

# Honours Bachelor of Applied Science – Space Engineering

## First Year:

SC/ENG 1000 6.0 Introduction to Engineering Design

Engineering design and professional practice within economic, health, safety, environmental, social and other constraints, including case studies, teamwork, 3D modeling, and a team design project. Communication skills are emphasized, including a mandatory writing workshop. Three lecture hours per week. Two terms. Six credits. Note: Open only to students in the Engineering program.

SC/CHEM 1000 3.0 Chemical Structure

Introduction to chemistry with emphasis on physical and electronic structure of matter, including gases, liquids and solids. Topics include behaviour of gases; thermochemistry; atomic structure and periodic table; chemical bonding and architecture; structure of liquids and solids; frontiers of chemistry. Two and one-half lecture hours per week, one tutorial hour per week, six three-hour laboratory sessions. One term. Three credits. Prerequisites: OAC chemistry, 12U chemistry or SC/CHEM 1500 4.00 or equivalent. Course credit exclusions: SC/CHEM 1000 6.00, SC/CHEM 1010 6.00.

### SC/CSE 1020 3.0

#### Introduction to Computer Science I

Conceptual foundations of object-oriented programming, including data types, control structures, class library usage, encapsulation, inheritance and other abstractions; the software development process, specification and implementation, with emphasis on software engineering principles. Three lecture hours and weekly laboratory sessions. Three credits. Prerequisites: One of (1) – (4) below must be met: (1) (New high school curriculum): Two 12U Math courses including advanced functions and introductory calculus with minimum mathematics average of 75% on the two courses, and no mathematics grade below 65%. (2) (Old high school curriculum): OAC calculus and one other OAC in mathematics (normally finite mathematics or algebra and geometry) with an average grade of 75% in all OAC mathematics and no grade less than 65%. (3) Completion of 6.0 credits from York University MATH courses (not including SC/MATH 1710 6.00 – prior to Fall 2009 AK/MATH 1710 6.00 – or courses with second digit 5) with a grade average of 5.00 (C+) or better over these credits; (4) Completion of SC/MATH 1710 6.00 – prior to Fall 2009 AK/MATH 1710 6.00 – or 6.0 credits from York University mathematics courses whose second digit is 5, with an average grade not below 7.00 (B+). Course credit exclusions: AK/AS/SC/COSC 1020 3.00, AP/ITEC 1620 3.00 Prior to Fall 2009: Course credit exclusions: AK/AS/SC/COSC 1020 3.00, AS/AK/ITEC 1620 3.00.

### SC/CSE 1030 3.0

#### Introduction to Computer Science II

This course builds on CSE 1020 3.00 covering class implementation and system design in object-oriented programming, including composition, inheritance, polymorphism, and exception handling. Other topics include recursion, searching and sorting, and introductory data structures. Prerequisite: SC/CSE 1020 3.00. Prior to Fall 2009: Prerequisite: AK/AS/SC/CSE 1020 3.00 or AK/AS/SC/COSC 1020 3.00. Course credit exclusions: AK/AS/SC/COSC 1030 3.00, AP/ITEC 2620 3.00. Prior to Fall 2009: Course credit exclusions: AK/AS/SC/COSC 1030 3.00, AK/AS/ITEC 2620 3.00.

SC/EATS 1010 3.0 The Dynamic Earth and Space Geodesy

An overview of modern geophysics: origin of the Earth, impact cratering, internal structure and rheology, earthquakes, plate tectonics, geomagnetism. Space geodetic positioning techniques such as VLBI, SLR and GPS are introduced as means of detecting and monitoring tectonic movements. One term. Three credits. Prerequisites: 12U calculus and vectors or 12U advanced functions and introductory calculus (pre 2007 version) or equivalent, or SC/MATH 1515 3.00; 12U physics or SC/PHYS 1510 4.00. Course credit exclusions: SC/EATS 1010 6.00, SC/NATS 1750 6.00. Prior to Fall 2009: Prerequisites: 12U calculus and vectors or 12U advanced functions and introductory calculus (pre 2007 version) or equivalent, or AS/SC/MATH 1515 3.00; 12U physics or SC/PHYS 1510 4.00. Course credit exclusions: SC/EATS 1010 6.00, SC/NATS 1750 6.00.

