 |
| **8. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

## Environmental Engineering Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5 credits in:** | | **4.5** |
| CHEM 1001 [0.5] | General Chemistry I | |
| CHEM 1002 [0.5] | General Chemistry II | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Second year** | | |
| **3. a) 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 | |
| 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 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| **b) Successful completion of** | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **4. 5.5 credits in:** | | 5.5 |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| 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** | | |
| **5. 3.0 credits in:** | | 3.0 |
| 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 | |
| **6. 1.0 credit from** | | 1.0 |
| ENVE 4918 [1.0] | Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **7. 1.0 credit from:** | | 1.0 |
| ACSE 3105 [0.5] | Green Building Design | |
| ACSE 4106 [0.5] | Indoor Environmental Quality | |
| 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 Systems | |
| CIVE 4400 [0.5] | Construction/Project Management | |
| ENVE 4002 [0.5] | Environmental Geotechnical Engineering | |
| ENVE 4200 [0.5] | Climate Change and Engineering | |
| 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 | |
| SREE 3001 [0.5] | Sustainable and Renewable Energy Sources | |
| SREE 4002 [0.5] | Modelling and Analysis of Energy Systems: Risk, Reliability, and Economics | |
| SYSC 3200 [0.5] | Industrial Engineering | |
| **8. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

## Mechanical Engineering Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.0 credits in:** | | **4.0** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **3. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Second year** | | |
| 4. a) 5.0 credits in: | | 5.0 |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ELEC 3605 [0.5] | Electrical 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 | |
| MAAE 2700 [0.5] | Engineering Materials | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **5. 5.5 credits in:** | | 5.5 |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 3800 [0.5] | Engineering Economics | |
| 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 | |
| MATH 3705 [0.5] | Mathematical Methods I | |
| 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. 2.0 credits in:** | | 2.0 |
| ECOR 4995 [0.5] | Professional Practice | |
| MAAE 4102 [0.5] | Materials: Strength and Fracture | |
| MECH 4003 [0.5] | Mechanical Systems Design | |
| MECH 4406 [0.5] | Heat Transfer | |
| 7.0 1.0 credit from | | 1.0 |
| MAAE 4907 [1.0] | Engineering Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **8. 2.0 credits in** 4000-level Mechanical and Aerospace Engineering (MAAE, AERO or MECH) | | 2.0 |
| **9. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

## Mechatronics Engineering Bachelor of Engineering (21.5 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.0 credits in:** | | **4.0** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **3. 0.5 credit in** Basic Science Electives | | 0.5 |

| | | |
|---|---|---|
| **Second year** | | |
| 4. a) 6.0 credits in: | | 6.0 |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ELEC 2501 [0.5] | Circuits and Signals | |
| ELEC 2507 [0.5] | Electronics I | |
| ELEC 2602 [0.5] | Electric Machines and Power | |
| MAAE 2001 [0.5] | Engineering Graphical Design | |
| MAAE 2101 [0.5] | Engineering Dynamics | |
| MAAE 2203 [0.5] | Mechanics of Solids | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| SYSC 2006 [0.5] | Foundations of Imperative Programming | |
| SYSC 2310 [0.5] | Introduction to Digital Systems | |
| SYSC 2320 [0.5] | Introduction to Computer Organization and Architecture | |
| **Third year** | | |
| **5. 5.5 credits in:** | | 5.5 |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| ECOR 3800 [0.5] | Engineering Economics | |
| ELEC 3508 [0.5] | Power Electronics | |
| ELEC 4709 [0.5] | Integrated Sensors | |
| MAAE 2300 [0.5] | Fluid Mechanics I | |
| MAAE 2401 [0.5] | Mechatronics Thermodynamics and Heat Transfer | |
| MAAE 3004 [0.5] | Dynamics of Machinery | |
| MAAE 3505 [0.5] | Mechatronics I | |
| MECH 3002 [0.5] | Machine Design and Practice | |
| SYSC 3310 [0.5] | Introduction to Real-Time Systems | |
| SYSC 3600 [0.5] | Systems and Simulation | |
| b) Successful completion of | | |
| **Fourth year** | | |
| **6. 4.0 credits in:** | | 4.0 |
| ECOR 4995 [0.5] | Professional Practice | |
| MAAE 4706 [0.5] | Mechatronics II | |
| MECH 4503 [0.5] | An Introduction to Robotics | |
| MECT 4907 [1.0] | Engineering Project | |
| SYSC 3320 [0.5] | Computer Systems Design | |
| SYSC 4505 [0.5] | Automatic Control Systems I | |
| SYSC 4709 [0.5] | Industrial Automation | |
| **7. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **8. 0.5 credit in** Engineering Elective or ECOR 2606 | | 0.5 |
| **Total Credits** | | **21.5** |

## Software Engineering
## Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5 credits in:** | | **4.5** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| SYSC 1006 [0.5] | Foundations of Imperative Programming | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Second year** | | |
| **3. a) 5.0 credits in:** | | **5.0** |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| COMP 1805 [0.5] | Discrete Structures I | |
| COMP 2804 [0.5] | Discrete Structures II | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series 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 3110 [0.5] | Software Development Project | |
| **b) Successful completion of:** | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **4. 0.5 credit from:** | | 0.5 |
| BIOL 1103 [0.5] | Foundations of Biology I | |
| BIOL 1104 [0.5] | Foundations of Biology II | |
| CHEM 2302 [0.5] | Analytical Chemistry I | |
| CHEM 2800 [0.5] | Foundations for Environmental Chemistry | |
| PHYS 1001 [0.5] | Foundations of Physics I | |
| PHYS 1003 [0.5] | Introductory Mechanics and Thermodynamics | |
| **Third year** | | |
| **5. 5.0 credits in:** | | 5.0 |
| COMP 3005 [0.5] | Database Management Systems | |
| SYSC 3101 [0.5] | Programming Languages | |
| 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] | The Software Economy and Project Management | |
| SYSC 4120 [0.5] | Software Architecture and Design | |
| SYSC 4130 [0.5] | Human Computer Interaction | |
| SYSC 4806 [0.5] | Software Engineering Lab | |

| | | |
|---|---|---|
| **6. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Fourth year** | | |
| **7. 1.5 credits in:** | | 1.5 |
| ECOR 4995 [0.5] | Professional Practice | |
| SYSC 4101 [0.5] | Software Validation | |
| SYSC 4810 [0.5] | Introduction to Network and Software Security | |
| **8. 1.0 credit in:** | | 1.0 |
| SYSC 4907 [1.0] | Engineering Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **9. 1.0 credit from** SYSC or ELEC courses at the 3000 level or above | | 1.0 |
| **10. 1.0 credit from** the list in Item 9 | | 1.0 |
| or 1.0 credit in Computer Science Electives for Software Engineering | | |
| or 1.0 credit in SYSC at the 5000 level (with permission of the department) | | |
| **11. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

## Software Engineering Stream A: Artificial Intelligence
## Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.5 credits in:** | | **4.5** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| SYSC 1006 [0.5] | Foundations of Imperative Programming | |
| b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of: | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Second year** | | |
| **3. a) 5.0 credits in:** | | **5.0** |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| COMP 1805 [0.5] | Discrete Structures I | |
| COMP 2804 [0.5] | Discrete Structures II | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| MATH 1005 [0.5] | Differential Equations and Infinite Series 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 3110 [0.5] | Software Development Project | |
| b) Successful completion of: | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **4. 0.5 credit from:** | | **0.5** |
| BIOL 1103 [0.5] | Foundations of Biology I | |
| BIOL 1104 [0.5] | Foundations of Biology II | |
| CHEM 2302 [0.5] | Analytical Chemistry I | |
| CHEM 2800 [0.5] | Foundations for Environmental Chemistry | |
| PHYS 1001 [0.5] | Foundations of Physics I | |
| PHYS 1003 [0.5] | Introductory Mechanics and Thermodynamics | |
| **Third year** | | |
| **5. 5.0 credits in:** | | **5.0** |
| COMP 3005 [0.5] | Database Management Systems | |
| SYSC 3101 [0.5] | Programming Languages | |
| 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] | The Software Economy and Project Management | |
| SYSC 4120 [0.5] | Software Architecture and Design | |
| SYSC 4130 [0.5] | Human Computer Interaction | |
| SYSC 4806 [0.5] | Software Engineering Lab | |
| **6. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Fourth year** | | |
| **7. 1.5 credits in:** | | **1.5** |
| ECOR 4995 [0.5] | Professional Practice | |
| SYSC 4101 [0.5] | Software Validation | |
| SYSC 4810 [0.5] | Introduction to Network and Software Security | |
| **8. 1.0 credit in:** | | **1.0** |
| SYSC 4907 [1.0] | Engineering Project | |
| **9. 0.5 credit from** SYSC or ELEC courses at the 3000 level or above, or 0.5 credit from Computer Science Electives for Software Engineering | | 0.5 |
| **10. 1.5 credits from:** | | **1.5** |
| SYSC 3200 [0.5] | Industrial Engineering | |
| SYSC 4415 [0.5] | Introduction to Machine Learning | |
| SYSC 4416 [0.5] | Artificial Intelligence in Engineering | |
| SYSC 5103 [0.5] | Software Agents | |
| **11. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

