

Course Outline (W2024)

ELE885: Optical Communication Systems

Instructor(s)	Dr. Xavier Fernando [Coordinator] Office: ENG437 Phone: (416) 979-5000 x 556077 Email: fernando@torontomu.ca Office Hours: Fridays 2-3 PM
Calendar Description	This course provides a good understanding of the fundamentals of optical communications; both fiber optics and emerging optical wireless systems will be covered. Some of the topics are: high speed single mode and low speed multimode fibers, step and graded refractive index profiles, different dispersion mechanisms and their effect on high-speed links, advantage of coherent (LASER) light source over incoherent (LED) sources for long haul, high-speed links, photo detectors and their role in bit error rate (BER). Students will do design calculations for point to point and star type fiber optic networks, and they will also be introduced to Synchronous Optical Networks (SONET) and wavelength division multiplexing scenarios. Signal processing performance improvements will also be discussed.
Prerequisites	ELE 635
Antirequisites	None
Corerequisites	None
Compulsory Text(s):	<ol style="list-style-type: none"> 1. Optical Fiber Communications, Gerd Keiser, McGraw-Hill Higher Education 4/e or 3/e 2. Radio over Fiber for Wireless Communications, Xavier Fernando, John Wiley & Sons Ltd, 2014 3. Detailed Lecture Notes with Problems, available on D2L
Reference Text(s):	<ol style="list-style-type: none"> 1. Vehicular Applications of Visible Light Communications, Xavier Fernando and Hasan Farahneh, IOP Publishing Ltd, Nov. 2020, Online ISBN: 978-0-7503-2284-3; Print ISBN: 978-0-7503-2282-9
Learning Objectives (Indicators)	<p>At the end of this course, the successful student will be able to:</p> <ol style="list-style-type: none"> 1. Understanding mathematical expressions to describe electromagnetic waves. Single and multi mode light wave propagation in cylindrical optical fibres. (1b) 2. Understanding material, wave-guide and modal dispersion mechanisms in cylindrical optical fibres. Effect of dispersion in achievable bit rate. Fibre bandwidth. (1c) 3. Understanding spontaneous and stimulated light wave generation; multi longitudinal mode (MLM) lasers and, laser dynamics via rate equations. (1d) 4. Photon detection. Different noise processes in optical receivers. Optimization of SNR. (2a) 5. Trade-offs between various Fibre-Optic design issues: external vs direct modulation; optimum bias point; LED/Laser line width plus detector gain, bandwidth, transit time and, intrinsic layer width. Trade off between noise and bandwidth in optical receivers. (3b) 6. Basic design of digital point to point fibre optic links. (4b)

	<p>7. Appropriate parameter/device selection in passive bus and star fibre optical network. (4c)</p> <p>8. Design calculations for point to point, passive star and bus networks. (4a)</p> <p>NOTE: Numbers in parentheses refer to the graduate attributes required by the Canadian Engineering Accreditation Board (CEAB).</p>										
Course Organization	<p>3.0 hours of lecture per week for 13 weeks</p> <p>1.0 hours of lab per week for 12 weeks</p> <p>0.0 hours of tutorial per week for 12 weeks</p>										
Teaching Assistants	Syed Ammad Ali Shah (s10shah@torontomu.ca)										
Course Evaluation	<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 70%;">Midterm Exam</td> <td style="text-align: right;">35 %</td> </tr> <tr> <td>Quizzes (in-class)</td> <td style="text-align: right;">20 %</td> </tr> <tr> <td>Practice Problem Sets</td> <td style="text-align: right;">0 %</td> </tr> <tr> <td>Final Exam</td> <td style="text-align: right;">45 %</td> </tr> <tr> <td>TOTAL:</td> <td style="text-align: right;">100 %</td> </tr> </table> <p>Note: In order for a student to pass a course, a minimum overall course mark of 50% must be obtained. In addition, for courses that have both "Theory and Laboratory" components, the student must pass the Laboratory and Theory portions separately by achieving a minimum of 50% in the combined Laboratory components and 50% in the combined Theory components. Please refer to the "Course Evaluation" section above for details on the Theory and Laboratory components (if applicable).</p>	Midterm Exam	35 %	Quizzes (in-class)	20 %	Practice Problem Sets	0 %	Final Exam	45 %	TOTAL:	100 %
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TOTAL:	100 %										
Examinations	<p>Midterm exam typically held in Week 7 and, it will cover materials studied during weeks 1-6. It will be a closed book examination for two hours with multiple-choice and written type questions.</p> <p>Final exam will be held during the posted exam period. It will primarily focus materials studied during weeks 7-13. It will be a closed book examination for three hours with multiple-choice and written type questions.</p>										
Other Evaluation Information	During tutorial hours, the TAs will solve selected problem from the Problem Sets. Students will have the chance to clarify doubts with the Teaching Assistants.										
Teaching Methods	Primarily teaching will be done via lectures during the calendar hours. Exams and quizzes will be conducted in person.										
Other Information	Attending the lectures and solving problem sets and on-line quizzes on your own are essential to gain a good understanding of the course material.										