SC/MATH 1013 3.0 Applied Calculus I

Introduction to the theory and applications of both differential and integral calculus. Limits. Derivatives of algebraic and trigonometric functions. Riemann sums, definite integrals and the Fundamental Theorem of Calculus. Logarithms and exponentials, Extreme value problems, Related rates, Areas and Volumes. Prerequisite: SC/MATH 1515 3.00 or SC/MATH 1520 3.00, or a high school calculus course. Course credit exclusions: SC/MATH 1000 3.00, SC/MATH 1300 3.00, SC/MATH 1505 6.00, SC/MATH 1513 6.00, SC/MATH 1530 3.00, SC/MATH 1550 6.00, GL/MATH/MODR 1930 3.00, AP/ECON 1530 3.00. Prior to Fall 2009: Prerequisite: AS/SC/MATH 1515 3.00 or AS/SC/MATH 1520 3.00, or a high school calculus course. Course credit exclusions: AS/SC/MATH 1000 3.00, AK/AS/SC/MATH 1300 3.00, AS/SC/MATH 1505 6.00, AS/SC/MATH 1513 6.00, AS/MATH 1530 3.00, AK/AS/MATH 1550 6.00, GL/MATH/MODR 1930 3.00, AS/ECON 1530 3.00.

SC/MATH 1014 3.0 Applied Calculus II

Calculus in Polar Coordinates. Techniques of Integration. Indeterminate Forms. Improper Integrals. Sequences, infinite series and power series. Approximations. Introduction to ordinary differential equations. Prerequisite(s): One of SC/MATH 1000 3.00, SC/MATH 1013 3.00, SC/MATH 1300 3.00, or SC/MATH 1513 6.00; for non-science students only, six credits from SC/MATH 1530 3.00 and SC/MATH 1540 3.00, SC/MATH 1550 6.00, AP/ECON 1530 3.00 and AP/ECON 1540 3.00. Course credit exclusions: SC/MATH 1010 3.00, SC/MATH 1310 3.00, SC/MATH 1505 6.00, GL/MATH/MODR 1940 3.00. Prior to Fall 2009: Prerequisite(s): One of AS/SC/MATH 1000 3.00, AS/SC/MATH 1013 3.00, AK/AS/SC/MATH 1300 3.00, or AS/SC/MATH 1513 6.00; for non-science students only, six credits from AS/MATH 1530 3.00 and AS/MATH 1540 3.00, AK/AS/MATH 1550 6.00, AS/ECON 1530 3.00 and AS/ECON 1540 3.00. Course credit exclusions: AS/SC/MATH 1010 3.00, AK/AS/SC/MATH 1310 3.00, AS/SC/MATH 1505 6.00, GL/MATH/MODR 1940 3.00.

SC/MATH 1025 3.0 Applied Linear Algebra

Topics include spherical and cylindrical coordinates in Euclidean 3-space, general matrix algebra, determinants, vector space concepts for Euclidean n-space (e.g. linear dependence and independence, basis, dimension, linear transformations etc.), an introduction to eigenvalues and eigenvectors. Prerequisites: One 12U or OAC mathematics course or equivalent. Course credit exclusions: SC/MATH 1021 3.00, SC/MATH 2021 3.00, SC/MATH 2221 3.00, GL/MATH/MODR 2650 3.00. Prior to Fall 2009: Course credit exclusions: AK/AS/SC/MATH 1021 3.00, AS/SC/MATH 2021 3.00, AK/AS/SC/MATH 2221 3.00, GL/MATH/MODR 2650 3.00.

