



- 1. Code:** 35681      **Name:** Advanced fiber optics
- 2. Credits:** 6,00      **–Lecture:** 3,00      **–Practice:** 3,00      **Type of Course:** Elective
- Degree:** 2314-Master's Degree in Telecommunication Engineering
- Module:** 3-Elective Module      **Subject:** 5-Elective training
- University Center:** SCHOOL OF TELECOMMUNICATIONS ENGINEERING
- 3. Coordinator:** Llorente Sáez, Roberto
- Departament:** COMMUNICATIONS

#### 4. References

Advanced Fiber Optics: Concepts and Technology

Berghmans, Francis | Dudley, John | Février, Sébastien | Geernaert, Thomas | Gentry, Goery | Gonzalez Herraiez, Miguel | Hotoleanu, Mircea | Kalli, Kyriacos | Marhic, Michel | Sylvestre, Thibaut | Thévenaz, Luc | Tur, Moshe | Webb, David | Wuilpart, Marc  
Derickson, Dennis | Derickson, Dennis  
Agrawal, Govind P.  
Agrawal, Govind P.

Fiber optic test and measurement  
Fiber-optic communication systems  
Nonlinear fiber optics

#### 5. Course Outline

##### Course objectives

In this course, optical fiber transmission will be studied alongside advanced applications enabled by state-of-the art optical fiber technology. These include long-reach optical transmission systems like submarine cabling, medium-reach optical networks, and short-range fiber optics employed in backplane, inter-rack and in-package optical interconnects supporting Machine Learning/Artificial Intelligence processing.

The course targets knowledge acquisition at three levels: First, studying the theoretical basis, second evaluating case studies by simulation, and third by experimental work in the laboratory. The course contents address optical transmission characteristics, including non-linear phenomena (XPM, XGM, FWM, Brillouin, Raman), considering single-mode optical media, and also multi-mode, few-mode and multicore optical fiber technology. Advanced optical transmission systems are discussed considering the different optical modulations employed, and also the different multiplexing schemes (WDM, TWDM, PDM, SDM, OAM). The course also covers optical fiber fabrication technology in order to provide a complete view to the student.

##### Contextualization of the course

This subject is an optative course of the Photonics Specialty in the second year of the Master's Degree in Telecommunication Engineering. This course permits the alumni to gain deep knowledge and hands-on experimental experience in most advanced fiber-based optical transmission technology, as the subject has been designed with the combined focus in theory, simulation and hands-on laboratory work following the experimental work schedule.

The subject is lectured in English. Students can interact in English, Spanish and Valencian languages.

#### 6. Recommended Prior Knowledge

#### 7. Results

##### Fundamental results

BA1(GE) Knowledge and understanding which provides a basis or opportunity to be original in the development and/or application of ideas, often within a research context.

##### UPV-Generic Student Outcomes

##### (5) Responsibility and decision-making

- Activities carried out to achieve the student outcome

The students following this course are presented with a multiple approach to advanced fiber optics: Different sessions cover theory, simulation and experimental work, which are interdependent and complementary. The student is responsible for completing during the lecturing time scheduled the different work assignments. At the end of each module, a short written problem or question will be proposed in the classroom. The students will justify their decision-making while providing their answer. Also during the experimental sessions, different activities are proposed to the students, falling in their responsibility how to perform them depending on the measurements or the evaluation required. The most appropriate experimental implementation will be shown in the lab following a guided decision-making process.





## 7. Results

### UPV-Generic Student Outcomes

- Assessment criteria

Responsibility is assessed by a short written problem or question after each laboratory session, and proper decision making is assessed by the proposed activities at the end of each module of the course.

Specific Learning Outcomes

RA5.1 - Identify, formulate and solve complex problems autonomously, applying the principles of the discipline.

