ITT Technical Institute

ET3430T

Fiber Optic Communications

Onsite Course

SYLLABUS

Credit hours: 4.5

Contact/Instructional hours: 54 (54 Theory Hours)

Prerequisite(s) and/or Corequisite(s):

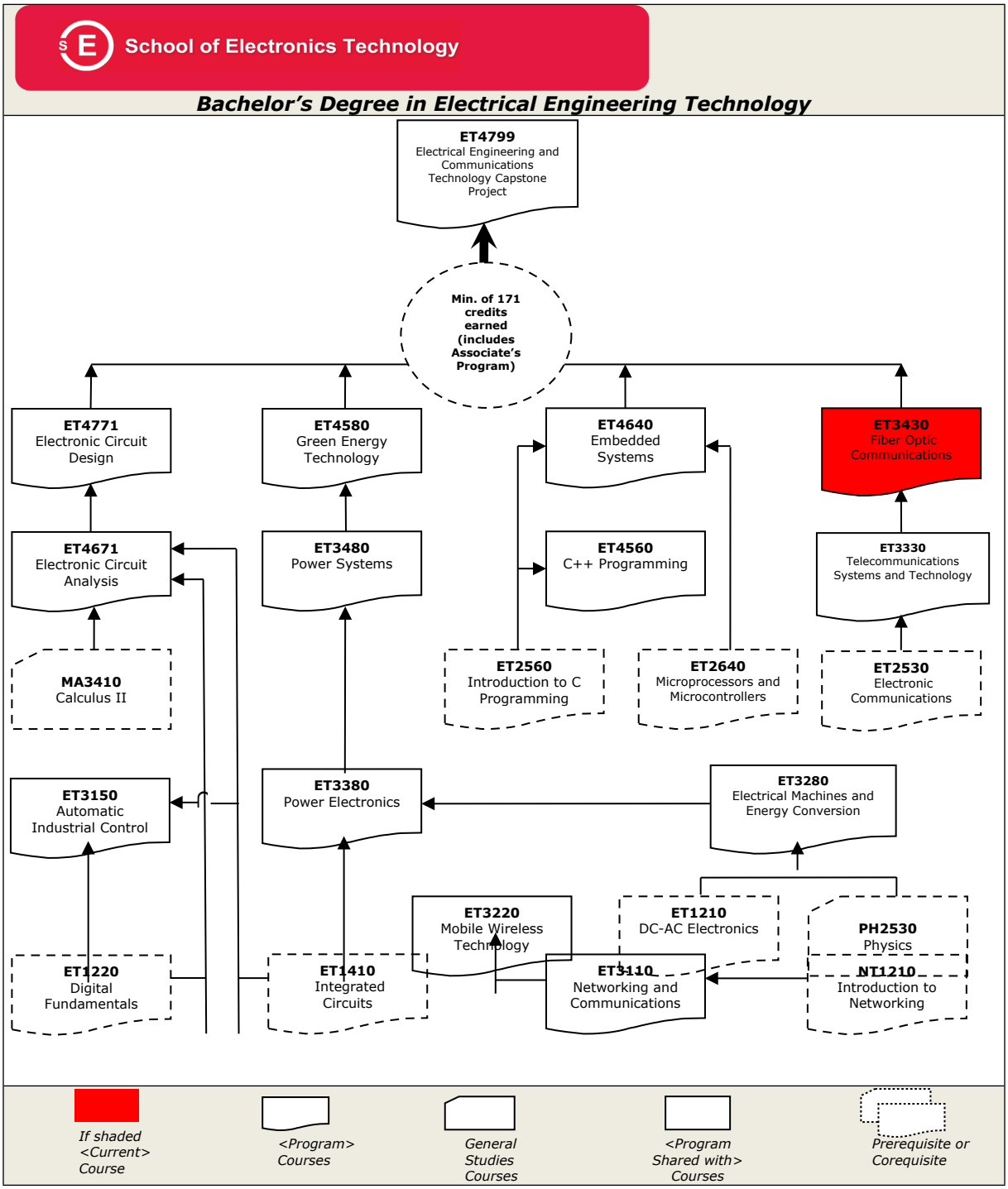
Prerequisites: ET3330T Telecommunications Systems and Technology or equivalent

Course Description:

This course explores concepts of fiber optic communication systems. Topics include light sources, optical fibers and their properties, optical amplifiers, optical transmitters and receivers, communications systems and optical networks.