## Sustainable and Renewable Energy Stream A: Smart Technologies for Power Generation and Distribution
## Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.0 credits in:** | | **4.0** |

| | | |
|---|---|---|
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **3. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Second year** | | |
| **4. a) 5.0 credits in:** | | **5.0** |
| ELEC 2501 [0.5] | Circuits and Signals | |
| ELEC 2507 [0.5] | Electronics I | |
| ELEC 2602 [0.5] | Electric Machines and Power | |
| 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 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| SYSC 2006 [0.5] | Foundations of Imperative Programming | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **5. 5.5 credits in:** | | 5.5 |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 3800 [0.5] | Engineering Economics | |
| ELEC 3105 [0.5] | Electromagnetic Fields | |
| ELEC 3508 [0.5] | Power Electronics | |
| ELEC 3602 [0.5] | Electrical Power Systems | |
| SREE 3001 [0.5] | Sustainable and Renewable Energy Sources | |
| SREE 3002 [0.5] | Electrical Distribution Systems | |
| SREE 3003 [0.5] | Sustainable and Renewable Electricity Generation | |
| SYSC 3006 [0.5] | Computer Organization | |
| SYSC 3600 [0.5] | Systems and Simulation | |
| **Fourth year** | | |
| **6. 3.5 credits in:** | | 3.5 |
| ECOR 4995 [0.5] | Professional Practice | |
| ELEC 4601 [0.5] | Microprocessor Systems | |
| ELEC 4703 [0.5] | Solar Cells | |
| SREE 4001 [0.5] | Efficient Energy Conversion | |
| SREE 4002 [0.5] | Modelling and Analysis of Energy Systems: Risk, Reliability, and Economics | |
| SYSC 4505 [0.5] | Automatic Control Systems I | |
| SYSC 4602 [0.5] | Computer Communications | |
| **7. 1.0 credit in:** | | 1.0 |
| SREE 4907 [1.0] | Energy Engineering Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **8. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **9. 0.5 credit in** any 4000-level Engineering course for which prerequisites have been satisfied | | 0.5 |
| **Total Credits** | | **21.0** |

## Sustainable and Renewable Energy Stream B: Efficient Energy Generation and Conversion Bachelor of Engineering (21.0 credits)

| | | |
|---|---|---|
| **First year** | | |
| **1. a) 4.0 credits in:** | | **4.0** |
| CHEM 1101 [0.5] | Chemistry for Engineering Students | |
| ECOR 1031 [0.5] | Programming and Data Management | |
| ECOR 1032 [0.5] | Circuits and Mechatronics | |
| ECOR 1033 [0.5] | Statics | |
| ECOR 1034 [0.5] | Dynamics | |
| MATH 1004 [0.5] | Calculus for Engineering or Physics | |
| MATH 1104 [0.5] | Linear Algebra for Engineering or Science | |
| PHYS 1004 [0.5] | Introductory Electromagnetism and Wave Motion | |
| **b) The Introduction to Engineering Disciplines requirement must be met through the successful completion of:** | | |
| ECOR 1055 [0.0] | Introduction to Engineering Disciplines I | |
| ECOR 1056 [0.0] | Introduction to Engineering Disciplines II | |
| ECOR 1057 [0.0] | Engineering Profession | |
| **2. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **3. 0.5 credit in** Basic Science Electives | | 0.5 |
| **Second year** | | |
| **4. a) 5.0 credits in:** | | **5.0** |
| ELEC 2501 [0.5] | Circuits and Signals | |
| ELEC 2602 [0.5] | Electric Machines and Power | |
| 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 1005 [0.5] | Differential Equations and Infinite Series for Engineering or Physics | |

| | | |
|---|---|---|
| MATH 2004 [0.5] | Multivariable Calculus for Engineering or Physics | |
| b) Successful completion of | | |
| ECOR 2995 [0.0] | Engineering Portfolio | |
| **Third year** | | |
| **5. 6.0 credits in:** | | 6.0 |
| CCDP 2100 [0.5] | Communication Skills for Engineering Students | |
| ECOR 2050 [0.5] | Design and Analysis of Engineering Experiments | |
| ECOR 3800 [0.5] | Engineering Economics | |
| 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 | |
| MATH 3705 [0.5] | Mathematical Methods I | |
| SREE 3001 [0.5] | Sustainable and Renewable Energy Sources | |
| SREE 3002 [0.5] | Electrical Distribution Systems | |
| SREE 3003 [0.5] | Sustainable and Renewable Electricity Generation | |
| SYSC 3600 [0.5] | Systems and Simulation | |
| **Fourth year** | | |
| **6. 3.0 credits in:** | | 3.0 |
| ECOR 4995 [0.5] | Professional Practice | |
| 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] | Modelling and Analysis of Energy Systems: Risk, Reliability, and Economics | |
| SYSC 3200 [0.5] | Industrial Engineering | |
| **7. 1.0 credit from** | | 1.0 |
| MAAE 4907 [1.0] | Engineering Design Project | |
| OR | | |
| ECOR 4907 [1.0] | Multidisciplinary Engineering Project | |
| **8. 0.5 credit from** | | 0.5 |
| Any 4000-level Engineering course for which prerequisites have been satisfied, or | | |
| ELEC 3602 [0.5] | Electrical Power Systems | |
| **9. 0.5 credit in** Complementary Studies Electives | | 0.5 |
| **Total Credits** | | **21.0** |

## Regulations

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

### Academic Continuation Evaluation

In addition to the requirements presented here, students must satisfy the University regulations common to all undergraduate students including the process of Academic Continuation Evaluation (see Section 3.2 Academic Progression, in the *Academic Regulations of the University*), with the following additions and amendments:

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 *Eligible to Continue* (EC) or *Academic Warning* (AW) will be required to leave the degree with either the status *Continue in Alternate* (CA) or *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. To be eligible for graduation, the most recent grade in every course used to meet the requirements of the Bachelor of Engineering degree must be a passing grade.

### 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 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.

**2nd year status**: Students may not continue into 2000-level (or higher) engineering courses unless all the following requirements are met:

1. Successful completion of all ECOR 1040 series or ECOR 1030 series of courses with a minimum grade of C-;
2. Successful completion of MATH 1004, MATH 1104, CHEM 1101 (or CHEM 1001 and CHEM 1002), and PHYS 1004 (or PHYS 1001 and PHYS 1002);
3. Successful completion of all English as a Second Language Requirements, and any additional requirements as determined in the admission process.

Students may not continue into 3000-level (or higher) engineering courses until they complete all first-year

requirements (including ECOR 1055, ECOR 1056, and ECOR 1057).

**3rd year status**: Students may not take courses with third-year status in Engineering as a prerequisite until successful completion of all first-year requirements and at least 4.0 credits from the second-year requirements of their current program.

**4th year status:** Students may not take courses with fourth-year status in Engineering as a prerequisite until successful completion of all second-year requirements and at least 3.5 credits from the third-year requirements of their current program.

#### 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* (CA).

#### 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 applies to a degree program with a Co-op option from high school, their university grades will be reviewed two terms to one year prior to their first work term to ensure they meet the academic requirements after their first or second year of study. The time at which the evaluation takes place depends on the program of study. Students will automatically receive an admission decision via their Carleton email account.

Students who did not request Co-op at the time they applied to Carleton can request Co-op after they begin their university studies. To view application instructions and deadlines, please visit carleton.ca/co-op.

To be admitted to Co-op, a student must successfully complete 5.0 or more credits that count towards their degree, meet the minimum CGPA requirement(s) for the student's Co-op option, and fulfil any specified course prerequisites. To see the unique admission and continuation requirements for each Co-op option, please refer to the specific degree programs listed in the Undergraduate Calendar.

## Participation Requirements

#### Co-op Participation Agreement

All students must adhere to the policies found within the Co-op Participation Agreement.

#### COOP 1000

Once a student has been admitted to the Co-op Program, they will be given access to register in COOP 1000. This zero-credit online course must be completed at least two terms prior to the student's first work term.

#### 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 Co-op students, no guarantee of employment can be made. The Co-op job search process is competitive, and success is dependent upon factors such as current market conditions, academic performance, skills, motivation, and level of commitment to the job search. It is the student's responsibility to apply for positions via the Co-op job board in addition to actively conducting a self-directed job search. Students who do not obtain a co-op work term are expected to continue with their academic studies. It should be noted that hiring priority for positions within the Federal Government of Canada is given to Canadian citizens.

#### Registration

- Students must be registered as full-time during all fall and winter study terms beginning the term in which they enroll in COOP 1000.
- Students will be registered in a Co-op Work Term course while at work. This course does not carry academic course credit, but is noted on academic transcripts.
- Students may register in a 0.5 credit during a work term, provided the course is offered during the evening or is offered asynchronously online.
- Students must have at least one term of full-time studies left to complete following their final co-op work term. Students cannot end their degree on a work term.

#### Work Term Assessment and Evaluation

#### Work Term Evaluation

Employers are responsible for submitting to Carleton University final performance evaluations for their Co-op students at the end of their work terms.

#### Work Term Assessment

In order to successfully complete the co-op work term, students must receive a Satisfactory (SAT) grade on their Co-op Work Term Report, which they must submit at the completion of each four-month work term.

**Graduation with the Co-op Designation**

In order to graduate with the Co-op Designation, students must satisfy all requirements of the degree program in addition to the successful completion of three or four work terms (the number is dependent upon the student's academic program). Students found in violation of the Co-op Participation Agreement may have the Co-op Designation withheld.

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 who are currently on a co-op work term or who have already committed to a co-op work term either verbally or in writing may not leave the position and/or withdraw from the co-op option until they have completed the work term and all related requirements.

**Involuntary or Required Withdrawal from the Co-op Option**

Students may be removed from the Co-op Program for any of the following reasons:

1. Failure to achieve a grade of SAT in COOP 1000;
2. Failure to attend all interviews for positions to which the student has applied;
3. Declining more than one job offer during the job search;
4. Reneging on a co-op position that the student has accepted either verbally or in writing;
5. Continuing a job search after accepting a co-op position;
6. Dismissal from a work term by the co-op employer;
7. Leaving a work term without approval from the Co-op Management Team;
8. Receipt of an unsatisfactory work term evaluation;
9. Receiving a grade of UNS on the work term report.

