Engineering Physics Additional Program Notes, Approved Technical Elective List, and Specialization Suggestions

Current as of Thu 2020-07-02 13:30:57

1. Additional Program Notes

There are 3 categories of Technical Electives that are listed in the Approved Technical Electives Section:

a) Courses from Engineering Physics
b) Courses outside of the Faculty of Engineering
c) Engineering courses within the Faculty of Engineering (excluding courses from Engineering Physics).

Please check the Undergraduate Calendar *for the year you entered the program*[+] to determine the number of technical electives you are required to take in each category.*

*For students who entered Level 2 in 2017-2018: maximum allowed List 1 or List 2 units should be interpreted as equivalent minimum required ENGPHYS units, see the tables below. Note: to apply this interpretation as your requirement you should contact your Academic Advisor in the Associate Dean's office to request it.

[+]IBEHS students should also review any updates separately listing temporary effects relevant to their entry year presented in subsequent calendar year.

Students who entered in 2016 and earlier should seek undergrad associate chair permission if course substitutions are necessary.

Stated in the calendar:

Entered Level 2 in...	Program	Total Tech Electives Required	ENGPHYS Electives Required	Science Courses ("List 1 ") Required	Other Department Engineering Courses ("List 2") Required	IBEHS Courses Required**	Calendar Link
2015	Eng Phys		18*	6	6		2015 Calendar
2015	Eng Phys & Mgmt		18*	6	6		2015 Calendar - Mgmt
2015	Eng Phys & Scty		18*	6	6		2015 Calendar - Scty
2016	Eng Phys		18*	6	6		2016 Calendar
2016	Eng Phys & Mgmt		18*	6	6		2016 Calendar - Mgmt
2016	Eng Phys & Scty		18*	6	6		2016 Calendar - Scty
2017	Eng Phys	30		0-8	3-8		2017 Calendar
2017	Eng Phys & Mgmt	30		0-8	3-8		2017 Calendar - Mgmt
2017	Eng Phys & Scty	30		0-8	3-8		2017 Calendar - Scty
2018	Eng Phys	33		0-8	3-8		2018 Calendar
2018	Eng Phys & Mgmt	33		0-8	3-8		2018 Calendar - Mgmt
2018	Eng Phys & Scty	33		0-8	3-8		2018 Calendar - Scty
2018	Eng Phys & IBEHS	21 24		0-8	3-8	10 6+	2018 Calendar - IBEHS except refer to the 2020-2021 calendar for Level 4+
2019	Eng Phys	33	17+		3+		2019 Calendar
2019	Eng Phys & Mgmt	33	17+		3+		2019 Calendar - Mgmt
2019	Eng Phys & Scty	33	17+		3+		2019 Calendar - Scty
2019	Eng Phys & IBEHS	21 24	6+		3+	9+ 6+	2019 Calendar - IBEHS except refer to the 2020-2021 calendar for Level 4+
2020	Eng Phys	36	17+		3+		2020 Calendar
2020	Eng Phys & Mgmt	33	17+		3+		2020 Calendar - Mgmt
2020	Eng Phys & Scty	33	17+		3+		2020 Calendar - Scty
2020	Eng Phys & IBEHS	21	6+		3+	6+	2020 Calendar - IBEHS

Interpret as:

Entered Level 2 in...	Program	Total Tech Electives Required	ENGPHYS Electives Required	Science Courses ("List 1 ") Required	Other Department Engineering Courses ("List 2") Required	IBEHS Tech Elective Required**	Calendar Link
2015	Eng Phys		18*	6	6		2015 Calendar
2015	Eng Phys & Mgmt		18*	6	6		2015 Calendar - Mgmt
2015	Eng Phys & Scty		18*	6	6		2015 Calendar - Scty
2016	Eng Phys		18*	6	6		2016 Calendar
2016	Eng Phys & Mgmt		18*	6	6		2016 Calendar - Mgmt
2016	Eng Phys & Scty		18*	6	6		2016 Calendar - Scty
2017	Eng Phys	30	14+		3+		2017 Calendar
2017	Eng Phys & Mgmt	30	14+		3+		2017 Calendar - Mgmt
2017	Eng Phys & Scty	30	14+		3+		2017 Calendar - Scty
2018	Eng Phys	33	17+		3+		2018 Calendar
2018	Eng Phys & Mgmt	33	17+		3+		2018 Calendar - Mgmt
2018	Eng Phys & Scty	33	17+		3+		2018 Calendar - Scty
2018	Eng Phys & IBEHS	21 24	6+		3+	10 6+	2018 Calendar - IBEHS except refer to the 2020-2021 calendar for Level 4+
2019	Eng Phys	33	17+		3+		2019 Calendar
2019	Eng Phys & Mgmt	33	17+		3+		2019 Calendar - Mgmt
2019	Eng Phys & Scty	33	17+		3+		2019 Calendar - Scty
2019	Eng Phys & IBEHS	21 24	6+		3+	9+ 6+	2019 Calendar - IBEHS except refer to the 2020-2021 calendar for Level 4+
2020	Eng Phys	36	17+		3+		2020 Calendar
2020	Eng Phys & Mgmt	33	17+		3+		2020 Calendar - Mgmt
2020	Eng Phys & Scty	33	17+		3+		2020 Calendar - Scty
2020	Eng Phys & IBEHS	21	6+		3+	6+	2020 Calendar - IBEHS

*from a specific set of courses
**Note that while many courses on the IBEHS tech elective list are also on the lists below, you cannot simultaneously count a course as a tech elective and IBEHS tech elective.

Subject to approval of the Department of Engineering Physics, courses not appearing on these lists may also qualify as acceptable technical electives.

- Note that Engineering Physics does not schedule courses outside of the Department and has no mechanism to ensure they are scheduled conflict-free with Engineering Physics courses.
- Students are responsible for ensuring that they can take the elective course conflict-free or seek permission to take them despite the conflict, using the Course Conflict Form.
- Students are responsible for ensuring that they fulfill the prerequisites for each elective course or that they receive permission from the Department offering each elective course (for courses outside of Engineering Physics).

2. Approved Technical Electives

2.1. Courses from Engineering Physics

Subject to approval of the Engineering Physics Department, students may replace Engineering Physics technical electives with approved Engineering courses.

Code	Title
ENGPHYS 3D03	Principles of Nuclear Engineering
ENGPHYS 3E04	Fundamentals of Physical Optics
ENGPHYS 3ES3	Introduction to Energy Systems
ENGPHYS 3F03	Advanced Applications of Quantum Mechanics
ENGPHYS 3H04 a/B S	Research Project in Engineering Physics
ENGPHYS 3O04	Introduction to Fluid Mechanics and Heat Transfer
ENGPHYS 3PD3	Photonic Devices
ENGPHYS 3PN4	Semiconductor Junction Devices
ENGPHYS 4D03	Nuclear Reactor Physics
ENGPHYS 4H04 a/B S	Research Project in Engineering Physics
ENGPHYS 4I03	Introduction to Biophotonics
ENGPHYS 4MD3	Nanoscale Semiconductor Devices
ENGPHYS 4NE3	Advanced Nuclear Engineering
ENGPHYS 4P03	Nuclear Power Plant Systems and Operation
ENGPHYS 4PP3	Plasma Physics Applications
ENGPHYS 4QC3	Introduction to Quantum Computing
ENGPHYS 4S03	Lasers and Electro-Optics
ENGPHYS 4UB2	Modern and Applied Physics Laboratory – Biomedical
ENGPHYS 4UM2	Modern and Applied Physics Laboratory – Nano- and Micro-devices
ENGPHYS 4UN2	Modern and Applied Physics Laboratory – Photonics
ENGPHYS 4UP2	Modern and Applied Physics Laboratory – Photonics
ENGPHYS 4US2	Modern and Applied Physics Laboratory – Smart Systems
ENGPHYS 4X03	Introduction to Photovoltaics
ENGPHYS 4Z03	Semiconductor Manufacturing Technology

2.2. Courses outside of the Faculty of Engineering (formerly known as "List 1")

Subject to approval of the Engineering Physics Department, courses not appearing on this list may also qualify as acceptable technical electives.

