22.11.2017 Tarihli Yükseköğretim Kurulu Kararıyla Geçerli İlk Eğitim Planı 2017-2018 Eğitim-Öğretim Yılı Bahar Yarıyılı İtibariyle Uygulamaya Geçmiştir.

İZMİR INSTITUTE OF TECHNOLOGY
GRADUATE SCHOOL OF ENGINEERING AND SCIENCES
DEPARTMENT OF PHOTONICS SCIENCE AND ENGINEERING
CURRICULUM OF THE PhD PROGRAM IN PHOTONICS SCIENCE AND ENGINEERING

The Photonics Science and Engineering PhD Program is a jointly operated interdisciplinary program. The Curriculum is supported by the graduate courses available at the Departments of Chemistry, Electrical and Electronics Engineering, and Physics.

Core Courses

PHOT 502	Fundamentals of Photonics I*	(3-0)3 / 9 ECTS
PHOT 503	Fundamentals of Photonics II*	(3-0)3 / 9 ECTS
PHOT 504	Quantum Photonics I*	(3-0)3 / 9 ECTS
PHOT 510	Ethical Issues in Research Methods*	(0-2)NC / 7 ECTS

PHOT 600	PhD Thesis	(0-1)NC / 26 ECTS
PHOT 601	Seminar	(0-2)NC / 8 ECTS
PHOT 8XX	Special Studies	(8-0)NC / 4 ECTS

* If these courses were taken during previous studies, they can be exempted.

Requirements of the Ph.D. program

The students should take at least 7 courses with credits and at least 5 of them must be PHOT5XX coded. The students with M.S. degrees must obtain at least 240 ECTS to graduate.

The students accepted to the Ph.D. program by B.S. degree should take at least 14 courses with credits and at least 10 of them should be PHOT5XX coded. Those students must obtain at least 300 ECTS to graduate.

The course listings for the various PhD Specialization Areas in Photonics are listed below.

Elective Courses

PHOT 505 Applied Photonics	(0-6)3 / 7 ECTS
PHOT 506 Photonic Materials and Devices	(3-0)3 / 7 ECTS
PHOT 507 Computational Photonics	(3-0)3 / 7 ECTS
PHOT 508Mathematical Methods in Photonics	(3-0)3 / 7 ECTS

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Field 1: Molecular photonics and photonic devices:

PHOT 511 Photophysics	(3-0)3 / 7 ECTS
PHOT 512 Molecular Photonics	(3-0)3 / 7 ECTS
PHOT 513 Molecular Electronics and Devices	(3-0)3 / 7 ECTS
PHOT 514 Photovoltaics	(3-0)3 / 7 ECTS
PHOT 515 Thin-film Transistors	(3-0)3 / 7 ECTS
PHOT 516 Radiation Detectors	(3-0)3 / 7 ECTS
PHOT 517 Organic Light Emitting Devices	(3-0)3 / 7 ECTS
PHOT 518 Low-dimensional Materials	(3-0)3 / 7 ECTS

Field 2: Quantum photonics and optical spectroscopy:

PHOT 521 Quantum Photonics II	(3-0)3 / 7 ECTS
PHOT 522 Optical Spectroscopy	(3-0)3 / 7 ECTS
PHOT 523 Nonlinear Optics	(3-0)3 / 7 ECTS

Field 3: Biophotonics and mediphotonics:

PHOT 531 Biophotonics	(3-0)3 / 7 ECTS
PHOT 532 Medical Photonics	(3-0)3 / 7 ECTS
PHOT 533 Biomedical Imaging and Image Processing	(3-0)3 / 7 ECTS

Field 4: Laser engineering and photonic integrated circuits:

PHOT 541 Lasers	(3-0)3 / 7 ECTS
PHOT 542 Laser Engineering	(3-0)3 / 7 ECTS
PHOT 543 Optical Instrumentation	(3-0)3 / 7 ECTS
PHOT 544 Integrated Photonic Circuits	(3-0)3 / 7 ECTS
PHOT 545 Basics of Lighting	(3-0)3 / 7 ECTS

For the students start to program with M.S. degrees

Total credit (min.) : 21 / 240 ECTS

Number of courses with credit (min.): 7

For the students start to program with B.S. degrees

Total credit (min.) : 42 / 300 ECTS

Number of courses with credit (min.): 14

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COURSE DESCRIPTIONS

PHOT 600 PhD Thesis (0-1)NC / 26 ECTS

A research topic which can be experimental and/or theoretical has to be pursued. Under supervision of an advisor/s, students write a thesis about topic that is allocated. The requirements set by the İzmir Institute of Technology should be fulfilled.

PHOT 601 Seminar (0-2)NC / 8 ECTS

The course consists of presentations of new scientific papers from high-profile journals by the students. The purpose of the paper, results, and conclusions must be presented, and a critical discussion of the methods and the results should also be included. Thesis proposal seminar must be presented as well.