**International Students**

All international students are required to possess a Co-op Work Permit issued by Immigration, Refugees and Citizenship Canada before they can begin working. The Co-operative Education Office will provide students with a letter of support to accompany their Co-op Work Permit application. Students are advised to discuss the application process and application requirements with the International Student Services Office.

**Co-op Fees**

All participating Co-op students are required to pay Co-op fees. For full details, please see the Co-op website.

## Bachelor of Engineering: Co-op Admission and Continuation Requirements

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

In addition to the following:

1. Registered as a full-time student in the B.Eng program;
2. Successfully completed 5.0 or more credits with an Overall CGPA of at least 8.00. It is strongly recommended that students complete all second-year Engineering requirements prior to entering their first work term;
3. An Overall CGPA of at least 8.00 must be maintained in order to remain eligible for the Co-op Program.

B.Eng students 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 |
| Mechatronics Engineering: | |
| MECT 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 program) | |

**Work/Study Patterns**

**Aerospace Engineering, Architectural Conservation and Sustainability Engineering, Biomedical and Mechanical Engineering, Civil Engineering, Communications Engineering, Electrical engineering, engineering physics, Environmental Engineering, Mechanical Engineering, mechatronics 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 | | Summer | W | Summer | W | 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

## Admissions Information

Admission Requirements are for the 2025-26 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.

## Admissions Information

Admission requirements are based on the Ontario High School System. Prospective students can view the admission requirements through the Admissions website at admissions.carleton.ca. The overall average required for admission is determined each year on a program-by-program basis. Holding the minimum admission requirements only establishes eligibility for consideration; higher averages are required for admission to programs for which the demand for places by qualified applicants exceeds the number of places available. All programs have limited enrolment and admission is not guaranteed. Some programs may also require specific course prerequisites and prerequisite averages and/or supplementary admission portfolios. Consult admissions.carleton.ca for further details.

**Note:** If a course is listed as *recommended*, it is not mandatory for admission. Students who do not follow the recommendations will not be disadvantaged in the admission process.

## Degree

- Bachelor of Engineering (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 4U courses: 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 French is recommended.

### Advanced Standing

Applications for admission beyond first year will be assessed on their merits. 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.

### 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).

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 2001 [0.5 credit]**
**Aerospace 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. Aerospace-specific CAD (Computer-Aided Design) assignments including production of detail and assembly drawings from actual aerospace physical models.
Includes: Experiential Learning Activity
Also listed as MAAE 2001.
Prerequisite(s): Second-year status in Engineering.
Lectures and tutorials two hours a week, laboratory four hours a week.

**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. Basic orbital mechanics; launch vehicle sizing.
Includes: Experiential Learning Activity
Prerequisite(s): AERO 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.
Includes: Experiential Learning Activity
Prerequisite(s): MAAE 3202.
Lectures three hours a week; problem analysis 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.
Includes: Experiential Learning Activity
Prerequisite(s): MAAE 2700.
Lectures three hours a week; problem analysis 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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Prerequisite(s): AERO 3002 and fourth-year status in Engineering.
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 or permission of the department.
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.
Includes: Experiential Learning Activity
Prerequisite(s): MAAE 3004 and (MAAE 3300 or MECH 3310) and fourth-year status in Engineering or by permission of department.
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.
Includes: Experiential Learning Activity
Prerequisite(s): MAAE 3300 or MECH 3310.
Lectures three hours a week, problem analysis two hours a week.

**AERO 4304 [0.5 credit]**
**Computational Fluid Dynamics**
Governing equations of fluid motion (full & simplified). Discretization based on finite difference, finite volume, and finite element methods. Explicit and implicit integration schemes. Numerical stability. Numerical solutions of the Navier-Stokes equations: RANS, LES and DNS. Turbulence modeling. Programming-based assignments (convection/diffusion).
Prerequisite(s): (MAAE 3300 or MECH 3310), AERO 4302 recommended and fourth-year status in Engineering or by permission of the department.
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 or MECH 3310) and fourth-year status in Engineering.
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): Fourth-year status in Engineering.
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, (MAAE 3300 or MECH 3310), and fourth-year status in Engineering or by permission of the department.
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): MAAE 2400, (MAAE 3300 OR MECH 3310) and fourth-year status in Engineering.
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 and (MAAE 3300 or MECH 3310) and fourth-year status in Engineering.
Lectures three hours a week.

**AERO 4504 [0.5 credit]**
**Avionics Systems**
RF engineering concepts. Aviation communication systems. Relative and absolute navigation; landing systems. Radar systems; weather radar. Aircraft systems integration; databus standards; electrical systems; power generation and distribution. Safety critical software. Electromagnetic compatibility and interference. Regulations and certification of avionic systems.
Includes: Experiential Learning Activity
Precludes additional credit for ELEC 4504.
Prerequisite(s): 4th year status in Engineering. Not open to students in Electrical Engineering, Computer Systems Engineering, Engineering Physics or Communications Engineering.
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): AERO 3240 and MAAE 3500 and fourth-year status in Engineering.
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 or MECH 3310) and SYSC 3600 and fourth-year status in Engineering.
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 3004 and (MAAE 3300 or MECH 3310) and fourth-year status in Engineering or by permission of the department.
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 2202 and fourth-year status in Engineering.
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): MAAE 2700 and fourth-year status in Engineering or by permission of the department.
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 and fourth-year status in Engineering.
Lectures three hours a 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.
Includes: Experiential Learning Activity
Prerequisite(s): Second-year status in Engineering or (GEOM 1004 for students in BSc in Geomatics).
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.
Precludes additional credit for ARCH 2222. 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]**
**Engineering Mechanics**
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.
Prerequisite(s): MATH 1004, MATH 1104 and second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Precludes additional credit for MAAE 2202.
Prerequisite(s): MATH 1004 and second-year status in Engineering for B.Eng.
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.
Includes: Experiential Learning Activity
Precludes additional credit for MAAE 2700.
Prerequisite(s): Second year status for students in an Engineering program.
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Also listed as ACSE 3207, ARCH 3881.
Precludes additional credit for 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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Also listed as ACSE 3209.
Prerequisite(s): MAAE 2400 and third-year status in B. Eng. Civil Engineering.
Lectures three hours a week, problem analysis three hours alternate weeks.

**CIVE 3210 [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.
Also listed as CIVE 4208.
Prerequisite(s): CIVE 3208.
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, considerations for different modes of travel; sight distance requirements; fundamentals of traffic flow theory; transportation planning and travel demand; environmental impacts; traffic safety.
Precludes additional credit for 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 3305 [0.5 credit]**
**Highway Engineering**
Road functional classification, human factors of road design; geometric design; traffic engineering; highway capacity and level of service; highway materials; frost action; pavement mix design; structural design of rigid and flexible pavements; maintenance and rehabilitation.
Also listed as CIVE 4209.
Prerequisite(s): CIVE 3304 or permission of the Department.
Lectures three hours a week, problem analysis three hours alternate weeks.

**CIVE 3407 [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.
Also listed as CIVE 4407.
Prerequisite(s): third-year status in Engineering.
Lectures three hours a week, problem analysis one and a half hours a week

**CIVE 3999 [0.0 credit]**
**Co-operative Work Term**
Includes: Experiential Learning Activity
Precludes additional credit for ACSE 3999.

**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): fourth-year status in engineering.
Also offered at the graduate level, with different requirements, as CIVE 5103, for which additional credit is precluded.
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.
Prerequisite(s): CIVE 2200, CIVE 2700 and third-year status in B.Eng.
Lectures three hours a week, problem analysis three hours alternate weeks.

**CIVE 4204 [0.5 credit]**
**Pavement Design**
Pavement design methods, flexible pavement materials and mix designs, stresses and strains in flexible pavements; fatigue and rutting design considerations; traffic loading and design loads; design of flexible pavements using AASHTO, M-E and AI methods; rigid pavement designs, design of overlays.
Includes: Experiential Learning Activity
Prerequisite(s): Fourth year status and CIVE 4209.
Lectures three hours a week, problem analysis three hours alternate weeks.

**CIVE 4205 [0.5 credit]**
**Traffic Engineering**
Introduction to principles of traffic engineering. Traffic operation concepts. Travel modes and modal characteristics. Traffic stream characteristics and queuing theory. Capacity and level of service analysis of roads and intersections.
Includes: Experiential Learning Activity
Prerequisite(s): Fourth year status in engineering; and (CIVE 4209 or CIVE 3305).
Also offered at the graduate level, with different requirements, as CIVE 5305, for which additional credit is precluded.
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.
Also listed as CIVE 3210.
Prerequisite(s): CIVE 3208.
Lectures three hours a week, problem analysis three hours alternate weeks.

**CIVE 4209 [0.5 credit]**
**Highway Engineering**
Road functional classification, human factors of road design; geometric design; traffic engineering; highway capacity and level of service; highway materials; frost action; pavement mix design; structural design of rigid and flexible pavements; maintenance and rehabilitation.
Also listed as CIVE 3305.
Prerequisite(s): CIVE 3304 or permission of the Department.
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 3203 and CIVE 3206.
Lectures three hours a week, problem analysis three hours alternate weeks.

**CIVE 4303 [0.5 credit]**
**Urban Systems**
A systematic approach to urbanism; Sustainability in urban systems; Urban sprawl; Urban form; Urban theory, Population projections; Zoning; Integration of urban infrastructure components (waste, electricity water, transportation and buildings); Analysis of issues in Canadian urban areas; The future of cities.
Prerequisite(s): fourth-year status in Engineering, second-year standing in B.A.S. (Urbanism), 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 one and a half hours a week.

