COURSE OUTLINE

(1) GENERAL

SCHOOL	HEALTH & CARE SCIENCES		
ACADEMIC UNIT	BIOMEDICAL SCIENCES		
DIVISION	OPTICS AND OPTOMETRY		
LEVEL OF STUDIES	UNDERGRADUATE		
COURSE CODE	3073-3074	**SEMESTER**	3o
COURSE TITLE	GEOMETRIC AND PHYSICAL OPTICS		

INDEPENDENT TEACHING ACTIVITIES	**WEEKLY TEACHIN GHOURS**	**CREDITS**
THEORETICAL LECTURES + LABORATORY EXERCISES	4+2	7

COURSE TYPE	GENERAL BACKROUND
PREREQUISITE COURSES:	This module requires a basic understanding of high school algebra, trigonometry, general scientific nomenclature, the scientific process, units conversions, and basic concepts in elementary physics and chemistry.
LANGUAGE OF INSTRUCTION and EXAMINATIONS:	GREEK
IS THE COURSE OFFERED TO ERASMUS STUDENTS	NO
COURSE WEBSITE (URL)	https://eclass.uniwa.gr/courses/BISC165/

(2) LEARNING OUTCOMES

Learning outcomes

Upon successful completion of this course, the students should be able to:

• Define the following properties of light:
– Speed
– Frequency
– Wavelength
– Energy
• Describe the dual nature of light, as a continuous wave and a discrete particle (photon), and give examples of light exhibiting both natures.
• Distinguish between light rays and light waves.
• State the *law of reflection* and show with appropriate drawings how it applies to light rays at plane and spherical surfaces.
• State *Snell's law of refraction* and show with appropriate drawings how it applies to light rays at plane and spherical surfaces.
• Define *index of refraction* and give typical values for glass, water, and air.
• Calculate the *critical angle* of incidence for the interface between two optical media and describe the process of *total internal reflection*.
• Describe how total internal reflection can be used to redirect light in prisms and trap light in fibers.
• Describe *dispersion* of light and show how a prism disperses white light.

- Calculate the *minimum angle of deviation* for a prism and show how this angle can be used to determine the refractive index of a prism material.
- Describe what is meant by *Gaussian* or *paraxial* optics.
- Describe the relationship between *collimated light* and the *focal points* of convex and concave *mirrors*.
- Use *ray-tracing techniques* to locate the images formed by plane and spherical mirrors.
- Use the *mirror equations* to determine location, size, orientation, and nature of images formed with spherical mirrors.
- Distinguish between a *thin lens* and a *thick lens*.
- Describe the shapes of three typical *converging (positive)* thin lenses and three typical *diverging (negative)* thin lenses.
- Describe *the* f-*number* and *numerical aperture* for a lens and explain how they control image brightness.
- Use *ray-tracing techniques* to locate images formed by *thin lenses*.
- Describe the relationship between *collimated light* and the *focal points* of a *thin lens*.
- Use the *lensmaker's equation* to determine the focal length of a thin lens.
- Use the *thin-lens equations* to determine location, size, orientation, and nature of the images formed by simple lenses.
- Describe the properties of electromagnetic waves and give everyday examples.
- Explain the mechanism that causes light to be polarized, explain the use of polarizing material, and give an example of the use of polarizers.
- Describe Huygens' principle and the superposition principle.
- Define the terms *reflection*, *refraction*, and *index of refraction* and explain how they are related.
- Explain diffraction and interference in terms of Huygens' principle.
- List the three types of emission and identify the material properties that control the emission type.
- Describe in a short paragraph the electromagnetic spectrum and sketch a diagram of the key optical regions and uses.
- Give a basic explanation of atoms and molecules and their ability to absorb, store, and emit quanta of energy.
- Define the primary equations describing the relationships between temperature of, wavelength of, and energy emitted by a blackbody and a graybody.
- Describe the mechanisms that affect light propagating in a medium and its transmission
- Describe a *wave front.*
- Describe the relationship between *light rays* and *wave fronts*.
- Define *phase angle* and its relationship to a *wave front*.
- Calculate *water wave displacement* on a sinusoid-like waveform as a *function of time and position.*
- Describe how *electromagnetic waves* are *similar* to and *different* from *water waves*.
- State the *principle of superposition* and show how it is used to combine two overlapping waves.
- State *Huygens' principle* and show how it is used to predict the shape of succeeding wave fronts.
- State the *conditions required* for producing *interference patterns*.
- Define *constructive* and *destructive* interference.
- Describe a *laboratory setup* to produce a *double-slit interference pattern*.
- State the *conditions* for an *automatic phase shift of 180° at an interface between two optical media*.
- *Calculate the* thickness of *thin films* designed to *enhance* or *suppress* reflected light.
- Describe how *multilayer stacks* of quarter-wave films are used to *enhance* or *suppress* reflection over a *desired wavelength region*.
- Describe how *diffraction* differs from *interference*.
- Describe *single-slit diffraction* and *calculate positions of the minima* in the diffraction pattern.
- Distinguish between *Fraunhofer* and *Fresnel* diffraction.
- Sketch typical Fraunhofer *diffraction patterns* for a *single slit, circular aperture,* and *rectangular aperture*, and use equations to calculate *beam spread* and *fringe locations*.
- *Describe* a transmission grating *and calculate positions of different orders of diffraction*.
- Describe what is meant by *diffraction-limited optics* and describe the difference between a *focal point in geometrical optics* and a *focal-point diffraction pattern in wave optics*.
- Describe how *polarizers/analyzers* are used with polarized light.
- State the *Law of Malus* and explain how it is used to calculate intensity of polarized light passing through a polarizer with a tilted transmission axis.
- Calculate *Brewster's angle of incidence* for a given interface between two optical media.

