**Students complete all of**

* BUS 238 – Introduction to Entrepreneurship & Innovation (3)
* CHEM 121 – General Chemistry and Laboratory I (4)
* CMPT 130 – Introduction to Computer Programming I (3)
* CMPT 135 – Introduction to Computer Programming II (3)
* MATH 152 – Calculus II (3)
* MATH 232 – Applied Linear Algebra (3)
* MATH 251 – Calculus III (3)
* MATH 260/310 – Introduction to Ordinary Differential Equations (3)
* PHYS 140 – Studio Physics - Mechanics and Modern Physics (4)
* PHYS 141 – Studio Physics - Optics, Electricity and Magnetism (4)
* REM 321 – Ecological Economics (4)
* SEE 100 – Engineering Graphics & Software for Design (3)
* SEE 101W – Process, Form & Convention in Professional Genres (3)
* SEE 110 – Energy, Environment & Society (3)
* SEE 111 – Integrated Energy Solution (IES) I (4)
* SEE 221 – Statics and Mechanics of Materials (4)
* SEE 222 – Engineering Materials for Energy Systems (3)
* SEE 224 – Thermodynamics for Energy Engineering (3)
* SEE 225 – Fluid Mechanics (4)
* SEE 230 – Electric Circuits (4)
* SEE 231 – Electronic Devices & Systems (4)
* SEE 241 – Engineering Measurement, Analysis and Forecasting (3)
* SEE 242 – Computational Methods for Engineers (3)
* SEE 251 – Electric Machines and Energy Conversion (3)
* SEE 300 – The Business of Engineering (3)
* SEE 310 – Integrated Energy Solution (IES) II (4)
* SEE 324 – Heat & Mass Transfer for Energy Engineering (3)
* SEE 331 – Power Electronics (4)
* SEE 332 – Power Systems Analysis and Design (3)
* SEE 341 – Signals and Systems (3)
* SEE 342 – Feedback Control Systems (4)
* SEE 351 – Bioprocess Engineering Systems (3)
* SEE 352 – Power Generation and Conversion (3)
* SEE 354 – Energy Storage (3)
* SEE 402 – Professional Engineering Ethics and Practice (2)
* SEE 410 (W) – Sustainable Energy Design Project I (3)
* SEE 411 – Sustainable Energy Design Project II (3)

**and one of**

* SEE 325 – Mechanical Design and Finite Element Analysis (3)
* SEE 333 – Network and Communication Systems (3)

**and one of**

* MATH 150 – Calculus I with Review (4)
* MATH 151 – Calculus I (3)

**and three of**

* ENSC 450 – VLSI Systems Design (4)
* ENSC 495 – Introduction to Microelectronic Fabrication (4)
* MSE 480 – Manufacturing Systems (3)
* MSE 481 – Industrial Control systems (3)
* SEE 460 – Additive Manufacturing and Sustainable Design (3)
* SEE 461 – Electronics Manufacturing and Assembly (3)
* SEE 462 – Manufacturing Processes and Materials (3)
* SEE 463 – Embedded Computer Systems (3)
* SEE 464 - Energy Systems Modeling for Buildings (3)
* SEE 486 - Directed Studies in Sustainable Energy Engineering (3)

**and one of**

* GEOG 324 – Geography of Transportation (4)
* GEOG 362 – Geography of Urban Built Environments (4)

**and one B-HUM elective**

**Course Descriptions:**

**CHEM 121 - General Chemistry and Laboratory I (4)**

Atomic and molecular structure; chemical bonding; thermochemistry; elements; periodic table; gases liquids, solids, and solutions. This course includes a laboratory component. Prerequisite: BC high school chemistry 12 or CHEM 109 or CHEM 111. Students may not count both CHEM 120 and 121 for credit. Quantitative/Breadth- Science.

**CMPT 130 - Introduction to Computer Programming I (3)**

An introduction to computing science and computer programming, using a systems oriented language, such as C or C++. This course introduces basic computing science concepts. Topics will include: elementary data types, control structures, functions, arrays and strings, fundamental algorithms, computer organization and memory management. Prerequisite: BC Math 12 (or equivalent, or any of MATH 100, 150, 151, 154, or 157). Students with credit for CMPT 102, 120, 126,

or 128 may not take this course for further credit. Quantitative/Breadth-Science.

