Course guides
370007 - 370007 - Wave Optics

Last modified: 07/09/2020

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: 2020 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish

LECTURER

Coordinating lecturer: Vega Lerin, Fidel

Others: Armengol Cebrián, Jesus

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CE04. (ENG) Conèixer el procés de foramció de imatges i propietats dels sistemes òptics. Conèixer les aberracions dels sistemes òptics. Conèixer els fonaments i lleis rediomètriques i fotomètriques.

CE07. (ENG) Conèixer i gestionar material i tècniques bàsiques de laboratori.

CE08. (ENG) Conèixer la porpagació de la llum en mitjans isotròpics, la interacció llum-materia, les interferències lluminoses, els fenòmens de difracció, les propietats de superfícies monocapes i multicapes i els principis del láser i les seves aplicacions.

Generical:
CG11. (ENG) Situar la informació nova i la interpretació de la mateixa en el seu context.

CG13. (ENG) Demostrar i interpretar mètodes d'anàlisis crític, desenvolupament de teories i la seva aplicació al camp disciplinari de l'optometria.

Transversal:
CT5. Efficient use of informacion resources. To manage data and technical and scientific information adquisition, organization, analysis and visualization and to provide a critical appraisal of the results of this management

TEACHING METHODOLOGY

In this course we propose to combine theory sessions with informal lectures of cooperative learning activities and working out exercises, and for the
lab work in small groups.

LEARNING OBJECTIVES OF THE SUBJECT

To be done

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

1. Light described as an electromagnetic wave.

Description:
1.1 Brief review of waves. Plane waves in isotropic dielectric media.
1.2 Electromagnetic waves.
1.3-Energy carried by electromagnetic waves.
1.4-Propagation of light in vacuum and in dielectric media

Specific objectives:
Specific objectives:
Objectives: To describe light as an electromagnetic wave.
- Define the following parameters (with their units): amplitude, wavelength, frequency and timing, speed, initial phase, characteristics of a wave I
- Determine the directions of propagation and vibration fields E and B comprising the light and the relationship between their amplitudes.
- Write the correct equation of E and B fields that make up a light wave (with its module and direction of vibration and propagation).
- Calculate the irradiance of a wave and its relationship with the radiant flux (power).
- Identify the order of magnitude of the wavelength of visible light.

Related activities:
Laboratory:
0 .- Practice Introductory session.

Full-or-part-time: 18h
Practical classes: 4h
Laboratory classes: 2h
Self study : 12h

2. Propagation of light in dielectric and isotropic media

Description:
2.1 Reflection and refraction of light in meters d. i. Fresnel equations.
2.2-Reflectance and Transmittance.

Specific objectives:
R & T Goals:
- Differentiate the external reflection of the internal.
- Define the plane of incidence.
- Determine if I light vibrates parallel or perpendicular to the plane of incidence.
- Understand the definition and formulas to explain the reflectance and transmittance perpendicular and parallel to the plane of incidence.
- Describe the curves of R and T depending on how about (in case of External and Internal Reflection).
- Define the Brewster angle and the conditions for it.
- Learn how to obtain the reflectance and transmittance of natural light.
- Justifying the need of antirreflection treatments in ophthlamic lenses.

Related activities:
Laboratory:
Practice 1 .- Measurement of Rperpendicular and Tperpendicular
Practice 2 .- Measurement of R / / and T / /. Brewster angle.
Practice 3 .- Measurement of R / / T and / / in a metal.

Full-or-part-time: 24h
Practical classes: 5h
Laboratory classes: 7h
Self study : 12h

3. Propagation of light in anisotropic dielectric media. Polarization of light.

Description:
3.1-What studies the polarization?
3.2-Type polarization:
3.3-What is a polarizer?
3.4-polarized wave equations.
3.5-linear polarizers. Ways to obtain linear polarized light:
3.6-retardant sheets.
3.7-Applications of the polarization (in the studio fotoelasticitat optics, 3D vision, filters ...)

