McGill
Faculty of Engineering

Course Outline
ECSE 571

Course Title: Optoelectronic Devices (ECSE 571)

Credits: 3

Contact Hours: (ECSE 571: 3-0-6) on average each week for 13 weeks: three hours of lectures, no tutorials, and six hours of individual work.

Course Prerequisite(s): ECSE 352 (EM Waves) or ECSE 354 (EM Wave Propagation)
Course Co-requisite(s): ECSE 533 Physical Basis of Semiconductor Devices

Course Description: Optoelectronic devices are devices which have an optical input and/or output and an electrical input and/or output. Widespread use of such devices has become practical only within the past three decades and has occurred primarily due to the development of advanced semiconductor materials technology and the development of low-loss optical fibers. As a result, optoelectronics is an enabling technology for numerous applications including telephone networks, data-com networks, remote controls, bar code readers, laser printers, laptop computers, flat-panel displays, and compact disc/DVD players. Stated differently, optoelectronics are present in the collection, transmission, storage, and display of information.

In this course we will cover the physical basis and general operating properties of a number of optoelectronic devices, including light emitting diodes (LEDs), laser diodes (edge, MQW, DFB, tunable, VCSEL), photodiodes (PN, PIN, APD), modulators (E-O, QCSE) amplifiers (SOA, OFA), and wavelength routing devices. The objective of the course is to provide the student with an understanding of the operating principles behind these devices and also to equip the student with sufficient knowledge to understand emerging optoelectronic devices. System implementation issues will be discussed throughout the course.

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Lectures:	TR	2:30 – 4:00 PM	ENGMD 280
Office Hour:	M	11:00 – 12:00 AM (or by appt.)	MC 847

Course Website:	https://mycourses2.mcgill.ca http://rahbardar.research.mcgill.ca All class material will be distributed online. Please check MyCourses regularly for announcements.	
Evaluation:	In-class presentation	20%
	Four Assignments	30%
	Two Midterms	30%
	Research Paper	20%

Learning Outcomes (LO)

The purpose of this course is to provide the student with the physical basis of optoelectronic devices. The student should then have the necessary background to take 'follow-up' graduate courses in photonics, e.g., ECSE 515 Fiber Optical Communications, ECSE 527 Optical Engineering, ECSE 572 Nonlinear Optics, and ECSE 596 Optical Waveguides.

Course Materials and Textbooks:

The following textbook will be used throughout the course and is available in the Schulich Science and Engineering Library on regular loan:

- A. Yariv and P. Yeh, *Photonics: Optical Electronics in Modern Communications*, 6th edition. University Press (200**7**). ISBN: 978-0195179460; Chapters: 4, 5, 6, 7, 15, 16.

Other recommended textbook:

- B. E. A. Saleh and M. C. Teich, *Fundamentals of Photonics*, 2nd edition. John Wiley and Sons, Inc. (2007). ISBN: 978-0-471-35832-9

Live Polling in Class

Polling will be used in this course to enhance engagement and increase interactivity. During a class with polling questions, student can respond to questions from the instructor from a personal device (smartphone, tablet, or laptop) connected to the Internet. Polling will be available through www.mcgill.ca/polling. To participate in Polling sessions, students need first register for an account by clicking on **Register Your Account** at www.mcgill.ca/polling and logging in with your McGill username and password. Follow the prompts to agree to the terms of use and create your account. For more information, please visit the **Getting Started for Students** section at www.mcgill.ca/polling.

Language:

"In accord with McGill University's Charter of Students' Rights, students in this course have the right to submit in English or in French any written work that is to be graded." (Approved by Senate on 21 January 2009 – also see the section in this document on Assignments and evaluation.)