General Competences
Obtain basic knowledge, necessary for practicing applied science Search for, analysis and synthesis of data and information, with the use of the necessary technology Adapting to new situations Decision-making Working independently Team work Working in an international environment Working in an interdisciplinary environment Production of new research ideas Project planning and management Criticism and self-criticism Production of free, creative and inductive thinking

(3) SYLLABUS

- Nature, Properties and Propagation of Light
- Dual Nature of Light - Light rays and light waves - Concept of a photon - Characteristics of light waves - Maxwell equations
- The Electromagnetic Spectrum
- Atomic Structure - Interactions of Light with Matter
- Blackbody Radiation - Spectral distribution
- Optical Rays - The Rectilinear Propagation of Light Optical path
- The Speed of Light in Vacuum and in Stationary Media – Index of Refraction
- REFLECTION AND REFRACTION OF LIGHT - The laws of reflection: plane & curved surfaces – mirrors – image formation - Graphical ray-trace method - Sign convention - Magnification of a mirror image
- Refraction of light from optical interfaces - Snell's law – Fermat's Principle - Least time principle
- Critical angle and total internal reflection - fiber optics
- THE PRINCIPLE OF REVERSIBILITY OF LIGHT
- DISPERSION OF LIGHT – PHYSICAL PHENOMENA
- Refraction in prisms - Minimum angle of deviation - Special applications of prisms
- Refraction from spherical surfaces - Thin lenses - IMAGE FORMATION WITH LENSES - Function of a lens - Types of lenses - Converging and diverging thin lenses - Focal points of thin lenses - Image location by ray tracing - Lens formulas for thin lenses - Sign convention – Linear/ Transverse Magnification - Combination of thin lenses - Lenses with thickness - Lens manufacturers' equations
- Gauss – Newton - Lens power - fundamental points - Radius paths - Introduction to the theory of matrices.
- Variation of Reflective index with wavelength - Lenses Aberrations (Spherical, Chromatic, etc. Aberrations)
- LIGHT WAVES AND PHYSICAL OPTICS
- Physics of waves and wave motion - The mathematics of sinusoidal waveforms – Oscillations - Harmonic waves
- INTERACTION OF LIGHT WAVES - The principle of superposition
- Huygens' Principle and wavelets
- INTERFERENCE - Young's double-slit interference experiment - Constructive and destructive interference – Thin-film interference
- DIFFRACTION - Diffraction by a single slit - Fraunhofer and Fresnel diffraction - Diffraction Grating - Diffraction-Limited Optics

- DISTINCTION BETWEEN INTERFERENCE AND DIFFRACTION
- POLARIZATION - Polarization of light waves - Types of Polarization - Methods of Polarizing Light – Malus’ Law - Polarization by reflection and Brewster’s angle
- Absorption of Light - Filters - Scattering of Light - Optical Windows

(4) TEACHING and LEARNING METHODS - EVALUATION

DELIVERY	DIRECT, IN CLASS, FACE TO FACE,
USE OF INFORMATION ANDCOMMUNICATIONS TECHNOLOGY	LEARNING SUPPORT WITH ASYNCHRONOUS EDUCATING PLATFORMS (e-class), LABORATORY EDUCATION
TEACHING METHODS	
STUDENT PERFORMANCE EVALUATION	I. WRITTEN EXAMINATION (problem solving, multiple choice questionnaires, short-answer questions, open-ended questions) II. LABORATORY WORK (written reports on laboratory experiments)

TEACHING METHODS

Activity	***Semester workload***
LECTURES	50
LABORATORY PRACTICE	50
FIELDWORK STUDY & ANALYSIS	80
Course total	180

(5) **ATTACHED BIBLIOGRAPHY**

GREEK

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FOREIGN

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6. Geometrical optics and related topics - Ferruccio Colombini, Nicolas Lerner, editors. - Boston : Birkhduser, 1997
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Waldman, Gary. Introduction to Light. Englewood Cliffs, New Jersey: Prentice Hall, Inc., 1983.