SC/MATH 1019 3.0 Discrete Mathematics for Computer Science

Introduction to abstraction. Use and development of precise formulations of mathematical ideas. Informal introduction to logic; introduction to naïve set theory; induction; relations and functions; big O–notation; recursive definitions, recurrence relations and their solutions; graphs and trees. Three lecture hours per week. Plus drop–in optional problem sessions as well as instructor office hours, as these are announced in each term. Prerequisites: SC/MATH 1190 3.00, or both of 12U Advanced Functions and Introductory Calculus and 12U Geometry and Discrete Mathematics. Course credit exclusion: SC/MATH 2320 3.00. Prior to Fall 2009: Prerequisites: AK/AS/SC/MATH 1190 3.00, or both of 12U Advanced Functions and Introductory Calculus and 12U Geometry and Discrete Mathematics. Course credit exclusion: AK/AS/SC/MATH 2320 3.00.

SC/PHYS 1010 6.0 Physics

Topics include linear, rotational and oscillatory motion; Newtonian mechanics; gravitation; electrostatics; magnetostatics; electric current and induction; heat; geometrical and physical optics and sound. Differential and integral calculus and vector algebra are used. This course covers fewer topics than SC/PHYS 1410 6.00, but covers them in greater depth. It should be taken by all those likely to enrol in 2000–level physics courses. Includes three hour laboratory component normally in alternating weeks. Prerequisite: OAC Physics or 12U Physics or SC/PHYS 1510 4.00. Corequisite(s): SC/MATH 1013 3.00 and SC/MATH 1014 3.00, or SC/MATH 1505 6.00, or equivalents. Course credit exclusions: SC/PHYS 1410 6.00 and SC/PHYS 1420 6.00. Prior to Fall 2009: Prerequisite: OAC Physics or 12U Physics or SC/PHYS 1510 4.00. Corequisite(s): AS/SC/MATH 1013 3.00 and AS/SC/MATH 1014 3.00, or AS/SC/MATH 1505 6.0, or equivalents. Course credit exclusions: SC/PHYS 1410 6.0 and SC/PHYS 1420 6.0.

## Second Year:

SC/ENG 2000 6.0

### Engineering Design II

Design using engineering materials (mechanical, electronic, magnetic, thermal and optical properties of materials, structural mechanics) and management and economics of engineering projects (workspace safety, work breakdown structures, Gantt charts, logic diagram, time value of money, comparison methods). Group design projects. Three lecture hours per week. Two terms. Six credits. Prerequisites: Completion of first year engineering common core.

SC/ENG 2110 2.0

### Geomatics and Space Engineering

Introduction to geodesy and geomatics engineering: surveying, geodesy, hydrography, space geodesy and geodynamics, photogrammetry and digital mapping. A survey of communications, remote sensing and geodetic satellites, their engineering characteristics, payloads and use; features of Low Earth Orbiter (LEO) missions. One and one-half lecture hours per week, one and one-half laboratory hours per week. One term. Two credits. Prerequisites: SC/EATS 1010 3.00; SC/PHYS 1010 6.00; or permission of the course instructor.

SC/ENG 2120 4.0

### Fundamentals of Surveying

Coordinate systems, conventions and transformations. First and second geodetic problem: trig sections, traverses, eccentricities, areas. Distance measurements, angular measurements, heights. Topographic mapping and property surveys. Route surveying. Introduction to other surveys: alignment, deformation surveys for buildings, bridges, dams, tunnels, pipelines. Three lecture hours per week and three laboratory hours per week. One term. Four credits. Prerequisites: SC/EATS 1010 3.00; SC/MATH 1014 3.00; SC/MATH 1025 3.00; SC/EATS 2610 2.00 or SC/ENG 2110 2.00; or permission of the course instructor.