**CMPT 135 - Intro to Computer Programming II (3)**

A second course in systems-oriented programming and computing science that builds upon the foundation set in CMPT 130 using a systems-oriented language such as C or C++. Topics: a review of the basic elements of programming; introduction to object-oriented programming (OOP); techniques for designing and testing programs; use and implementation of elementary data structures and algorithms; introduction to embedded systems programming. Prerequisite: CMPT 130. Students with credit

for CMPT 125, 126, or 129 may not take this course for further credit. Quantitative.

**BUS 238 - Introduction to Entrepreneurship & Innovation (3)**

Students will build collaborative and creative skills necessary to become effective innovators through hands-on application via interdisciplinary teamwork.

Entrepreneurship and innovation of all types will be addressed including social, commercial, creative, sustainable and technological perspectives. Prerequisite: 12 Units. Breadth-Social Sciences.

**MATH 152 - Calculus II (3)**

Riemann sum, Fundamental Theorem of Calculus, definite, indefinite and improper integrals, approximate integration, integration techniques, applications of integration. First-order separable differential equations and growth models. Sequences and series, series tests, power series, convergence and applications of power series. Prerequisite: MATH 150 or 151; or MATH 154 or 157 with a grade of at least B. Students with credit for MATH 155 or 158 may not take this course for further credit. Quantitative.

**MATH 232 - Applied Linear Algebra (3)**

Linear equations, matrices, determinants. Introduction to vector spaces and linear transformations and bases. Complex numbers. Eigenvalues and eigenvectors; diagonalization. Inner products and orthogonality; least squares problems. An emphasis on applications involving matrix and vector calculations.

Prerequisite: MATH 150 or 151; or MACM 101; or MATH 154 or 157, both with a grade of at least B. Students with credit for MATH 240 make not take this course for further credit. Quantitative.

**MATH 251 - Calculus III (3)**

Rectangular, cylindrical and spherical coordinates. Vectors, lines, planes, cylinders, quadric surfaces. Vector functions, curves, motion in space. Differential and integral calculus of several variables. Vector fields, line integrals, fundamental theorem for line integrals, Green's theorem. Prerequisite: MATH 152; or MATH 155 or MATH 158 with a grade of at least B. Recommended: It is recommended that MATH

240 or 232 be taken before or concurrently with MATH 251. Quantitative.

**MATH 310 - Introduction to Ordinary Differential Equations (3)**

First-order differential equations, second- and higher-order linear equations, series solutions, introduction to Laplace transform, systems and numerical methods, applications in the physical, biological and social sciences. Prerequisite: MATH 152; or MATH 155/158 with a grade of at least B, MATH 232 or 240. Quantitative.

**PHYS 140 - Studio Physics - Mechanics and Modern Physics (4)**

A general calculus-based introduction to mechanics taught in an integrated lecture- laboratory environment. Topics include translational and rotational motion, momentum, energy, gravitation, and selected topics in modern physics. Prerequisite: BC Principles of Physics 12, or PHYS 100 or equivalent, with a minimum grade of C-. Corequisite: MATH 150 or 151 or 154 must precede or be taken concurrently.

Students with credit for PHYS 125 or 120 or 101 may not take this course for further credit. Quantitative/Breadth-Science.

**PHYS 141 - Studio Physics - Optics, Electricity and Magnetism (4)**

A general calculus-based introduction to electricity, magnetism and optics taught in an integrated lecture-laboratory environment. Topics include electricity, magnetism, simple circuits, optics and topics from applied physics. Prerequisite: PHYS

120 or PHYS 125 or PHYS 140, with a minimum grade of C- (or PHYS 101 with a minimum grade of B). Corequisite: MATH 152 or 155 must precede or be taken concurrently. Students with credit for PHYS 126 or 121 or 102 may not take this course for further credit. Quantitative/Breadth-Science.

**REM 321 - Ecological Economics (4)**

Introduces students to the concepts and methods of ecological economics. Provides students with grounding in the core principles of conventional economics applied to the environment but then extends this to the integration of economics and ecology to create a new ecological-economic understanding of environmental change and sustainability. Prerequisite: minimum of 45 units. Students with credit for ENV

321 cannot take REM 321 for further credit.

**SEE 100 - Engineering Graphics & Software for Design (3)**

Introduction to graphical communication in the context of engineering design. Students learn to think and communicate visually. With the use of computer aided design (CAD) tools, students learn the theory and practice of design by dissecting, graphically representing, and redesigning products. Pre-requisites: Students with credit for ENSC 104, or MSE 100 may not take for further credit.