Where Does This Course Belong?

This is a required course in the Electrical Engineering and Communications Technology Bachelor program in the School of Electronics Technology. The following table demonstrates how this course fits in the program:



NOTE: *Refer to the catalog for the state-specific course information, if applicable.*

Course Summary

Major Instructional Areas

1. Need for fiber optic communication and advantages of fiber optics
2. Basic theory of light propagation in optical fibers
3. Different varieties of optical fibers, attenuation and dispersion in fibers, and cabling
4. Light sources: diode laser and LEDs and optical transmitters
5. Photo detectors: p-i-n and avalanche photodiodes and optical receivers
6. Connectors and splices for joining fibers and directional couplers
7. Single channel fiber optic link design, signal-to-noise ratio, bit-error-rate calculation, power and rise-time budget calculation
8. Erbium doped fiber amplifiers, optical repeaters, and dispersion compensation
9. Time and wavelength division multiplexing and demultiplexing and multi-channel systems

Course Objectives

1. Analyze the need for fiber-optic communications.
2. Describe optical fibers, their properties, and basic fiber-optics components.
3. Describe the role of light sources and optical transmitters in converting electrical signals to optical form in a fiber-optic system.
4. Describe the role of photodetectors and optical receivers in converting optical signals to electronic form in a fiber-optic system.
5. Analyze the role of various passive and active components that are used to manipulate optical-signals in fiber-optic systems.
6. Explain how fiber-optic components are assembled into systems to provide communication and network services.
7. Analyze design considerations for single-channel optical systems to meet loss and bandwidth requirements.
8. Describe the importance and use of multi-channel fiber-optic systems.

Learning Materials and References

Required Resources

Textbook Package	New to This Course	Carried over from Previous Course(s)	Required for Subsequent Course(s)
Hecht, J. (2012). *Understanding Fiber Optics* (Custom 5th ed.). Boston, MA: Pearson Custom.	■		

Recommended Resources

Books, Professional Journals

- Keiser, G. (2011*). Optical fiber communications*. (4th ed.). Columbus, OH: McGraw-Hill.
- Palais, J.C. (2004). *Fiber optics communication*. (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Professional Associations

- IEEE: Institute of Electrical and Electronics Engineers, Photonics Society
  http://photonicssociety.org/ (accessed 05/16/12)

The IEEE Photonics Society is a leading professional network of 7000+ members that provides access to technical information on all aspects of opto-electronics.

- The Fiber Optics Association

http://thefoa.org/ (accessed 05/16/12)

This is the Fiber Optic Association's Guide to fiber optics and premises cabling includes hundreds of pages of materials from the basics to advanced topics on fiber optics and premises cabling. This material is intended to be used as reference materials for those working in the industry, studying for FOA Certifications, for FOA training classes, and refresher tutorials for FOA CFOTs.

- The Optical Society of America (OSA)

http://www.osa.org/ (accessed 04/26/12)

This association provides a common ground where science and technology innovators in optics and photonics come together, researching and advancing the science of light.

- The International Society for Optics and Photonics (SPIE)

http://spie.org/ (accessed 04/26/12)

SPIE is dedicated to advancing the scientific research and engineering applications of optics, optical, photonic, imaging, and optoelectronic technologies.

- American National Standards Institute

http://www.ansi.org/(accessed 04/26/12)

A premier source for timely, relevant, actionable information on national, regional, international standards, and conformity assessment issues.

- IEEE Communications Society

www.comsoc.org (accessed 04/26/12)

The IEEE Communications Society is a professional society of the IEEE focused on the science of, and education about, communications engineering.