Specific objectives:
Polarization Objectives:
- Explain exactly what is polarized light in comparison with natural light.
- Express any polarized light as a sum of two harmonic & orthogonal plane waves with the correct amplitudes and relative phase difference.
- Explain the four processes to obtain linear polarized light from natural light. Know how to calculate the state of polarization and the irradiance resulting from a wave systems in two and three linear polarizers.
- Explain the working principle of the wave plates. Find the state of polarization of light through polarizing plates and wave plates.
- Find and explain applications of polarized light in other areas and subjects of the Degree

Related activities:
Laboratory:
Practice 4 .- Law of Malus.
Practice 5 .- Wave plate Lamba/2.
Practice 6 .- Wave plate Lambda/4.

Full-or-part-time: 34h
Practical classes: 7h
Laboratory classes: 7h
Self study : 20h

4. Interference with light waves

Description:
4.1-Principle of superposition. Duality wave-particle.
- Calculation of the intensity resulting in two overlapping waves:
- Conditions to observe interference
4.2-interferometers by wavefront division.
- Young's double slit:
- Interference pattern with white light. Justification.
4.2-Interferometer by amplitude division:
Interferometer Michelson - Morley:
Dielectric films.
4.3-Multilayer coatings. Interference effects in Optics and Ophthalmic optics.

Specific objectives:
Objectives
- Interference between two waves according to their phase difference. Interference term.
- Explain the conditions (coherence, same frequency ...) that are necessary fortwo waves to interfere.
- Determine from the interfringe, the wavelength and the separation between slits.
- Irradiance of the interference pattern with a double slit: the role of the phase difference.
- Double slit's interference pattern with both, monochromatic and white light.
- Problem intended to be solved with a thin anti/super reflectance layer
- Find the phase difference in the case of a thin layer with (close to) normal incidence.
- Ratio between the indices of the thin layer and the glass to have either an anti or super reflectance effect.
- Thickness of the thin layer derived from the interference maxima / or minima
- Wavelength dependence of the condition of interference.

Related activities:
Laboratory:
Practice 7 .- Young's double slit.
Practice 8 .- Biprisma Fresnel.
Practice 9 .- Interference in thin layers.

Full-or-part-time: 34h
Practical classes: 7h
Laboratory classes: 7h
Self study : 20h

5. Light diffraction

Description:
5.1 Fraunhofer diffraction from single apertures.
- The principle of Huygens - Fresnel.
- Condition for Fraunhofer diffraction.
- Diffraction of a single slit.
- Diffraction of an opaque barrier. Babinet's theorem.
- Diffraction from a pinhole.
- Rayleigh resolution criterion. Resolution limited by diffraction.
- Diffraction patterns under white light illumination.
5.2 Diffraction for 2.3, ... N slits. The diffraction grating.
- Two slits. Figure diffraction & interference from two slits.
- The diffraction grating:
- Power resolution color.
5.3 Diffractive intraocular lenses

Specific objectives:
Diffraction Goals:
- Describe the diffraction in a phenomenological way and to interprete it according to the Huygens-Fresnel model.
- Describe the Fraunhofer diffraction patterns of objects of simple geometry
(rectangular slit, double slit, diffraction grating and pinhole).
- Distinguish the diffraction versus the interference phenomena in systems of multiple slits.
- Calculate the wavelength and the size of the openings from the figures of diffraction.
- Apply the Rayleigh resolution limit to determine whether two points are resolved by imaging optical systems
- Diffractive intraocular lenses

Related activities:
Laboratory:
Practice 10 .- Diffraction by 1,2, ... N slits.
Practice 11 .- Diffraction grating.
Practice 12 .- Diffraction from a circular opening.

