



## 230550 – INTRO – Introduction to Photonics. Optics and Lasers

<b>Coordinating unit:</b>	230 - ETSETB Barcelona School of Telecommunications Engineering
<b>Teaching unit:</b>	721 - FEN - Department of Physics and Nuclear Engineering
<b>Academic year:</b>	2015 - 2016
<b>Degree:</b>	Master's Degree in Photonics Erasmus Mundus Master's Degree in Photonics Engineering, Nanophotonics and Biophotonics
<b>ECTS credits:</b> 5	<b>Teaching languages:</b> English

### Academic staff

<b>Coordinator:</b>	<a href="#">Ramon Vilaseca</a> (UPC)	<a href="mailto:ramon.vilaseca@upc.edu">ramon.vilaseca@upc.edu</a>
<b>Other professors:</b>	<a href="#">Alex Turpin</a> (UAB)	<a href="mailto:alejandro.turpin@uab.cat">alejandro.turpin@uab.cat</a>

### Degree competences to which the subject contributes

#### 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.
3. 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.

### Teaching methodology

#### Lectures

#### Activities:

- Research center or laboratory visits
- Seminars

### Objectives and short description of the course

This course presents a general overview of the world of Photonics, introducing the fundamental aspects and physical phenomena concerning light and its interaction with matter (excluding pure propagation phenomena in uniform materials, in particular beam propagation, image formation and Fourier Optics, as they are considered in the course "Beam propagation & Fourier Optics"). At the same time, in many of the subjects the state-of-the art in research and the variety of applications of Photonics in Science & Technology are pointed out.

The course is given in the first semester, to allow the student better follow the different Master courses, in any of the itineraries he/she can choose)

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### Study load

Total learning time: 125h	Hours large group:	37.5h	30%
	Hours medium group:	0h	0%
	Hours small group:	0h	0%
	Guided activity:	3.75h	3%
	Self study:	83.75h	67%

### Course index

#### 1. Light

- 1.1. Light from geometric and electromagnetic approaches (short review). Wave equation and electromagnetic waves. Classical properties of light and related quantities.
- 1.2. Quantum properties of light (introduction): photons, particle character and states of light, uncertainty and measurement.

#### 2. Light-matter interaction. Basic physical phenomena

- 2.1. At atomic scale: linear interaction phenomena between light and one atom or molecule. Classical and semiclassical approaches.
- 2.2. Consequences at macroscopic scale: complex refractive index, dispersion and light velocities. Main physical phenomena (introduction) arising in the interaction of light with: dielectrics, semiconductors and metals (excitons, polaritons, plasmonics). Idem with confined materials and structures (quantum dots, etc.), and with metamaterials.
- 2.3. Introduction to Nonlinear optics and dynamics. Perturbative phenomena, notion of solitons.

#### 3. - Light-matter interaction. Basic applications

- 3.1. Photoemitters by spontaneous emission (introduction): Thermal, LED's, etc.
- 3.2. Photoemitters by stimulated emission: Lasers. Fundamentals, types, performances. Short-generation
- 3.3. Photodetectors (introd.): Power –or point- photodetectors (thermal, quantum), position & im detectors.
- 3.4. Reading, measuring and sensing with light. Beyond the optical resolution limit.
- 3.5. Action over the center of mass (short introduction): cooling & trapping of atoms, optical tweezers.
- 3.6. Bounded and non-uniform media (introduction):
- 3.7. Light propagation and information transmission in optical fibers.
- 3.8. Light propagation in photonic crystals. (Random materials)

#### 4.- Scientific and technological applications, research trends (broad overview)

- 4.1. Photonics applications in different sectors: industry (sensors, metrology, material processing, lightning & energy), information technologies & telecomm., vision, chemistry (analysis, remote sensing),...
- 4.2. New fields: Nanophotonics, Biophotonics, Quantum information, etc.



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### Qualification system

Homework + exam ( $\approx 70\%$ ).

Attending seminars, lab visits, possible oral or video presentation, class attendance ( $\approx 30\%$ )

### Bibliography

- Fundamentals of Photonics, B. E.A. Saleh and M.C. Teich (Wiley, 2nd ed., 2007).
- Optoelectronics & Photonics: Principles & Practices, Safa O. Kasap (2nd ed., 2012)
- Principles of Lasers, O. Svelto (Springer, 5th ed., 2010).
- The Quantum Theory of Light, R. Loudon (Oxford Sci. Publ., 3rd ed. 2000)