- SC/CSE 2011 3.0      Fundamentals of Data Structures
- A study of fundamental data structures and their use in the efficient implementation of algorithms. Topics include abstract data types, lists, stacks, queues, trees and graphs.  
Prerequisites: General prerequisites, SC/CSE 1019 3.00 or SC/MATH 1019 3.00. Prior to Fall 2009: Prerequisites: General prerequisites, AK/AS/SC/CSE 1019 3.00 or AK/AS/SC/MATH 1019 3.00. Course credit exclusion: AK/AS/SC/COSC 2011 3.00
- SC/CSE 2031 3.0      Software Tools
- Tools commonly used in the software development process: the C language; shell programming; filters and pipes; version control systems and "make"; debugging and testing. Prerequisites: General prerequisites. Course credit exclusion: SC/COSC 2031 3.00.
- SC/CSE 2501 1.0      Fortran and Scientific Computing
- Covers computer-base problem solving in a variety of scientific and engineering settings. Introduces the FORTRAN programming language and its interface with scientific libraries. Applications are drawn mainly from scientific areas such as numerical methods, processing experimental data, simulation and data visualization. Prerequisites: One of SC/CSE 1020 3.00, SC/CSE 1530 3.00 Prior to Fall 2009: Prerequisites: One of AK/AS/SC/CSE 1020 3.00, AK/AS/SC/COSC 1020 3.00, AK/AS/SC/CSE 1530 3.00, AK/AS/SC/COSC 1530 3.00. Course credit exclusion: SC/COSC 2501 1.00.
- SC/EATS 2030 3.0      Geophysics and Space Science
- Seismic waves, earthquake fault plane solutions, tectonics on a sphere, geochronology, paleomagnetism, Earth's magnetic field, its origin and deformation by solar winds. VLBI measurements of fluctuations of Earth rotation, gravitational perturbations of satellite orbits, planetary exploration and communications issues. Three lecture hours and a one-hour computer laboratory. One term. Three credits. Prerequisites: SC/MATH 1014 3.00; SC/PHYS 1010 6.00, or a minimum grade of C in SC/PHYS 1410 6.00. Prior to Fall 2009: Prerequisites: AS/SC/MATH 1014 3.00; SC/PHYS 1010 6.00, or a minimum grade of C in SC/PHYS 1410 6.00.
- SC/EATS 2470 3.0      Introduction to Continuum Mechanics

Introductory tensor algebra and calculus. Stress and strain analysis. Symmetry of stress tensor, equilibrium conditions. Lagrangian and Eulerian descriptions of strain. Physical interpretation of stress, strain and strain rate tensors. Conservation laws in continua. Consistency and compatibility considerations. Constitutive relations. Two lecture hours and a tutorial or problems laboratory session. One term. Three credits. Prerequisites: SC/CSE 1540 3.00; SC/MATH 1025 3.00; SC/MATH 2015 3.00; SC/PHYS 1010 6.00, or a minimum grade of C in SC/PHYS 1410 6.00. Course credit exclusion: SC/EATS 2470 4.00. Prior to Fall 2009: Prerequisites: AK/AS/SC/CSE 1540 3.00 (formerly COSC); AS/SC/MATH 1025 3.00; AS/SC/MATH 2015 3.00; SC/PHYS 1010 6.00, or a minimum grade of C in SC/PHYS 1410 6.00. Course credit exclusion: SC/EATS 2470 4.00.

SC/MATH 2015 3.0 Applied Multivariate and Vector Calculus

Topics covered include partial derivatives; grad, div, curl and Laplacian operators; line and surface integrals; theorems of Gauss and Stokes; double and triple integrals in various coordinate systems; extrema and Taylor series for multivariate functions. Prerequisite: One of SC/MATH 1010 3.00, SC/MATH 1014 3.00, SC/MATH 1310 3.00; or SC/MATH 1505 6.00 plus permission of the course coordinator. Course credit exclusions: SC/MATH 2010 3.00, SC/MATH 2310 3.00, GL/MATH/MODR 2670 3.00, GL/MATH 3200 3.00. Prior to Fall 2009: Prerequisite: One of AS/SC/MATH 1010 3.00, AS/SC/MATH 1014 3.00, AK/AS/SC/MATH 1310 3.00; or AS/SC/MATH 1505 6.00 plus permission of the course coordinator. Course credit exclusions: AS/SC/MATH 2010 3.00, AK/AS/SC/MATH 2310 3.00, GL/MATH/MODR 2670 3.00, GL/MATH 3200 3.00.