- Telecommunications Industry Association

http://www.tiaonline.org/ (accessed 04/26/12)

The Telecommunications Industry Association (TIA) represents the global ICT industry through standards development, advocacy, tradeshows, and business conferences.

ITT Tech Virtual Library (accessed via Student Portal | https://studentportal.itt-tech.edu)

- You may click Books> Ebrary>:
  - Agrawal, G. P. (2010). *Fiber-optic communication systems*. (4th ed.). Hoboken, NJ: John Wiley.
- You may click "Periodicals" and use the E-Journal Lookup function to find periodicals on fiber optics. Some Periodicals are listed below:
  - Fiber and integrated optics (0146-8030)
  - Fiber optics news (8756-2049)
  - IEEE Communications Magazine
  - IEEE Optical Communications
- You may click Books> Books24x7:
  - Oliviero, Andrew and Woodward, Bill. (2009). *Cabling: the complete guide to copper and fiber-optic networking,* (4th ed.). Indianapolis, Indiana: Wiley Publishing, Inc.

Online tutorials

- Understanding Fiber Optic Communications

http://www.thefoa.org/PPT/hsintro/HSintro.htm (accessed 04/26/12)

This presentation provided an introduction to the technology of fiber optic communications.

- How Stuff Work: Fiber Optics

http://communication.howstuffworks.com/fiber-optic-communications/fiber-optic.htm

(accessed 04/26/12)

This resources provides information on why are fiber-optic systems revolutionizing telecommunications.

- Lascomm: Fiber Optic Communications

http://www.lascomm.com/tutorial.htm (accessed 04/26/12)

Lascomm supplies fiber optic data, video and audio products.

NOTE: All links are subject to change without prior notice.

Information Search

Use the following keywords to search for additional online resources that may be used for supporting your work on the course assignments:

- Fiber optics
- How fiber optics work
- Fiber optic communication
- Fiber optic technology
- Optical fibers
- Fiber optic signals
- Fiber optic cables
- Fiber optics for networks

Suggested Learning Approach

In this course, you will be studying individually and within a group of your peers. As you work on the course deliverables, you are encouraged to share ideas with your peers and instructor, work collaboratively on projects and team assignments, raise critical questions, and provide constructive feedback.

Use the following advice to receive maximum learning benefits from your participation in this course:

DO	DON'T
▪ Do take a proactive learning approach. ▪ Do share your thoughts on critical issues and potential problem solutions. ▪ Do plan your course work in advance. ▪ Do explore a variety of learning resources in addition to the textbook. ▪ Do offer relevant examples from your experience. ▪ Do make an effort to understand different points of view. ▪ Do connect concepts explored in this course to real-life professional situations and your own experiences.	▪ Don't assume there is only one correct answer to a question. ▪ Don't be afraid to share your perspective on the issues analyzed in the course. ▪ Don't be negative about the points of view that are different from yours. ▪ Don't underestimate the impact of collaboration on your learning. ▪ Don't limit your course experience to reading the textbook. ▪ Don't postpone your work on the course deliverables – work on small assignment components every day.

Course Outline

Unit 1: INTRODUCTION TO FIBER OPTICS AND OPTICAL COMMUNICATION

Out-of-class work:
7 hours

Upon completion of this unit, students are expected to:

- Describe the communication concepts and communication services.
- Explain the need for high data rate, low attenuation, and security in the communications.
- Describe the function of electromagnetic waves and spectrum.
- Explain the concept of light guiding in fiber transmission.
- Describe the advantages of fiber optics.
- Outline and define attributes of fiber transmission.
- Identify electro-optic components.
- Contrast connectivity and transmission in electric and optical signals.
- Explain voice, video, and data communication services offered through optical signals.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Hecht, Chapters 1, 2, and 3	Assignments	Unit 1 Assignment 1: Fiber Optics Basics	2.5%