Full-or-part-time: 34h
Practical classes: 7h
Laboratory classes: 7h
Self study : 20h

ACTIVITIES

Competences of the European diplomaname english

Description:
The Physical Optics subject participates totally or partially in the competence (1) wave optics and aberrations that is worked on in content 1. Light an electromagnetic wave with a weight of 1.8 ECTS
The Physical Optics subject participates totally or partially in the competence (2) interaction of light on matter that is dealt with in content 2. Propagation of light in isotropic dielectric media weighing 2.4 ECTS.
The Physical Optics subject participates totally or partially in the competence (3) polarization and (4) transmission through successive polarizers that is worked on in content 3. Propagation of light in anisotropic dielectric media. Light polarization with a weight of 3.4 ECTS.
The Physical Optics subject participates totally or partially in the competence (5) image quality and (6) diffraction and interference that is worked on in content 4. Interferences with light waves and 5. Diffraction of light with a weight of 6.8 ECTS.

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

COVID ADDENDA

Description:
The evaluation will be made through continuous assessment.
• ALFA=Scripts of the Practices carried out so far, deliverables and other on-line activities proposed at Atenea: 80%
(In no case will a deliverable have a decisive weight in the final grade).
• BETA= On-line exam: 20%.
Multiple-choice questions test covering the entire syllabus of the subject. Between the test questions there will be small basic problems and characteristics of each topic

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

GRADING SYSTEM

The evaluation will be based on continuous assessment.
The evaluation of the course is divided equally between the theory sessions (T) and laboratory (L).
The rating of theory (T) will be made from at least two tests. The laboratory rating will be based on at least two practice tests. No test will represent a weight of over 30% of the final mark.
The final (N) obtained by the formula:
N = 0.5T + 0.5 L
ASSESSMENT TRANSVERSAL SKILLS: It will be accomplished upon obtaining a final mark of 5 in the subject.

EXAMINATION RULES.

In case of partial or total copy of any evaluations of the course, will apply the provisions of General Academic Regulations UPC: perform any act of fraudulently assessment involves, at least a score of 0 in that self evaluation, and possibly more severe disciplinary processes. 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 the subject, without prejudice to any disciplinary proceedings that may result from that behaviour.
If a student disagrees with this decision, he or she may file a complaint with the dean or director of the school. If the student is not satisfied with the response, he or she may lodge an appeal with the rector.
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The director or dean of the school makes decisions regarding allegations about any aspects not covered in the regulations.

BIBLIOGRAPHY

Basic:
- Hewitt, Paul G; Escalona García, Héctor Javier. Física conceptual . 3ª ed. México [etc.] : Addison-Wesley Longman de México, cop. 1999. ISBN 968444298X.
- Hecht, Eugene. Óptica. 3A ED. Madrid. Addison-Wesley Iberoamericana, 2000. ISBN ISBN 8478290257..
- Pedrotti, Leno S; Pedrotti, Frank L. Optics and vision . Upper Saddle River, N.J. : Prentice Hall, cop. 1998. ISBN 0132422239.
- Tipler, Paul Allen; Mosca, Gene. Física per a la ciència i la tecnologia . Barcelona [etc.] : Reverté, 2010. ISBN 9788429144321.

Complementary:
- Carreño, Fernando; . Óptica física : problemas y ejercicios resueltos . Madrid [etc.] : Prentice Hall, cop. 2001. ISBN 8420531812.
- Meyer-Arendt, Jurgen R. Introduction to classical and modern optics . 4th ed. Englewood Cliffs : Prentice-Hall International, cop. 1995. ISBN 013124356X .
- Calvo Padilla, María Luisa. Óptica avanzada . Barcelona : Ariel, 2002. ISBN 8434480522.
- Pedrotti, Frank L; Pedrotti, Leno M; Pedrotti, Leno S. Introduction to optics . 3rd ed. San Francisco : Pearson Prentice-Hall, cop. 2007. ISBN 0131499335 .
- Vázquez, Carmen. Óptica física : cuestiones y problemas . Alicante : Universidad de Alicante, cop. 2006. ISBN 8479088613 .

RESOURCES

Other resources:
Software & videos available on the intranet and library