SC/MATH 2271 3.0 Differential Equations for Scientists and Engineers

Introduction to ordinary and partial differential equations, including their classification, boundary conditions, and methods of solution. Equations, methods, and solutions relevant to science and engineering are emphasized, and exploration is encouraged with the aid of software. Three lecture hours per week. One term. Three credits. Prerequisites: One of SC/MATH 2010 3.00, SC/MATH 2015 3.00, SC/MATH 2310 3.00 or equivalent; one of SC/MATH 1025 3.00, SC/MATH 2022 3.00, SC/MATH 2222 3.00 or equivalent. Course Credit Exclusions: SC/MATH 2270 3.00, GL/MATH 3400 3.00 Prior to Fall 2009: Prerequisites: One of AS/SC/MATH 2010 3.00, AS/SC/MATH 2015 3.00, AS/SC/MATH 2310 3.00 or equivalent; one of AS/SC/MATH 1025 3.00, AS/SC/MATH 2022 3.00, AS/SC/MATH 2222 3.00 or equivalent. Course Credit Exclusions: AS/SC/MATH 2270 3.00, GL/MATH 3400 3.00

SC/PHYS 2020 3.0 Electricity and Magnetism

The elements of electric and magnetic fields are developed together with DC and AC circuit theory. Prerequisites: SC/PHYS 1010 6.00, or a minimum grade of C in SC/PHYS 1410 6.00 or SC/PHYS 1420 6.00. Corequisite: SC/MATH 2015 3.00. Prior to Fall 2009: Prerequisites: SC/PHYS 1010 6.00, or a minimum grade of C in SC/PHYS 1410 6.00 or SC/PHYS 1420 6.00. Corequisite: AS/SC/MATH 2015 3.00.

**3 General Education credits**

## Third Year:

SC/ENG 3000 3.0

### Professional Engineering Practice

An introduction to the legal and ethical frameworks of the engineering profession, preparing students for the Professional Practice Examination required for certification as a professional engineer. Also covered are associated professional issues such as entrepreneurship, intellectual property and patents. Three lecture hours per week. One term. Three credits. Prerequisites: Second-year engineering courses (stream specific), including SC/ENG 2001 3.00 (or SC/ENG 2000 6.0 prior to 2009) and SC/ENG 1000 6.00. Course credit exclusions: SC/CSE 3000 3.00, SC/CSE 3001 1.00, SC/CSE 3002 1.00, SC/PHYS 3001 1.00, SC/EATS 3001 1.00.

SC/ENG 3110 4.0

### Geodetic Concepts

Geodesy. Reference systems, frames and datums; time systems; the natural system of coordinates; terrestrial, celestial and orbital coordinate systems. Coordinate system transformations. Relative three dimensional positioning; the inertial frame of reference. Positions on the ellipsoid and mapping plane. Height systems. Three lecture hours and three hours of laboratory exercises per week. One term. Four credits. Prerequisites: SC/EATS 2610 2.00 or SC/ENG 2110 2.00; SC/EATS 2620 4.00 or SC/ENG 2120 4.00; SC/MATH 2015 3.00; SC/CSE 2501 1.00. Corequisite: SC/EATS 3620 4.00 or SC/ENG 3120 4.00. Prior to Fall 2009: Prerequisites: SC/EATS 2610 2.00 or SC/ENG 2110 2.00; SC/EATS 2620 4.00 or SC/ENG 2120 4.00; AK/AS/SC/MATH 2015 3.00; AK/AS/SC/CSE 2501 1.00 (formerly COSC). Corequisite: SC/EATS 3620 4.00 or SC/ENG 3120 4.00.

SC/ENG 3310 3.0

### Space Mission Design

This course covers the basic aspects of space mission design including: mission types, objectives, technical readiness, risk mitigation, subsystems, and public outreach. Three lecture hours. Prerequisites: SC/ENG 2000 6.00 or permission of the instructor.