**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.
Also listed as CIVE 3407.
Prerequisite(s): third-year status in Engineering.
Lectures three hours a week, problem analysis one and a half hours a week

**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): 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.
Includes: Experiential Learning Activity
Also listed as ACSE 4601, 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.
Includes: Experiential Learning Activity
Precludes additional credit for ACSE 4907, ACSE 4917, 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.
Includes: Experiential Learning Activity
Precludes additional credit for ACSE 4907, ACSE 4917, 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.
Includes: Experiential Learning Activity
Precludes additional credit for ACSE 4918, ENVE 4918.
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 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.
Includes: Experiential Learning Activity
Precludes additional credit for ELEC 3605.
Prerequisite(s): MATH 1005 (may be taken concurrently) and (PHYS 1004 or PHYS 1002), and second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Precludes additional credit for OSS 2006, PLT 2006 (no longer offered).
Prerequisite(s): MATH 1005, ELEC 2501, and second-year status in Engineering.
Lectures three hours a week, laboratory and problem analysis three hours a week.

**ELEC 2602 [0.5 credit]**
**Electric Machines and Power**
Modeling and analysis of basic electric power systems. Single-phase and three-phase circuits: real and reactive power, per-phase analysis, power factor correction. Electro-mechanical energy conversion: operation, characteristics and analysis of transformers, DC-, induction-, and synchronous electric machines. Motor and generator operation.
Includes: Experiential Learning Activity
Prerequisite(s): PHYS 1004 and ELEC 2501, and second-year status in Engineering.
Lectures 3 hours per week. Laboratory and problem analysis 3 hours per week alternate weeks.

**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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 2310.
Prerequisite(s): PHYS 1004 or PHYS 1002 and second-year status in Engineering.
Lectures three hours a week, laboratory three hours alternate weeks.

**ELEC 3105 [0.5 credit]**
**Electromagnetic Fields**
Vector calculus: gradient, divergence, curl, integration of vector fields. Electrostatics, magnetostatics. Boundary conditions. Poisson's and Laplace's equations: method of images, separation of variables, iterative method. Electric and magnetic properties of matter. Magnetic circuits. Lorentz force. Motional emf, electromagnetic induction. Maxwell’s equations.
Includes: Experiential Learning Activity
Prerequisite(s): MATH 1005, MATH 2004, and (PHYS 1004 or PHYS 1002), and second-year status in Engineering.
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.
Includes: Experiential Learning Activity
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 semiconductor devices: Thyristor, GTO, IGBT, SiC, GaN. Converter circuits: controlled AC to DC rectifiers, choppers, DC to AC inverters, AC voltage controllers. Protection of conversion circuits. Applications to high-efficiency control of electric machines and electromechanical energy conversion devices.
Includes: Experiential Learning Activity
Prerequisite(s): ELEC 2507 and ELEC 2602.
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.
Includes: Experiential Learning Activity
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 3602 [0.5 credit]**
**Electrical Power Systems**
The electric power system. Components: power transformers and connections, transmission lines. Analysis: balanced and unbalanced three-phase systems, symmetrical components, load flow, FACTS. Operation: frequency and voltage control, steady state and transient stability, fault protection. Distribution systems: utility, residential, commercial. Electrical safety: code, grounding/bonding.
Also listed as ELEC 4602.
Prerequisite(s): ELEC 2602.
Lectures three hours a week, problem analysis two 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), and second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Prerequisite(s): ELEC 2507, ELEC 2607, third year status in Engineering, and enrolment in the Electrical Engineering or Engineering Physics 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.
Includes: Experiential Learning Activity
Precludes additional credit for ELEC 4705.
Prerequisite(s): ELEC 2507.
Lectures three hours a week, laboratory and problem analysis three hours alternate weeks.

**ELEC 3909 [0.5 credit]**
**Electromagnetic Waves**
Maxwell's equations and EM wave solutions. Polarization. Poynting vector. 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.
Includes: Experiential Learning Activity
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**
Includes: Experiential Learning Activity

**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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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, 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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours a week, laboratory three hours alternate weeks.

**ELEC 4509 [0.5 credit]**
**Communication Links**
Thermal noise, intermodulation, 1dB compression, dynamic-range, SNR, noise-figure, noise temperature, antenna gain, EIRP, G/T. Wireless: Earth's bulge, Fresnel clearance, path-loss, rainfall, receiver threshold, multipath, diversity. Fiber: loss, dispersion, lasers, PIN detectors. Satellite: GEO, link calculations, FDMA, TDMA, satellite tracking, spherical trigonometry, antenna pointing, LEO.
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**
Surveillance radar: radar equation, minimum detectable signal, pulse integration, cross-section fluctuations, PRF, range ambiguities, staggered PRF. MTI radars: coherent operation, delay Line cancellers, FFT. Radio navigation: lines of position, NDB, VOR, DME, ILS. GPS: orbits, pseudo-ranges, position determination, GDOP, ionosphere. Geoide, coordinate frames.
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.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 3006 (no longer offered), SYSC 3320, SYSC 3601.
Prerequisite(s): ELEC 2607 and one of SYSC 2003 or SYSC 3003 (no longer offered) 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 Systems**
The electric power system. Components: power transformers and connections, transmission lines. Analysis: balanced and unbalanced three-phase systems, symmetrical components, load flow, FACTS. Operation: frequency and voltage control, steady state and transient stability, fault protection. Distribution systems: utility, residential, commercial. Electrical safety: code, grounding/bonding.
Also listed as ELEC 3602.
Prerequisite(s): ELEC 2602.
Lectures three hours a week, problem analysis two hours a 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.
Includes: Experiential Learning Activity
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, coupling to sources. Optical sources: LEDs, 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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Prerequisite(s): ELEC 3908, ELEC 3909.
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 fundamental quantum mechanics, tunneling, quantization, solid-state theory, conductors, semiconductors, superconductors, insulators, and optical properties. Devices used in modern high speed electronic and communication systems: transistors, lasers, photodiodes, fiber optics, Josephson junctions. Nanotechnology and quantum applications.
Prerequisite(s): ELEC 3908.
Lectures three hours a week.

**ELEC 4706 [0.5 credit]**
**High-Speed Electronics: Circuits and Systems**
Challenges faced in designing high-speed electronic circuits and systems. Fundamentals of high-speed Tx/Rx architectures including: timing and HDL, PLL/DLL, Tx drivers, interface to photonic components, channel modelling, Rx channel, choice of modulation, equalization, clock and data recovery. VHDL hardware and CAD software laboratories.
Includes: Experiential Learning Activity
Prerequisite(s): ELEC 3500.
Lectures three 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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Prerequisite(s): (ELEC 3907 or SYSC 3010) and fourth-year status in Engineering.

**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.
Includes: Experiential Learning Activity
Prerequisite(s): Fourth-year status in Engineering. Certain projects may have additional prerequisites or corequisites.

## 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.
Includes: Experiential Learning Activity
Precludes additional credit for ECOR 1000 (no longer offered), ECOR 1034, ECOR 1047, ECOR 1054.
Lectures four hours per week, laboratories two hours per week.