**SEE 101W - Process, Form & Convention in Professional Genres (3)** Fundamentals of communicating technical information clearly and concisely for professional engineers. A focus on communicating persuasively about various contemporary technical, social, ethical and environmental issues with technical and non-technical audiences. Students will practice providing constructive feedback to peers, giving presentations and working in a team. Writing. Pre-requisites: Students with credit for CMPT 105W, ENSC 102W, ENSC 105W or MSE 101W may not take for further credit.

**SEE 110 - Energy, Environment & Society (3)**

Energy availability and sources, environmental consequences of energy supply and consumption, and societal impacts. Explores the environmental, economic, social, and political implications of the choices a society makes to meet its energy needs. Definitions of sustainability. Special emphasis on communication skills.

**SEE 111 Integrated Energy Solution (IES) I (4)**

Introduction to the process of sustainable engineering design. Historical perspective on role of energy, resources and technology in society. Development and demonstration of sustainability thinking through research, case study and design project undertaken by teams of students with integration of socio-economic factors and planning. Course introduces Project Based Learning methods. Pre-requisites: SEE 110.

**SEE 221 – Statics and Mechanics of Materials (4)**

Introduction to solid mechanics including statics, stress, strain, and deformation. Equilibrium conditions, axial loading, torsional loading, pure bending, stresses and deflections in rods and beams. Pre-requisites: PHYS 140, MATH 152. Students with credit for ENSC 281, MSE 221, or ENSC 385 may not take for further credit.

**SEE 222 - Engineering Materials for Energy Systems (3)**

Introduction to engineering materials by control of their structures to achieve different properties and performance. Techniques for modern materials engineering practice. Covers crystal and non-crystal structures and instruments for structure determination; principles of material failure, polymers, ceramics, nano-materials, and composites; electronic materials, and electro-chemical energy materials; quality control and reliability. Pre-requisites: PHYS 140, CHEM 121. Students with credit for ENSC 330 or MSE 220 may not take for further credit.

**SEE 224 – Thermodynamics for Energy Engineering (3)**

Basic energy concepts and definitions; first and second laws of thermodynamics; ideal and real gases; thermodynamic properties; with emphasis on analysis and applications to energy systems engineering. Pre-requisites: MATH 251

**SEE 225 - Fluid Mechanics (4)**

The fundamentals of fluid mechanics for engineers, emphasizing the basics of fluid statics and fluid motion, with applications in energy system engineering. Pre- requisites: PHYS 140, MATH 251, MATH 310. Students with credit for ENSC 283 or MSE 223 may not take for further credit.

**SEE 230 - Electric Circuits (4)**

Fundamental elements of electrical circuits; circuits laws; series and parallel circuits; operational amplifiers; network theorems; nodal and mesh methods; analysis of natural and step response of first and second order circuits; real, reactive and rms power. Covers worker safety implications of electricity, and safety of common laboratory practices such as soldering. Pre-requisites: PHYS 141, MATH 232. Pre- or co-requisite MATH 310. Students with credit for ENSC 220 or MSE 250 may not take for further credit.

**SEE 231 - Electronic Devices and Systems (4)**

Analysis of the basic electronic components, amplifiers, diodes, semiconductors, transistors and MOSFETs. Introduction to specific instrumentation, including actuators and sensors. Design of electronic circuits based on real world scenarios. Pre-requisites: SEE 230. Students with credit for MSE 251 or ENSC 225 may not take for further credit.

**SEE 241 – Engineering Measurement, Analysis and Forecasting (3)**

An introduction to methods for collecting and analysing engineering data. Topics include engineering data representation, probability density functions, engineering measurements, error analysis, test of hypotheses, regression, and design of experiments. Pre-requisites: PHYS 141, MATH 251 (co-req), MATH 232. Students with credit for ENSC 280, MSE 210 or PHYS 231 may not take for further credit.

**SEE 242 - Computational Methods for Engineers (3)**

Apply numerical methods to solve engineering problems with an emphasis on sustainable energy engineering. Pre-requisites: MATH 152, MATH 232. Students with credit for MACM 316 or MSE 211 may not take this course for further credit.

**SEE 251 - Electric Machines and Energy Conversion (3)**

Principles, operation, and analysis of electromechanical energy conversion systems and their applications. Pre-requisites: SEE 230, SEE 221, MATH 310.