« Conformément à la Charte des droits de l'étudiant de l'Université McGill, chaque étudiant a le droit de soumettre en français ou en anglais tout travail écrit devant être noté (sauf dans le cas des cours dont l'un des objets est la maîtrise d'une langue). »

Academic Integrity:
"McGill University values academic integrity. Therefore, all students must understand the meaning and consequences of cheating, plagiarism and other academic offences under the Code of Student Conduct and Disciplinary Procedures. (Approved by Senate on 29 Jan. 2003) (see www.mcgill.ca/students/srr/honest/ for more information).

If a student is suspected to have plagiarized or cheated on the quizzes, the situation will be handled through the Code of Student Conduct and Disciplinary Procedures by submitting evidence to the Faculty of Engineering Disciplinary Officer.

"Additional policies governing academic issues which affect students can be found in the McGill Charter of Students' Rights" (The Handbook on Student Rights and Responsibilities is available here).

Copyright of course materials:
© Instructor generated course materials (e.g., handouts, notes, summaries, exam questions, etc.) are protected by law and may not be copied or distributed in any form or in any medium without explicit permission of the instructor. Note that infringements of copyright can be subject to follow up by the University under the Code of Student Conduct and Disciplinary Procedures.

Course Schedule (*tentative*)*

Week	Date	Sections	Topic	Comments/Assessments
1	7 Jan.	Light – Incoherent and Coherent	Lecture 1	
	9 Jan.		Lecture 2	
2	14 Jan.	Optical Amplifiers	Lecture 3	
	16 Jan.		Lecture 4	A1 given
3	21 Jan.	Laser Oscillation	Lecture 5	
	23 Jan.		Lecture 6	
4	28 Jan.	Optical Properties of Semiconductors	Lecture 7	
	30 Jan.		Lecture 8	A1 due
5	4 Feb.		Lecture 9	A2 given
	6 Feb.	Semiconductor Amplifiers, LEDs, and Lasers	Lecture 10	
6	11 Feb.		Lecture 11	
	13 Feb.		Lecture 12	
7	18 Feb.		Lecture 13	A2 Due
	20 Feb.		Lecture 14	Paper abstract due
8	25 Feb.		Lecture 15	A3 given
	27 Feb.	Advanced Laser Diodes	Lecture 16	
9**	3 Mar.		Reading Week	
	5 Mar.		Reading Week	
10	10 Mar		Midterm #1	
	12 Mar.	Advanced Laser Diodes	Lecture 17	A3 due
11	17 Mar.		Lecture 18	
	19 Mar.	Detection Devices	Lecture 19	
12	24 Mar.		Lecture 20	A4 given
	26 Mar.	Optoelectronic Modulation	Lecture 21	
13	31 Mar.		Lecture 22	Final paper due
	2 Apr.		Midterm #2	
14	7 Apr.	Research Topics Presentations	Presentations	A4 due
	9 Apr.		Presentations	

***** In the event of extraordinary circumstances beyond the University's control, the content and/or evaluation in this course is subject to change.
** Reading week. No lecture on March 3 and March 5.

Course Content

1. Light – Incoherent and Coherent (2 lectures)
   a) Lineshape function, broadening
   b) Spontaneous emission, stimulated emission and absorption
   c) Rate equations
   d) Amplification, gain, gain saturation

2. Optical Amplifiers (2 lectures)
   a) Doped Fiber Amplifiers (EDFAs, PDFAs)
   b) Wide band amplifiers
   c) Raman amplification

3. Laser Oscillation (2 lectures)
   a) Fabry Perot laser/laser oscillation
   b) Rate equations/multilevel systems
   b) Power and coupling in laser oscillators

4. Optical Properties of Semiconductors (3 lectures)
   a) Review of semiconductor band structures
   b) Gain, absorption, transparency
   c) Recombination mechanisms

5. Semiconductor Amplifiers, LEDs, and Lasers (6 lectures)
   a) SOAs
   b) LEDs
   c) Fabry-Perot Laser Diodes
   d) Rate equations
   e) Operating characteristics (L-I-V-T-λ)
   f) Gain and index guided devices
   g) Modulation response (small/large signal)