Code	Title
BIOCHEM 2B03	Nucleic Acid Structure and Function
BIOCHEM 2BB3	Protein Structure and Enzyme Function
BIOCHEM 2EE3	Metabolism and Physiological Chemistry
BIOCHEM 3BP3	Practical Bioinformatics in the Genomics Era
BIOCHEM 3D03	Metabolism and Regulation
BIOCHEM 3G03	Proteins and Nucleic Acids
BIOCHEM 3H03	Clinical Biochemistry
BIOCHEM 4E03	Gene Regulation in Stem Cells and Development
BIOCHEM 4H03	Biotechnology and Drug Discovery
BIOCHEM 4J03	Immunological Principles in Practice
BIOCHEM 4M03	Cellular and Integrated Metabolism
BIOCHEM 4N03	Molecular Membrane Biology
BIOCHEM 4Q03	Biochemical Pharmacology
BIOLOGY 1A03	Cellular and Molecular Biology
BIOLOGY 2A03	Integrative Physiology of Animals
BIOLOGY 2b03	Cell Biology
BIOLOGY 2C03	Genetics
BIOLOGY 2EE3	Introduction to Microbiology and Biotechnology
MOLBIO 3B03	Advanced Cell Biology
BIOLOGY 4T03	Neurobiology
BIOLOGY 3P03	Cell Physiology
BIOLOGY 3VV3	Laboratory Methods in Molecular Biology
BIOLOGY 4PP3	Environmental Microbiology and Biotechnology
BIOPHYS 3D03	Origin of Life
BIOPHYS 3G03	Modelling Life
BIOPHYS 3S03	Soft Condensed Matter Physics
BIOPHYS 4S03	Introduction to Molecular Biophysics
CHEM 1AA3	Introductory Chemistry II
CHEM 2OA3	Organic Chemistry I
CHEM 2OB3	Organic Chemistry II
CHEM 2E03	Introductory Organic Chemistry
MATH 2R03	Linear Algebra II
MATH 3A03	Introduction to Real Analysis

Code	Title
MATH 3B03	Geometry
MATH 3C03	Mathematical Physics I
MATH 3CY3	Cryptography
MATH 3D03	Mathematical Physics II
MATH 3DC3	Discrete Dynamical Systems and Chaos
MATH 3GR3	Abstract Algebra
MATH 3H03	Number Theory
MATH 3QC3	Introduction to Quantum Computing
MATH 3TP3	Truth and Provability: Gödel's Incompleteness Theorems
MATH 3U03	Combinatorics
MATH 3V03	Graph Theory
MATH 4A03	Real Analysis II
MATH 4AT3	Topics in Analysis
MATH 4B03	Calculus on Manifolds
MATH 4BT3	Topics in Geometry
MATH 4E03	Galois Theory
MATH 4ET3	Topics in Algebra
MATH 4FM3	Financial Markets and Derivatives
MATH 4FT3	Topics in Differential Equations (Stability and Bifurcations)
MATH 4GR3	Groups and Rings
MATH 4L03	Introduction to Mathematical Logic
MATH 4LT3	Topics in Logic
MATH 4MB3	Mathematical Biology
MATH 4NA3	Numerical Methods for Differential Equations
MATH 4TT3	Topics in Topology
MATH 4W03	Reading in Mathematics
MATH 4WW3	Reading in Mathematics II
MATH 4X03	Complex Analysis II
MEDPHYS 3C03	Operational Health Physics: Laboratory & Communication
MEDPHYS 4B03	Radioactivity and Radiation Interactions
MEDPHYS 4D03	Imaging in Medicine and Biology
MEDPHYS 4F03	Fundamentals of Health Physics
MEDPHYS 4RA3	Radiation and Radioisotope Methodology I
MEDPHYS 4RB3	Radiation and Radioisotope Methodology II
MEDPHYS 4T03	Clinical Applications of Physics in Medicine
MEDPHYS 4U03	Radiation Biology
PHYS 3A03	Relativity
PHYS 3C03	Analytical Mechanics

Code	Title
PHYS 3MM3	Quantum Mechanics I
PHYS 3QI3	Quantum Information
PHYS 4B03	Electromagnetic Theory
PHYS 4E03	Particle and Nuclear Physics
PHYS 4F03	Quantum Mechanics II
PHYS 4G03	Computational Physics
PHYS 4K03	Solid State Physics
PHYS 4Q03	Quantum Field Theory
STATS 2D03	Introduction to Probability
STATS 2MB3	Statistical Methods and Applications
STATS 3A03	Applied Regression Analysis with SAS
STATS 3D03	Mathematical Statistics
STATS 4A03	Time Series
STATS 4C03	Generalized Linear Models
STATS 4CI3	Computational Methods for Inference
STATS 4D03	Intermediate Probability Theory
STATS 4I03	Inference
STATS 4M03	Multivariate Analysis
STATS 4P03	Advanced Applied Statistics

2.3. Engineering Courses within the Faculty of Engineering (excluding courses from Engineering Physics) (formerly known as "List 2").

Subject to approval of the Engineering Physics Department, courses not appearing on this list may also qualify as acceptable technical electives.

Code	Title
CHEMENG 2D04	Chemical Engineering Principles I
CHEMENG 3D03	Chemical Engineering Thermodynamics
CHEMENG 3K04	Introduction to Reactor Design
CHEMENG 3M04	Mass Transfer and Stagewise Operations
CHEMENG 3Q03	Introduction to Polymer Science
CHEMENG 4B03	Polymer Reaction Engineering
CHEMENG 4K03	Reactor Design for Heterogeneous Systems
CHEMENG 4M03	Industrial Separation Processes
CHEMENG 4T03	Applications of Chemical Engineering in Medicine
CHEMENG 4X03	Polymer Processing
CHEMENG 4Z03	Interfacial Engineering
CIVENG 2B04	Principles of Environmental Engineering
CIVENG 2J04	Principles of Geological and Geoenvironmental Engineering
CIVENG 3A03	Geotechnical Engineering I
CIVENG 3B03	Geotechnical Engineering II
CIVENG 3G04	Structural Analysis
CIVENG 3J04	Reinforced Concrete Design
CIVENG 3K03	Introduction to Transportation Engineering
CIVENG 3L03	Water Quality
CIVENG 3M03	Municipal Hydraulics
CIVENG 3P04	Civil Engineering Materials and Design
CIVENG 4A04	Engineering Hydrology
CIVENG 4BP4	Building Science
CIVENG 4ED4	Seismic Design of Structures
CIVENG 4G04	Pavement Materials and Design
CIVENG 4K04	Modern Methods of Structural Analysis
CIVENG 4L04	Design of Water Resources Systems
CIVENG 4N04	Steel Structures
CIVENG 4S04	Foundation Engineering

CIVENG 4SD4	Structural Dynamics and Earthquake Engineering
CIVENG 4T04	Transportation Engineering II - Modelling Transit and ITS
CIVENG 4V04	Biological Aspects of Wastewater Treatment
CIVENG 4W04	Design of Low Rise Buildings
CIVENG 4Y04	Bridges and Other Structural Systems
COMPENG 2SH4	Principles of Programming
COMPENG 2SI4	Data Structures, Algorithms, and Discrete Mathematics
COMPENG 3DQ5	Digital Systems Design
COMPENG 3DR4	Computer Organization
COMPENG 4DK4	Computer Communication Networks
COMPENG 4DM4	Computer Architecture
COMPENG 4DN4	Advanced Internet Communications
COMPENG 4DS4	Embedded Systems
COMPENG 4EK4	Microelectronics
COMPENG 4TL4	Digital Signal Processing
COMPENG 4TN4	Image Processing
COMPSCI 4TI3	Fundamentals of Image Processing
ELECENG 3BA3	Structure of Biological Materials
ELECENG 3BB3	Cellular Bioelectricity
ELECENG 3CL4	Introduction to Control Systems
ELECENG 3FK4	Electromagnetics II
ELECENG 3PI4	Energy Conversion
ELECENG 3TR4	Communication Systems
ELECENG 4BC3	Modelling of Biological Systems
ELECENG 4BD4	Biomedical Instrumentation
ELECENG 4BE4	Medical Robotics
ELECENG 4BF4	Medical Imaging
ELECENG 4CL4	Control System Design
ELECENG 4EM4	Photonic Devices and Systems
ELECENG 4FJ4	Devices and Antennas for Wireless Systems
ELECENG 4PK4	Power Electronics
ELECENG 4PL4	Energy Systems and Management
ELECENG 4PM4	Electrical Power Systems
ELECENG 4TK4	Digital Communications Systems
ELECENG 4TM4	Digital Communications II
ENGINEER 4EX3 A/B	Experiential Engineering Design
MATLS 2D03	Thermodynamics of Alloys and Phase Diagrams
MATLS 2X03	Crystalline Structure of Materials
MATLS 3B03	Materials Production
MATLS 3C03	Applied Thermodynamics