## 8. Syllabus

1. Introduction and state-of-the-art
  1. Basic concepts
  2. Optical fiber classification based on number of modes, refractive index profile, core/cable distribution or material
  3. Multicore (MCF), few-mode (FMF) and large-mode fibers
  4. Mode coupling theory (CMT)
  5. Optical amplification basis
2. Advanced optical transmission and processing
  1. Optical modulation schemes
  2. Time, wavelength and polarization multiplexing (SMF-based)
  3. Spatial and orbital angular momentum multiplexing (specialty fiber-based)
  4. Non-linear elastic effects (XPM, XGM, FWM)
  5. Non-linear inelastic effects (Raman, Brillouin)
3. Dispersion-managed long-reach transmission systems
  1. Dispersion map planning and compensation devices
  2. Long-reach amplification schemes
4. Advanced applications and specialty fibers
  1. Optical interconnects and PIC coupling
  2. Fiber coupling to integrated photonic devices
  3. Specialty fiber for bio and health applications
  4. Conventional and specialty fiber fabrication

## 9. Teaching and Learning Methodologies

<u>UN</u>	<u>LE</u>	<u>SE</u>	<u>PS</u>	<u>LS</u>	<u>FW</u>	<u>CP</u>	<u>AA</u>	<u>CH</u>	<u>NCH</u>	<u>TOTAL HOURS</u>
1	6,00	--	4,00	4,00	--	--	1,00	15,00	20,00	35,00
2	8,00	--	6,00	4,00	--	--	2,00	20,00	40,00	60,00
3	8,00	--	4,00	2,00	--	--	2,00	16,00	20,00	36,00
4	8,00	--	4,00	2,00	--	--	1,00	15,00	20,00	35,00
<b>TOTAL HOURS</b>	<b>30,00</b>	<b>--</b>	<b>18,00</b>	<b>12,00</b>	<b>--</b>	<b>--</b>	<b>6,00</b>	<b>66,00</b>	<b>100,00</b>	<b>166,00</b>

UN: Unit. LE: Lecture. SE: Seminar. PS: Practical session. LS: Lab sessions. FW: Field work. CP: Computer-mediated practice. AA: Assessment activities. CH: Contact hours. NCH: Non contact hours.

## 10. Assessment

### Outline

	<u>Num. Acts</u>	<u>Weight (%)</u>
(05) Academic work	1	30
(15) Practical laboratory/field/computing/classroom test	14	30
(14) Written test	4	40

The course evaluation comprises:

a) Academic work (30%): An academic work including an oral presentation about a topic of free choice related with the subject will be presented in class at the end of the course. This work will be done in group or individually and will be assessed using an evaluation grid provided in advance (Poliformat) with the topic assignment of the academic work.

b) Achievement tests/theory (40%): At the end of each module, a short written test/problem about the contents of that module will be proposed. All the tests will have the same weight on the final mark.

c) Practical laboratory activities (30%): Collection of weekly activities related to the concepts tackled in the lectures or lab sessions. Around 14 activities will be proposed and done in the classroom during the practical sessions (PS) and laboratory sessions (LS) along the course. The dates of these evaluation activities will be announced in advance in the introduction of the





## 10. Assessment

subject.

The students will be able to perform a remedial evaluation act covering 70% of the subject. In the case of the Academic work, the remedial evaluation is a resubmission following lecturers' guidance. The achievement tests and activities from the end of each module (40% weight) can be remedied in a final evaluation act comprising a written exam. If scheduled, the rest of students can take the written exam in order to improve their final grade. In this case, the marks from the remedial evaluation act will be final (which means upwards or downward modification of the previous grade). The student willing to improve their score must notify the teaching staff 3 days before the final evaluation act date. In the case of the practical laboratory tests, the remedial evaluation consists in a written exam covering the subjects addressed in the laboratory.

ALTERNATIVE EVALUATION: Students with an attendance waiver will be required to study the provided materials. They will be evaluated in different acts: One includes an exam covering theoretical concepts (40%) addressed during the course, another covers the laboratory practical contents (30%) and the academic work (30%). Preparation of the academic work requires following the same procedures and submission dates than conventional attendance students.

## 11. Absence threshold

<u>Activity</u>	<u>Percentage</u>	<u>Observations</u>
Seminar Theory	0	
Lecture Practice	0	
Laboratory Practical	10	Justified absence will not be taken into account
Computer Practice	0	
Field Practice	0	