6. Advanced Laser Diodes (3 lectures)
   a) Quantum well, multiple quantum well lasers
   b) Tunable lasers
   c) Vertical Cavity Surface Emitting Lasers (VCSELs)

7. Detection Devices (2 lectures)
   a) Photoconductive devices
   b) PIN diodes
   c) Avalanche Photo Diodes (APDs)

8. Optoelectronic Modulation (2 lectures)
   a) Franz-Keldysh and Stark Effect Modulators
   b) Quantum Confined Stark Effect (QCSE) modulators
   c) EO Modulators

Canadian Engineering Accreditation Board (CEAB) Curriculum Content

This course contributes the following curriculum category content:

CEAB curriculum category content	Number of AU's (Accreditation Units)	Description
Math	0	Mathematics include appropriate elements of linear algebra, differential and integral calculus, differential equations, probability, statistics, numerical analysis, and discrete mathematics
Natural science	0	Natural science includes elements of physics and chemistry, as well as life sciences and earth sciences. The subjects are intended to impart an understanding of natural phenomena and relationships through the use of analytical and/or experimental techniques.
Complementary studies	0	Complementary studies include the following areas of study to complement the technical content of the curriculum: engineering economics; the impact of technology on society; subject matter deals with central issues, methodologies, and thought processes of the arts, humanities and social sciences; management; oral and written communications; healthy and safety; professional ethics, equity and law; and sustainable development and environmental stewardship.
Engineering science	26	Engineering science involves the application of mathematics and natural science to practical problems. They may involve the development of mathematical or numerical techniques, modelling, simulation, and experimental procedures. Such subjects include, among others, applied aspects of strength of materials, fluid mechanics, thermodynamics, electrical and electronic circuits, soil mechanics, automatic control, aerodynamics, transport phenomena, elements of material science, geoscience, computer science, and environmental science.
Engineering design	26	Engineering design integrates mathematics, natural sciences, engineering sciences, and complementary studies in order to develop elements, systems, and processes to meet specific needs. It is a creative, iterative, and open-ended process, subject to constraints which may be governed by standards or legislation to varying degrees depending upon the discipline. These constraints may also relate to economic, health, safety, environmental, societal or other interdisciplinary factors.

Accreditation units (AU) are defined on an hourly basis for an activity which is granted academic credit and for which the associated number of hours corresponds to the actual contact time: one hour of lecture (corresponding to 50 minutes of activity) = 1 AU; one hour of laboratory or scheduled tutorial = 0.5 AU. Classes of other than the nominal 50-minute duration are treated proportionally. In assessing the time assigned to determine the AU of various components of the curriculum, the actual instruction time exclusive of final examinations is used.

Graduating Student Attributes

This course contributes to the obtention of the following attributes:

Graduating attribute	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
Level descriptor			**D**	**D**								

I = Introduced; D = Developed; A = Applied

***KB** - Knowledge Base for Engineering: Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.*

***PA** - Problem Analysis: An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.*

***IN** – Investigation: An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.*

***DE** – Design: An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, economic, environmental, cultural and societal considerations.*

***ET** - Use of Engineering Tools: An ability to create, select, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.*

***IT** - Individual and Team Work: An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.*

***CS** - Communication Skills: An ability to communicate complex engineering concepts within the profession and with society at large. Such abilities include reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.*

***PR** - Professionalism: An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.*

***IE** - Impact of Engineering on Society and the Environment: An ability to analyse social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.*

***EE** - Ethics and Equity: An ability to apply professional ethics, accountability, and equity.*

***EP** - Economics and Project Management: An ability to appropriately incorporate economics and business practices including project, risk and change management into the practice of engineering, and to understand their limitations.*

***LL** - Life-Long Learning: An ability to identify and to address their own educational needs in a changing world, sufficiently to maintain their competence and contribute to the advancement of knowledge.*