Course guide
370005 - OPTIGEO - Geometrical Optics

Last modified: 12/04/2024

Unit in charge: Terrassa School of Optics and Optometry
Teaching unit: 731 - OO - Department of Optics and Optometry.

Degree: BACHELOR'S DEGREE IN OPTICS AND OPTOMETRY (Syllabus 2020). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: Perez Cabre, Elisabet (https://futur.upc.edu/ElisabetPerezCabre)

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REQUIREMENTS

There are no entry requirements to take this course.
The basic concepts of algebra, trigonometry and plane geometry acquired in prior secondary and upper secondary school education will be used.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE04. (ENG) The ability to understand the process of image formation and the properties of optical systems. The ability to understand aberrations in optical systems. The ability to understand radiometric and photometric fundamentals and laws.
CE06. (ENG) The ability to recognise the eye as an optical system. The ability to understand the basic models of vision. The ability to understand ocular models and parameters.
CE07. (ENG) The ability to understand and manage basic laboratory materials and techniques.
CE08. (ENG) The ability to understand light propagation in isotropic media, light-matter interactions, light interference, diffraction phenomena, the properties of single- and multi-layer surfaces and the principles and applications of lasers.

CE10. (ENG) The ability to understand and calculate the most relevant geometric, optical and physical parameters that characterise the different kinds of ophthalmic lenses used in optometric prescriptions and to associate them with the properties involved in the fitting process. The ability to understand the processes of selecting, manufacturing and designing lenses. The ability to calculate the geometric parameters of particular visual compensation systems: vision loss, intraocular lenses, contact lenses and ophthalmic lenses.

Generical:
CG13. Demonstrate and interpret methods for critical analysis and theory development and apply them to the field of optometry.

Transversal:
CT6. Independent learning. Identify and overcome gaps in one's knowledge by thinking critically and choosing the best approach to extending one's knowledge.

TEACHING METHODOLOGY

Medium-group classes include:
MD1 - Participatory lecture on theory and problems.
MD2 - Active methodologies in the classroom (project-based learning [PBL], case studies, roleplaying, cooperative learning, etc.). These sessions will be mostly theoretical. Students can find related information (the schedules and presentations of each unit) on ATENEA.

Small-group classes include:
MD3 - Practical problem-solving class requiring student participation in case studies and/or exercises on topics related to the subject matter.
MD4 - Laboratory practicals.
MD5 - Reading of educational materials, texts and articles related to course topics.
MD6 - Completing problems, exercises and assignments, and resolving doubts via the ATENEA virtual campus.
Small group sessions will be divided into laboratory practicals and sessions for problem-solving and active student learning.
Students can find the scripts for the practicals on ATENEA, and they will be required to print, read and bring them to the laboratory. These scripts will be handed in to the professor, along with the results of the experiment, once the practical session has been completed.
For problem-solving sessions, students will have a sheet with problem statements that they must answer before the scheduled sessions.
Attending small-group practical sessions (whether in the laboratory or solving problems) is compulsory.

Independent learning tasks
Students must dedicate independent learning time to studying course content, completing individual assignments and taking the self-assessment tests available on ATENEA.

Professors will upload all necessary material to ATENEA. ATENEA will also serve as the preferred means of communication regarding any possible changes to the course. Thus, to properly follow the course, students should check ATENEA often.

LEARNING OBJECTIVES OF THE SUBJECT

To understand the laws of geometrical optics. To describe the different elements that make up the optical system (dioptres, mirrors and lenses). To apply the geometric model to explaining light trajectories and the formation of images using paraxial approximation. To understand the propagation of light. To understand the eye as an optical system.

STUDY LOAD

Type	Hours	Percentage
Hours small group	15,0	10.00
Self study	90,0	60.00
Hours medium group	45,0	30.00

Total learning time: 150 h

CONTENTS

FUNDAMENTALS OF GEOMETRICAL OPTICS

Description:
Unit 1. Introduction to optics.
Paradigms in optics. The ray of light in geometrical optics. The refractive index. Parts of an optical system.
Unit 2. Fundamental laws of geometrical optics.
Definition of the five fundamental laws. Light dispersion. Fermat's principle.

Related activities:
Laboratory practicals:
1. Rectilinear propagation. Camera obscura.
2. Reflection and refraction in a semicircle.

Independent learning:
Self-assessment tests.
Solving assigned problems.

Related competencies :
CG13. Demonstrate and interpret methods for critical analysis and theory development and apply them to the field of optometry.
CE08. (ENG) The ability to understand light propagation in isotropic media, light-matter interactions, light interference, diffraction phenomena, the properties of single- and multi-layer surfaces and the principles and applications of lasers.