**ECOR 1031 [0.5 credit]**
**Programming and Data Management**
Software development as an engineering discipline, modern programming language. Syntax and semantics. Tracing and visualizing program execution. Style and documentation. Testing and debugging. Binary number system. Container data types for data management. Introduction to designing and implementing numerical algorithms. Modules. Data files. Incremental, iterative development.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 1005, COMP 1405, ECOR 1041, ECOR 1042, ECOR 1051, ECOR 1606, SYSC 1005.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1032 [0.5 credit]**
**Circuits and Mechatronics**
Electrical circuit fundamentals: resistance, capacitance, inductance, voltage and current sources, Ohm's law, nodal analysis, mesh analysis, source transformation, superposition. Components for mechatronics: filters, operational amplifiers, digital logic gates and combinatorial circuits, analog to digital converters, sensors, actuators, simple control schemes. Project in microcontroller-embedded mechatronic system:.
Includes: Experiential Learning Activity
Precludes additional credit for ECOR 1043, ECOR 1044, and ECOR 1052.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1033 [0.5 credit]**
**Statics**
Force vectors, Dot product. Forces components and resultants. Particle equilibrium. Moments. Cross product. 2D Truss analysis. Centre of gravity and centroids. Rigid body equilibrium. 2D Frames and machines. Internal loads at a point.
Includes: Experiential Learning Activity
Precludes additional credit for ECOR 1045, ECOR 1046, ECOR 1053, ECOR 1101.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1034 [0.5 credit]**
**Dynamics**
Kinematics and Kinetics of a particle. Position velocity and acceleration using cartesian path and polar coordinates. Force and Acceleration. Mechanical work and energy conservation of energy. Principle of impulse and momentum, conservation of momentum. Systems of particles. Harmonic motion. Design Project on Projectile motion.
Includes: Experiential Learning Activity
Precludes additional credit for ECOR 1047, ECOR 1048, ECOR 1054, ECOR 1101, ECOR 1010.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1041 [0.25 credit]**
**Computation and Programming**
Software development as an engineering discipline, using a modern programming language. Language syntax and semantics. Tracing and visualizing program execution. Program style and documentation. Testing and debugging tools and techniques. Binary number system to represent data in a computer.
Precludes additional credit for COMP 1005, COMP 1405, ECOR 1051, ECOR 1606, SYSC 1005, ECOR 1031.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1042 [0.25 credit]**
**Data Management**
Software development using container data types (sequences, sets, maps) for data management. Modules. Data files. Incremental, iterative development of programs. Introduction to designing and implementing numerical algorithms.
Precludes additional credit for COMP 1005, COMP 1405, ECOR 1051, ECOR 1606, SYSC 1005, ECOR 1031.
Prerequisite(s): ECOR 1041 with a minimum grade of C- and MATH 1004 (may be taken concurrently). This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1043 [0.25 credit]**
**Circuits**
Electrical Quantities (Voltage, Charge, Current, Power). Conservation of charge and energy. Mathematical models of simple devices. Elementary circuit theory for passive elements. Thévenin's and superposition theorem. Signal filtering and amplification. Time and frequency domain. Circuit design and simulation.
Precludes additional credit for ECOR 1052, ECOR 1032.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1044 [0.25 credit]**
**Mechatronics**
Mechatronics applications. Analog to digital signal conversion. Control systems and PID controllers. Input devices, including sensors. Data collection and processing. Output devices, including displays, actuators, and motors. Project design and economics. Environmental Impact of mechatronics engineering. System failures and failsafe design.
Precludes additional credit for ECOR 1052, ECOR 1032.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Recommended background: ECOR 1041 and ECOR 1043.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1045 [0.25 credit]**
**Statics**
Cartesian vector representation of forces. Components of forces. Particle equilibrium and free body diagrams. Moments and cross product. Centre of gravity and centroids. Rigid body equilibrium.
Precludes additional credit for ECOR 1053, ECOR 1101, ECOR 1033.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1046 [0.25 credit]**
**Mechanics**
2D truss analysis (method of joints/sections). Normal stress/strain and shear stress/strain. 2D frames and machines. Internal loads - normal, shear and moment at a point. Shear and moment diagrams.
Precludes additional credit for ECOR 1053, ECOR 1033.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Recommended background: ECOR 1045.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1047 [0.25 credit]**
**Visual Communication**
Graphs and sketches, flow charts, block diagrams. Visual presentation, projection and perspectives of objects. 3D sketching. Free hand drawing. Reading engineering drawings and schematics. Introduction to scaling, dimensioning and tolerancing. Introduction to CAD.
Precludes additional credit for ECOR 1054, ECOR 1010, ECOR 1034.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1048 [0.25 credit]**
**Dynamics**
Kinematics and kinetics of a particle. Principle of work and energy. Conservation of energy, conservative forces, potential energy. Principles of impulse and momentum, conservation of momentum for a system of particles.
Precludes additional credit for ECOR 1054, ECOR 1101, ECOR 1034.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Recommended background: ECOR 1045.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1051 [0.5 credit]**
**Fundamentals of Engineering I**
Software development as an engineering discipline, using a modern programming language. Tracing and visualization of program execution. Testing and debugging. Data management: digital representation of numbers; numerical algorithms; storing data in files; container data types: sequences, sets, maps.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 1005, COMP 1405, ECOR 1031, ECOR 1041, ECOR 1042, ECOR 1606, SYSC 1005.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1052 [0.5 credit]**
**Fundamentals of Engineering II**
Electrical Quantities. Conservation of mass and energy. Mathematical models of simple devices. Elementary circuit theory for passive elements. Signal filtering and amplification. Time and frequency domain. Circuit design and simulation. Digital and analog signals. Mechatronics applications. Output devices. System failures and failsafe design.
Includes: Experiential Learning Activity
Precludes additional credit for ECOR 1032, ECOR 1043, ECOR 1044.
Prerequisite(s): ECOR 1051 (may be taken concurrently).
Lectures three hours per week, laboratories three hours per week.

**ECOR 1053 [0.5 credit]**
**Fundamentals of Engineering III**
Components of forces. Particle equilibrium and free body diagrams. Moments and cross product. Centre of gravity and centroids. Rigid body equilibrium. 2D Truss analysis (method of joints/sections). Normal stress/strain and Shear stress/strain. 2D frames and machines.
Includes: Experiential Learning Activity
Precludes additional credit for ECOR 1045, ECOR 1046, ECOR 1033, ECOR 1101.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures three hours per week, laboratories three hours per week.

**ECOR 1054 [0.5 credit]**
**Fundamentals of Engineering IV**
Engineering drawings and schematics. Graphs and sketches, flow charts, block diagrams. Computer#assisted design. Kinematics/Kinetics of a particle. Principles of work and energy. The Engineering Profession and Act. Organization and time management. Project management. Business, entrepreneurship and intellectual property.
Includes: Experiential Learning Activity
Precludes additional credit for ECOR 1010, ECOR 1034, ECOR 1047, ECOR 1048.
Prerequisite(s): ECOR 1053 (may be taken concurrently).
Lectures three hours per week, laboratories three hours per week.

**ECOR 1055 [0.0 credit]**
**Introduction to Engineering Disciplines I**
Overview of professional activities oriented to the student's discipline of study: Architectural Conservation and Sustainability. Civil and Environmental. Aerospace and Mechanical. Electrical. Engineering Physics. Computer Systems, Communications and Software. Biomedical (Electrical and Mechanical). Sustainable and Renewable Energy. Graded SAT/UNS.
Prerequisite(s): This course may not be taken concurrently with ESLA 1300 or ESLA 1500.
Lectures 1.5 hours per week.

**ECOR 1056 [0.0 credit]**
**Introduction to Engineering Disciplines II**
Selected lectures designed to provide students with exposure to the breadth of Engineering disciplines. Graded SAT/UNS.
Online course.

**ECOR 1057 [0.0 credit]**
**Engineering Profession**
Professional Engineers Act. Engineering documentation. History of the profession. Engineering practice: system life cycle, practice within the discipline, designing with others. Health and safety. Engineering Ethics, Equity and Diversity. Introduction to engineering law : Business, Entrepreneurship and Intellectual Property. Graded SAT/UNS.
Online course

**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.
Includes: Experiential Learning Activity
Precludes additional credit for ECOR 1033, ECOR 1034, ECOR 1045, ECOR 1048, ECOR 1053.
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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 1005, SYSC 1100 (no longer offered), SYSC 1102 (no longer offered), COMP 1005, COMP 1405, ECOR 1031, ECOR 1041, ECOR 1042, ECOR 1051.
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 2606 (no longer offered).
Prerequisite(s): MATH 1005 and (ECOR 1606 or SYSC 1005) and (ECOR 1010 or ELEC 1908).
Lectures three hours a week, laboratory one hour a week.

**ECOR 2995 [0.0 credit]**
**Engineering Portfolio**
Students will be asked to reflect on their skills, strengths and weaknesses as preparation for the professional practice course. Engineering students must submit samples of their writing and communications (including, for example, laboratory reports and professional memos).
Online

**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 or (second-year status in Engineering and permission of the department).
Lectures three hours a week.

**ECOR 4907 [1.0 credit]**
**Multidisciplinary Engineering Project**
Student teams develop professional-level experience by applying, honing, integrating, and extending previously acquired knowledge in an approved major multidisciplinary engineering design project. Lectures devoted to discussing project-related issues and student presentations. A project proposal, interim report, oral presentations, and comprehensive final report are required.
Includes: Experiential Learning Activity
Precludes additional credit for ACSE 4918, CIVE 4918, ELEC 4907, ELEC 4908, ENVE 4918, MAAE 4907, SREE 4907, SYSC 4907, SYSC 4917, SYSC 4927, SYSC 4937.
Prerequisite(s): (ECOR 3800 or SYSC 4106), fourth-year status in Engineering and Permission of the faculty.

**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 (all no longer offered).
Prerequisite(s): ECOR 2995 and 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.
Also listed as ACSE 2001, ARCH 1222.
Lectures three hours a week, problem analysis one and a half 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), and second-year status in Engineering.
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Prerequisite(s): CHEM 1002 or CHEM 1101, MATH 2004 (or concurrent), and second-year status in Engineering.
Additional recommended background: ENVE 2001.
Lectures three hours a week, problem analysis 2 hours a week, laboratory 1.5 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): third-year status in Engineering.
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 3999 [0.0 credit]**
**Co-operative Work Term**
Includes: Experiential Learning Activity

**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.
Includes: Experiential Learning Activity
Prerequisite(s): MAAE 2400 and fourth-year status in Engineering or permission of the department.
Also offered at the graduate level, with different requirements, as ENVE 5101/EVG 7101, 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.
Includes: Experiential Learning Activity
Prerequisite(s): ENVE 3001, ENVE 3002.
Also offered at the graduate level, with different requirements, as ENVE 5008, for which additional credit is precluded.
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 one and a half hours a week.

**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.
Includes: Experiential Learning Activity
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.
Also listed as ACSE 3105.
Prerequisite(s): Third-year status in B.Eng. in Architectural Conservation and Sustainability Engineering, Civil Engineering, or Environmental Engineering or fourth-year standing in B.A.S. concentration in Conservation and Sustainability.
Lectures three hours a week, problem analysis one and a half hours 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.
Also listed as ACSE 4106.
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, laboratory three hours alternate weeks.

**ENVE 4107 [0.5 credit]**
**Building Services Engineering**
This course provides details on how buildings are designed and operated. The materials provide foundational knowledge to understand building services: mechanical, electrical, plumbing systems with associated controls.
Also listed as ACSE 4107.
Prerequisite(s): CIVE 3209 and ENVE 4105.
Lecture three hours per week, problem analysis three hours every other week.

**ENVE 4200 [0.5 credit]**
**Climate Change and Engineering**
Survey of the physical science of climate change, impacts on the built environment, and climate adaptation in engineering. Greenhouse gases, global warming, paleoclimatology, and Earth system responses. Climate change impacts on structural, water, transportation, and energy systems. Climate vulnerability assessment, examples of design adaptation.
Prerequisite(s): Fourth-year status in Engineering.
Also offered at the graduate level, with different requirements, as ENVE 5200, for which additional credit is precluded.
Lecture three hours per week, problem analysis three hours every other week.

