Universidad de Alcalá

TEACHING GUIDE

Radiation and Radiocommunication

Degree in
Telecommunication Technologies Engineering

Universidad de Alcalá

Academic Year 2025/2026

4th Year - 1st Semester

Approved by the EPS School Board on June 16th, 2025

TEACHING GUIDE

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

1. COURSE SUMMARY

Nowadays, users of communications services (internet, telephony, multimedia data transmission) demand more and more network access from anywhere. No doubt, radiocommunications systems are the solution for rural and less populated areas. Trunk radio links are also necessary for 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 the 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 radio links 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. ANTENNAS IN RADIOCOMMUNICATION SYSTEMS. Characteristics of antennas in wireless systems. Wire antennas. Yagi antennas. Aperture antennas (patch antennas, horns, and parabolic reflectors). Radiation patterns: directional, sectorial, and omnidirectional. Analysis of commercial antenna data sheets.	4 hours
UNIT 2. SPACE WAVE PROPAGATION. INFLUENCE OF PROPAGATION ENVIRONMENT. Power balance. Curved Earth Two-ray model. Diffraction in multiple obstacles. Attenuation by atmospheric gases. Attenuation in vegetation.	4 hours
UNIT 3. FADING AND QUALITY IN FIXED RADIO LINKS. Statistical models of radio communication channels. Fading due to hydrometeors. Fading protection mechanisms. Radio links quality: availability and fidelity.	4 hours
UNIT 4. INFLUENCE OF RADIOELECTRIC NOISE. Sources of radioelectric noise. Calculation of radioelectric noise intensity. Noise-limited radiocommunication systems. Threshold degradation due to noise. Types of interference. Calculation of carrier-to-noise ratio.	4 hours
UNIT 5. SATELLITE RADIO LINKS. Satellite links structure. Multiple Access Techniques. Satellite link budget in symmetric and asymmetric systems.	5 hours
UNIT 6.TERRESTRIAL FIXED SERVICE RADIO LINKS. Terrestrial radio links general structure. Types of intermediate stations. Frequency planning. Planning radio links in transport networks.	5 hours
UNIT 7. POINT TO MULTIPOINT RADIO SYSTEMS. Single frequency networks (SFN) and multiple frequency networks (MFN). Semi-empirical wave propagation models. Coverage analysis.	2 hours

Laboratory Contents	Total number of hours
LAB EXERCISE 1. Antenna Parameters	4 hours
LAB EXERCISE 2. Propagation in the Presence of Multiple Obstacles.	5 hours
LAB EXERCISE 3. Calculation of the Optimal Operating Point in Satellite Radiocommunication Services with FDMA Access	5 hours
LAB EXERCISE 4 . Calculation of Coverages in Analog and Digital Broadcasting Services	4 hours
PROJECT OF A RADIO LINK. Calculation of antenna heights and analysis of multi-hop radio links using geographic information	10 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

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

4.2. Methodological strategies, teaching materials and resources

The collaborative learning methodology is articulated through a series of training activities developed both individually and in teams throughout the course. The assessment of both team and individual activities will be individual and will be based on the performance of each student throughout the process.

Team activities:

- **Lab exercises.** The students solve the lab exercises in teams of four students following an **Agile methodology** (Kanban). The students receive feedback from the teachers through a board implemented in Trello. During the course, they develop their teamwork skills and identify the roles that each member plays throughout the process (Belbin Team Roles). Although the work is carried out in teams, the qualification is individual and is established on the basis of the work observed on the board and the oral presentation of the delivered reports.

- **The project of a radio link** complements and strengthens the theoretical basis of the subject. Each team of students must solve the project together. Co-evaluation will be carried out through a web application (CETPE) which implements a peer evaluation methodology. The project will comprise several well-differentiated stages. In the first one, each team of students elaborates on the project in the lab. Secondly, peer evaluation is carried out. It comprises three phases:

    - **Phase 1.** Each student assesses the work of a classmate from another team 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 that quantifies each student's ability to evaluate is generated.

    - **Phase 2.** The assessed student assesses the interviewer's capacity to promote dialogue in order to foster learning. The score will be compared with the one assigned by the teacher to the interviewer. This comparison generates another mark for each student.