Full-or-part-time: 27h
Practical classes: 9h
Self study : 18h

PLANE SURFACES AND THEIR COMBINATIONS

Description:
Unit 3. Plane-parallel plates and prisms.
Plane-parallel plates. Deviating prisms. Deviation in thin prisms and applications in visual convergence and strabismus. Dispersive prisms. Totally reflecting prisms.
Unit 4. The plane mirror.
Formation and observation of images. Conjugate elements (object and image). Astigmatism. Visual field of a mirror. Optical levers and mirror displacement. Kaleidoscopes.
Related activities:
Laboratory practicals
3. Prisms.
4. Plane mirrors and kaleidoscopes.

Independent learning:
Self-assessment tests.
Solving assigned problems.

Related competencies :
CG13. Demonstrate and interpret methods for critical analysis and theory development and apply them to the field of optometry.
CE08. (ENG) The ability to understand light propagation in isotropic media, light-matter interactions, light interference, diffraction phenomena, the properties of single- and multi-layer surfaces and the principles and applications of lasers.

Full-or-part-time: 27h
Practical classes: 9h
Self study : 18h

SPHERICAL SURFACES AND THEIR COMBINATIONS

Description:
Unit 5. The spherical dioptre.
The spherical dioptre in the paraxial approximation. Signal criteria. Equations in image forming. Drawing ray diagrams. Vergences. Model of the reduced eye. Association of dioptres. The plane dioptre and plane-parallel plates as specific cases.
Unit 6. The spherical mirror.
The spherical mirror in the paraxial approximation. Equations in image forming. Drawing ray diagrams.
Unit 7. The thin lens.
Characteristics of thin lenses. Equations in image forming. Focal points and distances. Correspondence equations. Modifications. Prentice's rule. Drawing ray diagrams. Schematics of optical instruments with a single lens. Association of thin lenses. Afocal systems and the Badal system. Association of lenses and mirrors: mirror equivalents.

Related activities:
Practical laboratory sessions:
5. Image formation in spherical mirrors.
6. Characteristics of thin lenses. Formation of images.
7. Determining the power of thin lenses. Association of lenses.

Independent learning:
Self-assessment tests.
Exercises on drawing ray diagrams.
Solving assigned problems.

Related competencies :
CG13. Demonstrate and interpret methods for critical analysis and theory development and apply them to the field of optometry.
CE04. (ENG) The ability to understand the process of image formation and the properties of optical systems. The ability to understand aberrations in optical systems. The ability to understand radiometric and photometric fundamentals and laws.
CE10. (ENG) The ability to understand and calculate the most relevant geometric, optical and physical parameters that characterise the different kinds of ophthalmic lenses used in optometric prescriptions and to associate them with the properties involved in the fitting process. The ability to understand the processes of selecting, manufacturing and designing lenses. The ability to calculate the geometric parameters of particular visual compensation systems: vision loss, intraocular lenses, contact lenses and ophthalmic lenses.

Full-or-part-time: 44h
Practical classes: 14h
Self study : 30h

PARAXIAL CHARACTERISATION OF IMAGE-FORMING SYSTEMS

Description:
Unit 8. Optical systems.
Key primary elements (principal planes and focal planes). Other key elements (non-principal planes, nodal points, non-nodal points). Compound systems. The thick lens. Simplified model of the eye.

Related activities:
Independent learning: Self-assessment test.
Solving assigned problems.

Related competencies :
CG13. Demonstrate and interpret methods for critical analysis and theory development and apply them to the field of optometry.
CE06. (ENG) The ability to recognise the eye as an optical system. The ability to understand the basic models of vision. The ability to understand ocular models and parameters.

Full-or-part-time: 22h
Practical classes: 8h
Self study : 14h

ACTIVITIES

LABORATORY PRACTICALS

Description:
Completion of experimental sessions in the Geometrical Optics Laboratory (practicals 1-7). Students will work in groups of 2-3 in the laboratory.

Material:
Professors will upload the scripts for the practicals on ATENEA. Students must read and bring the printed script to each session.

Delivery:
Once the practical session has been completed, this script must be handed in to the professor for assessment, along with the results of the experiment.

Related competencies :
CG13. Demonstrate and interpret methods for critical analysis and theory development and apply them to the field of optometry.
CE07. (ENG) The ability to understand and manage basic laboratory materials and techniques.

Full-or-part-time: 14h
Laboratory classes: 14h

MID-SEMESTER EXAM

Description:
Individual, written mid-semester exam on units 1-4 (theory and problems).

Material:
Students must bring the following.
- The printed-out form that the professor will make available on ATENEA, free of any additional writing.
- A calculator (mobile phones may not be used as calculators).
- A set square and triangle for drawing ray diagrams.

Full-or-part-time: 2h
Practical classes: 2h

FINAL EXAM

Description:
Individual, written final exam on units 5-8 (theory and problems).

