Electrical and Computer Engineering

This section presents the requirements for programs in:

- **M.A.Sc. Electrical and Computer Engineering**
- **M.Eng. Electrical and Computer Engineering**
- **M.A.Sc. Electrical and Computer Engineering with Concentration in Modeling and Simulation**
- **M.Eng. Electrical and Computer Engineering with Concentration in Modeling and Simulation**
- **M.A.Sc. Electrical and Computer Engineering with Concentration in Software Engineering**
- **M.Eng. Electrical and Computer Engineering with Concentration in Software Engineering**
- **M.A.Sc. Electrical and Computer Engineering with Collaborative Specialization in Climate Change**
- **M.Eng. Electrical and Computer Engineering with Collaborative Specialization in Climate Change**
- **M.A.Sc. Electrical and Computer Engineering with Collaborative Specialization in Cybersecurity**
- **M.Eng. Electrical and Computer Engineering with Collaborative Specialization in Cybersecurity**
- **M.A.Sc. Electrical and Computer Engineering with Collaborative Specialization in Data Science**
- **M.Eng. Electrical and Computer Engineering with Collaborative Specialization in Data Science**
- **Cooperative Master's Degree**
- **Ph.D. Electrical and Computer Engineering**
- **Ph.D. Electrical and Computer Engineering with Concentration in Software Engineering**

Program Requirements

Subject to the approval of the departmental chair, a student may take up to half of the course credits in the program in other disciplines (e.g., Mathematics, Computer Science, Physics).

Master's programs with a thesis earn the Master of Applied Science degree, while other master's programs earn the Master of Engineering degree.

M.A.Sc. Electrical and Computer Engineering (5.0 credits)

Requirements:	
1. 2.5 credits in courses	2.5
2. 2.5 credits in Thesis	2.5
Total Credits	**5.0**

M.Eng. Electrical and Computer Engineering (4.5 credits)

Requirements - by project:		
1. 0.5 credit in:		0.5
SYSC 5902 [0.5]	Research Methods for Engineers	
2. 0.5 credit in project		0.5
3. 3.5 credits in courses, which may include up to an additional 0.5 credit in project		3.5
Total Credits		**4.5**

Requirements - by coursework:		
1. 0.5 credit in:		0.5
SYSC 5902 [0.5]	Research Methods for Engineers	
2. 4.0 credits in courses		4.0
Total Credits		**4.5**

M.A.Sc. Electrical and Computer Engineering with Concentration in Modeling and Simulation (5.0 credits)

Requirements - by thesis (5.0 credits)		
1. 1.5 credits from modeling and simulation core courses:		1.5
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5103 [0.5]	Software Agents	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5405 [0.5]	Pattern Classification and Experiment Design	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	
2. 1.0 credit in courses		1.0
3. 2.5 credits in:		2.5
SYSC 5909 [2.5]	M.A.Sc. Thesis (in the area of modeling and simulation)	
Total Credits		**5.0**

M.Eng. Electrical and Computer Engineering with Concentration in Modeling and Simulation (4.5 credits)

Requirements - by project		
1. 0.5 credit in:		0.5
SYSC 5902 [0.5]	Research Methods for Engineers	
2. 0.5 credit in project:		0.5
SYSC 5900 [0.5]	Systems Engineering Project (in the area of modeling and simulation)	
3. 2.0 credits from modeling and simulation core courses:		2.0
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5103 [0.5]	Software Agents	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5405 [0.5]	Pattern Classification and Experiment Design	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	

4. 1.5 credits in courses, which may include up to an additional 0.5 credit in project		1.5
Total Credits		**4.5**

Requirements - by coursework:

1. 0.5 credit in:		0.5
SYSC 5902 [0.5]	Research Methods for Engineers	
2. 2.0 credits from modeling and simulation core courses:		2.0
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5103 [0.5]	Software Agents	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5405 [0.5]	Pattern Classification and Experiment Design	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	
3. 2.0 credits in courses		2.0
Total Credits		**4.5**

M.A.Sc. Electrical and Computer Engineering with Concentration in Software Engineering (5.0 credits)

Requirements - thesis pathway:

1. 1.5 credits from Software Engineering core:		**1.5**
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5103 [0.5]	Software Agents	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5105 [0.5]	Software Quality Engineering and Management	
SYSC 5206 [0.5]	Resource Management on Distributed Systems	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5500 [0.5]	Designing Secure Networking and Computer Systems	
SYSC 5701 [0.5]	Operating System Methods for Real-Time Applications	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	
SYSC 5708 [0.5]	Model-Driven Development of Real-Time and Distributed Software	
SYSC 5709 [0.5]	Advanced Topics in Software Engineering	
SYSC 5805 [0.5]	Model-Driven Security Engineering	
SYSC 5807 [0.5]	Advanced Topics in Computer Systems	
SYSC 5809 [0.5]	The Internet of Things	
2. 1.0 credit in courses		**1.0**
3. 2.5 credits in:		**2.5**
SYSC 5909 [2.5]	M.A.Sc. Thesis (Thesis must be in the area of Software Engineering. Each candidate submitting a thesis will be required to undertake an oral defence of the thesis.)	
Total Credits		**5.0**

M.Eng. Electrical and Computer Engineering with Concentration in Software Engineering (4.5 credits)

Requirements (by coursework):

1. 0.5 credit in:		**0.5**
SYSC 5902 [0.5]	Research Methods for Engineers	
2. 2.0 credits from software engineering core courses:		**2.0**
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5103 [0.5]	Software Agents	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5105 [0.5]	Software Quality Engineering and Management	
SYSC 5206 [0.5]	Resource Management on Distributed Systems	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5500 [0.5]	Designing Secure Networking and Computer Systems	
SYSC 5701 [0.5]	Operating System Methods for Real-Time Applications	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	
SYSC 5708 [0.5]	Model-Driven Development of Real-Time and Distributed Software	
SYSC 5709 [0.5]	Advanced Topics in Software Engineering	
SYSC 5805 [0.5]	Model-Driven Security Engineering	
SYSC 5807 [0.5]	Advanced Topics in Computer Systems	
SYSC 5809 [0.5]	The Internet of Things	
3. 2.0 credits in courses		**2.0**
Total Credits		**4.5**

Requirements (by project):

1. 0.5 credit in:		**0.5**
SYSC 5902 [0.5]	Research Methods for Engineers	
2. 0.5 credit in:		**0.5**
SYSC 5900 [0.5]	Systems Engineering Project in the area of Software Engineering	
3. 2.0 credits from software engineering core courses:		**2.0**
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5105 [0.5]	Software Quality Engineering and Management	

SYSC 5206 [0.5]	Resource Management on Distributed Systems	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5500 [0.5]	Designing Secure Networking and Computer Systems	
SYSC 5701 [0.5]	Operating System Methods for Real-Time Applications	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	
SYSC 5708 [0.5]	Model-Driven Development of Real-Time and Distributed Software	
SYSC 5709 [0.5]	Advanced Topics in Software Engineering	
SYSC 5805 [0.5]	Model-Driven Security Engineering	
SYSC 5807 [0.5]	Advanced Topics in Computer Systems	
SYSC 5809 [0.5]	The Internet of Things	
4. 1.5 credits in courses, which may include up to an additional 0.5 credits in project in the area of Software Engineering		**1.5**
Total Credits		**4.5**

M.A.Sc. Electrical and Computer Engineering with Collaborative Specialization in Climate Change (5.0 credits)

Requirements:

1. 1.0 credit in:		1.0
CLIM 5000 [1.0]	Climate Collaboration	
2. 0.0 credit in:		0.0
CLIM 5800 [0.0]	Climate Seminar Series	
3. 1.5 credits in courses		1.5
4. 2.5 credits in:		2.5
SYSC 5909 [2.5]	M.A.Sc. Thesis (in the area of climate change)	
Total Credits		**5.0**

M.Eng. Electrical and Computer Engineering with Collaborative Specialization in Climate Change (4.5 credits)

Requirements - project pathway (4.5 credits)

1. 1.0 credit in:		1.0
CLIM 5000 [1.0]	Climate Collaboration	
2. 0.0 credit in:		0.0
CLIM 5800 [0.0]	Climate Seminar Series	
3. 0.5 credit in:		0.5
ELEC 5302 [0.5]	Renewable and Distributed Energy Resource Technologies	
SERG 5001 [0.5]	Sustainable Energy Policy for Engineers	
SERG 5003 [0.5]	Energy Evaluation and Assessment Tools	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
or approved Advanced Topic in the area of climate change		
4. 2.5 credits in courses		2.5
5. 0.5 credit in:		0.5
SYSC 5900 [0.5]	Systems Engineering Project (in the area of climate change)	
Total Credits		**4.5**

Requirements - coursework pathway (4.5 credits)

1. 1.0 credit in:		1.0
CLIM 5000 [1.0]	Climate Collaboration	
2. 0.0 credit in:		0.0
CLIM 5800 [0.0]	Climate Seminar Series	
3. 0.5 credit in:		0.5
ELEC 5302 [0.5]	Renewable and Distributed Energy Resource Technologies	
SERG 5001 [0.5]	Sustainable Energy Policy for Engineers	
SERG 5003 [0.5]	Energy Evaluation and Assessment Tools	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
or approved Advanced Topic in the area of climate change		
4. 3.0 credits in courses		3.0
Total Credits		**4.5**