MATLS 3E04	Mass Transfer
MATLS 3F03	High-Temperature Materials Production
MATLS 3M03	Mechanical Behaviour of Materials
MATLS 3Q03	Materials for Electronic Applications
MATLS 3T04	Phase Transformations
MATLS 4B03	Biomechanics and Tissue Engineering
MATLS 4C03	Modern Iron and Steelmaking
MATLS 4D03	Corrosion
MATLS 4FF3	Synthesis, Applications, and Environmental Impact of Nanomaterials
MATLS 4G03	Characterization of Nanomaterials
MATLS 4H03	Thin Film Science and Engineering
MATLS 4I03	Sustainable Manufacturing Processes
MATLS 4NN3	Computational Modelling in Materials Engineering
MATLS 4P03	Properties of Polymeric Materials
MATLS 4Q03	Materials for Sensors in Big Data and AI Systems
MATLS 4T03	Properties and Processing of Composites
MECHENG 2A03	Design Communication
MECHENG 2C04	Mechanical Engineering Design I
MECHENG 2D03	Mechanical Engineering Design Elements
MECHENG 2Q04	Digital Systems and Interfacing
MECHENG 3A03	Engineering Mechanics
MECHENG 3C03	Manufacturing Engineering
MECHENG 3E05	Mechanical Engineering Design II
MECHENG 4BB3	Biomechanics
MECHENG 4C03	Production Systems Engineering
MECHENG 4CC3	Experimental and Computational Biomechanics
MECHENG 4D03	Manufacturing Processes (Metal Removal)
MECHENG 4E03	Microelectromechanical Systems (MEMS)
MECHENG 4H03	Mechatronics
MECHENG 4I03	Noise Analysis and Control
MECHENG 4J03	Introduction to Computational Fluid Mechanics and Heat Transfer
MECHENG 4K03	Robotics
MECHENG 4L03	Industrial Design
MECHENG 4N03	Nanobio Engineering
MECHENG 4O04	Sustainable Energy Systems
MECHENG 4Q03	Mechanical Vibrations
MECHENG 4R03	Control Systems
MECHENG 4S03	Incompressible Flow
MECHENG 4T03	Finite Element Applications
MECHENG 4U03	Compressible Flow and Turbomachinery

MECHENG 4V03	Thermo-Fluids Systems Design and Analysis
MECHENG 4W03	Air Conditioning and Refrigeration Systems
MECHENG 4Y03	Internal Combustion Engines
MECHENG 4Z03	CAD/CAM/CAE
SFWRENG 2AA4	Software Design I - Introduction to Software Development
SFWRENG 2C03	Data Structures and Algorithms
SFWRENG 2DA4	Digital Systems and Interfacing
SFWRENG 2DM3	Mathematics with Applications I
SFWRENG 2FA3	Mathematics and Applications II
SFWRENG 2GA3	Computer Architecture
SFWRENG 2MD3	Data Structures, Algorithms, and Language Concepts for Mechatronics
SFWRENG 2MP3	Programming for Mechatronics
SFWRENG 2S03	Principles of Programming
SFWRENG 2XA3	Software Engineering Practice and Experience: Software Development Skills
SFWRENG 2XB3	Engineering Practice and Experience: Binding Theory to Practice
SFWRENG 3DB3	Databases
SFWRENG 3FP3	Functional Programming
SFWRENG 3GC3	Computer Graphics
SFWRENG 3K04	Software Development
SFWRENG 3O03	Linear Optimization
SFWRENG 3SH3	Operating Systems
SFWRENG 4AA4	Real-Time Systems and Control Applications
SFWRENG 4AD3	Advanced Databases
SFWRENG 4C03	Computer Networks and Security
SFWRENG 4E03	Performance Analysis of Computer Systems
SFWRENG 4F03	Parallel Computing
SFWRENG 4J03	Communications Systems
SFWRENG 4TE3	Continuous Optimization Algorithms
SFWRENG 4TH3	Theory of Computation

3. Specialization Suggestions

As stated in the calendar, several combinations of electives to form "specializations" are suggested, but students are by no means required to select all courses in a specific specialization, nor may it even be possible to do so. With that understood, this document nevertheless attempts to explore what each of the specializations can lead to and how you could arrange your choice of electives to attempt to take all

of them, at least for the 4-year program and suggestions for them may be helpful for the 5-year programs as well.

Students are free to choose technical elective courses according to their own interests (subject to satisfying the elective rules for their particular program listed above), but may also consider the following suggested combinations of technical electives to tailor their degree towards a particular specialization.

- **Nanotech Engineering (Nano- and Micro-Devices):** ENGPHYS 3F03, 3PN4, 4MD3, 4UM2, 4Z03, MATLS 4H03, MECH ENG 4E03
- **Nanotech Engineering (Photonics):** ENGPHYS 3E04, 3F03, 3PD3, 3PN4, 4S03, 4UP2, 4Z03, ELECENG 3FK4 and 4EM4
- **Nanotech Engineering (Solar):** ENGPHYS 3E04, 3ES3, 3F03, 3PN4, 4MD3, 4X03, 4UM3, 4Z03, MATLS 4Q03
- **Nuclear Engineering:** ENGPHYS 3D03, 3ES3, 3O04, 4D03, 4NE3, 4P03, 4PP3, 4UN2
- **Biomedical Engineering:** ENGPHYS 3E04, 3F03, 3PN4, 4I03, 4S03, 4UB2, 4Z03, ELECENG 4BD4, MECHENG 4E03
- **Smart Systems Engineering:** ENGPHYS 3F03, 3PN4, 4US2, SFWRENG 2MP3, 2MD3, MECHENG 4R03, ELECENG 4CL4, and 6-8 units from ELECENG 3FK4, 3TR4, MECHENG 4E03, 4H03
- **Quantum Computing:** ENGPHYS 4QC3, COMPENG 2SH4, 2SI4, MATH 2R03, 3C03, 3D03, 3QC3, PHYSICS 3MM3, 3QI3, 4F03
- **Interdisciplinary Engineering:** ENGPHYS 3D03, 3E04, 3O04, 3ES3, 3F03, 3PN4, 4MD3, 4P03 and 4S03

For students starting in Fall 2019 or later, required courses in the 4-year Eng Phys program by semester are as follows:

Level.Term	Eng Phys
2.1	ENGPHYS 2A04 ENGPHYS 2NE3 ENGPHYS 2P04 MATH 2Z03 3-4 elective
2.2	ENGPHYS 2CM4 ENGPHYS 2E04 ENGPHYS 2QM3 MATH 2ZZ3 3-4 elective
3.1	ENGPHYS 3BA4 ENGPHYS 3L04 ENGPHYS 3NM4 ENGPHYS 3EC4 3-5 elective
3.2	ENGPHYS 3BB4 ENGPHYS 3SM3 ENGPHYS 3W04 ENGINEER 2B03 6-7 elective

4.1	ENGPHYS 4A06/2 ENGINEER 4A03 12-14 elective
4.2	ENGPHYS 4A06/2 15-17 elective
5.1	
5.2	

By default, students will take courses in the years they are assigned and balance course load between terms. This "default" approach gives space for elective units as follows:

Level.Term	Eng Phys
2.1	3-4
2.2	3-4
3.1	3-4
3.2	6-7
4.1	12-14
4.2	15-17

Electives (and even core courses) do not need to be taken in the exact term or year that they are written in the calendar, but students need to keep their course load to 21 units or less per term to avoid a Term Unit Overload, which requires permission (students who take courses out of the order suggested in the calendar will still need to coordinate with their academic advisor). With this in mind, interested & able students may consider taking courses earlier (e.g., extra electives in level 2, summer school complementary studies electives, ENGINEER 2B03 early), because this helps ensure maximum flexibility later for fitting in key electives, dealing with possible schedule conflicts, providing space to repeat a course if something goes wrong, and being more involved in extracurricular clubs, teams, and TAing in upper years.