PHOT 502 Fundamentals of Photonics I (3-0)3 / 9 ECTS

The basic descriptions of light as rays (geometrical optics), waves (physical optics), and photons. Electromagnetic theory of light. Reflection and refraction of light rays and waves from planar and curved surfaces. Statistical optics and photon optics.

PHOT 503 Fundamentals of Photonics II (3-0)3 / 9 ECTS

Wave propagation through dielectric media and optical waveguides, polarization analysis, generation and detection of light from semiconductor devices and the modulation of light through the electro-optic and acousto-optic effects.

PHOT 504 Quantum Photonics I (3-0)3 /9 ECTS

Particles as waves, Schrödinger's equation. Expectations values, operators, eigenvalues, and stationary states. Dirac formalism. Commutators, unitary transformations, and matrix representation. Symmetry and conservation laws. Free particles, the potential well, and the harmonic oscillator. Quantum theory of light, matter and its interaction.

PHOT 505 Applied Photonics (0-6)3 / 7 ECTS

Design and fabrication of photonic devices such as photodetectors, LEDs and optical circuits; and measurement of optical processes; estimation of process through computational approaches.

PHOT 506 Photonic Materials and Devices (3-0)3 / 7 ECTS

Bulk crystals, single crystals, epitaxial crystals, narrow band-gap, wide band-gap semiconductors, structural characterization, electrical characterization, III-V ternary and quaternary compounds, electron transport within the III-nitride semiconductors, II-IV semiconductors for optoelectronics, II-VI narrow band gab semiconductors, Luminecent materials, quantum wells, band gap engineering, novel materials and selected applications, organic materials for chemical sensing, packaging materials, photoconductivity, electronic properties of semiconductor interphases, charge transport in ordered and disordered materials, graphene-based photonics, materials challenges for solar power, photoelectrochemistry and hybrid solar conversion, lighting.

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PHOT 507 Computational Photonics (3-0)3 / 7 ECTS

Maxwell's equations, waveguides and eigenmodes. Finite-difference time domain method, finite-difference frequency domain method, finite element method, Fourier method, contemporary problems in computational photonics.

PHOT 508 Mathematical Methods in Photonics (3-0)3 / 7 ECTS

Complex analysis, Fourier transform theory, linear algebra, vector algebra, ordinary and partial differential equations (e.g., wave equation), special functions (e.g., Bessel functions), numerical methods for solving ODE's and PDE's, eigensystems.

PHOT 510 Ethical Issues in Research Methods (0-2)NC / 7 ECTS

Ethical issues with some examples will be presented. The ethical rules in conduct will be overviewed.

PHOT 511 Photophysics (3-0)3 / 7 ECTS

Helping the students correlate the following topics: electromagnetic spectrum and interaction between material and solar radiation (AM1.5); absorption and emission in molecular structures; determination of ground state and excited state behaviors; photophysical processes (dipole-dipole interaction, electron exchange, quenching, etc); electron transfer processes that starts photochemical processes; differences of photophysical and photochemical processes and their impact on application areas.

PHOT 512 Molecular Photonics (3-0)3 / 7 ECTS

Light-matter interactions, fundamentals of photonics, basic instrumentation, fluorescence spectroscopy, quenching, anisotropy, fluorescence resonance energy transfer, fluorescence sensing, radiative decay engineering, fluorscence microscopy and nanoscopy.

PHOT 513 Molecular Electronics and Devices (3-0)3 / 7 ECTS

Semiconductor and molecular semiconductor definition and basics. Energy technologies (from source to use) and semiconductors. Semiconductor coatings. Optoelectronic applications. Bio- and medical photonics. Metal oxide based photocatalytic degradations. Photodetectors. Solar cells. Light emitting diode-LED and molecular and polymeric correspondences. Lasers. Transistors.

PHOT 514 Photovoltaics (3-0)3 / 7 ECTS

Introduction on semiconductors and controlling the band structures of semiconductors by dopping. Introduction on photovoltaic effect on semiconductors and basics of solar cells. Types of solar cells and state of the art in solar cell technology. Brief introduction on traditional solar cell technologies: c-Si solar cells and bulk thin film solar cells. Limitations in traditional solar cells. Why new generation photovoltaic technologies are needed. Physical structure, working principles, electronic properties and performance of tandem photovoltaic systems. Introduction to impact ionization (multiple exciton generation, MEG). Chemical and physical structures, working principle and electronic properties of quantum dot and mid-band (intermediate band) solar cells and their relationship with performance of mid-band solar cells. Introduction to ecxitonic solar cells. Chemical and physical structures, working principle and electronic properties of organic and plastic photovoltaic systems and their relationship with performance of Organic, plastic and hybrid photovoltaic systems. Chemical

and physical structures, working principle and electronic properties of dye sensitized and perovskite solar cells. Definition of the parameters to improve the efficiencies of dye sensitized and perovskite solar cells.

PHOT 515 Thin-film Transistors (3-0)3 / 7 ECTS

The subject-specific course on thin-film transistors (TFT) is organized as one-semester course for Master's and Ph.D. students, covering related knowledge of TFT device physics, modeling, circuit design, processing, characterization, and display technologies. A term project is required for the students to understand and deepen the design concept along with the theoretical support within the course.