M.A.Sc. Electrical and Computer Engineering with Collaborative Specialization in Cybersecurity (5.0 credits)

Requirements:

1. 1.0 credit in:		1.0
CYBR 5000 [1.0]	Science and Social Science of Cybersecurity	
3. 1.5 credits in courses		1.5
4. 2.5 credits in:		2.5
SYSC 5909 [2.5]	M.A.Sc. Thesis (in the area of cybersecurity)	
Total Credits		**5.0**

M.Eng. Electrical and Computer Engineering with Collaborative Specialization in Cybersecurity (4.5 credits)

Requirements - project pathway (4.5 credits)

1. 0.5 credit in:		0.5
SYSC 5902 [0.5]	Research Methods for Engineers	
2. 1.0 credit in:		1.0
CYBR 5000 [1.0]	Science and Social Science of Cybersecurity	
4. 2.5 credits in courses		2.5
5. 0.5 credit in:		0.5
SYSC 5900 [0.5]	Systems Engineering Project (in the area of cybersecurity)	
Total Credits		**4.5**

Requirements - coursework pathway (4.5 credits)

1. 0.5 credit in:		0.5
SYSC 5902 [0.5]	Research Methods for Engineers	
1. 1.0 credit in:		1.0
CYBR 5000 [1.0]	Science and Social Science of Cybersecurity	

4. 3.0 credits in courses, including 0.5 credit in approved elective in the area of the specialization		3.0
Total Credits		**4.5**

M.A.Sc. Electrical and Computer Engineering with Collaborative Specialization in Data Science (5.0 credits)

Requirements - by Thesis (5.0 credits)

1. 0.5 credit in:		0.5
DATA 5000 [0.5]	Data Science Seminar	
2. 0.5 credit from data science elective courses:		0.5
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5103 [0.5]	Software Agents	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5201 [0.5]	Computer Communication	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5303 [0.5]	Interactive Networked Systems and Telemedicine	
SYSC 5306 [0.5]	Mobile Computing Systems	
SYSC 5401 [0.5]	Adaptive and Learning Systems	
SYSC 5405 [0.5]	Pattern Classification and Experiment Design	
SYSC 5407 [0.5]	Planning and Design of Computer Networks	
SYSC 5500 [0.5]	Designing Secure Networking and Computer Systems	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	
3. 1.5 credits in courses		1.5
4. 2.5 credits in:		2.5
SYSC 5909 [2.5]	M.A.Sc. Thesis	
in the area of data science (each candidate submitting a thesis will be required to undertake an oral defence of the thesis)		
Total Credits		**5.0**

M.Eng. Electrical and Computer Engineering with Collaborative Specialization in Data Science (4.5 credits)

Requirements - by Project (4.5 credits)

1. 0.5 credit in:		0.5
DATA 5000 [0.5]	Data Science Seminar	
2. 1.0 credit from data science elective courses:		1.0
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5103 [0.5]	Software Agents	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5201 [0.5]	Computer Communication	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5303 [0.5]	Interactive Networked Systems and Telemedicine	
SYSC 5306 [0.5]	Mobile Computing Systems	
SYSC 5401 [0.5]	Adaptive and Learning Systems	
SYSC 5405 [0.5]	Pattern Classification and Experiment Design	
SYSC 5407 [0.5]	Planning and Design of Computer Networks	
SYSC 5500 [0.5]	Designing Secure Networking and Computer Systems	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	
3. 2.5 credits in courses, which may include up to an additional 0.5 credit in project		2.5
4. 0.5 credit in:		0.5
SYSC 5900 [0.5]	Systems Engineering Project	
in the area of data science		
Total Credits		**4.5**

Requirements - by Coursework (4.5 credits)

1. 0.5 credit in:		0.5
DATA 5000 [0.5]	Data Science Seminar	
2. 1.5 credits from data science elective courses:		1.5
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5103 [0.5]	Software Agents	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5201 [0.5]	Computer Communication	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5303 [0.5]	Interactive Networked Systems and Telemedicine	
SYSC 5306 [0.5]	Mobile Computing Systems	
SYSC 5401 [0.5]	Adaptive and Learning Systems	
SYSC 5405 [0.5]	Pattern Classification and Experiment Design	
SYSC 5407 [0.5]	Planning and Design of Computer Networks	
SYSC 5500 [0.5]	Designing Secure Networking and Computer Systems	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	
3. 0.5 credit in:		0.5
SYSC 5902 [0.5]	Research Methods for Engineers	
4. 2.0 credits in courses		2.0
Total Credits		**4.5**

Cooperative Master's Degree (5.0 credits)

Participation in the Cooperative Master's program is subject to acceptance by a suitable sponsoring organization.

Requirements - by thesis

1. 3.0 credits in courses	3.0
2. 2.0 credits in Thesis	2.0
Total Credits	**5.0**

Requirements - by project	
1. 4.0 credits in courses	4.0
2. 1.0 credit in two 0.5-credit projects (Each project conducted in one of two work terms)	1.0
Total Credits	**5.0**

Ph.D. Electrical and Computer Engineering (1.5 credits)

Subject to the approval of the advisory committee, a student may take up to half of the course credits in the program in other disciplines (e.g., Mathematics, Computer Science, Physics).

Requirements:	
1. 1.5 credits in courses	1.5
2. A comprehensive examination involving written and oral examinations and a written thesis proposal, to take place before the end of the fourth term of registration	
3. 0.0 credits in a thesis which must be defended at an oral examination	0.0
Total Credits	**1.5**

Ph.D. Electrical and Computer Engineering with Concentration in Software Engineering (1.5 credits)

Requirements:		
1. 1.0 credit from software engineering core courses:		**1.0**
SYSC 5001 [0.5]	Simulation and Modeling	
SYSC 5004 [0.5]	Optimization for Engineering Applications	
SYSC 5101 [0.5]	Design of High Performance Software	
SYSC 5103 [0.5]	Software Agents	
SYSC 5104 [0.5]	Methodologies For Discrete-Event Modeling And Simulation	
SYSC 5105 [0.5]	Software Quality Engineering and Management	
SYSC 5206 [0.5]	Resource Management on Distributed Systems	
SYSC 5207 [0.5]	Distributed Systems Engineering	
SYSC 5500 [0.5]	Designing Secure Networking and Computer Systems	
SYSC 5701 [0.5]	Operating System Methods for Real-Time Applications	
SYSC 5703 [0.5]	Integrated Database and Cloud Systems	
SYSC 5708 [0.5]	Model-Driven Development of Real-Time and Distributed Software	
SYSC 5709 [0.5]	Advanced Topics in Software Engineering	
SYSC 5805 [0.5]	Model-Driven Security Engineering	
SYSC 5807 [0.5]	Advanced Topics in Computer Systems	
SYSC 5809 [0.5]	The Internet of Things	
2. 0.5 credit in courses		**0.5**
3. 0.0 credit in comprehensive examination (one topic of which must be in the area of software engineering)		
4. 0.0 credits in:		**0.0**
SYSC 6909 [0.0]	Ph.D. Thesis (Thesis must be in the area of Software Engineering. Each candidate submitting a thesis will be required to undertake an oral defence of the thesis.)	
Total Credits		**1.5**

Graduate Courses

In all programs, the student may choose graduate courses from either university with the approval of the adviser or advisory committee. Course descriptions may be found in the departmental section of the calendar. All courses are of one term duration. Only a selection of courses listed is given in a particular academic year. The following codes identify the department offering the course.

Carleton University

- ELEC Department of Electronics
- SYSC Department of Systems and Computer Engineering

University of Ottawa

- EACJ School of Electrical Engineering and Computer Science

Course List by Research Area

BIOMEDICAL ENGINEERING

Systems and Computer Engineering (Carleton)	
SYSC 5302 (ELG 6321)	Biomedical Instrumentation
SYSC 5303 (ELG 6133)	Interactive Networked Systems and Telemedicine
SYSC 5304 (ELG 5127)	Medical Imaging Modalities
SYSC 5307 (ELG 6307)	Biological Signals

COMPUTER AIDED DESIGN FOR ELECTRONIC CIRCUITS

Department of Electronics (Carleton)	
ELEC 5401 (ELG 6341)	Signal Integrity in High-Speed Designs: Modeling and Analysis
ELEC 5402 (ELG 6342)	Introduction to Electronic Design Automation Algorithms and Techniques
ELEC 5404 (ELG 6344)	Neural Networks for High-Speed/ High-Frequency Circuit Design
ELEC 5405 (ELG 6340)	Advanced Linear and Nonlinear Circuit Theory and Applications
ELEC 5504 (ELG 6354)	Analysis of High-Speed Electronic Packages and Interconnects
ELEC 5506 (ELG 6356)	Simulation and Optimization of Electronic Circuits
ELEC 5508 (ELG 6358)	Advanced Methods for Simulation of Large-Scale Circuits and Systems
ELEC 5704 (ELG 6374)	Advanced Topics in CAD
ELEC 5803 (ELG 6383)	Behavioural Synthesis of ICs
School of Electrical Engineering and Computer Science (Ottawa)	