Unit 2: TYPES OF OPTICAL FIBERS, STRUCTURE, AND CABLING

Out-of-class work:
9 hours

Upon completion of this unit, students are expected to:

- Outline and explain properties of step-index fiber.
- Describe different fiber-optic modes and their effects.
- Explain and compute the single-mode fiber cutoff wavelength.
- Explain the concept of polarization in single-mode fibers.
- Outline fabrication of optical fibers.
- Explain cabling basics and outline requirements for cabling in communication systems.
- Describe and compare different types of fiber-optic cables.
- Outline and describe elements of cable structure.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Hecht, Chapter 4 • Hecht, Chapter 6, pp. 127-137 • Hecht, Chapter 8, pp. 173-190	Assignments	Unit 2 Assignment 1: Fiber Optics, Fabrication, and Cabling	2.5%
	Quizzes	Unit 2 Quiz 1	6.25%

Unit 3: PROPERTIES OF OPTICAL FIBERS

Out-of-class work: 7 hours

Upon completion of this unit, students are expected to:

- Describe and compute fiber attenuation, absorption, and scattering.
- Explain concepts of light collection, propagation, and numerical aperture.
- Outline and explain different types of dispersion in optical systems.
- Explain dispersion shifted fibers.
- Describe the non-linear optical effects in optical fibers.
- Identify mechanical properties of fibers.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Hecht, Chapter 5	Assignments	Unit 3 Assignment 1: Fiber Optics Properties	2.5%

Unit 4: LIGHT SOURCES AND OPTICAL TRANSMITTERS

Out-of-class work: 9 hours

Upon completion of this unit, students are expected to:

- Identify and describe optical light source and its attributes.
- Explain the laser principle and characteristics of different type of lasers.
- Compare laser and LED performance in optical communications.
- Describe optical transmitters and outline operational considerations.
- Explain multiplexing and applications of wavelength-division multiplexing in optical communications.
- Identify and explain the light source modulation.
- Describe the design and operation of single-channel transmitter.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Hecht, Chapter 9, pp. 197-214	Assignments	Unit 4 Assignment 1: Light Sources and Optical Transmitters	2.5%
• Hecht, Chapter 10	Quizzes	Unit 4 Quiz 2	6.25%

Unit 5: PHOTODETECTORS AND OPTICAL RECEIVERS

Out-of-class work: 7 hours

Upon completion of this unit, students are expected to:

- Explain the use of receivers and identify detectors basics in optical communication systems.
- Compare different types of light detectors based on their performance.
- Explain the concept of signal coding and quality.
- Explain the design and operation of a sample receiver circuit.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Hecht, Chapter 11	Assignments	Unit 5 Assignment 1: Receivers	2.5%

Unit 6: NOISE AND BIT-ERROR-RATE CALCULATION

Out-of-class work: 9 hours

Upon completion of this unit, students are expected to:

- Explain the concept of random noise in photo detector and electronic circuits.
- Explain the significance of thermal and shot-noise currents.
- Calculate signal-to-noise ratio.
- Compare the binary signals received in the presence of random noise with binary signals received without noise.
- Calculate bit error rate of binary optical signals.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Hecht, Chapter 17	Assignments	Unit 6 Assignment 1: Noise Calculations in Fiber Optics	2.5%
	Quizzes	Unit 6 Quiz 3	6.25%

Unit 7: CONNECTORS, SPLICES, AND PASSIVE COMPONENTS

Out-of-class work: 9 hours

Upon completion of this unit, students are expected to:

- Describe connectors and splices and explain their applications.
- Define and compute fiber-to-fiber attenuation.
- Identify and compute different types of losses in fiber optics.
- Outline and describe mechanical considerations in connectors.
- Distinguish between different connector structures and standards.
- Identify and compare different types of splicing.
- Explain the function of coupling and its applications.
- Compare different coupler types.
- Analyze the function of basic optical attenuators, isolators, and circulators.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Hecht, Chapters 13 and 14	Assignments	Unit 7 Assignment 1: Connectors, Splices, Optical Attenuators, Isolators, and Circulators	2.5%

