University of Tehran
School of Electrical and Computer Engineering

Course:	**8101XXX - Optoelectronics**
Course type:	<table><tr><td></td><td colspan="6">EE*</td><td colspan="3">CE*</td><td rowspan="2">Credit: 3</td></tr><tr><td></td><td>Com</td><td>E</td><td>P</td><td>B</td><td>Con</td><td>D</td><td>SW</td><td>HW</td><td>IT</td></tr><tr><td>Required</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td></tr><tr><td>Elective</td><td>☐</td><td>☒</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td></tr></table>
Level:	Undergraduate ☐ Graduate ■
Co-requisite(s):	None.
Prerequisite(s):	Electronic Physics(8101277)
Prerequisite by topic:	-
Textbook(s):	[1] *Physics of Optoelectronic Devices*, S. L. Chuang, 2009. [2] *Semiconductor Optoelectronics: Physics and Technology*, J. Singh, Mc Graw-Hill, 1995. *[3] Electronic and Optoelectronic Properties of Semiconductor Structures*, J. Singh, Cambridge University Press, 2003.
Coordinator:	Dr. Ali Afzali Kusha, Professor, School of ECE
Goals:	The course teaches graduate students the basic physics concepts related to the operation principles of optoelectronic devices, their operation principles, and introduction to optical communication as an important application of these devices.
Outcome:	Upon the successful completion of the course, students should have learned about 1. Quantum mechanics and solid-state electronics basic concepts related to the optical processes in semiconductors 2. Operation principles and efficiency parameters in solar cells 3. Operation principles, efficiency parameters, and types of semiconductor photodetectors. 4. Operation principles, efficiency parameters, and types of LEDs. 5. Operation principles, efficiency parameters, and types of LASERs.
Topics:	1. Review of solid-state electronics a. Material classification and semiconductor comparison b. Crystal growth techniques c. Types of crystal materials 2. Review of quantum mechanics a. Wave-particle duality, electron wave function, and

	Schrödinger equation b. Electron in hydrogen atom and other materials in the periodic table c. Energy band structure theory and wave number (vector) d. Types of particles, Pauli exclusion principle, and Spin e. Distribution function and density of states based on energy 3. Energy band structure a. Models for obtaining energy band structure and Tight Binding method b. Direct and indirect energy gap semiconductor materials c. Wave function symmetry and *k.p* method for calculating energy band structure d. Time-dependent and time-independent perturbation theory e. Band structure modifications using alloying, strain, and electron confinement f. Effective mass 4. Light-material interaction a. Modeling light: photon and wave b. Classical and quantum electrodynamics theories c. 1^{st} and 2^{nd} quantization d. Classical and quantum light theories e. Electromagnetic waves and polarity f. Light photon model g. Absorption and spontaneous and stimulated emission h. Absorption rate and coefficient i. Emission rate and gain coefficient j. Matrix element in bulk and quantum well structures k. Einstein's A/B coefficients 5. Optical transitions a. Interband transitions in bulk semiconductors b. Joint density of states c. Photon density of states d. Interband and intraband transitions in quantum well e. Light absorption and amplification 6. Photodetector a. Types of photodetector b. Photoelectric (external photo effect) c. Internal photo effect d. Efficiency parameters of photodetector e. Photoconductive photodetector f. PN, PiN, Schottky barrier, avalanche photodiodes, … g. Phototransistor, MSM, and infrared quantum well photodetector, … h. Photovoltaic mode (solar cell) i. Efficiency parameters of solar cell j. Photoconductive mode k. Erbium-doped fiber amplifier 7. Light Emitting Diode (LED) a. Injection luminance b. Double heterostructures and their material systems c. Types of optical transitions d. Wavelengths of emitted light

	e. Efficiency parameters f. Packaging g. Communication application h. Edge and surface emitting structures i. Optical fiber coupling 8. LASER a. Two-level system b. Laser operational principles c. Four-level system d. Semiconductor diode laser e. Fabry-Perot cavity f. LED and LASER comparison g. Population inversion h. Lasing operation condition i. Cavity threshold condition j. Gain threshold k. Gain medium inside cavity l. Standing waves and longitudinal and transversal modes m. Performance characteristics n. Output temperature dependence o. Output profile p. Single and double heterojunction structures q. Horizontal (stripe) confinement structures guided by gain and index r. GRINSCH, ECL, C^3, DBR, DFB, … structures s. Quantum well and dot structures t. Current density threshold u. Frequency response v. Chirp and mode hopping phenomena
Computer usage:	None.
Assignments:	None.
Projects:	-
Grading:	Project(+Assignments) 30% Exams 70%
Further readings:	[1] [2]
Prepared by:	Dr. Ali Afzali Kusha, Professor, School of ECE
Date:	September 2017

*EE: Electrical Engineering		CE: Computer Engineering	
Com	Communications	SW	Software
E	Electronics	HW	Hardware
P	Power	IT	Information Technology
B	Bioelectronics		
Con	Control		
D	Digital System		