EACJ 5705 (ELG 5195)	Digital Logic Design

COMPUTER AND SOFTWARE ENGINEERING

Systems and Computer Engineering (Carleton)	
SYSC 5101 (ELG 6111)	Design of High Performance Software
SYSC 5103 (ELG 6113)	Software Agents
SYSC 5104 (ELG 6114)	Methodologies For Discrete-Event Modeling And Simulation
SYSC 5105 (ELG 6115)	Software Quality Engineering and Management
SYSC 5108 (ELG 6118)	Topics in Information Systems
SYSC 5701 (CSI 5117)	Operating System Methods for Real-Time Applications
SYSC 5703 (ELG 6173)	Integrated Database and Cloud Systems
SYSC 5704 (ELG 6174)	Elements of Computer Systems
SYSC 5708 (ELG 6178)	Model-Driven Development of Real-Time and Distributed Software
SYSC 5709 (ELG 6179)	Advanced Topics in Software Engineering
SYSC 5807 (ELG 6187)	Advanced Topics in Computer Systems
School of Electrical Engineering and Computer Science (Ottawa)	
EACJ 5100 (ELG 5200)	Machine Vision
EACJ 5203 (ELG 5191)	Distributed System Software
EACJ 5204 (ELG 5124)	Virtual Environments
EACJ 5205 (ELG 5125)	Quality Service Mgmt/Multimed
EACJ 5703 (ELG 5194)	Reliable Digital Systems
EACJ 5705 (ELG 5195)	Digital Logic Design
EACJ 5807 (ELG 7186)	Topics in Computers I
EACJ 5808 (ELG 7187)	Topics in Computers II
EACJ 5900 (ELG 7573)	Sujets choisis sur les ordinat

COMPUTER COMMUNICATIONS, DISTRIBUTED SYSTEMS, AND MULTIMEDIA

Systems and Computer Engineering (Carleton)	
SYSC 5201 (ELG 6121)	Computer Communication
SYSC 5207 (ELG 6127)	Distributed Systems Engineering
SYSC 5306 (ELG 6136)	Mobile Computing Systems
SYSC 5403 (ELG 6143)	Network Access Techniques
SYSC 5407 (ELG 5137)	Planning and Design of Computer Networks
SYSC 5408	Cross Layer Design for Wireless Networks
SYSC 5500 (ELG 6189)	Designing Secure Networking and Computer Systems
SYSC 5502 (ELG 6152)	Advanced Linear Systems
SYSC 5801 (ELG 6181)	Advanced Topics in Computer Communications
School of Electrical Engineering and Computer Science (Ottawa)	
EACJ 5009 (ELG 5383)	Survivable Optical Networks
EACJ 5104 (ELG 5199)	Distributed Database Systems
EACJ 5108 (ELG 5382)	Switching and Traffic Theory
EACJ 5200 (ELG 5120)	Queuing Systems
EACJ 5202 (ELG 5122)	Analysis/Perf Eval: Comp Comm
EACJ 5206 (ELG 5126)	Source Coding and Data Compress.
EACJ 5208 (ELG 7185)	Wireless Ad Hoc Networking
EACJ 5500 (ELG 5371)	Digital Comm by Satellite
EACJ 5605 (ELG 7177)	Topics in Communications I
EACJ 5606 (ELG 7178)	Topics in Communications II
EACJ 5607 (ELG 5374)	Computer-Communication Network
EACJ 5369 (ELG 5396)	Internetworking Technologies
EACJ 5384/ COMP 5406 [0.5] (ELG 5384,CSI 5105,LEG 5384)	Network Security and Cryptography

DIGITAL AND OPTICAL COMMUNICATIONS

Department of Electronics (Carleton)	
ELEC 5605 (ELG 6365)	Optical Fibre Communications
ELEC 5606 (ELG 6366)	Phase-Locked Loops and Receiver Synchronizers
Systems and Computer Engineering (Carleton)	
SYSC 5200 (ELG 6120)	Algebraic Coding Theory
SYSC 5503 (ELG 6153)	Stochastic Processes
SYSC 5504 (ELG 6154)	Principles of Digital Communication
SYSC 5506 (ELG 5170)	Information Theory
SYSC 5605 (ELG 6165)	Advanced Digital Communication
SYSC 5606 (ELG 6166)	Introduction to Mobile Communications
SYSC 5607 (ELG 6167)	Source Coding and Data Compression
SYSC 5608 (ELG 6168)	Wireless Communications Systems
SYSC 5804 (ELG 6184)	Advanced Topics in Communications Systems

School of Electrical Engineering and Computer Science (Ottawa)	
EACJ 5003 (ELG 5106)	Fourier Optics
EACJ 5105 (ELG 5373)	Secure Comm and Data Encryption
EACJ 5109 (ELG 5119)	Stochastic Processes
EACJ 5131 (ELG 5131)	Topics in Electromagnetics
EACJ 5132 (ELG 5132)	Smart Antennas
EACJ 5133 (ELG 5133)	Intro to Mobile Communications
EACJ 5300 (ELG 7114)	Topics in Systems and Control II
EACJ 5301 (ELG 7574)	Sujets choisis en systemes
EACJ 5360 (ELG 5360)	Digital Watermarking
EACJ 5501 (ELG 5170)	Information Theory
EACJ 5503 (ELG 5179)	Detection and Estimation
EACJ 5504 (ELG 5372)	Error Control Coding
EACJ 5506 (ELG 5375)	Principles of Digital Comm
EACJ 5605 (ELG 7177)	Topics in Communications I
EACJ 5606 (ELG 7178)	Topics in Communications II
EACJ 5702 (ELG 7572)	Sujets choisis en telecommun
EACJ 5704 (ELG 5180)	Advanced Digital Communication

INTEGRATED CIRCUITS AND DEVICES

Department of Electronics (Carleton)	
ELEC 5502 (ELG 6352)	Analog Integrated Filters
ELEC 5503 (ELG 6353)	Radio Frequency Integrated Circuit Design
ELEC 5509 (ELG 6359)	Integrated Circuit Technology
ELEC 5600 (ELG 6360)	Digital Integrated Circuit Testing
ELEC 5703 (ELG 6373)	Advanced Topics in Solid State Devices and IC Technology
ELEC 5705 (ELG 6375)	Advanced Topics in VLSI
ELEC 5706 (ELG 6376)	Submicron CMOS and BiCMOS Circuits for Sampled Data Applications
ELEC 5707 (ELG 6377)	Microsensors and MEMS
ELEC 5800 (ELG 6380)	Theory of Semiconductor Devices
ELEC 5801 (ELG 6381)	High-Speed and Low-Power VLSI
ELEC 5802 (ELG 6382)	Surface-Controlled Semiconductor Devices
ELEC 5804 (ELG 6384)	VLSI Design
ELEC 5805 (ELG 6385)	VLSI Design Project
ELEC 5808 (ELG 6388)	Signal Processing Electronics
ELEC 5809 (ELG 6389)	Nonlinear Electronic Circuits
Systems and Computer Engineering (Carleton)	
School of Electrical Engineering and Computer Science (Ottawa)	
EACJ 5006 (ELG 7132)	Topics in Electronics I
EACJ 5007 (ELG 7133)	Topics in Electronics II
EACJ 5008 (ELG 7575)	Sujets choisis en electronique
EACJ 5103 (ELG 5198)	Parallel Processing with VLSI
EACJ 5208/ ELEC 5200 [0.5] (ELG 6320)	Wireless Ad Hoc Networking

MICROWAVES AND ELECTROMAGNETICS

Department of Electronics (Carleton)	
ELEC 5409 (ELG 6349)	Microwave and Millimeterwave Integrated Circuits
ELEC 5501 (ELG 6351)	Passive Microwave Circuits
ELEC 5602 (ELG 6362)	Microwave Semiconductor Devices and Applications
ELEC 5604 (ELG 6364)	Radar Systems
ELEC 5607 (ELG 6367)	Fundamentals of Antenna Engineering
ELEC 5608 (ELG 6368)	Fourier Optics
ELEC 5609 (ELG 6369)	Nonlinear Microwave Devices and Effects
ELEC 5707 (ELG 6377)	Microsensors and MEMS
ELEC 5709 (ELG 6379)	Advanced Topics in Electromagnetics
School of Electrical Engineering and Computer Science (Ottawa)	
EACJ 5308 (ELG 7500)	Sujets choisis electromagnetiq
EACJ 5401 (ELG 5104)	Electromagnetic Waves
EACJ 5402 (ELG 5379)	Numerical Methods: Electromag
EACJ 5404 (ELG 7100)	Topics in Electromagnetics I
EACJ 5405 (ELG 7101)	Topics in Electromagnetics II

PHOTONIC SYSTEMS

Department of Electronics (Carleton)	
ELEC 5701 (ELG 6371)	Fibre and Waveguide Components for Communications and Sensors
ELEC 5702 (ELG 6372)	Principles of Photonics

ELEC 5705 (ELG 6375)	Advanced Topics in VLSI
ELEC 5708 (ELG 6378)	ASICs in Telecommunications
ELEC 5709 (ELG 6379)	Advanced Topics in Electromagnetics
EACJ 5004 (ELG 5381)	Photonics Networks
EACJ 5201 (ELG 5103)	Optical Communications Systems
EACJ 5404 (ELG 7100)	Topics in Electromagnetics I

