Universidad de Alcalá

# TEACHING GUIDE

# Radiation and Radiocommunication

## Degree in
## Telecommunication Technologies Engineering

## Universidad de Alcalá

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## Academic Year 2021/2022

4th Year - 1st Semester

Approved by the School Board on July 6, 2021

# TEACHING GUIDE

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| Course Name: | **Radiation and Radiocommunication** |
| Code: | **350037** |
| Degree in: | **Telecommunication Technologies Engineering** |
| Department and area: | **Teoría de la Señal y Comunicaciones**<br>**Signal Theory and Communications** |
| Type: | **Optional (Specialized)** |
| ECTS Credits: | **6.0** |
| Year and semester: | **4th Year, 1st Semester** |
| Teachers: | David de la Mata Moya<br>Judith Redoli Granados |
| Tutoring schedule: | david.mata@ uah.es; judit.redoli@ uah.es |
| Language: | Spanish/English friendly |

# 1. COURSE SUMMARY

Today, communications services users (internet, telephony, multimedia data transmission) demand network access from anywhere more and more. No doubt, radiocommunications systems are the solution for rural and less populated areas. Trunk radiolinks are also necessary in those places where cabled trunk networks are not an option.

Radiation and Radiocommunication course introduces the student to the basics of radio systems that use troposphere as the transmission medium. The course starts with the comprehension of the basic parameters and way of working principles of antennas. Then the main propagation models for fixed radiolinks are introduced. Finally the course deals with the influence of noise and interferences, and availability calculations. The course is oriented to a case study in which the students apply the learned concepts to the fixed systems in the real world.

**Prerequisites and Recommendations:**

It is recommended that you complete successfully the courses Wave propagation and Digital Communications before attending Radiation and Radiocommunication course.

# 2. SKILLS

### Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Orden CIN/352/2009:

**en_TR2** - Knowledge of basic subjects and technologies that enables to learn new methods and technologies, as well as to provide versatility that allows adaptation to new situations.

**en_TR3** - Aptitude to solve problems with initiative, decision making, creativity, and to communicate and to transmit knowledge, skills and workmanship, comprising the ethical and professional responsibility of the activity of the Technical Engineer of Telecommunication.

**en_TR5** - Easy to handle specifications, regulations and mandatory standards.

**en_TR8** - Capacity of working in a multidisciplinary and multilingual team and of communicating, both in spoken and written language, knowledge, procedures, results and ideas related to telecommunications and electronics.

### Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Orden CIN/352/2009:

**en_CST1** - Ability to build, operate and manage telecommunications networks, services, processes and applications, understood as systems for capturing, transporting, representing, processing, storing, managing and presenting multimedia information, from the point of view of transmission systems .

**en_CST4** - Capacity for the selection of circuits, subsystems and systems of radiofrequency, microwaves, radio broadcasting, radio links and radiodetermination.

**en_CST5** - Ability to select antennas, equipment and transmission systems, propagation of guided and unguided waves, by electromagnetic means, radiofrequency or optical and the corresponding radioelectric space management and frequency assignment.

### Learning Outcomes

Upon successful completion of this course, students will display the following learning outcomes:

**RA1.** Classify the different types of antennas according to their basic parameters and their application in different radiocommunication services.

**RA2.** Calculate the propagation losses in a radiolink according to free space model and curved Earth two ray model including the additional frequency dependent attenuations present in radio systems.

**RA3.** Determine the influence of Earth topography on a radio link

**RA4.** Calculate the influence of noise and co-channel interference in radio communication systems.

**RA5.** Maximize the quality of frequency division medium access satellite radiolinks

**RA6.** Evaluate different antenna height solutions for a radio link composed of several hops and its influence on viability for one of several suggested transceivers.