    - **Phase 3.** Each student evaluates his teammates and auto evaluate their own work.

Individual activities:

- **Intermediate assessment tests.** Two intermediate tests will be carried out throughout the course. The aim of this activity is to assess students acquire basic concepts properly. The first intermediate test will be related to units 1, 2, 3, and 4. The second one will be focused on units 5, 6, and 7.

- **Pre-class quizzes:** Before attending class, the students will answer a quiz that helps them to

prepare for the class in advance. They will also solve some exercises for each unit through other questionnaires.

Team formation:

A team is composed of four students. Each team will identify its strong roles in the first session of the course and will reflect throughout the course on the different roles adopted by each of its members during the process.

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

Blackboard Virtual Classroom: allows the construction of knowledge throughout the course in an easy and simple way, as well as collaborative and dialogic learning through the various tools (file sharing, blogs, forums...) that each team has at its disposal. All the material provided by the teachers for the subject will appear progressively throughout the four-month period. The student becomes the center of the learning process. They are also key active participants in the knowledge construction carried out throughout the course.

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

CETPE methodology allows consolidation of the knowledge acquired in the project as well as the 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 (Learning Assesment Guidelines, LAG, 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 Learning Assesment Guidelines 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

Ongoing Formative Assessment:

Project of a terrestrial radio link: A peer co-evaluation technique will be applied at the end of the project. Students will assess their peers using a rubric. The final mark will be a combination of the mark assigned by the teacher and the marks obtained through the peer evaluation process.

The student's ongoing **individual activities** will be assessed as follows:

- **Two assessment tests.** The first test will consist of theoretical-practical exercises related to topics 1, 2, 3, and 4. It will be performed in the middle of the quarter. The second test will consist of theoretical-practical exercises related to topics 5, 6, and 7. It will be performed at the end of the quarter.
- **Quizzes.** There are both quizzes that contain questions and are sent in advance for class preparation and quizzes that are made up of practical exercises.

The student's ongoing **team activities** will be assessed as follows:

- **4 Lab exercises:** At the end of the quarter each team of students will make a brief presentation of the lab exercises. All team members must participate. Every member of the team will be assessed individually according to their presentation and their answers to the teacher's questions.

- **Project of a terrestrial radio link:** A peer co-evaluation technique will be applied at the end of the project. Students will assess their peers using a rubric. The final mark will be a combination of the mark assigned by the teacher and the marks obtained through the peer evaluation process.

In this learning process, it is essential to keep ongoing monitoring of the student in all suggested activities, both through their learning activities and their daily performance and progress throughout the quarter. In this way, the gradual development of their skills can be assessed. Therefore, **it is highly recommended that students attend class.** Attending class means participating in 80% of classes, both small and large groups. Nevertheless, those sessions in which any type of evaluation activity is performed are mandatory.

Final Assessment:

In case the student declines formative ongoing assessment, they will be assessed as follows:

- **4 Lab exercises.** Students will be assessed through their final reports which will be delivered at the end of the semester.

- **Additional individual essay.** This essay will be focused on some selected contents of the subject and it will allow assess their ability for self-directed learning and bibliographic search.

- **Final test.** It will be composed of two parts. The first part will consist of theoretical-practical exercises related to topics 1, 2, 3, and 4 and the second part will consist of theoretical-practical exercises related to topics 5, 6, and 7.

Attending classes is not mandatory for students who are granted the final assessment procedure.

Extraordinary Call

The extraordinary call will follow the same procedure as the final assessment of 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 for a radio communication system depending on the length of the link and its frequency.

CE3. The student demonstrates his ability to describe, characterize 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 estimate 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 regardless of its specific structure.

CE8. The student is able to work in a team and present their learning outcomes orally and in writing in a multilingual environment.