**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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Precludes additional credit for ACSE 4918, CIVE 4918.
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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, residual stresses. Machining theory and methods. Hardening: diffusion, wear resistance.
Includes: Experiential Learning Activity
Prerequisite(s): MAAE 2700.
Lectures three hours a week, problem analysis and laboratories three hours a week on alternate weeks.

**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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Prerequisite(s): MECH 3002 and fourth-year status in Engineering.
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 3004 and fourth-year status in Engineering or by permission of the department.
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 3004 and fourth-year status in Engineering or by permission of the department.
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.
Includes: Experiential Learning Activity
Prerequisite(s): MECH 3710, MAAE 3202, and MECH 4210 and fourth-year status in Engineering.
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 and fourth-year status in Engineering or by permission of the department.
Lectures three hours a week.

**MECH 4102 [0.5 credit]**
**Corrosion and Corrosion Control**
Introduction to corrosion. Corrosion mechanisms. Thermodynamics of corrosion. Electro-chemical kinetics of corrosion. Corrosion: types, prevention, control, testing, monitoring and inspection techniques. Corrosion in specific metals (eg. Fe, Ni, Ti and Al). Corrosion issues in specific industries: power generation and chemical processing industries.
Prerequisite(s): Fourth-year status in Engineering or by permission of the department.
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 and fourth-year status in Engineering or by permission of the department.
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 and fourth-year status in Engineering or by permission of the department.
Lectures three hours per week.

**MECH 4105 [0.5 credit]**
**Introduction to Nuclear Engineering**
Atomic theory, nuclear physics, radioactivity, photoelectric effect, mass defect, binding energy, nuclides, neutron diffusion and moderation. Reactor theory, kinetics, control. Reactor types, reactor poisoning, xenon oscillations. Reactor materials, corrosion, fuel and fuel cycle. Nuclear medicine. Radiation protection, reactor safety fundamentals.
Prerequisite(s): Fourth-year status in Engineering or by permission of the department.
Lectures three hours a week.

**MECH 4106 [0.5 credit]**
**Nuclear Power Plant Design**
Elements of design, basic design, and new generation of nuclear reactors. Major systems of CANDU reactor and its safety principles. Balance of Plant Systems. Licensing requirements for design (IAEA, CNSC and USNRC regulations). Analytical/computer codes in safety assessments and design.
Prerequisite(s): Fourth-year status in Engineering or by permission of the department.
Lectures three hours per week.

**MECH 4107 [0.5 credit]**
**Internal Combustion Engines**
This course explores the design process of an internal combustion engine including: Internal Aerodynamics, Combustion, Rotating and Reciprocating Components, Structures, Control Systems, Manufacturing and Testing Methods. Students will design/optimize an engine component utilizing industry standard Ricardo Wave simulation software.
Prerequisite(s): Fourth-year status in Engineering or by permission of the department.
Lecture 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.
Includes: Experiential Learning Activity
Prerequisite(s): MAAE 2101 and fourth-year status in Engineering.
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 or MECH 3310) and fourth-year status in Engineering or by permission of the department.
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 AERO 4402.
Prerequisite(s): MAAE 2400 and fourth-year status in Engineering or by permission of the department.
Lectures three hours a week.

**MECH 4403 [0.5 credit]**
**Power Generation Systems**
Energy sources and resources. Basic elements of power generation. Hydro-electric, fossil-fuel, fissile-fuel power plants. Geothermal, solar and wind power plants. Economic and environmental considerations. Energy storage. Future power needs.
Precludes additional credit for SREE 4001.
Prerequisite(s): MAAE 2300 and MAAE 2400 and fourth-year status in Engineering or by permission of the department.
Lectures three hours a 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 and (MAAE 3300, MECH 3310, or (ENVE 3001 and permission of the Department of Mechanical and Aerospace Engineering)) and fourth-year status in Engineering.
Lectures three hours a week. Problem analysis and laboratories 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 fourth-year status in Engineering or by permission of the department.
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 fourth-year status in Engineering.
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 3500 or SYSC 4505) and fourth-year status in Engineering or by permission of the department.
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): (MAAE 3500 or SYSC 4505) and fourth-year status in Engineering or by permission of the department.
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 fourth-year status in Engineering or by permission of department.
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): Fourth-year status in Engineering or by permission of the department.
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): (AERO 2001 or MAAE 2001) and fourth-year status in Engineering or by permission of the department.
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 ELEC 4805.
Prerequisite(s): ECOR 2050 and fourth-year status in Engineering or by permission of the department.
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 3500 or SYSC 4505) and fourth-year status in Engineering or by permission of the department.
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.
Includes: Experiential Learning Activity
Also listed as AERO 2001.
Prerequisite(s): Second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Precludes additional credit for CIVE 2101.
Prerequisite(s): Second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Precludes additional credit for CIVE 2200.
Prerequisite(s): Second-year status in Engineering.
Lectures three hours a week, problem analysis and laboratory three hours a week.

**MAAE 2203 [0.5 credit]**
**Mechanics of Solids**
Covers the essentials of solids for machine design, failure theories and stress concentrations.
Includes: Experiential Learning Activity
Prerequisite(s): second-year status in Engineering.
Lectures three hours a week, laboratory three hours alternate weeks.

**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, Bernoulli, 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.
Includes: Experiential Learning Activity
Prerequisite(s): Second-year status in Engineering.
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 for closed and steady-flow open systems. Thermodynamic properties of pure substances; changes of phase; equation of state. Second law: entropy. Simple power and refrigeration cycles. Introduction to heat transfer: conduction, convection, radiation.
Includes: Experiential Learning Activity
Prerequisite(s): Second-year status in Engineering.
Lectures three hours a week, laboratory and problem analysis three hours a week.

**MAAE 2401 [0.5 credit]**
**Mechatronics Thermodynamics and Heat Transfer**
Basic concepts of thermodynamics: temperature, work, heat, internal energy and enthalpy. First law for closed and steady-flow open systems. Properties of pure substances. Second law: entropy. Simple power and refrigeration cycles. Introduction to heat transfer: conduction, convection, radiation. Heat exchangers and heat sinks.
Includes: Experiential Learning Activity
Prerequisite(s): Second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Precludes additional credit for CIVE 2700.
Prerequisite(s): Second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Prerequisite(s): MAAE 2101 and MATH 1005.
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.

Includes: Experiential Learning Activity
Precludes additional credit for CIVE 3202.
Prerequisite(s): MAAE 2202 and MATH 1005 (co-req).
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Prerequisite(s): MATH 1005 and MAAE 2400.
Lectures three hours a week, problem analysis and laboratories three hours 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.
Includes: Experiential Learning Activity
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 and laboratories three hours a week.

**MAAE 3505 [0.5 credit]**
**Mechatronics I**
Introduction to mechatronics systems. Lectures, labs, assignments, and a semester-long project to develop a mechatronics system and program microcontrollers.
Includes: Experiential Learning Activity
Prerequisite(s): ELEC 3508, ELEC 4709, MAAE 3002.
Lectures three hours a week, laboratory three hours a week.

**MAAE 3999 [0.0 credit]**
**Co-operative Work Term**
Includes: Experiential Learning Activity

**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 2202 and MAAE 2700 and fourth-year status in Engineering.
Lectures three hours a week.

**MAAE 4706 [0.5 credit]**
**Mechatronics II**
Advanced topics in mechatronics, including a semester-long project to develop a fully integrated mechatronic system.
Includes: Experiential Learning Activity
Prerequisite(s): MAAE 3505.
Lectures three hours a week, laboratory three hours a week.

**MAAE 4902 [0.5 credit]**
**Special Topics: Mechanical and Aerospace Engineering**
Selected advanced topics of interest to Aerospace and Mechanical Engineering students, subject to the discretion of the Faculty of Engineering and Design.
Prerequisite(s): permission of the Department.
Lecture 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 4904 [0.5 credit]**
**Special Topics: Mechanical and Aerospace Engineering**
Selected advanced topics of interest to Aerospace and Mechanical Engineering students, subject to the discretion of the Faculty of Engineering and Design.
Prerequisite(s): permission of department.
Lectures 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.
Includes: Experiential Learning Activity
Prerequisite(s): Fourth-year status in engineering and (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**
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.
Includes: Experiential Learning Activity
Prerequisite(s): permission of the Department and completion of, or concurrent registration in, MAAE 4907.

## Mechatronics Engineering (MECT) Courses

**MECT 3999 [0.0 credit]**
**Co-operative Work Term**
Includes: Experiential Learning Activity
Prerequisite(s): Registration in the Co-operative Education Option, and permission of the the Faculty of Engineering and Design.

**MECT 4907 [1.0 credit]**
**Engineering Project**
Student teams develop professional-level experience by applying previously acquired knowledge to a major design project. Project meetings discuss project-related issues and student presentations. A project proposal, interim report, oral presentations, and a comprehensive final report are required.
Includes: Experiential Learning Activity
Prerequisite(s): Fourth-year status in Engineering. Certain projects may have additional prerequisites.
No formal lectures

## 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 their associated fundamental physics of conversion. Renewables: wind, large hydro, solar radiation, solar thermal. Fossil and biofuels. Nuclear. Climate science: the carbon cycle and the role of anthropogenic GHG emissions in climate warming. Terrestrial, thermodynamic and electrical limitations.
Includes: Experiential Learning Activity
Prerequisite(s): ENVE 2001 and MAAE 2300 and (ELEC 2602 or fourth-year status in Environmental Engineering).
Lectures three hours per week, laboratories/problem analysis one hour per week.