SIGNAL, SPEECH, AND IMAGE PROCESSING

Systems and Computer Engineering (Carleton)	
SYSC 5304 (ELG 5127)	Medical Imaging Modalities
SYSC 5370 (ELG 5370)	Wavelets and Multiresolution Signal Analysis
SYSC 5600 (ELG 6160)	Adaptive Signal Processing
SYSC 5602 (ELG 6162)	Digital Signal Processing
School of Electrical Engineering and Computer Science (Ottawa)	
EACJ 5360 (ELG 5360)	Digital Watermarking
EACJ 5385 (ELG 5385)	Matrix MethodandAlgor Sign Proce
EACJ 5507 (ELG 5376)	Digital Signal Processing
EACJ 5508 (ELG 5776)	Traitement numer des signaux
EACJ 5509 (ELG 5378)	Image Proc and Image Comm
EACJ 5600 (ELG 7172)	Topics in Signal Processing I
EACJ 5601 (ELG 7173)	Topics in Signal Processing II
EACJ 5603 (ELG 7179)	Topics in Signal Processing 3
EACJ 5800 (ELG 5377)	Adaptive Signal Processing

SYSTEMS AND MACHINE INTELLIGENCE

Systems and Computer Engineering (Carleton)	
SYSC 5001 (ELG 6101)	Simulation and Modeling
SYSC 5004 (ELG 6104)	Optimization for Engineering Applications
SYSC 5401 (ELG 6141)	Adaptive and Learning Systems
SYSC 5405 (ELG 6102)	Pattern Classification and Experiment Design
School of Electrical Engineering and Computer Science (Ottawa)	
EACJ 5100 (ELG 5163)	Machine Vision
EACJ 5204 (ELG 5124)	Virtual Environments
EACJ 5207 (ELG 5161)	Robotics:Control/Sensing/Intel
EACJ 5209 (ELG 7113)	Topics in Systems and Control I
EACJ 5709 (ELG 5196)	Neural Networks and Fuzzy System
EACJ 7116 (ELG 7116)	Signal Proc: Intr Convex Optim
EACJ 5386 (ELG 5386)	Neural Networks and Fuzzy System

Admission

The normal requirement for admission to a master's program is a bachelor's degree in electrical engineering or a related discipline with a CGPA of B+.

Accelerated Pathway

The accelerated pathway in the M.A.Sc. and M.Eng. Electrical and Computer Engineering program is a flexible and individualized plan of graduate study for students in their final year of a Carleton B.Eng degree. Students with demonstrated academic excellence and aptitude for research may qualify for this option.

Students in their third-year of study in the B.Eng. degree should consult with both the Undergraduate Chair and the Graduate Chair to determine if the accelerated pathway is appropriate for them and to confirm their selection of courses for their final year of undergraduate studies.

Accelerated Pathway Requirements

1. At least 0.5 credit in ELEC or SYSC courses, or other approved courses, at the 5000-level with a grade of B+ or higher.
2. Minimum overall CGPA of A-.

Students may receive advanced standing with transfer of credit of up to 1.0 credit which can reduce their time to completion.

Admission

The normal requirement for admission into the Ph.D. program is a master's degree with thesis in electrical engineering or a related discipline.

Regulations

See the General Regulations section of this Calendar.

Regularly Scheduled Break

For immigration purposes, the summer term (May to August) for the M.Eng. Electrical and Computer Engineering (coursework and research project pathways only), including all concentrations and specializations, is considered a regularly scheduled break approved by the University. Students should resume full-time studies in September.

Note: a Regularly Scheduled Break as described for immigration purposes does not supersede the requirement for continuous registration in Thesis, Research Essay, or Independent Research Project as described in Section 8.2 of the Graduate General Regulations.

Electrical Engineering - Joint (EACJ) Courses

EACJ 5003 [0.5 credit]
Fourier Optics

EACJ 5004 [0.5 credit]
Photonics Networks

EACJ 5006 [0.5 credit]
Topics in Electronics I

EACJ 5007 [0.5 credit]
Topics in Electronics II

EACJ 5008 [0.5 credit]
Sujets choisis en electronique

EACJ 5009 [0.5 credit]
Survivable Optical Networks

EACJ 5100 [0.5 credit]
Machine Vision

EACJ 5101 [0.5 credit]
Directed Studies

EACJ 5103 [0.5 credit]
Parallel Processing with VLSI

EACJ 5104 [0.5 credit]
Distributed Database Systems

EACJ 5105 [0.5 credit]
Secure Comm and Data Encryption

EACJ 5107 [0.5 credit]
Multimedia Communications

EACJ 5108 [0.5 credit]
Switching and Traffic Theory

EACJ 5109 [0.5 credit]
Stochastic Processes

EACJ 5131 [0.5 credit]
Topics in Electromagnetics

EACJ 5132 [0.5 credit]
Smart Antennas

EACJ 5133 [0.5 credit]
Intro to Mobile Communications

EACJ 5200 [0.5 credit]
Queuing Systems

EACJ 5201 [0.5 credit]
Optical Communications Systems

EACJ 5202 [0.5 credit]
Analysis/Perf Eval: Comp Comm

EACJ 5203 [0.5 credit]
Distributed System Software

EACJ 5204 [0.5 credit]
Virtual Environments
Includes: Experiential Learning Activity

EACJ 5205 [0.5 credit]
Quality Service Mgmt/Multimed

EACJ 5206 [0.5 credit]
Source Coding and Data Compress.

EACJ 5207 [0.5 credit]
Robotics:Control/Sensing/Intel

EACJ 5208 [0.5 credit]
Wireless Ad Hoc Networking

EACJ 5209 [0.5 credit]
Topics in Systems and Control I

EACJ 5211 [0.5 credit]
Software Engineering Proj Mgmt

EACJ 5300 [0.5 credit]
Topics in Systems and Control II

EACJ 5301 [0.5 credit]
Sujets choisis en systemes

EACJ 5308 [0.5 credit]
Sujets choisis electromagnetiq

EACJ 5360 [0.5 credit]
Digital Watermarking

EACJ 5369 [0.5 credit]
Internetworking Technologies

EACJ 5384 [0.5 credit]
Network Security and Cryptography

EACJ 5385 [0.5 credit]
Matrix MethodandAlgor Sign Proce

EACJ 5386 [0.5 credit]
Neural Networks and Fuzzy System

EACJ 5401 [0.5 credit]
Electromagnetic Waves

EACJ 5402 [0.5 credit]
Numerical Methods: Electromag

EACJ 5404 [0.5 credit]
Topics in Electromagnetics I

EACJ 5405 [0.5 credit]
Topics in Electromagnetics II

EACJ 5500 [0.5 credit]
Digital Comm by Satellite

EACJ 5501 [0.5 credit]
Information Theory

EACJ 5503 [0.5 credit]
Detection and Estimation

EACJ 5504 [0.5 credit]
Error Control Coding

EACJ 5506 [0.5 credit]
Principles of Digital Comm

EACJ 5507 [0.5 credit]
Digital Signal Processing

EACJ 5508 [0.5 credit]
Traitement numer des signaux

EACJ 5509 [0.5 credit]
Image Proc and Image Comm

EACJ 5600 [0.5 credit]
Topics in Signal Processing I

EACJ 5601 [0.5 credit]
Topics in Signal Processing II

EACJ 5603 [0.5 credit]
Topics in Signal Processing 3

EACJ 5605 [0.5 credit]
Topics in Communications I

EACJ 5606 [0.5 credit]
Topics in Communications II

EACJ 5607 [0.5 credit]
Computer-Communication Network

EACJ 5702 [0.5 credit]
Sujets choisis en telecommun

EACJ 5703 [0.5 credit]
Reliable Digital Systems
Includes: Experiential Learning Activity

EACJ 5704 [0.5 credit]
Advanced Digital Communication

EACJ 5705 [0.5 credit]
Digital Logic Design

EACJ 5709 [0.5 credit]
Neural Networks and Fuzzy System

EACJ 5800 [0.5 credit]
Adaptive Signal Processing

EACJ 5807 [0.5 credit]
Topics in Computers I

EACJ 5808 [0.5 credit]
Topics in Computers II

EACJ 5900 [0.5 credit]
Sujets choisis sur les ordinat

EACJ 7116 [0.5 credit]
Signal Proc: Intr Convex Optim

Electronics (ELEC) Courses

Note: The Departments of Electronics and Systems and Computer Engineering offer courses in: Biomedical and Electrical Engineering, Communications Engineering, Computer Systems Engineering, Electrical Engineering, Software Engineering and Engineering Physics.

ELEC 5200 [0.5 credit] (ELG 6320)
Advanced Topics in Integrated Circuits and Devices
Topics vary from year to year.

ELEC 5301 [0.5 credit]
Silicon Photonics
Fundamentals of silicon photonics, advanced electromagnetic theory, guided wave optics, interferometry, silicon-on- insulator (SOI) photonics, silicon based waveguide devices (planar, rib, strip), fabrication of photonic devices, passive and active silicon photonic devices such as modulators, lasers, detectors, silicon opto-electronic integration.

ELEC 5302 [0.5 credit]
Renewable and Distributed Energy Resource Technologies
Topics covered include renewable energy resources, photovoltaic systems, wind generation systems, energy storage units, electric vehicles, grid integration, distributed generation, microgrid, active distribution network, modeling and analysis of power system components, state-of-the-art power system simulation tools.