SC/ENG 3320 3.0

### Microsystems Technology

The course covers the principles and implementations of miniaturised sensors and actuators in a range of physical domains, such as optical, magnetic, thermal, and mechanical systems. Examples include electronic cameras, micro-electro-mechanical systems, thermal microsystems and display technologies. Three lecture hours. Prerequisite: SC/PHYS 2020 3.00; SC/PHYS 2211 1.00; SC/PHYS 2060 3.00 recommended; SC/PHYS 2212 1.00 recommended. Corequisite: SC/PHYS 3050 3.00 recommended.

SC/ENG 3330 3.0

### Space Engineering Materials

This course covers the basic behaviour and processing of engineering materials. The emphasis is on metals and alloys plus discussion of ceramics, plastics and composites. Three lecture hours. Prerequisite: SC/ENG 2000 6.00 or permission of the instructor.

SC/ENG 3340 3.0

### Mechanical Design

This course provides an advanced treatment of machine elements such as bearings, springs, gears, cams, and mechanisms. Analysis of these elements includes extensive application of core engineering curriculum including solid mechanics and fluid dynamics. The course offers practice in skills needed for machine design such as estimation, drawing, and experimentation. Students work in small teams to design and build machines that address real-world challenges.

- SC/ENG 3350 3.0      Finite Element Methods In Engineering Design
- Basic principles of finite element method, variational and weighted residual principle procedures in discretizing and building up governing equations of physical models. Use of industrial FEM codes to understand model response to external effects such as stress, heat, vibration, and fluids. Prerequisites: SC/MATH 1025 3.00; SC/MATH 2015 3.00; SC/MATH 2271 3.00; SC/PHYS 1010 6.00, or a minimum grade of C in SC/PHYS 1410 6.00; SC/PHYS 2010 3.00; SC/PHYS 2030 3.00; SC/EATS 2470 3.00.
- SC/EATS 3020 3.0      Global Geophysics and Geodesy
- Studies of isostatic equilibrium and glacial rebound; seismic tomography and spherical harmonic representation of gravity and the geoid; Earth rotation and geodesy; geothermal heat flow and mantle convection. Three lecture hours. One term. Three credits. Prerequisites: SC/EATS 2030 3.00; SC/EATS 2470 3.00 or SC/PHYS 2010 3.00; SC/MATH 2015 3.00; SC/MATH 2271 3.00; SC/PHYS 2020 3.00. Prior to Fall 2009: Prerequisites: SC/EATS 2030 3.00; SC/EATS 2470 3.00 or SC/PHYS 2010 3.00; AS/SC/MATH 2015 3.00; AK/AS/SC/MATH 2271 3.00; SC/PHYS 2020 3.00.
- SC/EATS 3280 3.0      Physics of the Space Environment
- An introduction to the physical processes of the upper atmosphere, the ionosphere, the magnetosphere and the heliosphere, and the interactions that occur with space vehicles that traverse these regions of space. Prerequisites: SC/PHYS 2020 3.00, AS/SC/MATH 2015 3.00, AS/SC/MATH 2271 3.00.
- SC/PHYS 2030 3.0      Computational Methods for Physicists and Engineers
- The symbolic and numeric computing environments provided by Maple and Matlab are used to solve problems in mechanics and electromagnetism. Prerequisites: SC/PHYS 1010 6.00 or SC/PHYS 1410 6.00; One of AK/AS/SC/CSE 1020 3.00, AK/AS/SC/COSC 1020 3.00, AK/AS/SC/CSE 1540 3.00 or AK/AS/SC/COSC 1540 3.00; AS/SC/MATH 1014 3.00 or equivalent. Corequisite: AS/SC/MATH 2015 3.00 or equivalent.