**SEE 300 - The Business of Engineering (3)**

Economic and entrepreneurial concepts important to engineers who manage projects, run businesses, or need to decide on the most efficient method for accomplishing a task. Topics include: financial accounting and metrics, economic equivalence, rates of return, depreciation, income taxes, project and cost-benefit analyses, capital budgeting, financing methods, risk and uncertainty, business plans. Pre-requisites: A minimum of 75 units. Students with credit for ENSC 201, ENSC 311, ENSC 410, ENSC 411 or MSE 300 may not take for further credit.

**SEE 310 - Integrated Energy Solution (IES) II (4)**

Integrated design methodology for sustainable engineering problems; implementation through an energy system project undertaken in a project based learning environment. Introduction to modelling, simulation and optimization of energy systems. Global and local regulatory and policy frameworks. Demonstration of integrated sustainability thinking through design project, report and presentation. Special emphasis on communication skills. Pre-requisites: Completion of one co-op term, SEE 251, 224, 242

**SEE 324 - Heat and Mass Transfer for Energy Engineering (3)**

Introduces the basic principles of heat and mass transfer with analysis and application to real-world sustainable energy systems. Pre-requisites: PHYS 141, SEE 224, SEE 225

**SEE 331 - Power Electronics (4)**

Introduction to the fundamentals of power electronic circuits, components, and operation, and principles of electric power conversion in DC and AC applications. Pre-requisites: SEE 231. Students with credit for MSE 353 may not take for further credit

**SEE 332 - Power Systems Analysis and Design (3)**

Interconnected power systems including generators, transformers, electric motors and transmission lines; active and reactive power flow; symmetrical components; symmetrical and unsymmetrical short circuit fault calculations; protection systems, circuit breakers, transient stability, and grid voltage and frequency control. Labs, field trips and projects related to power grid operation, control, and design. Pre- requisites: SEE 331; SEE 251; Co-requisite 342.

**SEE 341 - Signals and Systems (3)**

Modelling and analysis of continuous and discrete signals using linear techniques. Laplace transforms; methods for basic modelling of physical systems; discrete and continuous convolution; impulse and step response; transfer functions and filtering; continuous Fourier transform and its relationship to the Laplace transform; frequency response and Bode plots; sampling; Z-transform. Pre-requisites: SEE 242, SEE 230. Students with credit for MSE 280 or ENSC 380 may not take for further credit.

**SEE 342 - Feedback Control Systems (4)**

Fundamentals of feedback control system design and analysis, including practical and theoretical aspects. Significant lab component in which students design controllers and evaluate their robustness to modeling errors and nonlinearities. Pre- requisites: SEE 341. Students with credit for ENSC 383 or MSE 381 may not take for further credit.

**SEE 351 - Bioprocess Engineering Systems (3)**

Combines biotechnology and engineering for materials and energy harvesting from renewable feedstocks. Covers fundamental biomolecular research on proteins, enzymes, microbes, biosensors, bioseparations and bioreactors. Applications in food processing preservation; biofuel; air and wastewater treatment; supramolecular materials for solar energy/photosynthesis; microfluidics for bioreactors; DNA chips; bioenergy; bio fuel cells; pulp/paper. Pre-requisites: MATH 310, SEE 224, pre- or co-requisite SEE 324.

**SEE 352 - Power Generation and Conversion (3)**

Application of thermodynamics, chemistry, and transport physics to energy conversion technologies and systems. Analysis of energy conversion systems with emphasis on efficiency, performance, and environmental impact. Pre-requisites: SEE 222, SEE 224, SEE 331.

**SEE 354 - Energy Storage (3)**

The characteristics, applications, limitations, and environmental impacts of various energy storage technologies and techniques are analyzed, compared and implemented in a lab setting. Electrochemical, mechanical, thermal and emerging energy storage options are considered. Pre-requisites: SEE 222, SEE 331, SEE 324.

**SEE 402 – Professional Engineering Ethics and Practice (2)**

An introduction to the engineering profession, law and ethics, and the engineers' responsibility to society. Students will explore issues related to worker and public safety and the social implications and environmental impacts of engineering.

Includes how to successfully negotiate the transition to the next career stage. Special emphasis on communication skills. Pre-requisites: 100 units, SEE 110. Students with credit for ENSC 406 or MSE 402 may not take this course for further credit..