Course Content

Week	Hours	Chapters / Section	Topic, description

1	3		<p>Introduction Wave Basics (Chapters 1 & 2)</p> <ul style="list-style-type: none"> - Overview of Optical Fiber Communications (Sec 1.1-1.3) - Basic Optical Laws and Definitions (Sec 2.2)
2-3	4.5		<p>Optical Fibers (Chapter 2)</p> <ul style="list-style-type: none"> - Optical fiber modes and configurations (Sec 2.3) - Mode Theory (Sec. 2.4.1 2.4.2) - Single Mode Fibers (Sec 2.5) - Graded Index Fibers (Sec 2.6)
3-4	4.5		<p>Signal Degradation in Optical Fibers (Chapter 3)</p> <ul style="list-style-type: none"> - Attenuation (Sec 3.1) - Wave guide Distortion (Sec 3.2) - Design Optimization (Sec 3.5)
5-6	6		<p>Optical Sources (Chapter 4)</p> <ul style="list-style-type: none"> - LED (Sec 4.2) - Laser Diode (Sec 4.3) - Linearity (Sec 4.4) - Noise (Sec 4.5)
7-8	6		<p>Photo detectors and Receivers (Chapters 6 and 7)</p> <ul style="list-style-type: none"> - Overview of Physical Principles (Sec 6.1) - Noise (Sec 6.2) - Response Time (Sec 6.3) - Comparisons (Sec 6.7) - Digital Receivers (Sec 7.1 7.2)
9-10	6		<p>Digital Transmission Systems (Chapter 8)</p> <ul style="list-style-type: none"> - Point to Point Links (Sec 8.1) - Power Budget (Sec 8.1.2) - Rise Time Limit (Sec 8.1.3) - Line Coding (Sec 8.2)
10-11	4.5		<p>Optical Networks and WDM (Chapters 10 and 12)</p> <ul style="list-style-type: none"> - WDM Concepts and Components - Optical Networks - SONET - BLSR - UPSR - Broadcast and Select WDM Networks

11-12	4.5		Radio over Fiber (Chapter 3) - Fiber wireless systems - losses and gains - power budget calculations - optical electrical and cumulative SNRs
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Laboratory(L)/Tutorials(T)/Activity(A) Schedule

Week	L/T/A	Description
2-3	Problem Set 1	Fundamentals of wave optics
4-5	Problem Set 2	The Fiber
6-8	Problem Set 3	The Optical Transmitters
9-10	Problem Set 4	The Optical Receivers
11-12	Problem Set 5 and 6	Digital Network Design and Radio over Fiber

University Policies & Important Information

Students are reminded that they are required to adhere to all relevant university policies found in their online course shell in D2L and/or on [the Senate website](#)

Refer to the [Departmental FAQ page](#) for further information on common questions.