3.1. Nanotech Engineering (Nano- and Micro-Devices)

Nanotechnology and micro-systems are the technological core of the current computer and communications revolution.
Devices that are constructed on the nanometer or micrometer scale are the technological backbone of modern society. Since the invention of the transistor in 1947 and the introduction of the integrated circuit in the early 1960's, device components have continuously decreased in size and cost at an exponential rate, while increasing in speed and capabilities. The invention of fibre optic communications, essential for the internet, also relies on the development of optoelectronics, which is the study and application of electronic devices that generate, detect and control light. More recently, the fabrication techniques developed for the integrated circuit industry have also been extended to micro-electro-mechanical systems (MEMS) which create tiny moving mechanical parts such as beams, gears, diaphragms, and springs that are used in inkjet-printers, accelerometers, inertial sensors, micro-mirrors, optical scanners, fluid pumps, and sensors. Novel micro-fluidic devices are also being developed

for integration with lab-on-a-chip systems for biomedical and health care applications. The department is also developing nanotechnology to grow integrated circuits and systems directly on a chip.

Students interested in pursuing the nanotech engineering: nano- and micro-devices specialization should complete the following ENGPHYS 4UM2 along with the following 19 technical elective units: ENGPHYS 3F03, 3PN4, 4MD3, 4Z03, MATLS 4H03, MECHENG 4E03.

Course Code	Title	EngPhys, Other Eng, or Science?	Term	Prerequisites	Description
ENGPHYS 3F03	Advanced Applications of Quantum Mechanics	EP	1	ENGPHYS 2QM3	Application of quantum mechanics to the electronic, structural and optical behaviour of solids. Topics will include crystal structures, diffraction, electrical conductivity, band theory, lattice vibrations and semiconductors.
ENGPHYS 3PN4	Semiconductor Junction Devices	EP	2	ENGPHYS 3F03	Electronic properties of semiconductors: non-equilibrium carrier conditions; steady state and non-steady state; p-n junctions; Schottky diodes; bipolar junction transistors. Detailed coverage of a range of diodes including photodiodes, solar cells, light emitting diodes, zener diodes, and avalanche diodes.
ENGPHYS 4MD3	Nanoscale Semiconductor Devices	EP	2	ENGPHYS 3F03	Nanoscale semiconductor devices and associated materials including organic electronics (OLEDs, organic solar cells), quantum well devices (LEDs, high electron mobility transistors), quantum dots, quantum wires, graphene, emerging nanoscale materials and devices.
ENGPHYS 4UM2	Modern and Applied Physics Laboratory – Nano- and Micro-devices	EP	1	ENGPHYS 3PN4, MATLS 3Q03 or ELECENG 3EJ4	Students will learn semiconductor device fabrication by constructing and testing a semiconductor device, such as a photovoltaic solar cell. The ISFET forms the foundation for different classes of electronic biosensors used for health monitoring.

ENGPHYS 4Z03	Semiconductor Manufacturing Technology	EP	1	ENGPHYS 3F03	Detailed description of fabrication technologies used in the semiconductor industry; computer modelling of device fabrication; analysis of device performance.
MATLS 4H03	Thin Film Science and Engineering	OE	1* (irregularly)	Registration in Level III or above of Materials Engineering; or permission of the department	Deposition and fabrication techniques, surfaces, growth mechanisms, epitaxy, kinetic effects in thin films, defects and properties of thin films. Materials for packaging.
MECHENG 4E03	Microelectromechanical Systems (MEMS)	OE	2* irregularly	Level 4+ of Engphys etc.	Introduction, microfabrication and micromachining fundamentals, scaling effects, mechanics and transduction at microscale, actuation and sensing methods - Electrostatic, piezoelectric, thermal, electromagnetic, resonant, tunneling and microfluidic techniques. Capacitative sensors, resonators, lab on chip devices, microfluidic devices, micromirrors, assembly techniques for MEMS, microsystem packaging.

Notes:

1. ENGPHYS 3F03 & 3PN4 both need to be taken by the end of your second last year because 3PN (term 2) requires 3F (term 1), and 4UM2 (term 1) requires 3PN.
2. MATLS 4H03 (first term) and MECHENG 4E03 (second term) are both offered on an irregular basis so should be taken as soon as possible. Schedule at present (subject to change):
    a. MATLS 4H is offered in 2020-2021, 2022-2023, etc.
    b. MECHENG 4E is offered in 2021-2022, 2023-2024, etc.

Sample course ordering:

Level.Term	Must take in this term:	Can take in this term:
2.1		
2.2		
3.1*	ENGPHYS 3F03	MATLS 4H03
3.2	ENGPHYS 3PN4	ENGPHYS 4MD3 MECHENG 4E03
4.1	ENGPHYS 4Z03 ENGPHYS 4UM2	MATLS 4H03
4.2		ENGPHYS 4MD3, MECHENG 4E03

Note that term 1 of level 3 only has space for 1 elective course. While not ideal, if you absolutely need to fit two elective courses in, you can delay taking ENGPHYS 3EC4.

3.2. Nanotech Engineering (Photonics)

From manufacturing to medicine, the applications of light are everywhere. Photons are the quantum mechanical unit of light. They play a central role in many technologies. In the past two decades, photonics engineering experienced explosive growth in fibre optic communications, where light is used to transfer information over great distances. This formed the basis of the internet. The application of light also extends to many other industries such as medicine, displays, and sensors.

Photonics is also beginning to play a bigger role in clean, renewable electrical energy generation through solar and thermal photovoltaics (solar electricity). Our research encompasses a wide spectrum of projects involving light sources, lasers and light emitting diodes, photodetectors, sensors, photovoltaics, and optical displays. We are also conducting research in biophotonics, a fast emerging field in which light is used for applications in medicine, biomedical engineering, life sciences, agriculture, and environmental science.

To complete the photonics specialization, students should complete the following courses: ENGPHYS 3E04, 3F03, 3PD3, 3PN4, 4S03, 4UP2, 4Z03, ELECENG 3FK4 and 4EM4
Course information is as follows:

Course Code	Title	Term	Prerequisites	Description
ENGPHYS 3E04	Fundamentals of Physical Optics	1	MATH 2Z and ENGPHYS 2A	Geometrical optics, electromagnetic waves, interference of light, Fraunhofer and Fresnel diffraction, polarized light, Fresnel equations, optical properties of materials, introduction to optical systems and precision optics experiments, selected topics in modern optics.
ENGPHYS 3F03	Principles of Solid-state Materials and Devices	1	ENGPHYS 2QM3	Application of quantum mechanics to the electronic, structural and optical behaviour of solids. Topics will include crystal structures, diffraction, electrical conductivity, band theory, lattice vibrations and semiconductors.
ENGPHYS 3PD3	Photonic Devices	2	ENGPHYS 3E04	This course covers the theory, design and operation of photonic devices, with an emphasis on their application in integrated and fiber optical systems for communications.
ENGPHYS 3PN4	Semiconductor Junction Devices	2	ENGPHYS 3F03	Electronic properties of semiconductors: non-equilibrium carrier conditions; steady state and non-steady state; p-n junctions;

				Schottky diodes; bipolar junction transistors. Detailed coverage of a range of diodes including photodiodes, solar cells, light emitting diodes, zener diodes, and avalanche diodes.
ENGPHYS 4S03	Lasers and Electro-Optics	1	ENGPHYS 3E04	Basic principles and applications of lasers, nonlinear optics (materials and devices), and optical modulation.
ENGPHYS 4UP2	Modern and Applied Physics Laboratory: Photonics	2	ENGPHYS 3E04	The course will explore the design, fabrication and characterization of integrated photonic devices such as waveguides, couplers, modulators and detectors. Students will study the operation of such devices in photonic integrated circuits for applications including high-speed communications.
ENGPHYS 4Z03	Semiconductor Manufacturing Technology	1	ENGPHYS 3F03	Detailed description of fabrication technologies used in the semiconductor industry; computer modelling of device fabrication; analysis of device performance.
ELECENG 3FK4	Electromagnetics 2	1	ENGPHYS 2A04	Time-varying fields, uniform plane waves, reflection and transmission, dispersion, transmission lines and impedance matching, waveguides, elements of theory of radiation and antennas.
ELECENG 4EM4	Photonic Devices and Systems	2	ENGPHYS 3BA4 & 3BB4	Fundamentals of light. Optical fibres and their propagation characteristics. Lasers and photo-diodes. Optical amplifiers and modulators. Photonic networks.

