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230553 - BEAMFO - Beam Propagation and Fourier Optics

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 1022 - UAB - (ANG) pendent
Academic year: 2019
Degree: MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Teaching unit Compulsory)
ERASMUS MUNDUS MASTER'S DEGREE IN PHOTONICS ENGINEERING, NANOPHOTONICS AND BIOPHOTONICS (Syllabus 2010). (Teaching unit Optional)
MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: Juan Campos, UAB.

Others: Salvador Bosch, UB.

Degree competences to which the subject contributes

Basic:

CB7. (ENG) Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.
CB6. (ENG) Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación

Specific:

CE4. (ENG) Màster en Fotònica:
Demostrar que conoce los fundamentos de la formación de imagen, de la propagación de la luz a través de los diferentes medios y de la Óptica de Fourier.

Generical:

CG2. (ENG) Màster en Fotònica:
Capacidad para la modelización, cálculo, simulación, desarrollo e implantación en centros de investigación, centros tecnológicos y empresas, particularmente en tareas de investigación, desarrollo e innovación en todos los ámbitos relacionados con la Fotónica.

Transversal:

1. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
2. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.
5. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.
4. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

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Teaching methodology

- Lectures
The students should bring their own desktop computer. Along the lectures, we will use scripts to show the explained concepts. The computer languages we will use are Python and Matlab/Octave. Octave is a free clone of Matlab. In particular, OctaveUPM also have the user interface. You can download it in https://mat.caminos.upm.es/octave/. The concepts to program in these languages will be given in the first part of the course.
The student should select 5 items of the course index shown below, and present the homework?s and exam corresponding to them. The student may attend to the other items if he/she wishes.

Learning objectives of the subject

The subject will address the basics of geometrical optics, intermediate topics of electromagnetic optics, polarization of light and anisotropic media, the fundamentals of light beam propagation and elements of Fourier optics, including concepts of digital holography.
The aim is to develop several topics (which are key for the future subjects of the Master) that usually are not covered in previous physics or engineering courses.

Study load

Total learning time: 125h	Hours large group:	40h	32.00%
	Self study:	85h	68.00%

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Content

1. Python.	Learning time: 8h Theory classes: 8h

Description:
1.1 Python programming
1.2 Matrices. Graphics. Basic algorithms.
1.3 Introduction to Matlab/Octave

2. Geometrical optics.	Learning time: 8h Theory classes: 8h

Description:
2.1.- Basic concepts. Ray tracing.
2.2.- Perfect and real optical systems. Aberrations. Seidel and Zernike polynomials.
2.3.- Review of image forming instruments.

3.- Electromagnetic optics.	Learning time: 8h Theory classes: 8h

Description:
3.1.Propagation in media with complex refractive index.Inhomogeneous plane waves.Energy flux.
3.2. Fields near interfaces. Reflection and refraction.Fresnel equations.
3.3. Evanescent waves.

4. Polarization of light.	Learning time: 8h Theory classes: 8h

Description:
4.1.TE and TM electromagnetic waves in layered structures.Thin films.
4.2. Guided waves.
4.3.- Polarization Ellipse. Jones vectors. Jones matrix. Combinations of polarizing devices.
4.4.- Stokes parameters. Mueller matrices. Poincaré sphere.

5. Anisotropic media.	Learning time: 6h Theory classes: 6h

Description:
5.1.- Anisotropic media: Susceptibility of an anisotropic media. Wave propagation, normal modes. Index ellipsoid. Effective refraction index.
5.2.- Distortion of the index ellipsoid. Pockels effect. Liquid crystals.

6.- Fourier Transform.	Learning time: 6h Theory classes: 6h

Description:
6.1.- Definition and FT of some functions.
6.2.- The FT as a decomposition. Wave Packets. 2D FT of images.
6.3.- Convolution and correlation between two functions.
6.4.- Linear systems. Impulse response. Transfer function.

7- Beam propagation and focalization.	Learning time: 7h Theory classes: 7h

Description:
7.1.- Angular spectrum of plane waves.
7.2.- Field propagators.
7.3.- Gaussian beams. Description and properties. Transmission through a thin lens.
7.4.- Other beams with particular polarization (radial, azimuthal,...)
7.5.- Focusing of fields through high numerical aperture systems.

8. Fourier Optics.	Learning time: 8h Theory classes: 8h

Description:
8.1.- Coherent optical processing. Point spread function and optical transfer function. Resolving power of optical instruments.
8.2.- Holography (basic concepts). Digital holography.

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Qualification system

- Homework (35%).
- Exam (65%)

To pass the course will require a quite accessible level of knowledge but high final grades will be obtained only by demonstrating enough proficiency.

Regulations for carrying out activities

The exam will have two parts corresponding to each Professor. The material the student may have during the exams will be expalined at the begining of the course.

Bibliography

Basic:

Hetch, E. Optics. 5th ed. Pearson, 2016. ISBN 9781292096933.

Born, M.; Wolf, E. Principles of optics: electromagnetic theory of propagation, interference and diffraction of light. 7th. Cambridge University Press, 1999. ISBN 9780521642224.

Goodman, J. W. Introduction to Fourier optics. 3rd. Roberts and Company Publishers, 2005. ISBN 9780974707723.

Lizuka, Keigo. Elements of photonics Volume I. Wiley-Interscience, 2002. ISBN 9780471839385.

Saleh B.; Teich M. Fundamentals of photonics. John Wiley & Sons, 2007. ISBN 9780471358329.

Novotny L., Hecht B. Principles of nano-optics. Cambridge University Press, 2012. ISBN 9781107005464.

Goldstein D. H. Polarized light. 3rd. Marcel Dekker, 2011. ISBN 9781439830406.

Mahajan, v.n. Aberration theory made simple. SPIE, 2011. ISBN 0819488259.