## 3. CONTENTS

| Contents Blocks | Total number of hours |
|---|---|
| **UNIT 1. SPACE WAVE PROPAGATION.**<br>Curved Earth Two-ray model. Divergence due to the curvature of the Earth. Influence of antenna radiation patterns on propagation. Propagation by diffraction in multiple obstacles. | 4 hours |
| **UNIT 2. ANTENNAS IN RADIOCOMMUNICATION SYSTEMS**<br>Types of antennas depending on the frequency band. Parameters and characteristics of radiation. | 4 hours |
| **UNIT 3. MODELING PROPAGATION IN FIXED RADIOLINKS**<br>Propagation models based on computing free space and additional excess path losses. Attenuation due to rain. Attenuation due to atmospheric gases. Attenuation due to vegetation. Modeling the variability of the signal over time. Margin due to fading. | 6 hours |
| **UNIT 4. INFLUENCE OF NOISE AND INTERFERENCES IN RADIOLINKS**<br>Calculation of noise power in radiocommunication systems. Calculation of carrier to noise ratio. Interference in radiolinks. Types of interference. Calculation of carrier to interference ratio. | 4 hours |
| **UNIT 5. ANALYSIS OF TERRESTRIAL AND SATELLITE RADIO LINKS**<br>General structure of radiolinks. Types of repeaters. Radio frequency channel arrangements for fixed wireless systems. Band plans. Modulation techniques. Quality in digital radiolinks.<br>Satellite links structure. Multiple Access Techniques. Satellite link budget in symmetric and asymmetric systems. DVB-S2 standard. | 10 hours |

| Laboratory Contents | Total number of hours |
|---|---|
| **LAB EXERCISE 1.** Propagation in presence of multiple obstacles. | 4 hours |
| **LAB EXERCISE 2.** Antenna parameters | 4 hours |
| **LAB EXERCISE 3.** Calculation of Coverages in Analog and Digital Broadcasting Servic | 6 hours |
| **LAB EXERCISE 4.** Calculation of the optimal work point in Satellite Radiocommunication Services with FDMA Access | 4 hours |
| **CASE STUDY.** Calculation of antenna heights and analysis of multi-hop radiolinks using geographic information | 10 hours |

# 4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

## 4.1. Credits Distribution

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|---|---|
| Number of on-site hours: | 28 hours in large group<br>28 lab hours in small group<br>2 tests hours |
| Number of hours of student work: | 92 |
| Total hours | 150 |

## 4.2. Methodological strategies, teaching materials and resources

The methodology used in this course incorporates collaborative learning strategies. During the semester, teachers propose a series of training activities (case study, practical laboratory) that will be translated into different contributions from students.
Collaborative learning methodology using portfolios is articulated through a series of both group and individual training activities. Through the semester, each student will carry out individual activities as well as a group activity, the case study. At the end of the course, all the material generated by the students will be included in his personal folder within the virtual classroom.

**Group activities:**

- **Case Study** complements and strengthens the theoretical basis of the subject. Each group of students must solve the case study as a team. Co-evaluation will be carried out through a web application (CETPE) which implements a peer evaluation methodology. The case study will comprise several well differentiated stages. In the first one, each group of students ellaborate the case study in the laboratory. Secondly, the peer evaluation is carried out in three phases:
  - **Phase 1.** Each student assess the work of a classmate from another working group through an interview. Each assessor student has to justify the assigned score. Then, this score is compared with the one assigned by the teacher to the same student. Out of this comparison a mark is generated (calibration mark) that quantifies each student's ability to evaluate.
  - **Phase 2.** The assessed student assesses the assessment received. The score they assign will be compared with the calibration mark of the assessor student. This comparison generates the revision mark for each student.

- **Phase 3.** Each student evaluates his teammates.

**Individual activities:**

- **Laboratory exercises.** Although the students work in groups in the laboratory , each student will have to defend their lab reports in an oral presentation.
- **Interim assessment tests.** Two interim tests will be carried out throughout the course. The aim of this activity is to assess the students acquire basic concepts properly. First interim test will be related to topics 1, 2 and 3. The second one will be focused on topics 4 and 5.
- **Pre-class quizzes**: Before attending to class, the students may answer a quiz that helps them to prepare for the class in advance

**Working groups formation:**

A working group is a group of three or four students that will carry out the portfolio activities assigned throughout the course together. The number of students per group will be established at the beginning of the course depending on the students enrolled.