Sample course ordering:

Level.Term	Must take in this term:	Can take in this term:
2.1		
2.2		
3.1*	ENGPHYS 3E04 ENGPHYS 3F03	
3.2		ENGPHYS 3PD3 ENGPHYS 3PN4 ENGPHYS 4UP2
4.1	ENGPHYS 4S03 ENGPHYS 4Z03 ELECENG 3FK4	
4.2	ELECENG 4EM4	ENGPHYS 3PD3 ENGPHYS 3PN4

		ENGPHYS 4UP2

*to take both 3E and 3F in term 1 of level 3, you'll need to push a required course to level 4; of the required courses, 3BA, 3L, and 3NM are not good options for moving since they're (actual or effective) prereqs for 3BB, 3W, and 4A.

3.3. Nanotech Engineering (Solar)

This program focuses on understanding how solar cells function and how to make them, to equip you to use and make further improvements to this exciting continuously-improving technology.
Courses suggested: Nanotech Engineering (Solar): ENGPHYS 3E04, 3ES3, 3F03, 3PN4, 4MD3, 4X03, 4UM2, 4Z03, MATLS 4Q03

Course Code	Title	EngPhys, Other Eng, or Science?	Term	Prerequisites	Description
ENGPHYS 3E04	Fundamentals of Physical Optics	EP	1	MATH 2Z and ENGPHYS 2A	Geometrical optics, electromagnetic waves, interference of light, Fraunhofer and Fresnel diffraction, polarized light, Fresnel equations, optical properties of materials, introduction to optical systems and precision optics experiments, selected topics in modern optics.
ENGPHYS 3ES3	Introduction to Energy Systems	EP	1	Level 2+ of any Eng	A survey course on energy systems with emphasis on the analytic tools needed to evaluate them in terms of performance, resources and environmental sustainability, costs, and other relevant factors over their life cycles.
ENGPHYS 3F03	Advanced Applications of Quantum Mechanics	EP	1	ENGPHYS 2QM3	Application of quantum mechanics to the electronic, structural and optical behaviour of solids. Topics will include crystal structures, diffraction, electrical conductivity, band theory, lattice vibrations and semiconductors.

ENGPHYS 3PN4	Semiconductor Junction Devices	EP	2	ENGPHYS 3F03	Electronic properties of semiconductors: non-equilibrium carrier conditions; steady state and non-steady state; p-n junctions; Schottky diodes; bipolar junction transistors. Detailed coverage of a range of diodes including photodiodes, solar cells, light emitting diodes, zener diodes, and avalanche diodes.
ENGPHYS 4MD3	Nanoscale Semiconductor Devices	EP	2	ENGPHYS 3F03	Nanoscale semiconductor devices and associated materials including organic electronics (OLEDs, organic solar cells), quantum well devices (LEDs, high electron mobility transistors), quantum dots, quantum wires, graphene, emerging nanoscale materials and devices.
ENGPHYS 4UM2	Modern and Applied Physics Laboratory – Nano- and Micro-devices	EP	1	ENGPHYS 3PN4, MATLS 3Q03 or ELECENG 3EJ4	Students will learn semiconductor device fabrication by constructing and testing a semiconductor device, such as a photovoltaic solar cell. The ISFET forms the foundation for different classes of electronic biosensors used for health monitoring.
ENGPHYS 4X03	Introduction to Photovoltaics	EP	1	ELECENG 2EI5, MATLS 3Q03 or ENGPHYS 3BA3	A review of photovoltaic devices including solar cell operation, characterization, manufacturing, economics and current and next generation technologies.
ENGPHYS 4Z03	Semiconductor Manufacturing Technology	EP	1	ENGPHYS 3F03	Detailed description of fabrication technologies used in the semiconductor industry; computer modelling of device fabrication; analysis of device performance.
MATLS 4Q03	Materials for Sensors in Big Data and AI Systems	OE	*irregular term & year	MATLS 2Q03 or 2Q04 or ENGPHYS 3PN4	Sensors and sensing materials for big data and artificial intelligence systems. Discussion of the theory, design and fabrication of

					chemical, thermal, electrical, magnetic and optical sensors.

As with the photonics program, this requires taking 3E and 3F, but does not require any course which has 3E as a prereq, so 3E can be safely delayed for level 4. 3F must be taken in term 1 of the penultimate year because of the chain 3F → 3PN → 4UM2, and the chain 3F → 4MD.

3.4. Nuclear Engineering

The sun and stars are powered by nuclear fusion, a process whereby lighter elements are combined to form heavier ones, releasing energy. On earth, nuclear processes are controlled in reactors where nuclear energy is released and converted to electricity for human use. In nuclear engineering, we apply scientific principles, engineering design and analysis, and computer modeling and simulation for the peaceful use of nuclear energy. Situated on campus is the university's very own nuclear research reactor, with a long and proud tradition, providing many exciting and unique research opportunities in the areas of reactor physics, nuclear safety analysis, advanced nuclear materials, and nuclear fuel and waste management.

We also conduct extensive research in photovoltaics (solar electricity) in which semiconductor devices are used to convert sunlight directly into electricity. The efficiency by which sunlight can be converted to electricity is approaching 50%, but only by using expensive materials and processes. We are exploring alternative methods of producing high efficiency and low cost solar electricity using nanotechnology and micro-systems engineering.

The Nuclear Engineering specialization recommends the following courses within Engineering Physics: ENGPHYS 3D03, 3ES3, 3O04, 4D03, 4NE3, 4P03, 4PP3, 4UN2

Course Code	Title	EngPhys, Other Eng, or Science?	Term	Prerequisites	Description
ENGPHYS 3D03	Principles of Nuclear Engineering	EP	2	Level 2+ of any Eng	Introduction to fission and fusion energy systems. Energetics of nuclear reactions, interactions of radiation with matter, radioactivity, design and operating principles of fission and fusion reactors.

ENGPHYS 3ES3	Introduction to Energy Systems	EP	1	Level 2+ of any Eng	A survey course on energy systems with emphasis on the analytic tools needed to evaluate them in terms of performance, resources and environmental sustainability, costs, and other relevant factors over their life cycles.
ENGPHYS 3O04	Introduction to Fluid Mechanics and Heat Transfer	EP	2	Math 2Z & Credit or Reg in Math 2ZZ	Fluid properties and statics are introduced. Basic equations of continuity, energy and momentum for internal and external flows are discussed. Similitude, dimensional analysis, measuring devices, fluid machinery and hydraulic networks. Conduction and convection heat transfer.
ENGPHYS 4D03	Nuclear Reactor Physics	EP	1	ENGPHYS 3D03	Introduction to nuclear fission and the physics of nuclear reactors; reactor statics for homogeneous reactors; reactor kinetics for simple time-dependent situations; effects of saturating fission products (Xe-135); reactivity coefficients
ENGPHYS 4NE3	Advanced Nuclear Engineering	EP	2	ENGPHYS 3D03	Energy generation and conversion, heat transfer and transport in a nuclear reactor. Characteristics and performance of nuclear fuels. Thermal margins and safety limits. Aging of core structural materials. Structural integrity of components.
ENGPHYS 4P03	Nuclear Power Plant Systems and Operation	EP	2	Level 4+ of any Eng Program (EP 4D is recommended)	Systems and overall unit operations relevant to nuclear power plants; includes all major reactor and process systems; self-study using interactive nuclear power plant.