ELEC 5303 [0.5 credit] (ELG 6320 100)
Advanced Power Systems Analysis
Power system sustainability and control, transmission lines, transformers, synchronous generators, induction motor, power flow, small-signal stability, transient stability, voltage stability, state of the art power system simulation tools.
Precludes additional credit for ELEC 5200.

ELEC 5304 [0.5 credit] (ELG 6397)
Solar Cells - Principles, Materials, Systems and Operation
Solar radiation. Solar cells: crystalline silicon, thin film technologies, space and concentrator cells, organic and dye sensitized. Photovoltaic systems: introduction, balance of system components, grid-connected systems, space and concentrator systems. Testing, monitoring, and calibration standards. Economics, environment and business strategy.
Precludes additional credit for ELEC 5703.

ELEC 5305 [0.5 credit] (ELG 7113)
Electric Motor Drives
DC and AC motors, speed and torque control, efficiency, maximum torque per ampere, power converters, rectifiers, inverters, field-oriented vector control, direct torque control, and sensorless control.
Precludes additional credit for EACJ 5209.

ELEC 5401 [0.5 credit] (ELG 6341)
Signal Integrity in High-Speed Designs: Modeling and Analysis
Crosstalk, distortion, ground bounce, skin effect. Interconnect modeling/simulation, packages, ground/power planes, Elmore delay, lossy-coupled, frequency-dependent transmission lines, telegraphers equations, extraction, measured parameters, macromodeling: passivity/causality, MoC/MRA, vector fit, model reduction, electromagnetic compatibility/interference, mixed-domain systems, concurrent analysis.
Precludes additional credit for ELEC 5704 (ELG 6374).
Prerequisite(s): permission of the Department.

ELEC 5402 [0.5 credit] (ELG 6342)
Introduction to Electronic Design Automation Algorithms and Techniques
Digital design process; overview of design automation tools/methodologies; theory of computational complexity; layout compaction; placement and partitioning; floorplanning; routing; digital simulation; switch-level simulation; logic synthesis; verification; analog and RF simulation.
Precludes additional credit for ELEC 5704 Section "Y" (ELG 6374 Section "Y").

ELEC 5404 [0.5 credit] (ELG 6344)
Neural Networks for High-Speed/High-Frequency Circuit Design
Introduction to neural network methodologies for computer-aided design of high-speed/high-frequency circuits, including modeling of passive and active devices/circuits, and their applications in high-level design and optimization in wired and wireless electronic systems.

ELEC 5405 [0.5 credit] (ELG 6340)
Advanced Linear and Nonlinear Circuit Theory and Applications
Graph theory, incidence matrices, cutset matrices, generalized KCL, topological formulation, state-space equations, Tellegen's theorem, state-transition matrix, multi-port representation, stability, passivity, causality, synthesis of passive circuits, active networks, nonlinear dynamic circuits.

ELEC 5408 [0.5 credit] (ELG 7100 100)
Wireless Power Transfer and Energy Harvesting
Principles and design guidelines for efficient wireless power transfer and harvesting, short and long range power transfer, RF energy scavenging, and contactless communication. System and subsystem circuit design and analysis is expected and commercial software will be used for all course deliverables.
Precludes additional credit for EACJ 5131.
Lecture

ELEC 5409 [0.5 credit] (ELG 6349)
Microwave and Millimeterwave Integrated Circuits
Design of communications electronics components with emphasis on GaAs MMIC implementation. Overview of MESFET, HEMT, HBT device modeling. Integrated lumped/ distributed passive element modeling. Broadband impedance matching. Design of direct-coupled amplifiers, distributed amplifiers, power devices and amplifiers, phase shifters, switches, attenuators, mixers, oscillators.

ELEC 5501 [0.5 credit] (ELG 6351)
Passive Microwave Circuits
Characteristics of homogeneous and inhomogeneous transmission lines and waveguides. Planar transmission lines: stripline, microstrip, coplanar line, slotline. Coupled transmission lines. Modeling of discontinuities. Ferrite components. Microwave network analysis: s-parameters, CAD models. Design of impedance-matching networks, directional couplers, power splitters, filters. Applications in MICs and MMICs.

ELEC 5502 [0.5 credit] (ELG 6352)
Analog Integrated Filters
The fundamentals and details of analog continuous-time and SAW filters. Comparison to switched-capacitor filters. Review of filter concepts, types of filters, approximations, transformations. Building blocks such as op amps, transconductance amplifiers, and gyrators. Design using cascaded second-order sections, multiple loop feedback and LC ladder simulations.

ELEC 5503 [0.5 credit] (ELG 6353)
Radio Frequency Integrated Circuit Design
Integrated radio front-end component design. Overview of radio systems, frequency response, gain, noise, linearity, intermodulation, image rejection, impedance matching, stability, and power dissipation. Detailed design of low-noise amplifiers, mixers, oscillators and power amplifiers. Use of on-chip inductors and baluns. Process variations, parasitics, and packaging.

ELEC 5504 [0.5 credit] (ELG 6354)
Analysis of High-Speed Electronic Packages and Interconnects
Introduction to modeling, simulation and optimization of high-speed VLSI packages; models for packages, interconnects and ground/power planes; lumped, distributed and EM models for interconnects; delay, crosstalk and switching noise; moment matching techniques; concurrent thermal/electrical analysis of IC packages and boards.

ELEC 5506 [0.5 credit] (ELG 6356)
Simulation and Optimization of Electronic Circuits
Introduction to computer simulation and optimization of electrical circuits. Time- and frequency-domain formulations for sensitivity analysis and optimization. Optimization techniques for performance-, cost- and yield-driven design of electronic circuits. Optimization approaches to modeling and parameter extraction of active and passive elements.

ELEC 5508 [0.5 credit] (ELG 6358)
Advanced Methods for Simulation of Large-Scale Circuits and Systems
Formulation of circuit equations. Sparse matrix techniques. Frequency and time-domain solutions. Relaxation techniques and timing analysis. Noise and distortion analysis. Transmission line effects. Interconnect analysis and crosstalk simulation. Numerical inversion techniques. Asymptotic waveform estimation. Mixed frequency/time domain techniques. Sensitivity analysis.

ELEC 5509 [0.5 credit] (ELG 6359)
Integrated Circuit Technology
Survey of technology used in silicon VLSI integrated circuit fabrication. Crystal growth and crystal defects, oxidation, diffusion, ion implantation and annealing, gettering, CVD, etching, materials for metallization and contacting, and photolithography. Structures and fabrication techniques required for submicron MOSFETs. Applications in advanced CMOS processes.

ELEC 5600 [0.5 credit] (ELG 6360)
Digital Integrated Circuit Testing
Production testing of digital integrated circuits. Outline of methods of testing used in production. Testing schemes and design for testability. Faults and fault models, yield estimates, testability measures, fault simulation, test generation methods, sequential testing, scan design, boundary scan, built-in self test, CMOS testing.

ELEC 5602 [0.5 credit] (ELG 6362)
Microwave Semiconductor Devices and Applications
Theory of operation for microwave diodes (varactor, p-i-n, Gunn, IMPATT) and transistors (BJT, MESFET, HBT, HEMT). Small-signal, large-signal, and noise models for CAD. Diode oscillators and reflection amplifiers. Design of transistor oscillators and amplifiers. Discussion of technology/fabrication issues and MMIC applications.

ELEC 5604 [0.5 credit] (ELG 6364)
Radar Systems
Fundamentals; range equation, minimum detectable signal, radar cross-section, pulse repetition frequency, range ambiguities. Radar classes: CW, FM-CW, MTI, tracking, air surveillance, SSR, PAR, MLS, SAR, SLAR, OTH, 3D and bistatic radars. Radar subsystems; transmitters, antennas, receivers, processors, displays, detection criteria; CFAR receivers, noise, clutter precipitation.

ELEC 5605 [0.5 credit] (ELG 6365)
Optical Fibre Communications
Transmission characteristics of and design considerations for multi-mode and single-mode optical fibre waveguides; materials, structures, and device properties of laser light sources; properties and performance of p-i-n and avalanche photodiodes; types of optical fibre signal formats, preamplifier topologies, noise, receiver sensitivity, transmitter design, link design.

ELEC 5606 [0.5 credit] (ELG 6366)
Phase-Locked Loops and Receiver Synchronizers
Phase-locked loops; components, fundamentals, stability, transient response, sinusoidal operation, noise performance, tracking, acquisition and optimization. Receiver synchronizers: carrier synchronizers including squaring loop, Costas loop, and remodulator for BPSK, QPSK BER performance; clock synchronizers including early-late gate, in-phase/midphase, and delay line multiplier.

ELEC 5607 [0.5 credit] (ELG 6367)
Fundamentals of Antenna Engineering
Basic properties of antennas (gain, radiation patterns, polarization, antenna temperature). Analysis of common antennas (dipoles, loops, helices, aperture antennas, microstrip, dielectric resonator antennas, reflectors). Analysis and design of linear and planar arrays (array factors, beam scanning, amplitude weighting, feed networks).

ELEC 5608 [0.5 credit] (ELG 6368)
Fourier Optics
The theory and applications of diffractive and non-diffractive coherent optics, with emphasis on holograms, tomography and high-speed optical computing. Mathematical basis: generalized 2-D Fourier transforms, transfer function of an optical system, 2-D sampling theory, Helmholtz equation, Green's theorem, and the classical diffraction theories.