Material:
Students must bring the following.
- The printed-out form that the professor will make available on ATENEA, free of any additional writing.
- A calculator (mobile phones may not be used as calculators).
- A set square and triangle for drawing ray diagrams.

Full-or-part-time: 2h
Practical classes: 2h

LABORATORY EXAM

Description:
Individual laboratory exam on the experimental sessions.

Full-or-part-time: 1h
Laboratory classes: 1h

EXAM ON RAY TRACING

Description:
Individual, written exam consisting of exercises on ray tracing.

Material:
Students must bring the following.
A set square and triangle for ray tracing diagrams.

Full-or-part-time: 1h
Practical classes: 1h

ASSESSMENT OF INDEPENDENT LEARNING

Description:
Assessment of independent learning (problems, self-assessment tests on ATENEA, etc.).

Related competencies :
CT6. Independent learning. Identify and overcome gaps in one's knowledge by thinking critically and choosing the best approach to extending one's knowledge.

Full-or-part-time: 10h
Self study: 10h

EUROPEAN DIPLOMA COMPETENCIES

Description:
The subject GEOMETRICAL OPTICS participates in the competences of the European diploma:
- with numbers 1, 2, 3, 4, 5, 6, 7 and 9 of the area A1 Geometrical Optics, which are worked on in units 2-8, with a weight of 3 ECTS.
- with number 1 of the area A2 Physical Optics, which is worked on in Unit 1, with a weight of 0.3 ECTS.
- with number 1 of the area A3 Visual Optics, which is worked on in Units 5 and 8, with a weight of 0.3 ECTS.

GRADING SYSTEM

The final course assessment will include the following marks.
Individual, written mid-semester exam on units 1-4 (theory and problems): P
Individual, written final exam on units 6-9 (theory and problems): F
Individual, written exam with exercises on drawing ray diagrams: G
Individual laboratory exam on the experimental sessions: L
Self-assessment tests on ATENEA/solutions to exercises/participation in problem-solving classes: T

The final mark (N) is obtained using the following formula: N = 0.30 P + 0.30 F + 0.15 G + 0.20 L + 0.05 T

RESIT EXAM
To be eligible for the resit exam, students must meet the general conditions established in the Academic Regulations for Bachelor's and Master's Degrees at the UPC (NAGRAMA) and the specific conditions established by the FOOT (to have been awarded a final mark of at least 3 in the subject). The resit exam will consist of a single exam (100% of the mark) on all of the topics covered throughout the course. Students who pass the resit exam are given a final mark of 5 in the course. Otherwise, they keep the highest mark they received between the previous assessment and the resit exam.

Assessment of the cross-disciplinary independent learning competency will be favourable if students complete all of the course's self-assessment tests and have passed the subject with a final mark of 5 or greater. The mark given for the cross-disciplinary independent learning competency will be the same the final mark received in the course.

Assessment of the European Diploma competencies will be favourable if students have passed the subject with a final mark of 5 or greater.

EXAMINATION RULES.

If any of the laboratory or continuous assessment activities are not completed, students will be given a mark of 0 for the activity. Students must have attended 80% of practicals to be able to take the laboratory exam.

For final and mid-semester exams, the professor will provide students with a form on ATENEA that must be printed and brought to the exam session free of any additional notes.

If copying (either partial or total) is found to have taken place on any course assessment, that which is stipulated in the Academic Regulations for Bachelor's and Master's Degrees at the UPC will apply:
"Irregular actions potentially leading to a significant variation of the marks obtained by one or more students will be considered a breach of the assessment regulations. Such behaviour will result in a descriptive mark of "Fail" and a numerical mark of 0 for the examination in question and for the subject, without prejudice to any disciplinary proceedings that may result from that behaviour.
If students disagree with this decision, they may file a complaint with the dean or director of the school. If students are not satisfied with the response, they may lodge an appeal with the rector.
The total or partial reproduction of academic and research works, or their use for any other purpose, must have the express permission of the author or authors of the works.
The director or dean of the school makes decisions regarding allegations about any aspects not covered in the regulations."

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- Pedrotti, Frank L.; Pedrotti, Leno M.; Pedrotti, Leno S. Introduction to optics. Third edition [re-issued]. Cambridge, United Kingdom ; New York, NY: Cambridge University Press, 2018. ISBN 9781108428262.

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- Falk, David S.; Stork, David G.; Brill, Dieter R. Seeing the light : optics in nature, photography, color vision and holography. Chichester [etc.]: John Wiley & sons, cop. 1986. ISBN 0471603856.
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- Meyer-Arendt, Jurgen R. Introduction to classical and modern optics. 3rd ed. Englewood Cliffs (New Jersey): Prentice-Hall International, cop. 1989. ISBN 013479155X.