ENGPHYS 4PP3	Plasma Physics Applications	EP	1	ENGPHYS 2A04, or PHYSICS 2B03 and 2BB3, or ELECENG 2FH3	An introduction to plasma physics with emphasis on occurrence of plasmas in nature, and applications of plasmas in thermonuclear fusion and other engineering disciplines.
ENGPHYS 4UN2	Modern and Applied Physics Laboratory: Nuclear Labs	EP	offered twice per year; once per term	ENGPHYS 3D03	Students perform a choice of labs involving the McMaster Nuclear Reactor. The learning outcome is an experience with an actual nuclear reactor and an understanding of the nuclear physics processes underlying its operation and its applications (neutron radiography).

Interested students may also consider enhancing their specialization's focus on fluid mechanics & heat transfer using the following courses:

Course Code	Title	EngPhys, Other Eng, or Science?	Term	Prerequisites	Description
MECHENG 4O04	Sustainable Energy Systems	OE	2	ENGPHYS 2NE & 3O04	Assessment of current and future energy systems, covering resources, extraction, conversion with emphasis on meeting regional and global energy needs in a sustainable manner. Different renewable and conventional energy technologies and their attributes. Evaluation and analysis of energy technology systems in the context of political, social, economic and environmental goals.
MECHENG 4S03	Incompressible Flow	OE	1	ENGPHYS 3O	Introduction to internal and external laminar and turbulent incompressible flows. Topics include turbulent boundary layers, aerodynamics and convective heat transfer.

MECHENG 4U03	Compressible Flow and Turbomachinery	OE	1	ENGPHYS 2NE & 3O04	Compressible flows: Fanno and Rayleigh flows, normal and oblique shocks. Turbomachines: axial flow gas and wind turbines, axial flow compressors and fans.
MECHENG 4V03	Thermo-Fluids Systems Design and Analysis	OE	1	MECHENG 2W04, 3O04, 3R03	Design, operation and application characteristics of equipment commonly used in thermal systems. Modelling performance characteristics of piping systems, pumps, compressors, fans, heat exchangers, boilers and cooling towers. System simulation and optimization. Selection criteria of thermal equipment. Design optimization and system performance evaluation.
MECHENG 4W03	Air Conditioning and Refrigeration Systems	OE	1	ENGPHYS 2NE & Reg in level 4+ of EP	Re-examination of laws of thermodynamics, multicomponent vapour systems, psychrometry, air conditioning, mechanical vapour compression refrigeration, absorption refrigeration, heating and cooling load calculations, air quality and human thermal comfort.

3.5. Biomedical Engineering

Our department specializes in biophotonics and biosensors. The term biophotonics denotes a combination of biology and photonics. Photonics is the science and technology of the generation, manipulation, and detection of photons, which are the quantum units of light. Biophotonics is the development and application of optical techniques, particularly imaging, to the study of biological molecules, cells and tissue. One of the main benefits of using optical techniques is that they preserve the integrity of the biological cells being examined. Biophotonics has therefore become the established general term for all techniques that deal with the interaction between biological items and photons. This refers to emission, detection, absorption, reflection, modification, and creation of radiation from biomolecules, cells, tissues, organisms and biomaterials. Our faculty are also involved in the development and application of micro- and nano-sensors for the detection of DNA, proteins, viruses, and other biological materials.

Interested students should consider a combination of the following courses: ENGPHYS 3E04, 3F03, 3PN4, 4I03, 4S03, 4UB2, 4Z03, ELECENG 4BD4, MECHENG 4E03, 4N03

Course Code	Title	EngPhys, Other Eng, or Science ?	Term	Prerequisites	Description
ENGPHYS 3E04	Fundamentals of Physical Optics	EP	1	MATH 2Z and ENGPHYS 2A	Geometrical optics, electromagnetic waves, interference of light, Fraunhofer and Fresnel diffraction, polarized light, Fresnel equations, optical properties of materials, introduction to optical systems and precision optics experiments, selected topics in modern optics.
ENGPHYS 3F03	Advanced Applications of Quantum Mechanics	EP	1	ENGPHYS 2QM3	Application of quantum mechanics to the electronic, structural and optical behaviour of solids. Topics will include crystal structures, diffraction, electrical conductivity, band theory, lattice vibrations and semiconductors.
ENGPHYS 3PN4	Semiconductor Junction Devices	EP	2	ENGPHYS 3F03	Electronic properties of semiconductors: non-equilibrium carrier conditions; steady state and non-steady state; p-n junctions; Schottky diodes; bipolar junction transistors. Detailed coverage of a range of diodes including photodiodes, solar cells, light emitting diodes, zener diodes, and avalanche diodes.
ENGPHYS 4I03	Introduction to Biophotonics	EP	2	Level 3+ of any Eng, Sci, HS, or IBEHS program	This course covers the basic principles of light interaction with biological systems and specific biomedical applications of photonics such as optical light microscopy, endoscopic imaging, spectroscopy in clinical diagnosis, flow cytometry, micro-optical sensors, etc.
ENGPHYS 4S03	Lasers and Electro-Optics	EP	1	ENGPHYS 3E04	Basic principles and applications of lasers, nonlinear optics (materials and devices), and optical modulation.
ENGPHYS 4UB2	Modern and Applied Physics Laboratory – Biomedical	EP	2	one of ENGPHYS 3PN4, MATLS 3Q03 or ELECENG	Students will complete the fabrication and testing of a working MOSFET/ISFET using semiconductor fabrication methods.

				3EJ4, and registration in one of the Faculty of Engineering or the Integrated Biomedical Engineering & Health Sciences (IBEHS) program.	
ENGPHYS 4Z03	Semiconductor Manufacturing Technology	EP	1	ENGPHYS 3F03	Detailed description of fabrication technologies used in the semiconductor industry; computer modelling of device fabrication; analysis of device performance.
MECHENG 4E03	Microelectromechanical Systems (MEMS)	OE	2* irregularly	Level 4+ of Engphys etc.	Introduction, microfabrication and micromachining fundamentals, scaling effects, mechanics and transduction at microscale, actuation and sensing methods - Electrostatic, piezoelectric, thermal, electromagnetic, resonant, tunneling and microfluidic techniques. Capacitative sensors, resonators, lab on chip devices, microfluidic devices, micromirrors, assembly techniques for MEMS, microsystem packaging.
MECHENG 4N03	Nanobio Engineering	OE	1	Reg in level 4+ or any Eng or IBEHS	Introduction to nanotechnology, nanomaterials, nanotechnology in living systems, nanotechnology in biomedical devices, nanobiomaterials, characterization of biomaterials, nano-coatings, nano-biofunctional interfaces, biosensing and diagnostics, organs-on-chips.

3.6. Smart Systems Engineering

Smart systems integrate various sensors and actuators to analyze and control a process. Smart systems cover a wide range of technologies, ranging from nano- and micro-device engineering to nuclear power systems to health care devices. Nuclear power reactors, such as McMaster's nuclear reactor, employ smart systems that measure and provide feedback for proper control of the reactor. In Engineering Physics, we are developing a "Smart Home" that seeks to integrate various home sensors to provide safer living for elderly persons. Engineering Physicists are seeking to integrate various electronic devices, making them faster and cheaper, but also giving them new functionalities.

Nano- and micro-device engineering seeks to miniaturize and integrate electronic components to make unique digital devices. This has enabled computer processor speeds to increase from a few MHz decades ago to several GHz today, and to shrink cell phones from the size of bricks to practical hand-held devices. These are just two examples of how nano- and micro-device engineering has revolutionized the world and will continue to do so. Engineering Physicists are involved in the design and fabrication of next generation devices in this exciting and fast-paced field. Smart systems seek to integrate diverse electronic and optoelectronic devices, such as electronic circuits, photodetectors, sensors, light modulators, and lasers into a single integrated system.