**SEE 410W - Sustainable Energy Design Project I (3)**

This is the first course in a team-based, two-course capstone sequence. Focuses on project management, technical writing skills, and teamwork skills and strategies within the context of an engineering design project. Documentation topics cover proposals, functional and design specifications, progress reports and user manuals. An interim project report and presentation is required. Writing. Pre-requisites: 100 units, 2 completed co-op terms, SEE 310, SEE 100, SEE 101W. SEE 411 must be taken in the term directly following the successful completion of SEE 410W. Teams formed during this course will be maintained for the completion of the capstone project in SEE 411. Grades awarded in SEE 410W are conditional on the successful completion of SEE 411 in the subsequent term. Sustainable Energy Engineering students cannot take MSE 410, MSE 411, ENSC 405W or ENSC 440 for credit.

**SEE 411 - Sustainable Energy Design Project II (3)**

This is the second course in the team-based, two-course capstone sequence. Students synthesize their learning across the SEE program to research, design, build and test the hardware implementation of a working system. Includes a shop training workshop, engineering standards on how to design for safety, and human factors. A final report and presentation is required. Pre-requisites: SEE 410W. Must be taken in the term immediately following 410W. In order to obtain credit, students must successfully complete both SEE 410W and SEE 411. Students will be automatically enrolled in SEE 411 in the term immediately following successful completion of SEE 410W. Sustainable Energy Engineering students cannot take MSE 410, MSE 411, ENSC 405W or ENSC 440 for credit.

**In addition, students take one of MATH 150 or MATH 151**

**MATH 150 - Calculus I with Review (4)**

Designed for students specializing in mathematics, physics, chemistry, computing science and engineering. Topics as for Math 151 with a more extensive review of functions, their properties and their graphs. Recommended for students with no previous knowledge of Calculus. In addition to regularly scheduled lectures, students enrolled in this course are encouraged to come for assistance to the Calculus Workshop (Burnaby), or Math Open Lab (Surrey). Prerequisite: Pre-Calculus 12 (or equivalent) with a grade of at least B+, or MATH 100 with a grade of at least B-, or achieving a satisfactory grade on the Simon Fraser University Calculus Readiness Test. Students with credit for either MATH 151, 154 or 157 may not take MATH 150 for further credit. Quantitative.

**MATH 151 - Calculus I (3)**

Designed for students specializing in mathematics, physics, chemistry, computing science and engineering. Logarithmic and exponential functions, trigonometric functions, inverse functions. Limits, continuity, and derivatives. Techniques of differentiation, including logarithmic and implicit differentiation. The Mean Value Theorem. Applications of differentiation including extrema, curve sketching, Newton's method. Introduction to modeling with differential equations. Polar coordinates, parametric curves. Prerequisite: Pre-Calculus 12 (or equivalent) with a grade of at least A, or MATH 100 with a grade of at least B, or achieving a satisfactory grade on the Simon Fraser University Calculus Readiness Test. Students with credit for either MATH 150, 154 or 157 may not take MATH 151 for further credit. Quantitative.

**In addition, as part of the elective focus areas, students must also take one of the following two electives: GEOG 362, GEOG 324.**

**GEOG 362 – Geography of Urban Built Environments (4)**

Current concepts and approaches in urban geography regarding the development of built environments. Central concerns are the relationships between urbanization and the state, capital, and civil society at various scales. Prerequisite: At least 30 units, including one of GEOG 221, 241, or 261. Students with credit for GEOG 362W may not take this course for further credit.

**GEOG 324 – Geography of Transportation (4)**

An empirical and theoretical examination of the geographical aspects of transportation systems. Prerequisite: GEOG 221 or 241.

**In addition, students take one of SEE 325 or SEE 333**

**SEE 325 - Mechanical Design and Finite Element Analysis (3)**

Introduction and application of Finite Element Analysis (FEA) to energy systems design problems involving engineering mechanics, heat transfer and machine elements. Includes an introduction to commercial FEA software and applications to practical problems. Concepts relating to engineering mechanics and machine elements are developed in the context of design projects. Pre-requisites: SEE 100, SEE 221, SEE 222, SEE 324.

