CIMET Photonics and Optics Fundamentals

Course name: Photonics and Optics Fundamentals **Course code:** CIMET POF
Course level: Master **ECTS Credits:** 5.00

Course instructors: Javier Romero (University of Granada)
Education period (Dates): 1st semester **Language of instruction:** English

Expected prior-knowledge: undergraduate course of Physics (waves and electromagnetism), undergraduate course of mathematics (algebra and calculus).

Aim and learning outcomes:

This course develops an understanding of the fundamentals of Optics and Photonics focused on light models (geometrical, electromagnetic, quantum), propagation of light (rays), classical interaction of light with matter (reflection, refraction, absorption, scattering, chromatic dispersion), classical interaction of light with light (interferences, diffraction), paraxial theory of imaging systems and quality of imaging systems (aberrations, resolving power).

On completion of this course the students will be able to:

- know basic optical phenomena involved in the generation of color of objects from a physical point of view.
- understand the fundamentals and the basic tools which explain these phenomena.
- use the basic techniques involved in the geometrical theory of imaging systems.
- have a clear idea of the influence of aberrations and diffraction in the quality of images.

Topics to be taught (may be modified):

- Introduction: Overview of light models: geometrical, electromagnetic and quantum. Basic concepts: refraction index, ray and optical length. Light propagation: rays in homogenous and heterogeneous media. Reflection and refraction laws.
- Fundamentals of Electromagnetic Optics: Electromagnetic waves characteristics. Electromagnetic spectrum. Plane and spherical waves. Intensity. Coherence.
- Polarization: Unpolarized, partially polarized and polarized lights. Types of polarized light: linear, circular and elliptical. Reflection and refraction: Fresnel formulas. Polarization and reflection: Brewster angle. Birefringence. Polarizers. Half- and quarter-wave plates. Liquid crystals.
- Classical interaction of light with matter: Absorption. Chromatic dispersion. Scattering. Polarization in the Atmosphere.
- Interferences and diffraction: Double-slit Young's experiment. Multiple-wave interferences. Disfraction phenomena. Huygens-Fresnel Principle. Fresnel and Fraunhofer diffraction. Fraunhofer diffraction through different apertures: rectangular and circular apertures. Diffraction gratings.
- Imaging systems: Paraxial Optics. Principal planes and points. Focal planes and points. Spherical refractive surface. Mirrors. Prisms. Thin lenses. Thick lenses. Basic optical instruments: the human eye and the photographic camera.
- Quality of imaging systems: Third-order aberrations. Chromatic aberrations. Difraction-limited systems: resolving power.

- Quantum Optics: Photons. Matter quantization. Basic processes between energy levels: absorption, spontaneous emission and stimulated emission.

Lab experiments:

1. Polarization.
2. Difraction
3. Interferences.
4. Imaging systems.

Teaching methods: Lectures and lab classes, and homework exercises.

Form(s) of Assessment: 66.66% written exam (33.33% theoretical questions + 33.33% exercises).
33.33% lab work (22.22 % including reports) + home work (11.11% solving proposed exercises).

Examination:

Two exams along the semester, both 2h long. We consider them as two parts of the same exam, and then each of them has a value of 50% of the final mark. The first part will take place at the end of October and will cover the course program up to interferences (included). The second part will take place before Christmas and will cover the rest of the program.
Each exam will consist in 4 or 5 questions: 2 or 3 theoretical questions and 2 or 3 exercises containing different parts with increasing level of difficulty.
The exams will be done by the students without the help of notes or books.
Second opportunity for the students who fail an exam will take place in November for the first part and at the beginning of the second semester for the second part.

Grading

From 0 to 10 in all the exams and evaluation of reports of the lab work.

Literature and study materials:

Reference book:

"Fundamentals of Photonics" B.E.A. Saleh and M.C. Teich. Wiley, 1991.

Additional books:

"Fundamentals of Optics" F.A. Jenkins and H.E. White, McGraw-Hill 1995.
"Optics" E. Hetch. Addisson Wesley 2002.
"Optics and Photonics. An Introduction" F.G. Smith, T.A. King and D. Wilkins, Wiley 2007.
"Introduction to Color Imaging Science" H-S Lee. Cambridge 2005.

Additional information:

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