Micro-electro-mechanical systems, known as MEMS, are tiny moving machines usually made from the element silicon. MEMS can include tiny vibrating structures that may be used to generate and detect electromagnetic waves, used to produce radio frequency identification tags for tracking packages or parts in a manufacturing line. Engineering Physicists are developing MEMS devices as sensitive detectors used in medicine and biology (e.g., to detect viruses). MEMS devices can be used to create tiny fluid pumps to mix small volumes of chemicals. This could be used in the pharmaceutical industry in drug testing, or by a physician to test for diseases. MEMS are used to move tiny mirrors used in digital micro-mirror devices (DMD) such as projection displays. Finally, MEMS are used in optical communications to produce tiny moving mirrors that control where light goes. Smart systems seek to integrate these diverse functions into a single chip for sensing and actuating.

Mechatronics refers to the control and feedback mechanisms used in manufacturing processes. For example, in the manufacture of a substance, you might want to measure the pressure in a reaction chamber and use that pressure to open or close a valve to keep the pressure constant. Mechatronics involves instrumentation, data acquisition and processing, actuators, motors and motion controllers, electronics, robotics, etc. – basically, anything that can be used to measure and control a process. Smart systems seek to cost effectively integrate these diverse functions into a single system. Companies hiring product or process engineers will be interested in Engineering Physicists with some knowledge in mechatronics. If you've read this far, you'll realize that Engineering Physicists design and fabricate components and systems used in mechatronics such as MEMS and electronic devices. In Engineering Physics at McMaster, you will be involved in a number of hands-on mechatronics projects such as our 4A06 Project that will prepare you for this important field.

This stream suggests the following set of elective courses:
ENGPHYS 3F03, 3PN4, 4US2, SFWRENG 2MP3, 2MD3, MECHENG 4R03, ELECENG 4CL4, and 6-8 units from ELECENG 3FK4, 3TR4, MECHENG 4E03, 4H03

Priority & logic is as follows:

1. Enhanced Core Programming:
    a. COMPENG 2SH4 or SFWRENG 2MP3, then
    b. COMPENG 2SI4 or SFWRENG 2MD3

2. Enhanced Control Systems:
    a. ELECENG 3CL4 or MECHENG 4R03 or MECHTRON 3DX4 or SFWRENG 3DX4, then
    b. ELECENG 4CL4
3. Smart-systems Design Project:
    a. ENGPHYS 4US2 (ideally take after 3BB4 is completed)
4. Nanotech & Sensors Information:
    a. ENGPHYS 3F03 then
    b. ENGPHYS 3PN4
5. Options:
    a. RF Communications Info (for embedding communications in system-on-a-chip): ELECENG 3FK4 & 3TR4
    b. MEMS for understanding microfabrication & microsystems in general: MECHENG 4E03
    c. Mechatronics for understanding sensors & actuators in general: MECHENG 4H03

Course Code	Title	EngPhys, Other Eng, or Science?	Term	Prerequisites	Description
COMPENG 2SH4	Principles of Programming	OE	1	ENGINEER 1D04 and registration in a program in Electrical and Computer Engineering or the Integrated Biomedical Engineering and Health Sciences (IBEHS) program	Fundamental concepts of programming languages: data types, assignment, control constructs, basic data structures, iteration, recursion, exceptions; imperative and object-orientated paradigms; composing and testing small programs.
COMPENG 2SI4	Data Structures, Algorithms, and Discrete Mathematics	OE	2	ENGINEER 1D04, COMPENG 2SH4	Data abstraction; algorithm analysis; recursion; lists; stacks; queues; trees; searching; hashing; sorting; sets; relations; functions; modular arithmetic; graph theory and algorithms.
ELECENG 3CL4	Introduction to Control Systems	OE	2	ELECENG 3TP3	Modelling of control systems in the continuous-time domain; state space representations; model linearization; performance of control systems in time and frequency; stability; control design.
ELECENG 3FK4	Electromagn etics 2	OE	1	ENGPHYS 2A04	Time-varying fields, uniform plane waves, reflection and transmission, dispersion,

					transmission lines and impedance matching, waveguides, elements of theory of radiation and antennas.
ELECENG 3TR4	Communication Systems	OE	2	ELECENG 3TP3; One of ELECENG 3TQ4, 3TQ3 or STATS 3Y03; or ENGPHYS 3W04	Review of continuous-time signals and systems; amplitude modulation, phase and frequency modulation schemes; digital modulation; stochastic processes; noise performance.
ELECENG 4CL4	Control System Design	OE	1	ELECENG 3CL4	Design of linear control systems using classical and state-space techniques; performance limitation; sampled-data control; nonlinear systems; multi-input multi-output control systems.
ENGPHYS 3F03	Advanced Applications of Quantum Mechanics	EP	1	ENGPHYS 2QM3	Application of quantum mechanics to the electronic, structural and optical behaviour of solids. Topics will include crystal structures, diffraction, electrical conductivity, band theory, lattice vibrations and semiconductors.
ENGPHYS 3PN4	Semiconductor Junction Devices	EP	2	ENGPHYS 3F03	Electronic properties of semiconductors: non-equilibrium carrier conditions; steady state and non-steady state; p-n junctions; Schottky diodes; bipolar junction transistors. Detailed coverage of a range of diodes including photodiodes, solar cells, light emitting diodes, zener diodes, and avalanche diodes.

ENGPHYS 4US2	Modern and Applied Physics Laboratory: Smart Systems	EP	1	ENGPHYS 2E04	The course will explore the design, assembly and test of smart systems based on software, computer, electronic, and photonic components. Students will study the operation of such systems to address real-world problems.
MECHENG 4E03	Microelectro mechanical Systems (MEMS)	OE	2* irregul arly	Level 4+ of Engphys etc.	Introduction, microfabrication and micromachining fundamentals, scaling effects, mechanics and transduction at microscale, actuation and sensing methods - Electrostatic, piezoelectric, thermal, electromagnetic, resonant, tunneling and microfluidic techniques. Capacitative sensors, resonators, lab on chip devices, microfluidic devices, micromirrors, assembly techniques for MEMS, microsystem packaging.
MECHENG 4H03	Mechatronics	OE	2	MECHENG 4R03, MECHTRON 3DX4, ELECENG 3CL4 or SFWRENG 3DX4 and registration in any Mechanical Engineering, Mechatronics Engineering or Electrical Engineering program	Integration of mechanical engineering with electronics and computer control. Sensors, actuators (including pneumatic and hydraulic), modelling using building block and state space methods, model-based control, programming of PLCs with practical demonstrations.
MECHENG 4R03	Control Systems	OE	2	Level 3+ of mecheng or 4+ of mecheng&	Fundamentals of linear, continuous control systems. Control system performance in both time and frequency domains. Design and analysis of controllers.

MECHTRON 3DX4	Dynamic Models and Control of Physical Systems	OE	2	SFWRENG 3MX3	Modelling of control systems in the continuous-time domain; state space representations; model linearization; performance of control systems in time and frequency; stability; control design.
SFWRENG 2MD3	Data Structures, Algorithms, and Language Concepts for Mechatronics	OE	2	SFWRENG 2MP & reg in mechatronics	Advanced programming with emphasis on embedded systems. Program specifications: Pre- and post-conditions, loop and datatype invariants; use of tools to demonstrate correctness. Selecting data structures for implementation of mathematical abstractions. Finite state machines, automata and languages; lexing and parsing. Algorithm analysis (time and space). Modelling of graphs, relations, corresponding algorithms.
SFWRENG 2MP3	Programming for Mechatronics	OE	1	ENG 1D04 or 1P13 or IBEHS 1P10 & Reg in Mechatronics	This course focuses on learning programming using the high-level systems programming language C, and on understanding how its features are implemented using the CPU and the memory hierarchy. Mathematical abstractions are implemented using fundamental data structures such as arrays, stacks, queues, etc., with static and dynamic memory allocation.
SFWRENG 3DX4	Dynamic Models and Control of Physical Systems	OE	2	SFWRENG 3MX3	Modelling of control systems in the continuous-time domain; state space representations; model linearization; performance

					of control systems in time and frequency; stability; control design.