Online learning platforms and tools used to carry out the activities are the following:

**Blackboard Virtual Classroom** allows the construction of portfolios in an easy and simple way, as well as collaborative learning through blogs, forums, documents sharing. Likewise, all the material provided by the teachers for the semester together with those materials from the students will be published gradually. In this way, the student participates in the knowledge construction process carried out throughout the course and becomes the central core of it.

**CETPE** is a web app focused on implementing a peer assessment process based on rubrics. Each assessed student must present their final report of their case study to a peer assessor. The process itself leads to the need of deepening in the underlying concepts in order to be able to explain all their work and conclusions neatly and clearly. On the other hand, through the assessment of a peer from other working group, each student will be able to compare their work with others and reach broader conclusions. In addition, they also gain a deeper understanding of the different approaches to the solving of the case study.

CETPE methodology allows consolidation of the knowledge acquired in the case study as well as development of critical reasoning, analytical capacity and teamwork through reflection induced by their own assessment process.

# 5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

## 5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Regulations for the Regulation of Teaching Learning Processes, NRPEA, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Regulations for the Evaluation of Apprenticeships (approved by the Governing Council on March 24, 2011 and modified in the Board of Directors). Government of May 5, 2016) as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

### Ordinary Call

Continous Assessment:

The student continuos work will be assessed as follows:

- Two interim assessment tests. First interim test will consist of theoretical-practical exercises related to topics 1, 2 and 3. The second one will consist of theoretical-practical exercises related to topics 4 and 5.
- 4 Laboratory exercises: The assessment proccess will be held at the end of the semester. Each group will make a brief presentation of the lab exercises, in which all group members must participate. Every member
  of the group will be assessed individually according to their presentation and their answers to the professor's questions.
- Case study: CETPE peer co-evaluation methodology, described in section 4.2., will be used. The final mark will be a combination of the mark assigned by the teacher and other three marks, fruit of the peer evaluation process.
- Pre-class quizzes to prepare for the class in advance

In this learning process, it is essential to keep an ongoing monitoring of the student in all suggested activities, as well as their daily involvement both in the classroom and in the laboratory to assess the gradual development of their competences. Therefore, it is considered highly recommended class attendance. Attending class is attending 80% of large group classes and 100% of small group classes.

Assessment through final exam:

In case the student renounces continuous assessment, they will be assessed as follows:

- 4 Laboratory exercises and case study: The students will be assessed through their final reports for the 4 lab exercises and the case study, which will be delivered at the end of the semester.
- An additional individual work focused on some selected contents in order to assess their ability for autonomous learning and literature searching.
- A written final test focused on both practical and theoretical aspects of the subject

Students who are granted with non-continuous assessment have no obligation to attend classes.

### Extraordinary Call

The procedure will be the same as the one described for assessment through final exam in the ordinary call.

## 5.2. EVALUATION

### EVALUATION CRITERIA

Evaluation criteria measure the level of competence the students have acquired. For that purpose, the following are defined:

**CE1.** The student is able to define the basic parameters of an antenna, identify different types of antennas and associate them with the different radio communication services.

**CE2.** The student is able to determine the most appropriate propagation model to a radio communication system depending on the length of the link and its frequency.

**CE3.** The student demonstrates his ability to describe, characterise and select the devices that are

part of a radio communication system.

**CE4.** The student is able to manage fidelity quality and availability parameters of radio communication systems as well as estimating the effect of undesirable disturbances due to noise and interference.

**CE5** The student is able to analyze fixed terrestrial and spatial radio links.

**CE6.** The student is able to work with international regulations, specifications and recommendations related to wireless services.

**CE7.** The student will demonstrate his ability to calculate the noise power drawn from the basic noise parameters of any typical radio link receiver system with independence of its specific structure.

**CE8.** The student is able to work in a group, in a multilingual environment. presenting their learning outcomes orally and in writing.