**SREE 3002 [0.5 credit]**
**Electrical Distribution Systems**
Electricity Distribution: topology, load characteristics, load prediction, voltage regulation, power flow, power loss, capacitors, state estimation, system reliability, system protection. Distribution Automation: components and architectures, communication systems. Distributed Generation: guides and regulations, microgrids, case study.
Includes: Experiential Learning Activity
Prerequisite(s): SREE 3001 and (ELEC 2602 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 cell: model, current#voltage curves, maximum power point tracking, grid connection; grid connection of wind generator; DC# AC and AC#DC converter simulation and analysis; energy storage classification; battery: equivalent circuit model, charging and discharging; renewable generation; feed#in tariff program.
Includes: Experiential Learning Activity
Prerequisite(s): SREE 3001 and (ELEC 2602 or ELEC 3605).
Lectures three hours per week, laboratories three hours per week alternate weeks.

**SREE 4001 [0.5 credit]**
**Efficient Energy Conversion**
Sustainable large-scale power generation. Geothermal, solar thermal, hydrogen power plants. Thermal grids and thermal energy storage. Environmental and economic aspects of power generation. Impacts of intermittent power generation. Sizing of wind, solar PV, run-of-river hydro, and offshore power plants. Current and future energy network topologies.
Includes: Experiential Learning Activity
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]**
**Modelling and Analysis of Energy Systems: Risk, Reliability, and Economics**
Energy technologies exist within a context of economic, policy, and behavioral choices that affect their adoption. This course will introduce engineering methods for analyzing risk, uncertainty, and system-level decision-making. We will investigate criteria that affect energy systems: reliability, resilience, economics, financing, health, and environmental impacts.
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.
Includes: Experiential Learning Activity
Prerequisite(s): SREE 3002 and SREE 3003, and fourth-year status in Sustainable and Renewable Energy Engineering. Certain projects may have additional prerequisites or corequisites.

## 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.
Includes: Experiential Learning Activity
Precludes additional credit for ECOR 1031, ECOR 1041, ECOR 1042, ECOR 1051, ECOR 1606, SYSC 1100 (no longer offered), COMP 1005 and COMP 1405.
Lectures three hours a week, laboratory three hours a week.

**SYSC 1006 [0.5 credit]**
**Foundations of Imperative Programming**
The imperative programming paradigm: assignment and state, types and variables, static and dynamic typing. Memory management and object lifetimes: static allocation, automatic allocation in activation frames, dynamic allocation. Function argument passing. Recursion. Data structures: dynamic arrays, linked lists, hash tables. Encapsulation and information hiding.
Includes: Experiential Learning Activity
Also listed as SYSC 2006.
Precludes additional credit for COMP 2401, SYSC 4006.
Prerequisite(s): ECOR 1031 or (ECOR 1041 and ECOR 1042), all with a minimum grade of C-.
Lectures three hours a week, laboratory two 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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 1006 and COMP 1406.
Prerequisite(s): SYSC 1006 or SYSC 2006 or permission of the department, and second-year status in Engineering.
Lectures three hours a week, laboratory two hours a week.

**SYSC 2006 [0.5 credit]**
**Foundations of Imperative Programming**
The imperative programming paradigm: assignment and state, types and variables, static and dynamic typing. Memory management and object lifetimes: static allocation, automatic allocation in activation frames, dynamic allocation. Function argument passing. Recursion. Data structures: dynamic arrays, linked lists, hash tables. Encapsulation and information hiding.
Includes: Experiential Learning Activity
Also listed as SYSC 1006.
Precludes additional credit for COMP 2401, SYSC 4006.
Prerequisite(s): Second-year status in Engineering.
Lectures three hours a week, laboratory two hours a week.

**SYSC 2010 [0.5 credit]**
**Programming Project**
Programming, testing, and debugging of small team-based software projects that use data from sensors to display results graphically. Modern programming tools: frameworks, libraries, version control, package management, tool chains. Sensors, signal acquisition, display, and basic filtering. Introductory network programming.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3010, SYSC 3110.
Prerequisite(s): 2nd year status in Biomedical and Electrical Engineering or Communications Engineering.
Lectures three hours a week, laboratory three 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.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 2402.
Prerequisite(s): (SYSC 1006 or SYSC 2006) with a minimum grade of C-, and second-year status in Engineering.
Lectures three hours a week, laboratory two hours a week, problem analysis one hour alternate weeks.

**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.
Includes: Experiential Learning Activity
Precludes additional credit for ELEC 2607.
Prerequisite(s): Enrolment in Computer Systems Engineering, Communications Engineering, or Software engineering, and second-year status in 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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 2001 and SYSC 3006.
Prerequisite(s): SYSC 2310 or ELEC 2607, and second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Prerequisite(s): MATH 1004 and MATH 1104, and second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 2320.
Prerequisite(s): (SYSC 1006 or SYSC 2006) and (SYSC 2310 or ELEC 2607).
Lectures three hours a week, laboratory three hours a week.

**SYSC 3010 [0.5 credit]**
**Computer Systems Development Project**
Development of expertise in designing, implementing and testing industrial-quality embedded systems through team projects. Applying modern programming languages, system design practices, current development processes (refactoring, iterative and incremental development) as well as current team-management tools (communication, version control) to medium-scale projects.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 2404, SYSC 2010, SYSC 2101 (no longer offered), and SYSC 3110.
Prerequisite(s): SYSC 2100 and either SYSC 2003 or SYSC 3310 (may be taken concurrently), and enrolment 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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3120, SYSC 4120 and COMP 3004.
Prerequisite(s): SYSC 2004.
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).
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 2404, SYSC 2010, SYSC 2101 and SYSC 3010.
Prerequisite(s): SYSC 2004 and SYSC 2100, and enrolment 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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3020 and COMP 3004.
Prerequisite(s): SYSC 2004 and enrolment 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.
Includes: Experiential Learning Activity
Precludes additional credit for BUSI 2300, ECON 4004, or MATH 3801.
Prerequisite(s): MATH 1004 and MATH 1104, and second-year status in Engineering.
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. Amplifier designs: inverting, noninverting, differential, and bioinstrumentation. Differentiators, integrators, and rectifiers. Oscillators and timers. Filter design. Sampling and quantization. Electrical machines. Electrical safety.
Includes: Experiential Learning Activity
Prerequisite(s): MATH 1005 and (ELEC 2507 or ELEC 3605), and enrolment in Biomedical and Electrical Engineering or Biomedical and Mechanical Engineering, and second-year status in Engineering.
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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3313.
Prerequisite(s): For students in the Faculty of Engineering and Design: SYSC 2004 and SYSC 4001. For students in Computer Science: COMP 2401, COMP 2402, and COMP 3000.
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.
Includes: Experiential Learning Activity
Prerequisite(s): (SYSC 1006 or SYSC 2006) with a minimum grade of C- and (SYSC 2320 or SYSC 3006).
Lectures three hours a week, laboratory two hours a week.

**SYSC 3313 [0.5 credit]**
**Real-Time Embedded 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 modern software engineering principles. Converting designs into programs targeting embedded systems. Team project.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3303.
Prerequisite(s): SYSC 3310 and SYSC 4001 and third-year status in Computer Systems Engineering, or permission of the Department.
Lectures three hours a week, laboratory two hours a week.

**SYSC 3320 [0.5 credit]**
**Computer Systems Design**
System on Chip based computer system design, including internal organization, direct memory access, floating-point units, HDL and FPGAs. Interfacing and high-level systems design. Input/output interfaces, including serial communication protocols.
Includes: Experiential Learning Activity
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 hours 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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3600 and SYSC 3610.
Prerequisite(s): MATH 1005 and enrolment in Communications Engineering, and second-year status in 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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3503.
Prerequisite(s): 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.
Includes: Experiential Learning Activity
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 3512 [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.
Includes: Experiential Learning Activity
Also listed as SYSC 4602.
Precludes additional credit for COMP 3203.
Prerequisite(s): ECOR 2050 or 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 3522 [0.5 credit]**
**Communications Software Laboratory**
Project-oriented experience in the design of communication systems to meet user and system requirements. Lectures on various network architectures and layered protocols and programming; teletraffic analysis and traffic engineering; system specification and design: requirements analysis, solution alternatives, evaluation of alternative technologies, design, costing, implementation, testing.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 4502, SYSC 4701.
Prerequisite(s): (SYSC 1006 or SYSC 2006) with a minimum grade of C-, and (SYSC 3512 or SYSC 4602).
Lectures three hours a week, laboratory four 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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3500 or SYSC 3610.

Prerequisite(s): MATH 1005 and second-year status in Engineering.
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3500 or SYSC 3600.

Prerequisite(s): MATH 1005 and enrolment in Biomedical and Electrical Engineering or Biomedical and Mechanical Engineering, and second-year status in Engineering.
Lectures three hours a week, laboratory three hours a week.

**SYSC 3999 [0.0 credit]**
**Co-operative Work Term**
Includes: Experiential Learning Activity

**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.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 3000.
Prerequisite(s): (SYSC 1006 and SYSC 2006) with a minimum grade of C-.
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.
Includes: Experiential Learning Activity
Prerequisite(s): (ECOR 2050 or 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 4006 [0.5 credit]**
**Introduction to Systems Programming**
Introduction to C programming: Data types, flow control, functions, arrays, pointers, and arithmetic, logical and bitwise operators. Memory models, collections. Low-level I/O. Build pipeline (version control, make, preprocessing, compiling, linking) in Linux. Testing and debugging.
Precludes additional credit for SYSC 1006, SYSC 2006.
Prerequisite(s): Third-year status in Engineering, or enrollment in the M.Eng. Program in Electrical & Computer Engineering.
Lectures three hours 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.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 4004.
Prerequisite(s): SYSC 3120 or SYSC 3020.
Lectures three hours a week, laboratory/problem analysis three hours a week.