3.7. Quantum Computing

Quantum computing is an emerging discipline that has the potential to revolutionize computing power, and potentially create a system that invents things better than we can.
Students interested in pursuing this exciting emerging discipline will benefit from a more solid foundation in mathematics, quantum mechanics, and programming, so should consider the following courses:

1. Enhanced Core Programming:
    a. COMPENG 2SH4 or SFWRENG 2MP3, then
    b. COMPENG 2SI4 or SFWRENG 2MD3
2. Necessary mathematics:
    a. MATH 2R03, 3C03, and 3D03
3. Quantum Physics:
    a. PHYSICS 3MM3 and 4F03
4. Quantum Computing:
    a. ENGPHYS 4QC3
    b. PHYSICS 3QI3
    c. MATH 3QC3

Course Code	Title	EngPhys, Other Eng, or Science?	Term	Prerequisites	Description
COMPENG 2SH4	Principles of Programming	OE	1	ENGINEER 1D04 and registration in a program in Electrical and Computer Engineering or the Integrated Biomedical Engineering and Health Sciences (IBEHS) program	Fundamental concepts of programming languages: data types, assignment, control constructs, basic data structures, iteration, recursion, exceptions; imperative and object-orientated paradigms; composing and testing small programs.
COMPENG 2SI4	Data Structures, Algorithms, and Discrete Mathematics	OE	2	ENGINEER 1D04, COMPENG 2SH4	Data abstraction; algorithm analysis; recursion; lists; stacks; queues; trees; searching; hashing; sorting; sets;

					relations; functions; modular arithmetic; graph theory and algorithms.
ENGPHYS 4QC3	Introduction to Quantum Computing	EP	2* (Not in 2020-2021)	ENGPHYS 2QM3 or PHYSICS 2C03	An introduction to quantum computing including qubits, entanglement, quantum key cryptography, teleportation, quantum circuits and algorithms, spin qubits.
MATH 2R03	Linear Algebra II	S	2 or summer	1ZC or equiv	Abstract vector spaces. Linear transformations. Inner product spaces. Spectral theorems. Orthogonal bases, other topics.
MATH 3C03	Mathematical Physics I	S	1	2Z & 2ZZ or equivs	Eigenvalue problems, Fourier transforms, special functions, spherical harmonics, partial differential equations, boundary value problems.
MATH 3D03	Mathematical Physics II	S	2	MATH 3C03	Functions of a complex variable, contour integrals, probability and statistics.
MATH 3QC3	Introduction to Quantum Computing	S	2	One of MATH 2A03, 2X03 or ISCI 2A18 A/B; and MATH 2R03	Postulates of quantum mechanics for finite dimensional systems; information on quantum bits, logical operations and quantum gates; quantum parallelism and complexity theory; examples of quantum algorithms. This course includes a scientific communication component.
PHYSICS 3MM3	Quantum Mechanics I	S	1	EP 2QM & Credit or Reg in Math 3C	Quantum physics in 1D and 3D systems, with applications including the hydrogen atom.

PHYSICS 3QI3	Quantum Information	S	2	Math 1ZB & 1ZC or equivs	An introduction to basic notions of quantum information and information processing. Topics may include the Einstein-Podolsky-Rosen (EPR) paradox, Bells inequalities, the measurement problem, quantum entanglement, quantum teleportation, quantum cryptography, and quantum computing.
PHYSICS 4F03	Quantum Mechanics II	S	2	PHYSICS 3MM & credit or reg in MATH 3D	Advanced quantum mechanics with applications such as scattering, perturbation theory and the variational method.
SFWRENG 2MD3	Data Structures, Algorithms, and Language Concepts for Mechatronics	OE	2	SFWRENG 2MP & reg in mechatronics	Advanced programming with emphasis on embedded systems. Program specifications: Pre- and post-conditions, loop and datatype invariants; use of tools to demonstrate correctness. Selecting data structures for implementation of mathematical abstractions. Finite state machines, automata and languages; lexing and parsing. Algorithm analysis (time and space). Modelling of graphs, relations, corresponding algorithms.
SFWRENG 2MP3	Programming for Mechatronics	OE	1	ENG 1D04 or 1P13 or IBEHS 1P10 & Reg in Mechatronics	This course focuses on learning programming using the high-level systems programming language C, and on understanding how its features are implemented using the CPU and the memory hierarchy.

					Mathematical abstractions are implemented using fundamental data structures such as arrays, stacks, queues, etc., with static and dynamic memory allocation.

3.8. Interdisciplinary Engineering Physics

Interdisciplinary area where new and advanced materials, devices and systems are engineered based on a fundamental understanding of physics.

Our faculty and students push the envelope of new technologies. Research in the Engineering Physics Department emphasizes new engineering disciplines that have emerged in recent years. In these high technology areas the link between basic science and engineering application is particularly important. Research activities stress the fundamental physics that relates to the new technologies, as well as its application to practical engineering problems.

Through strong ties to industry, government, and other centres of excellence, our researchers work with others around the world to create knowledge and find engineering solutions to many of society's problems and challenges.

The following suggested list of courses from Eng Phys ensures a broad and deep understanding of the high tech physics applications that Eng Phys grads are known for (but is certainly not the only way to build an interdisciplinary program of study!): ENGPHYS 3D03, 3E04, 3O04, 3ES3, 3F03, 3PN4, 4MD3, 4P03 and 4S03

Course Code	Title	EngPhys, Other Eng, or Science?	Term	Prerequisites	Description
ENGPHYS 3D03	Principles of Nuclear Engineering	EP	2	Level 2+ of any Eng	Introduction to fission and fusion energy systems. Energetics of nuclear reactions, interactions of radiation with matter, radioactivity, design and operating principles of fission and fusion reactors.
ENGPHYS 3ES3	Introduction to Energy Systems	EP	1	Level 2+ of any Eng	A survey course on energy systems with emphasis on the analytic tools needed to evaluate them in terms of performance, resources and

					environmental sustainability, costs, and other relevant factors over their life cycles.
ENGPHYS 3O04	Introduction to Fluid Mechanics and Heat Transfer	EP	2	Math 2Z & Credit or Reg in Math 2ZZ	Fluid properties and statics are introduced. Basic equations of continuity, energy and momentum for internal and external flows are discussed. Similitude, dimensional analysis, measuring devices, fluid machinery and hydraulic networks. Conduction and convection heat transfer.
ENGPHYS 4P03	Nuclear Power Plant Systems and Operation	EP	2	Level 4+ of any Eng Program (EP 4D is recommended)	Systems and overall unit operations relevant to nuclear power plants; includes all major reactor and process systems; self-study using interactive nuclear power plant.
ENGPHYS 3E04	Fundamentals of Physical Optics	EP	1	MATH 2Z and ENGPHYS 2A	Geometrical optics, electromagnetic waves, interference of light, Fraunhofer and Fresnel diffraction, polarized light, Fresnel equations, optical properties of materials, introduction to optical systems and precision optics experiments, selected topics in modern optics.
ENGPHYS 3F03	Advanced Applications of Quantum Mechanics	EP	1	ENGPHYS 2QM3	Application of quantum mechanics to the electronic, structural and optical behaviour of solids. Topics will include crystal structures, diffraction, electrical conductivity, band theory, lattice vibrations and semiconductors.
ENGPHYS 3PN4	Semiconductor Junction Devices	EP	2	ENGPHYS 3F03	Electronic properties of semiconductors: non-equilibrium carrier conditions; steady state and non-steady

					state; p-n junctions; Schottky diodes; bipolar junction transistors. Detailed coverage of a range of diodes including photodiodes, solar cells, light emitting diodes, zener diodes, and avalanche diodes.
ENGPHYS 4MD3	Nanoscale Semiconductor Devices	EP	2	ENGPHYS 3F03	Nanoscale semiconductor devices and associated materials including organic electronics (OLEDs, organic solar cells), quantum well devices (LEDs, high electron mobility transistors), quantum dots, quantum wires, graphene, emerging nanoscale materials and devices.
ENGPHYS 4S03	Lasers and Electro-Optics	EP	1	ENGPHYS 3E04	Basic principles and applications of lasers, nonlinear optics (materials and devices), and optical modulation.