Unit 8: SINGLE-CHANNEL COMMUNICATION LINK DESIGN

Out-of-class work: 9 hours

Upon completion of this unit, students are expected to:

- Discuss various signaling formats used in fiber-optic transmission.
- Explain the concept of connecting an optical transmitter, optical fibers, connector/coupler, and optical receivers to make a single communication channel.
- Explain optical loss and optical-power budgeting.
- Explain transmission capacity budgeting.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES

	Grading Category	Activity/Deliverable Title	Grade Allocation (% of all graded work)
• Hecht, Chapter 21	Assignments	Unit 8 Assignment 1: Power Budgeting and Transmission Capacity	2.5%
	Quizzes	Unit 8 Quiz 4	6.25%

Unit 9: REPEATERS, REGENERATORS, OPTICAL AMPLIFIERS, AND DISPERSION COMPENSATION

Out-of-class work:
7 hours

Upon completion of this unit, students are expected to:

- Explain the concepts of amplification and regeneration.
- Describe the function of repeaters and regenerators.
- Identify and compare different types of optical amplifiers.
- Explain the concepts of optical regeneration.
- Explain how optical amplifiers can help reduce overall cost by reducing the number of repeaters.
- Explain how dispersion can be compensated in an optical-fiber system.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES		
	Grading Category	Activity/Deliverable Title	Grade Allocation (% of all graded work)
• Hecht, Chapter 12 • Hecht, Chapter 22, pp. 550-560	Assignments	Unit 9 Assignment 1: Amplification, Regeneration, and Wavelength Conversion	2.5%

Unit 10: OPTICAL NETWORKS, FIBER SYSTEM STANDARDS, AND WAVELENGTH-DIVISION MULTIPLEXING (WDM)

Out-of-class work:
9 hours

Upon completion of this unit, students are expected to:

- Explain telecommunication networks structure.
- Identify and describe different transmission topologies.
- Explain the function of fiber-optic communication standards.
- Describe the function of standard layers.
- Identify and explain fiber transmission standards.
- Identify WDM requirements, technologies, and their advantages.

READING ASSIGNMENT	GRADED ACTIVITIES/DELIVERABLES		
	Grading Category	Activity/Deliverable Title	Grade Allocation (% of all graded work)
• Hecht, Chapter 15, pp. 363-375	Assignments	Unit 10 Assignment 1: Network Topologies, Layer Standards, and WDM	2.5%
• Hecht, Chapter 19 • Hecht, Chapter 20	Project	Fiber Optics Research Project (Assigned Unit 7)	25%

Unit 11: REVIEW AND FINAL EXAM			***Out-of-class work:*** 7 hours
READING ASSIGNMENT	**GRADED ACTIVITIES/DELIVERABLES**		
	Grading Category	**Activity/Deliverable Title**	**Grade Allocation** (% of all graded work)
• Review all assigned readings.	Exam	Final Exam	25%

NOTE: Your instructor may add a few learning activities that will change the grade allocation for each assignment in a category. The overall category percentages will not change.

Evaluation and Grading

Evaluation Criteria

The graded assignments will be evaluated using the following weighted categories:

Category	Weight
Assignments	25%
Project	25%
Quizzes	25%
Exam	25%
TOTAL	**100%**

Grade Conversion

The final grades will be calculated from the percentages earned in the course, as follows:

Grade	Percentage	Credit
A	90–100%	4.0
B+	85–89%	3.5
B	80–84%	3.0
C+	75–79%	2.5
C	70–74%	2.0
D+	65–69%	1.5
D	60–64%	1.0
F	<60%	0.0

Academic Integrity

All students must comply with the policies that regulate all forms of academic dishonesty, or academic misconduct, including plagiarism, self-plagiarism, fabrication, deception, cheating, and sabotage. For more information on the academic honesty policies, refer to the Student Handbook and the Course Catalog.

(End of Syllabus)