**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.
Includes: Experiential Learning Activity
Prerequisite(s): (ECOR 2050 or 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 4106 [0.5 credit]**
**The Software Economy and Project Management**
Introduction to software project management and economics; Return on software investments; Software life cycle; Work breakdown structure, scheduling and planning; Risk analysis and management; Product size and cost estimation; Earn value management; Statistical process control; Managing project team and process improvement; Bidding and contract types.
Prerequisite(s): SYSC 3120 (may be taken concurrently) and third-year status in Software Engineering or COMP 3004 and enrolment in the Bachelor of Computer Science.
Lectures three hours a week.

**SYSC 4111 [0.5 credit]**
**Formal Methods in Software Engineering**
Introduction to formal methods in software engineering with coverage of propositional and first-order logic (syntax, semantics, proof theory), formal specification languages, bounded analysis and validation, formal specification tools, and model checking with finite-state machines, temporal logic, and model checking tools.
Prerequisite(s): COMP 1805, SYSC 3120, and SYSC 4001.
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, methods, processes and tools used in software architecture and system design. Software architectures, architectural patterns, design patterns, software qualities, software reuse.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 3004, SYSC 3020 and SYSC 4800 (no longer offered).
Prerequisite(s): SYSC 3120.
Lectures three hours a week, laboratory three hours alternate weeks.

**SYSC 4130 [0.5 credit]**
**Human Computer Interaction**
User-centric design, evaluation, and implementation of interactive computing systems. Topics include: designing, prototyping, implementing, and evaluating user-facing systems and interfaces; data gathering, analysis, and interpretation; persuasive design; dark patterns; accessibility; design for security and privacy.
Precludes additional credit for COMP 3008.
Prerequisite(s): SYSC 3020 or SYSC 3120.
Lectures three hours a week, problem analysis 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).
Includes: Experiential Learning Activity
Prerequisite(s): ECOR 2050 and third-year status in Biomedical and Electrical Engineering or Biomedical and Mechanical Engineering.
Lectures three hours a week, problem analysis one and a half hours per week.

**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.
Includes: Experiential Learning Activity
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, electrical safety, and biocompatibility; bioelectric signals; biopotential electrodes: material properties, selection; data acquisition; signal processing; biomedical imaging technologies; bioamplifier systems performance and characteristics; major physiological systems and associated measurements.
Includes: Experiential Learning Activity
Prerequisite(s): SYSC 3610 and (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.
Includes: Experiential Learning Activity
Prerequisite(s): MATH 1005 and fourth-year status in Engineering.
Lectures three hours a week, laboratory/problem analysis three hours alternate weeks.

**SYSC 4206 [0.5 credit]**
**Surgical Robotics**
Surgical robotic system architecture, forward and inverse kinematics of articulated robot arms, force and position control, unilateral and bilateral teleoperation of surgical robots, haptics and force feedback, instrumentation, image-guided surgery, design and implementation of robotic systems for minimally invasive surgery.
Includes: Experiential Learning Activity
Prerequisite(s): SYSC 3600 or SYSC 3610, and fourth-year status in Engineering.
Lectures three hours a week, laboratory three hours a week.

**SYSC 4310 [0.5 credit]**
**Computer Systems Architecture**
Evolution of computer systems architecture to improve performance, including memory hierarchy, hardware accelerators, and thread level parallelism. Advanced computer architecture topics such as instruction level parallelism, superscalar, out-of-order execution, speculative execution, multicore, many-core, heterogeneous systems, and virtualization.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 4507.
Prerequisite(s): SYSC 3320, and enrolment 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 enrolment 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.
Includes: Experiential Learning Activity
Prerequisite(s): SYSC 3500 or SYSC 3600 or SYSC 3610.
Lectures three hours a week, laboratory three hours alternate weeks.

**SYSC 4415 [0.5 credit]**
**Introduction to Machine Learning**
Introduction to supervised and unsupervised machine learning (ML), including deeper knowledge of several algorithms of each type. Evaluation and quantification of predictive performance of ML systems. Use of one or more ML development environments.
Precludes additional credit for COMP 3105, COMP 4105 (no longer offered).
Prerequisite(s): (ECOR 2050 or STAT 3502 or STAT 2605 or SYSC 2510), (SYSC 1006 or SYSC 2006) with a minimum grade of C-, and third-year status in Engineering.

Lectures three hours a week, problem analysis one hour a week.

**SYSC 4416 [0.5 credit]**
**Artificial Intelligence in Engineering**
Fundamental ideas and techniques underlying the design of intelligent computer systems. Topics include intelligent agents, problem solving by searching, uncertain knowledge and reasoning, introduction to machine learning, and selected AI applications. A special focus is given to engineering use cases and applications of AI.
Precludes additional credit for COMP 3106.
Prerequisite(s): (ECOR 2050 or STAT 3502 or STAT 2605 or SYSC 2510), (SYSC 1006 or SYSC 2006), and third-year status in Engineering.
Lectures three hours a week, laboratory/problem analysis one hour per week.

**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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3522.
Prerequisite(s): (SYSC 1006 or SYSC 2006) with a minimum grade of C-, and SYSC 4602.
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.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 2406.
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.
Includes: Experiential Learning Activity
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.
Includes: Experiential Learning Activity
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 4511 [0.5 credit]**
**Digital Wireless Communication**
Band-limited communication systems, orthogonal frequency division multiplexing; multiple-access techniques (TDMA, FDMA, CSMA, OFDMA); wireless channel models (pathloss, fading, multipath); MIMO systems and diversity; introduction to information theory (entropy, differential entropy, AMI, capacity); source coding; block codes and error detection; convolutional codes and error correction.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 4600, SYSC 4604, SYSC 4607.
Prerequisite(s): SYSC 3501 and ECOR 2050.
Lectures three hours a week, laboratory three hours alternate weeks.

**SYSC 4600 [0.5 credit]**
**Digital Communications**
Probability theory, signal representation. Baseband data transmission: Nyquist criterion, optimal receiver, error probability. Digital modulation, performance. Synchronization. Introduction to information theory. Error detection and correction. OFDM. Applications to current digital wired and wireless communications systems.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3503, SYSC 4511, SYSC 4604.
Prerequisite(s): SYSC 3501 and ECOR 2050.
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.
Includes: Experiential Learning Activity
Also listed as SYSC 3512.
Precludes additional credit for COMP 3203.
Prerequisite(s): ECOR 2050 or 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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 4511, 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.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 4511.
Prerequisite(s): SYSC 3501 or SYSC 3503.
Lectures three hours a week, laboratory three hours alternate weeks.

**SYSC 4700 [0.5 credit]**
**Topics in Communications Networks**
Contemporary and emerging topics in communications networks and technologies. Communications as a national and international infrastructure. Systems view of network architecture and management: transmission, access, interference, routing, softwarization, virtualization, security. Regulations and standards. Examples include cellular 5G/6G, Wi-Fi, terrestrial, optical, aerial, and satellite networks.
Includes: Experiential Learning Activity
Prerequisite(s): SYSC 3501 or SYSC 3503, and fourth-year status in Engineering.
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 teletraffic analysis; system specification and design: requirements analysis, solution alternatives, evaluation of alternative technologies, design, costing, implementation, test.
Includes: Experiential Learning Activity
Precludes additional credit for SYSC 3522.
Prerequisite(s): SYSC 4602 and Fourth-year status in Communications Engineering or permission of the department.
Lectures two hours a week, laboratory four hours a week.

**SYSC 4709 [0.5 credit]**
**Industrial Automation**
Introduction to automation and digitalization, Ladder logic, PLC, Sensors and actuators (Monitor/measurement), Ladder Diagrams, Pneumatics, Fluid Power, Pumps and Actuators, Open and closed systems, accumulators, regeneration, counterbalancing, pilot-operated systems, Coolers and heat exchangers, reservoirs, and sequencing, Hydraulic diagrams, design, control, and implementation of full systems.
Includes: Experiential Learning Activity
Prerequisite(s): fourth-year status in Engineering.
Lectures three hours a week, laboratory three hours alternate weeks.

**SYSC 4805 [0.5 credit]**
**Computer Systems Design Lab**
Project-oriented experience in the design of embedded computer systems. Lectures will discuss practical aspects related to the design and development of embedded systems, starting from sensor data acquisition and processing to decision systems, testing and embedded-system based project management, with practical application examples.
Includes: Experiential Learning Activity
Prerequisite(s): SYSC 3310 and enrolment 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.
Includes: Experiential Learning Activity
Prerequisite(s): COMP 3005, SYSC 3110, and enrolment in Software Engineering, or permission of the department.
Lectures two hours a week, laboratory four hours a week.

**SYSC 4810 [0.5 credit]**
**Introduction to Network and Software Security**
Fundamental concepts, terminologies, and theories of computer security; principles underlying common security controls; various types of threats and attacks on networks and software systems, how they work, and controls for dealing with them; security risk assessment and management; legal and ethical aspects of computer security.
Includes: Experiential Learning Activity
Precludes additional credit for COMP 4108, CSEC 3108.
Prerequisite(s): fourth-year status in Communications, Computer Systems or Software Engineering.
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.
Includes: Experiential Learning Activity
Prerequisite(s): Fourth-year status in Engineering. Certain projects may have additional prerequisites.

**SYSC 4918 [0.5 credit]**
**Undergraduate Directed Study**
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 independent studies. Requires supervising faculty member and proposal from student.
Includes: Experiential Learning Activity
Prerequisite(s): Permission of the department and completion of, or concurrent registration in, one of SYSC 4907, ELEC 4907, or ECOR 4907.
Directed study.