EVALUATION TOOLS

The evaluation tools applied to assess the previous criteria are the following:

- **Lab exercises (PL):** Each team of students will make a brief presentation of the lab exercises. All team members must participate. Every member of the team will be assessed individually according to their presentation, their answers to the teacher's questions, and their progress throughout the course.
- **Intermediate Assessment Tests (PEI1-2):** Both intermediate tests will consist of theoretical-practical exercises related to topics 1, 2, 3 and 4 and topics 5, 6, and 7 respectively.
- **Radio link Project report (E1):** Final mark will be a combination of the mark assigned by the teacher and the other three marks related to Phase 1, phase 2, and phase 3 of the CETPE peer evaluation technique.
- **Quizzes (E2):** Both quizzes previous to class and exercises quizzes are considered here.
- **Additional individual essay (E3).** An essay will be delivered at the end of the semester. This essay will be focused on some selected contents of the subject and it will allow assessing their ability for self-directed learning and bibliographic search.
- **Final test (PEF):** This is a written final test 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 part associated with PEP1 will be optional for students who wish to upgrade their mark and are following the subject under the ongoing assessment procedure.

GRADING CRITERIA

The relationship between skills, learning outcomes, criteria, and evaluation tools in the ongoing formative assessment procedure of the ordinary call is the following:

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 weighted average of the two intermediate tests must be at least 4 points, both if PEP1 is taken during the course or as a part of the final test. If this minimum grade is not reached, the final mark will be the lowest between the weighted average and 4 points.

Students may retake the PEP1 test at the end of the quarter to improve their mark in this specific test. The new mark will only be considered if it is higher than the previous one.

The relationship between skills, learning outcomes, criteria, and evaluation tools in the final test (PEF) is the following:

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%

If the student does not participate in the teaching-learning process as established in this teaching guide in terms of attendance, completion, and deliverables, their work will be considered as not submitted in the ordinary call. Failing to submit 75% of deliverables in the first month of teaching implies no grading. The mark will be NP (not submitted).

Ordinary call: final assessment

The relationship between skills, learning outcomes, criteria, and evaluation tools in the ordinary call-final assessment procedure is the following:

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 final assessment of the ordinary call will be applied to the

extraordinary call. In this case, the student will have the choice of doing a lab test or keeping the mark obtained previously in the ordinary call.

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- Hernando Rábanos, José María. Transmisión por radio. Ed. Centro de Estudios Ramón Areces, Madrid, 1993.
- Freeman, R.L. Radio System Design for Telecommunications (1-100 GHz) John Wiley, 1987.
- Balanis, C. “Antenna Theory. Analysis and Design”.-John Wiley and Sons. Tercera Edición. 2005.
- Cardama, A.; Jofré, L.; Rius, J.M.; Romeu, J. y Blanch, S.- “Antenas”. Ediciones UPC. 1998.

6.2. Additional Bibliography

- Krauss, J.D. “Antennas”. McGraw Hill Inc.1988.
- Stutzman W., Thiele G., “Antenna theory and design”.-John Wiley and Sons.1998.
- S.Shibuya. “A Basic Atlas of Radio-Wave Propagation”. Wiley&sons
- Boithias, Lucien. Radiowave Propagation. McGraw-Hill, 1987.
- Townsend, A.A.R. Digital line-off-sigth radiolinks. Prentice-Hall, 1989.
- Greenstein, L.J.; Shafi, M. (ed.). Microwave digital radio. I.E.E.E. Press, 1988.
- Tri; Ha. Digital Satellite Communications. McGraw-Hill, 1990.
- Pratt; Bostian. Satellite communications. John Wiley, 1986.
- F.Ivanek. “Terrestrial Digital Microwave Communications”. Artech House, 1992.
- Robert M. Gagliardi; "Satellite Communications". Van Nostrand Reinhold, 1991.
- Gary D. Gordon, Walter L. Morgan; "Principles of communications satellites". Wiley Interscience.
- G. Maral, M. Bousquet; "Satellite communications systems". John Wiley & Sons, 1993
- Unión Internacional de Telecomunicaciones. Recomendaciones UIT-R. Sector de Radiocomunicaciones, Series: F, M, PI, PN, S, SF, SM, Ginebra 1997.
- Unión Internacional de Telecomunicaciones. Reglamento de Radiocomunicaciones. Ginebra, 1998.
- Digital MW Radio Systems Performance Calculations and Network Planning. Siemens Telecomunicaciones. 1991

Disclosure Note

During the evaluation tests, the guidelines set out in the Regulations establishing the Rules of Coexistence of the University of Alcalá must be followed, as well as the possible implications of the irregularities committed during said tests, including the consequences for committing academic fraud according to the Regulation of Disciplinary Regime of the Students of the University of Alcalá.