SC/PHYS 3050 3.0    Electronics I

Introduction to physical electronics including DC and AC circuit theory and network analysis; bandpass filter; introduction to the p-n junction and semiconductor devices: diodes, DC power supplies, transistors, analysis and design of basic amplifiers, operational amplifiers. With laboratory exercises. Two lecture hours, three laboratory hours. One term. Prerequisites: SC/PHYS 1010 6.00; SC/PHYS 2020 3.00 and SC/PHYS 2211 1.00 recommended.

SC/PHYS 3150 3.0    Electronics II

The concept of feedback and its use in circuits employing operational amplifiers; analysis/design of such circuits, including amplifiers, filters, oscillators, pulse generators; digital concepts and logic circuits with applications to data manipulation (computers) and storage. Laboratory exercises and project. Two lecture hours, three laboratory hours. One term. Prerequisite: SC/PHYS 1010 6.00; and SC/PHYS 3050 3.00 recommended.

SC/PHYS 3250 3.0    Introduction to Space Communications

The course covers all aspects of communications between spacecraft and ground stations. Topics include orbital aspects of satellite communications, communications components of satellites and interplanetary spacecraft and ground stations, transmission, reception, link equations, modulation, multiplexing techniques and access to a satellite. Prerequisite: SC/PHYS 2020 3.00.

### 3 General Education credits

Note: Between third and fourth year, an optional, non-credit, 4–16 month internship program where students will gain professional experience is available. Students are required to enrol in ENG 3900 0.0 (Engineering Internship Term) in each term of their internship. During the work placement students earn a salary typical of entry-level positions

## Fourth Year:

SC/ENG 4000 6.0

### Engineering Project

The project will include significant elements of design and implementation. The format is intended to resemble engineering projects in practice, including specifications, background research, innovative solutions, analysis, testing and communication. Two terms. Six credits. Prerequisites: 21 3000-level science or engineering credits in the Engineering Program, exclusive of SC/ENG 3000 3.00. Prerequisite or corequisite: SC/ENG 3000 3.00. Course credit exclusions: SC/CSE 4001 6.00, SC/CSE 4080 3.00, SC/CSE 4081 6.00, SC/CSE 4082 6.00, SC/CSE 4084 6.0, SC/EATS 4001 6.0, SC/PHYS 4001 6.0

SC/ENG 4350 3.0

### Space Hardware

Primarily a laboratory course with modules focusing on communications and data transfer technologies typically used in spacecraft operations or integration and testing. Three laboratory hours per week with some lecture hours, added to refresh theoretical concepts. Prerequisites: AK/AS/SC/CSE 1540 3.00 or AK/AS/SC/CSE 2031 3.00 or equivalent programming experience; SC/PHYS 3150 3.00; SC/PHYS 3250 3.00. Corequisite: SC/ENG/PHYS 4330 3.00

SC/ENG 4360 3.0

### Payload Design

A survey of typical applications of spacecraft technology including communications systems, location systems, terrestrial applications and exploration missions. Prerequisites: SC/PHYS 3050 3.00; SC/PHYS 3280 3.00 or SC/ENG 3310 3.00 or SC/PHYS 3310 3.00.

SC/CSE 4421 3.0

### Introduction to Robotics

An introduction to robot arms and autonomous vehicles. The course covers control and manipulator theory, In robot sensors and navigation. Prerequisites: General prerequisites and AS/SC/MATH 1025 3.00; AK/AS/SC/MATH 1310 3.00; AK/AS/SC/CSE 2031 3.00 or AK/AS/SC/COSC 2031 3.00. Course credit exclusion: AK/AS/SC/COSC 4421 3.00.