**SEE 333 - Network and Communication Systems (3)**

Fundamentals of communication networks: reference models, layered architecture. Physical layer analysis and design. Performance analysis of communication protocols at the data link, network, and transport layers. Medium access control, congestion control, routing. Network security, privacy, and social issues. Tools for simulation and analysis of communication networks. Pre-requisites: SEE 341

**In addition, as part of the elective focus areas, students must also take three SEE technical electives.**

**SEE 460 - Additive Manufacturing and Sustainable Design (3)**

Additive manufacturing processes; Design for additive manufacturing; Problem- based additive manufacturing, Project-based additive manufacturing; Light-based 3D printing, Metal 3D printing, Extrusion-based 3D printing; 3D printed electronics; Direct digital manufacturing; 4D printing. Pre-requisites: SEE 100, SEE 221, and SEE 222.

**SEE 461 - Electronics Manufacturing and Assembly (3)**

Electronics manufacturing and assembly technologies and processes in the context of sustainability. PCB and interconnect technologies, component selection and handling, material properties and selection, thermal, mechanical and environmental effects, product testing, environmental and legal standards. Pre-requisites: SEE 221, SEE 231

**SEE 462 - Manufacturing Processes and Materials (3)**

Manufacturing processes and engineering materials in the context of sustainable manufacturing. Manufacturing technologies and process flow. Productivity and green manufacturing practices. Engineering material selection. Manufacturing processes including forming, separating, fabrication, conditioning and finishing. Pre- requisites: SEE 221, SEE 310

**SEE 463 - Embedded Computer Systems (3)**

Implementation and design of embedded computer systems used in various real-time applications including energy systems, power electronics, and automation. Pre- requisites: CMPT 135, SEE 231

**SEE 464 - Energy Systems Modeling for Buildings (3)**

Introduction to modeling energy systems for buildings, focusing on envelope and mechanical systems, and their effects on energy use. Using the applicable codes and standards to define schedules for the buildings, calculate heating and cooling loads, and set sustainability targets. Applying industry standard software to model, and experiment with innovative methods to enhance energy use, and reach sustainability targets.

**SEE 486 - Directed Studies in Sustainable Energy Engineering (3)**

Directed reading and research in a topic chosen in consultation with a supervisor. Admission requires agreement by a proposed faculty supervisor and submission of a proposal to the school at least one month prior to the start of the term in which the course will be taken. Upon completion of a directed study course, the student must submit a copy of the 'deliverables' to the chair of the undergraduate curriculum committee.

**ENSC 450 – VLSI Systems Design (4)**

An introduction to the design of Very Large Scale Integrated (VLSI) circuits and systems (System-on-Chip, SoC) using mainly CMOS technology. SoC design techniques and applications will be covered. Basic topics will include: CMOS technology and circuit layout rules; combinational and sequential logic; logic simulation; systems design; design for verification and testability; and embedded- processor design and application. An advanced digital design flow based on the VHDL hardware description language will be introduced and exercised in the labs. Prerequisite: ENSC 225 and ENSC 350.

**ENSC 495 – Introduction to Microelectronic Fabrication (4)**

Lectures provide the theory of integrated circuit fabrication. Students fabricate diodes, transistors and test structures in the laboratory. Topics: clean room practice, thermal oxidation and diffusion, photolithography, thin film deposition, etching, ion implantation, packaging, CMOS and bipolar processes. Prerequisite: ENSC 225 or ENSC 226 or MSE 251 or PHYS 365, and permission of the instructor and a minimum of 80 units. Enrolment in this course is by application only.

**MSE 480 – Manufacturing Systems (3)**

An introduction to manufacturing systems: industrial robotics, manufacturing system components and definitions, material handling systems, production lines, assembly systems, robotic cell design, cellular manufacturing, flexible manufacturing systems, quality control, manufacturing support systems. Prerequisite: MSE 310 (or ENSC

387) and a minimum of 80 credits. Students with credit for ENSC 432 may not take MSE 480 for further credit.

**MSE 481 – Industrial Control systems (3)**

Examines modern industrial control systems and applications. Topics include: review of industrial sensors and actuators; computer interfacing; ladder logic and programmable logic controllers; industrial computer and programming methods; industrial networks; human-machine interfaces; supervisory control and data acquisition (SCADA); manufacturing execution systems; and enterprise-wide integration. Prerequisite: MSE 351 (or ENSC 332) and MSE 381 (or ENSC 383) and a minimum of 80 credits. Students with credit for ENSC 484 may not take MSE 481 for further credit.