ELEC 5609 [0.5 credit] (ELG 6369)
Nonlinear Microwave Devices and Effects
The physical basis and mathematical modeling of a variety of microwave/millimeter-wave devices, (some of which exhibit the most extreme nonlinear behaviour known), how they can be exploited in practical circuits and systems, and how the resulting device/circuit interactions can be analyzed.

ELEC 5701 [0.5 credit] (ELG 6371)
Fibre and Waveguide Components for Communications and Sensors
Optical wave propagation in dielectric waveguides. Theory and practice for passive photonic devices used for routing, filtering, and signal processing, including structural and biochemical sensors. Directional couplers and splitters, filters (gratings and etalons), Mach-Zehnder interferometers, Arrayed waveguide gratings, and dispersion compensators.

ELEC 5702 [0.5 credit] (ELG 6372)
Principles of Photonics
Electromagnetic wave propagation in crystals; review of geometric optics; Gaussian beam propagation; optical fibres; dielectric waveguides for optical integrated circuits; optical resonators; optical properties of materials; theory of laser oscillation; specific laser systems; electro-optic modulators; photorefractive materials and applications; holography; optical interconnects.

ELEC 5703 [0.5 credit] (ELG 6373)
Advanced Topics in Solid State Devices and IC Technology
Recent and advanced topics in semiconductor device physics, modeling, and integrated circuit fabrication technology. Topic varies from year to year according to departmental research interests. Students may be expected to contribute lectures or seminars on selected topics.

ELEC 5704 [0.5 credit] (ELG 6374)
Advanced Topics in CAD
Recent and advanced topics in computer-aided techniques for the design of VLSI and telecommunications circuits. Topics will vary from year to year according to the departmental research interests. Students may be expected to contribute lectures or seminars on selected topics.

ELEC 5705 [0.5 credit] (ELG 6375)
Advanced Topics in VLSI
Recent and advanced topics in the design of very large scale integrated circuits, with emphasis on mixed analog/digital circuits for telecommunications applications. Topic varies from year to year according to departmental research interests. Students may be expected to contribute lectures or seminars on selected topics.

ELEC 5706 [0.5 credit] (ELG 6376)
Submicron CMOS and BiCMOS Circuits for Sampled Data Applications
The analog aspects of digital CMOS and BiCMOS circuit design in submicron technologies including reliability; sampled analog circuits, including amplifier non-ideal characteristics and switch charge injection; CMOS/BiCMOS amplifier design considerations, leading up to standard folded-cascode and two-stage circuits.

ELEC 5707 [0.5 credit] (ELG 6377)
Microsensors and MEMS
Physical design of microelectromechanical systems (MEMS) and microfabricated sensors and actuators. An overview of thin and thick film processes and micromachining techniques will provide fabrication background. Device design including piezoresistive, piezoelectric, electromagnetic, thermal, optical, and chemical sensors and actuators.

ELEC 5708 [0.5 credit] (ELG 6378)
ASICs in Telecommunications
Introduction to modern ASIC technologies for Telecom. Review of circuit-level building blocks for typical wireline and wireless applications, including power/performance tradeoffs. Corresponding FPGA analog and digital IO circuits are discussed. A topical literature study and circuit level design exercises.

ELEC 5709 [0.5 credit] (ELG 6379)
Advanced Topics in Electromagnetics
Recent and advanced topics in electro-magnetics, antennas, radar systems, microwave devices and circuits, or optoelectronics. The subject material will vary from year to year according to research interests in the department and/or expertise provided by visiting scholars or sessional lecturers.

ELEC 5800 [0.5 credit] (ELG 6380)
Theory of Semiconductor Devices
Equilibrium and non-equilibrium conditions in a semiconductor. Carrier transport theory. Physical theory of basic semiconductor device structures and aspects of design: PN junctions and bipolar transistors, field effect devices. Current transport relationships for transistors. Charge control theory. Modeling of device mechanisms. Performance limitations of transistors.

ELEC 5801 [0.5 credit] (ELG 6381)
High-Speed and Low-Power VLSI
High-Speed and Low-Power CMOS VLSI circuit techniques. Low and high levels of abstraction; transistor, switch, logic-gate, module, system levels. State-of-the-art techniques to optimize the performance and energy consumption of a circuit. One or more of these techniques are used in a design project.
Prerequisite(s): ELEC 4708 or ELEC 5804 or the equivalent or permission of the instructor.

ELEC 5802 [0.5 credit] (ELG 6382)
Surface-Controlled Semiconductor Devices
Fundamentals of the MOS system; MOS capacitors. Long channel behaviour: theory, limitations and performance of the SPICE level 1 and 2 models. Small geometry effects. Subthreshold operation and modeling. Hot electron effects and reliability.

ELEC 5803 [0.5 credit] (ELG 6383)
Behavioural Synthesis of ICs
Various topics related to computer analysis and synthesis of VLSI circuits including: logic synthesis, finite state machine synthesis, design methodologies, design for reuse, testing, common VLSI functions, a review of Verilog.
Prerequisite(s): Some IC design knowledge such as given in ELEC 4708.

ELEC 5804 [0.5 credit] (ELG 6384)
VLSI Design
IC design course with strong emphasis on design methodology, to be followed by ELEC 5805 (ELG 6385) in the second term. Design philosophies considered will include Full Custom design, standard cells, gate-arrays and sea-of-gates using CMOS and BiCMOS technology. State-of-the-art computer-aided design tools are used.

ELEC 5805 [0.5 credit] (ELG 6385)
VLSI Design Project
Using state-of-the-art CMOS and BiCMOS technologies, students will initiate their own design of an integrated circuit using tools in the CAD lab and submit it for fabrication where the design warrants.

ELEC 5807 [0.5 credit] (ELG 6375)
RF System Design
System level design of a typical integrated radio. System architectures for radio front ends. Detailed design procedures going from a radio specification to determine block level specifications: determining NF, EVM, phase noise, linearity from BER and radio range requirements.
Precludes additional credit for ELEC 5705.
Prerequisite(s): None.
Seminar

ELEC 5808 [0.5 credit] (ELG 6388)
Signal Processing Electronics
CCDs, transveral filters, recursive filters, switched capacitor filters, with particular emphasis on integration of analog signal processing techniques in monolithic MOS ICs. Detailed op amp design in CMOS technology. Implications of nonideal op amp behaviour in filter performance. Basic sampled data concepts.

ELEC 5809 [0.5 credit] (ELG 6389)
Nonlinear Electronic Circuits
Introduction to non-linear circuits used in today's telecommunications ICs; CMOS non-linear circuits such as direct-RF-sampling mixers, phase-detectors; digital loop-filters, DCOs, frequency synthesizers and clock-and-data-recovery are introduced. Modeling of these non-linear circuits and existing options for simulations and closed form circuit analysis is presented.
Precludes additional credit for ELEC 5705 (ELG 6375).
Prerequisite(s): permission of the Department.

ELEC 5900 [0.5 credit] (ELG 6389)
Engineering Project I
A one-term course, carrying 0.5 credit, for students pursuing the course work M.Eng. program. An engineering study, analysis and/or design project under the supervision of a faculty member. Written and oral reports are required. This course may be repeated for credit.
Includes: Experiential Learning Activity

ELEC 5901 [1.0 credit] (ELG 6389)
Engineering Project II
A one-term course, carrying full-course credit, for students pursuing the course work or co-op M.Eng. program. An engineering study, analysis and/or design project under the supervision of a faculty member. Written and oral reports are required.
Includes: Experiential Learning Activity

ELEC 5906 [0.5 credit] (ELG 6389)
Directed Studies
Various possibilities exist for pursuing directed studies on topics approved by a course supervisor, including the above listed course topics where they are not offered on a formal basis.

ELEC 5909 [2.5 credits]
M.A.Sc. Thesis
Includes: Experiential Learning Activity

ELEC 6909 [0.0 credit]
Ph.D. Thesis
Includes: Experiential Learning Activity

Systems and Computer Engineering (SYSC) Courses

SYSC 5001 [0.5 credit] (ELG 6101)
Simulation and Modeling
Simulation as a problem solving tool. Random variable generation, general discrete simulation procedure: event table and statistical gathering. Analyses of simulation data: point and interval estimation. Confidence intervals. Overview of modeling, simulation and problem solving using SIMSCRIPT, MODSIM and other languages.
Also offered at the undergraduate level, with different requirements, as SYSC 4005, for which additional credit is precluded.

SYSC 5004 [0.5 credit] (ELG 6104)
Optimization for Engineering Applications
Introduction to algorithms and computer methods for optimizing complex engineering systems. Includes linear programming, networks, nonlinear programming, integer and mixed-integer programming, genetic algorithms and search methods, and dynamic programming. Emphasizes practical algorithms and computer methods for engineering applications.

SYSC 5101 [0.5 credit] (ELG 6111)
Design of High Performance Software
Designing software to demanding performance specifications. Design analysis using models of computation, workload, and performance. Principles to govern design improvement for sequential, concurrent and parallel execution, based on resource architecture and quantitative analysis.
Prerequisite(s): SYSC 5704 (ELG 6174) and a course in software engineering, or equivalent.
Also offered at the undergraduate level, with different requirements, as SYSC 4102, for which additional credit is precluded.