Important Resources Available at Toronto Metropolitan University

- [The Library](#) provides research [workshops](#) and individual assistance. If the University is open, there is a Research Help desk on the second floor of the library, or students can use the [Library's virtual research help service](#) to speak with a librarian.
- [Student Life and Learning Support](#) offers group-based and individual help with writing, math, study skills, and transition support, as well as [resources and checklists to support students as online learners](#).

- You can submit an [Academic Consideration Request](#) when an extenuating circumstance has occurred that has significantly impacted your ability to fulfill an academic requirement. You may always visit the [Senate website](#) and select the blue radio button on the top right hand side entitled: **Academic Consideration Request (ACR)** to submit this request.

For Extenuating Circumstances, Policy 167: Academic Consideration allows for a once per semester ACR request without supporting documentation if the absence is less than 3 days in duration and is not for a final exam/final assessment. Absences more than 3 days in duration and those that involve a final exam/final assessment, require documentation. Students must notify their instructor once a request for academic consideration is submitted. See Senate [Policy 167: Academic Consideration](#).

- If a student is requesting accommodation due to a religious, Aboriginal and/or spiritual observance, they must submit their request via the online [Academic Consideration Request \(ACR\) system](#) **within the first two weeks of the class or, for a final examination, within two weeks of the posting of the examination schedule**. If the required absence occurs within the first two weeks of classes, or the dates are not known well in advance as they are linked to other conditions, these requests should be submitted with as much lead time as possible in advance of the required absence.
- If taking a remote course, familiarize yourself with the tools you will need to use for remote learning. The [Remote Learning Guide](#) for students includes guides to completing quizzes or exams in D2L Brightspace, with or without [Respondus LockDown Browser and Monitor, using D2L Brightspace](#), joining online meetings or lectures, and collaborating with the Google Suite.
- Information on Copyright for [Faculty](#) and [students](#).

Accessibility

- Similar to an [accessibility statement](#), use this section to describe your commitment to making this course accessible to students with disabilities. Improving the accessibility of your course helps minimize the need for accommodation.
- Outline any technologies used in this course and any known accessibility features or barriers (if applicable).
- Describe how a student should contact you if they discover an accessibility barrier with any course materials or technologies.

Academic Accommodation Support

Academic Accommodation Support (AAS) is the university's disability services office. AAS works directly with incoming and returning students looking for help with their academic accommodations. AAS works with any student who requires academic accommodation regardless of program or course load.

- Learn more about [Academic Accommodation Support](#).
- Learn [how to register with AAS](#).

Academic Accommodations (for students with disabilities) and Academic Consideration (for students faced with extenuating circumstances that can include short-term health issues) are governed by two different university policies. Learn more about [Academic Accommodations versus Academic Consideration and how to access each](#).

Wellbeing Support

At Toronto Metropolitan University, we recognize that things can come up throughout the term that may interfere with a student's ability to succeed in their coursework. These circumstances are outside of one's control and can have a serious impact on physical and mental well-being. Seeking help can be a challenge, especially in those times of crisis.

If you are experiencing a mental health crisis, please call 911 and go to the nearest hospital emergency room. You can also access these outside resources at anytime:

- **Distress Line:** 24/7 line for if you are in crisis, feeling suicidal or in need of emotional support (phone: 416-408-4357)
- **Good2Talk:** 24/7-hour line for postsecondary students (phone: 1-866-925-5454)
- **Keep.meSAFE:** 24/7 access to confidential support through counsellors via [My SSP app](#) or 1-844-451-9700

If non-crisis support is needed, you can access these campus resources:

- **Centre for Student Development and Counselling:** 416-979-5195 or email csdc@torontomu.ca

- **Consent Comes First - Office of Sexual Violence Support and Education:** 416-919-5000 ext 3596 or email osvse@torontomu.ca
- **Medical Centre:** call (416) 979-5070 to book an appointment

We encourage all Toronto Metropolitan University community members to access available resources to ensure support is reachable. You can find more resources available through the [Toronto Metropolitan University Mental Health and Wellbeing](#) website.