PHOT 516 Radiation Detectors (3-0)3 / 7 ECTS

Modern scientific research based on single photon detection, low energy x-ray detection for *synchrotron* research, gamma ray detection for nuclear security, terrahertz detection for imaging and material science, ultra sensitive IR detectors for bolometric research, millimeter wave detection for imaging through the barriers will be covered within this master's level course. Superconducting tunnel junctions, Transition edge sensors, scientific CCD, CMOS an Si-strip detectors, superconducting terahertz detectors and hybrid systems for mm wave detectors will be discussed as introductory levels.

PHOT 517 Organic Light Emitting Devices (3-0)3 / 7 ECTS

Making students, familiar to light emitting diodes and their organic correspondences that are used in energy efficient lighting and display technologies; understand the relationships between the chemical structures and physical properties of organic molecules, energy levels, exciton types and their diffusions; decide thin film and pattern preparation technique; apply experimental techniques and calculations for the determination of electrical parameters during device operation; and design organic light emitting devices.

PHOT 518 Low-dimensional Materials (3-0)3 / 7 ECTS

What is dimension, quantum confinement, low-dimensional structures, formation and synthesis of low-dimensional structures, structural, electronic, magnetic, vibrational, optical and transport properties of materials in two, one and zero dimensions.

PHOT 521 Quantum Photonics II (3-0)3 / 7 ECTS

Quantization of light field, quantum states of light, optical coherence theory, atom-photon interaction (quantum and semi-classical theory), open quantum systems. Quantum gases.

PHOT 522 Optical Spectroscopy (3-0)3 / 7 ECTS

Basics of light-matter interaction. Common components of different optical spectroscopy techniques. Spectroscopy systems. Absorption and emission spectroscopy. IR and Raman spectroscopy. Time-resolved spectroscopy. Non-linear spectroscopy. Laboratory work.

PHOT 523 Nonlinear Optics (3-0)3 / 7 ECTS

Overview of basic formalism and classification of nonlinear optical processes; non-phase matched processes, phase-matched processes, slow nonlinear optics, microscopic (quantum) origins of nonlinear susceptibilities. Nonlinear optical susceptibilities; wave propagation and coupling in nonlinear media; harmonic, sum, and difference frequency generation; parametric

amplification and oscillation; phase-conjugation via four-wave mixing; self-phase modulation and solitons.

PHOT 531 Biophotonics (3-0)3 / 7 ECTS

Review of fundemantal optics, light-tissue interaction, basics of microscopy, optical biosensors, fluorescence spectroscopy, FRAP, FRET, optogenetics, neurophotonics, photodynamic therapy, optical microscopy methods, confocal microscopy, nonlinear microscopies, optical coherence tomography.

PHOT 532 Medical Photonics (3-0)3 / 7 ECTS

Review of optics, photon-tissue interactions, medical diagnosis and monitoring therapy, theranostics methods and applications, photodynamic therapy, molecular imaging, MRI, SPECT, PET, endoscopy.

PHOT 533 Biomedical Imaging and Image Processing (3-0)3 / 7 ECTS

Biomedical imaging technologies. Image reconstruction and noise reduction techniques. Segmentation and mathematical morphology. Bioimaging in histopathology. Digitized histological slides: sectioning of tissue samples, immunohistochemical staining, image acquisition. Preprocessing of histology image data. Tissue segmentation. Region segmentation. Segmentation and morphological characterization of cell nuclei. Abnormality detection via pattern classification.

PHOT 541 Lasers (3-0)3 / 7 ECTS

Resonant Optical Cavities, Atomic Radiation, Laser Oscillation and Amplification, Characteristics of Lasers, Laser Excitation, Semiconductor Lasers.

PHOT 542 Laser Engineering (3-0)3 / 7 ECTS

Basics and design of Semiconductor lasers, solid state lasers and fiber lasers.

PHOT 543 Optical Instrumentation (3-0)3 / 7 ECTS

Light sources and detectors, noise, optical components, polarization of light and polarizers, designing and building electro-optical systems.

PHOT 544 Integrated Photonic Circuits (3-0)3 / 7 ECTS

On-chip waveguides, lasers and modulators. Design and analysis of on-chip photonic components and systems. Current literature on silicon photonics and III-V system.

PHOT 545 Basics of Lighting (3-0)3 / 7 ECTS

Covers the fundamentals, generalities, and specific applications; Gives priority to people over lighting technology; Provides up-to-date reviews of the role of lighting in visual performance, visual discomfort and visual perception; Delivers detailed reviews of how the lighting of offices, industry, and roads affects people; Examines the role of lighting as it affects human safety, crime, the elderly, and health; Explores how people react to light pollution and how they use lighting controls.

PHOT 8XX Special Studies (8-0)NC / 4 ECTS

Graduate students supervised by the same faculty member study advanced topics under the guidance of their advisor.