SYSC 5103 [0.5 credit] (ELG 6113)
Software Agents
Agent-based programming; elements of Distributed Artificial Intelligence; beliefs, desires and intentions; component-based technology; languages for agent implementations; interface agents; information sharing and coordination; KIF; collaboration; communication; ontologies; KQML; autonomy; adaptability; security issues; mobility; standards; agent design issues and frameworks, applications in telecommunications.
Prerequisite(s): Knowledge of Java, C/C++ or Smalltalk.

SYSC 5104 [0.5 credit] (ELG 6114)
Methodologies For Discrete-Event Modeling And Simulation
Methodological aspects of simulation. Modeling discrete events systems. Modeling formalisms: FSA, FSM, Petri Nets, DEVS, others. Verification and validation. Cellular models: Cellular Automata, Cell-DEVS. Continous and hybrid models. Parallel and Distributed simulation (PADS) techniques. PADS middleware: HLA, Parallel-DEVS, Time-Warp.
Prerequisite(s): knowledge of C++ and of basic concepts of concurrency and distributed systems.

SYSC 5105 [0.5 credit] (ELG 6115)
Software Quality Engineering and Management
All aspects of software quality engineering. Software testing, at all stages of the software development and maintenance life cycle. Software reviews and inspections. Use of software measurement and quantitative modeling for the purpose of software quality control and improvement.
Precludes additional credit for CSI 5111 (COMP 5501).
Prerequisite(s): an undergraduate course in software engineering such as SYSC 4800 or SEG 3300, or equivalent, and basic statistics.

SYSC 5108 [0.5 credit] (ELG 6118)
Topics in Information Systems
Recent and advanced topics in the field of Information Systems and its related areas.

SYSC 5200 [0.5 credit] (ELG 6120)
Algebraic Coding Theory
Review of Algebra, Finite Fields, Linear Block Codes and their Properties, Hamming Codes, Cyclic Codes, Hadamard Matrices and Hadamard Codes, Golay Codes, Reed-Muller Codes, BCH and Reed-Solomon Codes, Decoding Algorithms, Coding Bounds.

SYSC 5201 [0.5 credit] (ELG 6121)
Computer Communication
Computer network types, introductory queuing theory and performance analysis. OSI layering and BISDN layering modifications. Data link layer. Local area networks and random access (CSMA- CD, switched ethernet, token ring, wireless LAN). Public Networks. IP networks, addressing, routing. Transport layer, flow control. Introduction to ISDN.
Precludes additional credit for EACJ 5607 (ELG 5374) or SYSC 4602 (ELG 4181).
Prerequisite(s): Undergraduate preparation in probability theory equivalent to STAT 3502.

SYSC 5202 [0.5 credit] (BMG 5107)
Applications in Biomedical Image Processing
Image processing methods applied to biomedical images. Overview of medical imaging modalities. Image enhancement, segmentation, registration and fusion. Image quality metrics. Image formats. Application examples.
Includes: Experiential Learning Activity
Also listed as BIOM 5202.

SYSC 5206 [0.5 credit]
Resource Management on Distributed Systems
Principles and techniques for resource management on distributed systems including clouds, grids and data analytics platforms; management of computing and storage resources; service level agreements; performance and energy aware techniques for scheduling, allocation, dynamic resource provisioning; cyber-physical systems and BigData; resource management for BigData analytics.

Includes: Experiential Learning Activity

SYSC 5207 [0.5 credit] (ELG 6127)
Distributed Systems Engineering
Techniques for representing distributed systems: graphical and textual models. Processes, threads, synchronization and inter-process communication techniques, RPC. Middleware: client-server (CORBA), grids, Web services. Resource management: processor allocation, load sharing, Grid scheduling, real-time issues. Protocol: OSI model, application and presentation layers.
Prerequisite(s): permission of the Department.

SYSC 5302 [0.5 credit] (ELG 6321)
Biomedical Instrumentation
Instrumentation designed to measure physiological variables related to the function of the heart, lungs, kidney, nervous and musculo-skeletal system; emergency, critical care, surgery and anaesthesia equipment.
Also listed as EACJ 5302 (ELG 6321).
Precludes additional credit for BIOM 5100 (BMG 5103).
Prerequisite(s): permission of the instructor.

SYSC 5303 [0.5 credit] (ELG 6133)
Interactive Networked Systems and Telemedicine
Telemanipulator; human motoring and sensory capabilities; typical interface devices; mathematical model of haptic interfaces; haptic rendering; stability and transparency; remote control schemes; time delay compensation; networking and realtime protocols, history and challenges of telemedicine; telemedicine applications: telesurgery, telemonitoring, telediagnosis and telehomecare.
Also listed as BIOM 5402 (BMG 5304).
Prerequisite(s): permission of the Department.

SYSC 5304 [0.5 credit] (ELG 5127)
Medical Imaging Modalities
Mathematical models of image formation based on the image modality and tissue properties. Linear models of image degradation and reconstruction. Inverse problems and regularization for image reconstruction. Image formation in radiology, computed tomography, magnetic resonance imaging, nuclear medicine, ultrasound, positron emission tomography.
Also listed as BIOM 5200 (BMG 5105).

SYSC 5306 [0.5 credit] (ELG 6136)
Mobile Computing Systems
Systems to build mobile applications. Covers data link layer to application layer. Emphasis on existing wireless infrastructure and IETF protocols. Focuses on view of mobile application developer; communication systems, middleware and application frameworks, defacto standards proposed/developed by industry consortia.
Precludes additional credit for COMP 5402 (CSI 5142).
Prerequisite(s): EACJ 5607 (ELG 5374) or SYSC 5201 (ELG 6121) or permission of the Department.

SYSC 5307 [0.5 credit] (ELG 6307)
Biological Signals
Modeling of neuromuscular biological signals, including subthreshold phenomena, active behaviour of cell membranes, and innervation processes. Measurement of biological signals, including electrode effects. Time domain, frequency domain, and adaptive filtering techniques for noise reduction.
Precludes additional credit for BIOM 5101 (BMG 5104).

SYSC 5370 [0.5 credit] (ELG 5370)
Wavelets and Multiresolution Signal Analysis
Multirate signal processing: sampling rate conversion, polyphase representation. Bases, filter banks: series expansion of discrete-time signals, series expansion of continuous-time signals, multiresolution concept and analysis, construction of wavelet, wavelet series. Complexity of multirate discrete-time processing, filter banks, and wavelet series computation.

SYSC 5401 [0.5 credit] (ELG 6141)
Adaptive and Learning Systems
System identification. Least squares and recursive identification techniques. Asymptotic and theoretical properties. Model structure selection. Prediction and estimation. Model reference adaptive control and self-tuning regulators. Nonlinear adaptive systems. Stability. Neural networks and neuro-control. Applications to robotics, control and pattern recognition.
Prerequisite(s): SYSC 5502 (ELG 6152) or equivalent.

SYSC 5403 [0.5 credit] (ELG 6143)
Network Access Techniques
A range of access technologies with emphasis on broadband access. Physical channels and the state-of-the-art of coding, modulation, multiplexing strategies to overcome physical impairments. including high-speed transmission over twisted pair, wireless, fibre and co-axial media.
Prerequisite(s): SYSC 5503 (ELG 6153), and SYSC 5504 (ELG 6154) or ELG 5375 (EACJ 5506).

SYSC 5405 [0.5 credit] (ELG 6102)
Pattern Classification and Experiment Design
Introduction to a variety of supervised and unsupervised pattern classification techniques with emphasis on correct application. Statistically rigorous experimental design and reporting of performance results. Case studies will be drawn from various fields including biomedical informatics.

Includes: Experiential Learning Activity
Also listed as BIOM 5405.
Prerequisite(s): undergraduate introductory probability and statistics.

SYSC 5407 [0.5 credit] (ELG 5137)
Planning and Design of Computer Networks
Planning process of computer networks; needs and technical requirements; modeling of different network planning problems; exact and approximate algorithms; topological planning and expansion problems; equipment (switch, router) location problem; approximate and optimal routing algorithms; presentation of various case studies.
Includes: Experiential Learning Activity

SYSC 5408 [0.5 credit]
Cross Layer Design for Wireless Networks
Quality of service measures at different layers. Parameter adaptation, tradeoffs, and optimization at physical, data-link, network, transport, and application layers. Examples of cross-layer design in cellular, ad hoc, sensor, local area, green, and cognitive radio networks.

SYSC 5500 [0.5 credit] (ELG 6189)
Designing Secure Networking and Computer Systems

Network security with coverage of computer security in support of networking concepts. Covers various security issues in data networks at different protocol layers. Routing security, worm attacks, and botnets. Security of new mobile networks and emerging networked paradigms such as social networks and cloud computing.
Precludes additional credit for SYSC 5801 Section "X" (ELG 6181).

SYSC 5502 [0.5 credit] (ELG 6152)
Advanced Linear Systems
Modeling and state space realization. Review of signals and systems. Solution to the matrix DE. Discrete time systems and the Z transform. Canonical representations and transformations. Controllability, observability and controller and observer design. LQR design and the Kalman filter. Numerous examples and applications.
Precludes additional credit for MECH 4501.

SYSC 5503 [0.5 credit] (ELG 6153)
Stochastic Processes
Basic concepts of randomness, as applied to communications, signal processing, and queuing systems; probability theory, random variables, stochastic processes; random signals in linear systems; introduction to decision and estimation; Markov chains and elements of queuing theory.
Precludes additional credit for EACJ 5109 (ELG 5119).