SC/PHYS 4110 3.0 Dynamics of Space Vehicles

The dynamics of spacecraft in the near Earth and deep space environments, including the classical theory of orbits, the effects of perturbations on satellite orbits, rocket propulsion, orbital manoeuvres, interplanetary trajectories, and satellite attitude control. Prerequisites: SC/PHYS 2010 3.00 or SC/EATS 2470 3.00; AS/SC/MATH 2015 3.00; AS/SC/MATH 2271 3.00

SC/PHYS 4250 3.0 Signal and Communications Theory

Signal representation using orthogonal functions; Fourier series and transforms as applied to signals; ideal and physically realizable filters; the sampling theorem; definitions and characterizations of energy, power and their spectral densities; the modulation theorem; various kinds of modulation and bandwidth requirements. Prerequisites: SC/PHYS 3250 3.00; AS/SC/MATH 2015 3.00; AK/AS/SC/MATH 2270 3.00. Course credit exclusion: AS/SC/MATH 4130B 3.00.

**6 General Education credits**

**Three of the following five courses:**

SC/ENG 4110 3.0 Global Positioning Systems

Positioning by space vehicles. Coordinate systems and transformations. GPS, GLONASS, GALILEO, Satellite Laser Ranging, Very Long Baseline Interferometry. Positioning of moving vehicles and platforms: marine, land, airborne and space vehicles. GPS/INS integration. Real time kinematic applications. Three lecture hours weekly and three hours of laboratory exercises every other week. One term. Three credits. Prerequisites: SC/EATS 3020 3.00; SC/EATS 3610 4.00 or SC/ENG 3110 4.00; SC/EATS 3620 4.00 or SC/ENG 3120 4.00; or permission of the course director.

SC/ENG 4330 3.0 Radio Techniques for Space Exploration

The theory and application of modern radio science and radio techniques in space exploration and space navigation. Topics include signal processing, radio astronomy fundamentals, Deep Space Network instrumentation, antenna theory, arrays, Very Long Baseline Interferometry, spacecraft navigation, radar systems, range, range rate and the radar equation. Prerequisite: SC/PHYS 3250 3.00.

- SC/EATS 4220 3.0 Remote Sensing of the Earth's Surface
- Principles used in extracting physical information about the Earth's surface using remote sensing. Remote sensing in the visible, short-wave infrared, thermal infrared and microwave regions is discussed in terms of potential applicability to forestry, agriculture, water resources and geology. Two lecture hours, three laboratory hours. One term. Three credits. Prerequisite(s): SC/PHYS 2020 3.00, or SC/PHYS 2060 3.00, or both SC/PHYS 2211 1.00 and SC/PHYS 2212 1.00.
- SC/EATS 4230 3.0 Remote Sensing of the Atmosphere
- An introduction to and summary of the area of remote sensing of the atmosphere from space platforms and from the ground. Topics include atmospheric radiation, atmospheric spectroscopy, inversion theory, instrumentation, satellites, space platforms and future technology. Three lecture hours per week, occasional laboratory sessions. One term. Three credits. Prerequisites: SC/EATS 2010 3.00 or SC/PHYS 2060 3.00; AS/SC/MATH 1025 3.00; AS/SC/MATH 2015 3.00; AK/AS/SC/MATH 2271 3.00. Prerequisite or corequisite: SC/EATS 3030 3.00 or permission of the course director.
- SC/PHYS 3070 3.0 Planets and Planetary Systems
- Survey of planetary astrophysics. Specific emphases vary, Topics include: the formation and evolution of planetary systems; the search for and discovery of extra-solar planets; current knowledge of the atmospheres, interiors and surfaces of planets, satellites and minor bodies within the Solar System. Prerequisite: SC/PHYS 1010 6.00 or SC/PHYS 1410 6.00 with a minimum grade of C; SC/PHYS 1070 3.00, Prerequisite(s) or corequisite: AS/SC/MATH 2015 3.00; AS/SC/MATH 2271 3.00.

### General Education Courses

All Engineering students must complete a minimum of 15 credits from two different areas of study outside the Faculty of Science and Engineering. The courses taken will be chosen from among those offered by the Faculty of Arts, the Faculty of Environmental Studies, the Faculty of Fine Arts, Atkinson College or Glendon College that are approved for General Education credit by the Faculty of Science and Engineering and shall include the following course within the 15 credit requirement:

EN/ENVS 2150 3.0 Environment, Technology and Sustainable Society