## GRADING TOOLS

The work of the student is graded according to the assessment criteria defined above. For that purpose the following grading tools are used:

1. Ordinary call. Continuous assessment:
   - **Laboratory exercise (PL1-4):** Each group will make a brief presentation of the lab exercises, in which all group members must participate. Every member of the group will be assessed individually according to their presentation and their answers to the professor's questions. All exercises will have the same weight in the grading.
   - **Interim Assessment Tests (PEI1-2):** Both interim test will consist of theoretical-practical exercises related to topics 1, 2 and 3 and topics 4 and 5 respectively.
   - **Delivery associated to case study (E1):** Final mark will be a combination of the mark assigned by the teacher and other three marks related to Phase 1, phase 2 and phase 3 of CETPE methodology.
   - **Portfolio deliveries associated with pre-class quizzes (E2)**
     carried out in groups of students. The deliveries will be available to all the students and serve as
     useful learning tools in their learning process
   - **Final evaluation test (PEF):** written final exam related to the contents of the whole subject syllabus. It is subdivided into two parts equivalent to PEP1 and PEP2. All students will be required to do PEP2 while the equivalent portion of PEP1 will be optional for students who follow the continuous assessment and wish to upgrade their mark in PEP1.
2. Extraordinary Call. Final assessment:
   - **Laboratory exercise (PL):** final reports for the 4 lab exercises.
   - **Additional individual work (E3).** A report will be delivered at the end of the semester
   - **Final evaluation test (PEF):** written final exam related to the contents of the whole subject syllabus.

## GRADING CRITERIA

In ordinary call-continuous assessment the relationship between skills, learning outcomes, criteria and evaluation instruments is as follows.

| Skill | Learning Outcomes | Evaluation criteria | Grading Tool | Contribution to the final mark |
|---|---|---|---|---|
| TR2, TR3, TR5, TR8, CST4, CST5 | RA1-RA4 | CE1, CE4, CE6, CE7, CE8 | PL1-4 | 25% |
| TR2, TR3, TR5, CST4, CST5 | RA1,RA2, RA3 | CE1, CE2, CE3, CE8 | PEI1 | 15% |
| TR2, TR3, TR5, TR8, CST1, CST4, CST5 | RA2, RA3, RA4, RA6 | CE1-CE8 | E1 | 20% |
| TR2, TR5, TR8, CST1, CST4, CST5 | RA4, RA5, RA6 | CE4, CE5, CE6, CE7, CE8 | E2 | 10% |
| TR2, TR3, TR5, CST1, CST4, CST5 | RA4-RA6 | CE1-CE8 | PEI2 | 30% |

The point average obtained in the two interim tests must be at least 4 points, no matter if the tests are done during the course, or as part of the final test in order to upgrade a mark. If this minimum is not reached, the final grade will be the lowest between the weighted average and 4 points.

It's possible for students, as described in section GRADING TOOLS, take a new test at the end of the course, in order to upgrade their marks on PEP1 interim test. The new mark will only be taken into account if it is higher than the previous one.

Weight and assessment of learning outcomes and evaluation criteria in the final test (PEF) are shown in the following table.

| Skill | Learning Outcomes | Evaluation criteria | Grading Tool | Contribution to the final mark |
|---|---|---|---|---|
| TR2, TR3, TR5, CST1,CST4, CST5 | RA1-RA6 | CE1-CE8 | PEF | 15+30=45% |

Students will be considered as not showing up in the ordinary call if they do not participate in the teaching-learning process as it is established in this teaching guide in terms of assistance, completion and delivery of learning and assessment activities. Students not submitting 75% of the assessable activities within the first month of continuous assessment process will be also considered as they have not shown up in the ordinary call.

In the ordinary call-final evaluation, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

| Skill | Learning Outcomes | Evaluation criteria | Grading Tool | Contribution to the final mark |
|---|---|---|---|---|
| TR2, TR3, TR5, TR8, CST1, CST4 | RA1-RA4 | CE1, CE4, CE6, CE7, CE8 | PL | 20% |
| TR2, TR3, TR5, CST1, CST4, CST5 | RA2-RA6 | CE1, CE2, CE3, CE4, CE5 | E3 | 10% |
| TR2, TR3, TR5, CST1, CST4, CST5 | RA1-RA6 | CE1-CE8 | PEF | 70% |

Extraordinary call

The same percentages established for the evaluation through final exam will be applied for the extraordinary call. In this case, the student will have the choice of doing a lab test or keeping the mark obtained in the ordinary call.

# 6. BIBLIOGRAPHY

## 6.1. Basic Bibliography


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## 6.2. Additional Bibliography


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## Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.