SYSC 5504 [0.5 credit] (ELG 6154)
Principles of Digital Communication
Elements of communication theory and information theory applied to digital communications systems. Characterization of noise and channel models. Optium Receiver theory. Modulation and coding for reliable transmission: MPSK, MQAM, M-ary orthogonal modulation. Channel coding, trellis coded modulation. Spread spectrum and CDMA communications.
Precludes additional credit for EACJ 5506 (ELG 5375).
Prerequisite(s): SYSC 5503 (ELG 5503) or ELG 5119 (EACJ 5109) or equivalent (may be taken concurrently).

SYSC 5506 [0.5 credit] (ELG 5170)
Information Theory
Measure of information: entropy, relative entrophy, mutual information, asymptotic equipartition property, entropy rates for stochastic processes; data compression: Huffman code, arithmetic coding; channel capacity: random coding bound, reliability function, Blahut-Arimoto algorithm, Gaussian channels, coloured Gaussian noise and 'water-filling'; rate distortion theory; network information theory.
Precludes additional credit for EACJ 5501 (ELG 5170).
Prerequisite(s): SYSC 5503 (ELG 6153) or EACJ 5109 (ELG 5119) or equivalent.

SYSC 5600 [0.5 credit] (ELG 6160)
Adaptive Signal Processing
Theory and techniques of adaptive filtering, including Wiener filters, gradient and LMS methods; adaptive transversal and lattice filters; recursive and fast recursive least squares; convergence and tracking performance; implementation. Applications, such as adaptive prediction, channel equalization, echo cancellation, source coding, antenna beamforming, spectral estimation.
Precludes additional credit for EACJ 5800 (ELG 5377).
Prerequisite(s): SYSC 5503 (ELG 5503)or ELG 5119 (EACJ 5109) or equivalent; SYSC 5602 (ELG 6162) or ELG 5376 (EACJ 5507) or equivalent.

SYSC 5602 [0.5 credit] (ELG 6162)
Digital Signal Processing
Review of discrete time signals and systems, A/D and D/A conversions, representation in time, frequency, and Z domain, DFT/FFT transforms, FIR/IIR filter design, quantization effects. Correlation functions. Cepstrum analysis. Multi-rate signal processing. Power spectrum estimation. Introduction to joint time-frequency analysis. DSP architecture: implementation approaches. Applications.
Precludes additional credit for EACJ 5507 (ELG 5376).

SYSC 5605 [0.5 credit] (ELG 6165)
Advanced Digital Communication
Techniques and performance of digital signalling and equalization over linear bandlimited channels with additive Gaussian noise. Fading multipath channels: diversity concepts, modeling and error probability performance evaluation. Synchronization in digital communications. Spread spectrum in digital transmission over multipath fading channels.
Precludes additional credit for EACJ 5704 (ELG 5780).
Prerequisite(s): SYSC 5504 (ELG 6154) or equivalent.

SYSC 5606 [0.5 credit] (ELG 6166)
Introduction to Mobile Communications
Mobile radio channel characterization: signal strength prediction techniques and statistical coverage; fading; delay spread; interference models and outage probabilities. Digital modulation and transmission system performance. Signal processing techniques: diversity and beamforming, adaptive equalization, coding. Applications to TDMA and CDMA cellular systems.
Prerequisite(s): SYSC 5503 (ELG 5503) and SYSC 5504 (ELG 6154) (may be taken concurrently with SYSC 5606).

SYSC 5607 [0.5 credit] (ELG 6167)
Source Coding and Data Compression
Discrete and continuous sources. Discrete sources: Huffman coding & run length encoding. Continuous sources: waveform construction coding; PCM, DPMC, delta modulation; speech compression by parameter extraction; predictive encoding; image coding by transformation and block quantization. Fourier and Walsh transform coding. Applications to speech, television, facsimile.
Prerequisite(s): SYSC 5503 (ELG 5503) or ELG 5119 (EACJ 5109) or equivalent.

SYSC 5608 [0.5 credit] (ELG 6168)
Wireless Communications Systems
Fundamentals of antenna systems and radio propagation, wireless channel characterization, link budget, spectrum, cellular and personal wireless communication systems, channel reuse, system capacity, mobility and location management, channel resource allocation, radio access network (RAN), multiple access principles, security and authentication, satellite networks, wireless LANs.

SYSC 5701 [0.5 credit] (CSI 5117)
Operating System Methods for Real-Time Applications
Principles and methods for operating system design with application to real-time, embedded systems. Concurrent programming: mechanisms and languages; design approaches and issues; run-time support (kernel). Methods for hard real-time applications. Methods for distributed systems. Programming assignments in a suitable programming language.
Prerequisite(s): SYSC 3303 or SYSC 5704 (ELG 6174) or equivalent courses and/or experience. Programming experience in high level and assembly languages.

SYSC 5702 [0.5 credit]
Sensor Fusion for Autonomous Systems
Sensor fusion for autonomous navigation systems. Topics include reference frames, maps representation, state estimation, error modelling, localization and mapping, sensors for autonomous navigation, sensor fusion algorithms. The course is for students with background in signals/systems, linear-algebra, and probability. Programming in Matlab or Python is essential.
Includes: Experiential Learning Activity

SYSC 5703 [0.5 credit] (ELG 6173)
Integrated Database and Cloud Systems
Review of database concepts: Conceptual database design, relational and object-oriented data models; application of SQL, recursive queries, relational algebra, and data integration; normalization theory, deductive approach to database, and query processing; object-oriented database; OLAP, data warehousing and data mining; Cloud computing, Hadoop, and MapReduce.

SYSC 5704 [0.5 credit] (ELG 6174)
Elements of Computer Systems
Concepts in basic computer architecture, assembly languages, high level languages including object orientation, compilers and operating system concepts (including concurrency mechanisms such as processes and threads and computer communication). Designed for graduate students without extensive undergraduate preparation in computer system engineering (or equivalent experience).
Prerequisite(s): programming experience with at least one high level language and permission of the Department.

SYSC 5708 [0.5 credit] (ELG 6178)
Model-Driven Development of Real-Time and Distributed Software
Advanced development of real-time and distributed systems by model-driven development that shifts the focus from coding to modeling. Different types of models. Generating code by model transformations. Design patterns for distributed/concurrent systems with examples from communication applications. Design issues for reusable software.
Prerequisite(s): knowledge of UML and operating systems concepts, and permission of the Department.

SYSC 5709 [0.5 credit] (ELG 6179)
Advanced Topics in Software Engineering
Recent and advanced topics in the field of software engineering and related areas. Primary references are recent publications in the field.
Prerequisite(s): permission of the Department.

SYSC 5801 [0.5 credit] (ELG 6181)
Advanced Topics in Computer Communications
Recent and advanced topics in computer-communication networks intended as a preparation for research. Students are expected to contribute to seminars or present lectures on selected topics.
Prerequisite(s): SYSC 5201(ELG 6121) or ELG 5374 (EACJ 5607) or equivalent and permission of the Department.

SYSC 5804 [0.5 credit] (ELG 6184)
Advanced Topics in Communications Systems
Recent and advanced topics in communications systems.
Prerequisite(s): permission of the Department.

SYSC 5805 [0.5 credit]
Model-Driven Security Engineering
Fundamentals of security engineering and its activities, with emphasis on model-driven approaches for asset identification, threat and risk assessment, security requirements elicitation, security controls selection, security evaluation, and security assurance for software intensive-systems. Examination of challenges for engineering secure software.
Includes: Experiential Learning Activity

SYSC 5807 [0.5 credit] (ELG 6187)
Advanced Topics in Computer Systems
Recent and advanced topics in computer systems. The course will generally focus on one or more of the following areas: specification, design, implementation, and modeling/analysis. Students may be expected to contribute to lectures or seminars on selected topics.
Prerequisite(s): permission of the Department.

SYSC 5809 [0.5 credit]
The Internet of Things
Main concepts of the Internet of Things (IoT) ranging from the physical devices and sensor networks to the applications and standards.
Includes: Experiential Learning Activity

SYSC 5900 [0.5 credit] (ELG 6188)
Systems Engineering Project
Students pursuing the non-thesis M.Eng. program conduct an engineering study, analysis, and/or design project under the supervision of a faculty member.
Includes: Experiential Learning Activity

SYSC 5902 [0.5 credit]
Research Methods for Engineers
Topics required to perform engineering research including literature surveys, identifying issues, objectives, and methodology. Technical writing, documenting and presenting engineering ideas and a review of statistics, simulation, optimization and data analysis.
Includes: Experiential Learning Activity

SYSC 5903 [0.5 credit]
Systems Engineering Project II
Students pursuing the non-thesis M.Eng. program conduct an engineering study, analysis, and/or design project under the supervision of a faculty member.
Includes: Experiential Learning Activity
Prerequisite(s): permission of the Department.

SYSC 5905 [2.0 credits] (ELG 6188)
M.C.S. Thesis
Also listed as MATH 5905, COMP 5905.

SYSC 5906 [0.5 credit]
Directed Studies

SYSC 5909 [2.5 credits]
M.A.Sc. Thesis
Includes: Experiential Learning Activity

SYSC 6909 [0.0 credit]
Ph.D. Thesis
Includes: Experiential Learning Activity