ANX-PR/CL/001-01

LEARNING GUIDE

SUBJECT

93000923 - Advanced Topics On Antenna Technologies

DEGREE PROGRAMME

09AT - Master Universitario En Teoria De La Señal Y Comunicaciones

ACADEMIC YEAR & SEMESTER

2021/22 - Semester 1

PR/CL/001
COORDINATION PROCESS OF
LEARNING ACTIVITIES

ANX-PR/CL/001-01
LEARNING GUIDE

ETSIT UPM

E.T.S. de Ingenieros de
Telecomunicacion

Index

Learning guide

1. Description

1.1. Subject details

Name of the subject	93000923 - Advanced Topics On Antenna Technologies
No of credits	6 ECTS
Type	Optional
Academic year ot the programme	First year
Semester of tuition	Semester 1
Tuition period	September-January
Tuition languages	English
Degree programme	09AT - Master Universitario en Teoria de la Señal y Comunicaciones
Centre	09 - Escuela Tecnica Superior De Ingenieros De Telecomunicacion
Academic year	2021-22

2. Faculty

2.1. Faculty members with subject teaching role

Name and surname	Office/Room	Email	Tutoring hours *
Manuel Sierra Castañer	C-410	manuel.sierra@upm.es	Sin horario. Appointment arranged by email
Francisco Eduardo Carrasco Yepez	B-417	eduardo.carrasco@upm.es	Sin horario. Appointment arranged by email

Belen Galocha Iraguen	C-410	belen.galocha@upm.es	Sin horario. Appointment arranged by email
Jose Antonio Encinar Garcinuño	B-414	jose.encinar@upm.es	Sin horario. Appointment arranged by email
Jose Manuel Fernandez Gonzalez (Subject coordinator)	C-416	josemanuel.fernandez.gonzalez@upm.es	Sin horario. Appointment arranged by email
Adrian Tamayo Dominguez	C-418	a.tamayo@upm.es	Sin horario. Appointment arranged by email

* The tutoring schedule is indicative and subject to possible changes. Please check tutoring times with the faculty member in charge.

2.2. Research assistants

Name and surname	Email	Faculty member in charge
Martinez De Rioja Del Nido, Jose Daniel	jd.martinezderioja@upm.es	Carrasco Yepez, Francisco Eduardo

3. Prior knowledge recommended to take the subject

3.1. Recommended (passed) subjects

The subject - recommended (passed), are not defined.

3.2. Other recommended learning outcomes

- It is recommended to know Matlab programming

- It is recommended to have a strong knowledge in basic concept about antennas, radiated fields, electromagnetic waves and basic antenna parameters

4. Skills and learning outcomes *

4.1. Skills to be learned

CB06 - 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

CB07 - 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

CB08 - Que los estudiantes sean capaces de integrar conocimientos y enfrentarse a la complejidad de formular juicios a partir de una información que, siendo incompleta o limitada, incluya reflexiones sobre las responsabilidades sociales y éticas vinculadas a la aplicación de sus conocimientos y juicios

CB09 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades

CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo

CE01 - Analizar y aplicar técnicas para el diseño y desarrollo avanzado de equipos y sistemas, basándose en la teoría de la señal y las comunicaciones, en un entorno internacional

CE02 - Evaluar y sintetizar los resultados de un trabajo en equipo en proyectos relacionados con la teoría de la señal y las comunicaciones, en un entorno internacional.

CE03 - Valorar y contrastar la utilización de las diferentes técnicas disponibles para la resolución de problemas reales dentro del área de teoría de la señal y comunicaciones.

CETFM - Capacidad de realizar un trabajo o proyecto integrando y relacionando las competencias adquiridas en las distintas asignaturas del máster, junto con la capacidad de defenderlo en público ante un grupo de personas expertas en el tema del trabajo

CT01 - Capacidad para comprender los contenidos de clases magistrales, conferencias y seminarios en lengua inglesa

CT03 - Capacidad para adoptar soluciones creativas que satisfagan adecuadamente las diferentes necesidades planteadas

CT04 - Capacidad para trabajar de forma efectiva como individuo, organizando y planificando su propio trabajo, de forma independiente o como miembro de un equipo

CT05 - Capacidad para gestionar la información, identificando las fuentes necesarias, los principales tipos de documentos técnicos y científicos, de una manera adecuada y eficiente

CT06 - Capacidad para emitir juicios sobre implicaciones económicas, administrativas, sociales, éticas y medioambientales ligadas a la aplicación de sus conocimientos

4.2. Learning outcomes

RA22 - Knowing conduct a technical presentation before an audience of peers, describing the work and results clearly and well structured, on time, and using precise language

RA25 - Handle with ease the bases of linear algebra and calculus necessary to formulate problems optimization.

RA24 - Knowledge of advanced techniques used in the Radio Access Technologies

RA9 - To evaluate and to implement RF systems and equipments.

RA28 - Know and evaluate the different types of antennas according to their specifications

RA23 - Knowing the antenna measurement systems and their limitations

RA27 - Ability to design antenna arrays (arrays)

RA30 - Ability antenna design for communications and radar systems

RA26 - Ability of oral and written communication

RA31 - To carry out novel designs and applications in the field of MIMO antennas and systems

RA29 - Knowing the mathematical algorithms of adaptive antenna systems

RA35 - Understanding the need of computational electromagnetics

* The Learning Guides should reflect the Skills and Learning Outcomes in the same way as indicated in the Degree Verification Memory. For this reason, they have not been translated into English and appear in Spanish.

5. Brief description of the subject and syllabus

5.1. Brief description of the subject

This course presents advanced concepts and techniques in antenna topics. The students will acquire the required knowledge for the analysis and design of antennas using in-house software and commercial software. These techniques cover either theoretical and practical design aspects. With this goal, the students obtain the knowledge needed to perform antenna analysis and design in the most recent antenna technology and using commercial and self-made software. The course learning method is based on the main parts of the antenna design topics based on student work and Project Based Learning methodology with the support of the professors.

All the course classes are referred to practical antenna systems. Several antenna design and optimization methods are presented in the classroom. The students will use the software packages at the Signals, Systems and Radiocommunications Department of The E.T.S.I. Telecomunicación to perform practical analysis either by the professors and for practical students projects. The students will understand the concepts of the antenna analysis and design. The students will be able to afford all the stages of the antenna design (Antenna Project). The students oral presentations of the Antenna Project allow professors and the rest of the students to learn and evaluate analysis and design projects.

5.2. Syllabus

1. Printed antennas

    1.1. Overview of printed antennas

    1.2. Wideband and multiband antennas

    1.3. Example: Practical design of printed antennas

2. Aperture antennas

    2.1. Overview of advanced horn antennas

    2.2. Overview of reflector antennas

    2.3. Example: Practical design of aperture antennas

3. Reflectarray and Transmitarray antennas

    3.1. Overview of refectarray and transmitarray antennas

    3.2. Analysis and design of transmitarray antennas

    3.3. Analysis and design of reflectarray cells and reflectarray antennas

PR/CL/001
COORDINATION PROCESS OF
LEARNING ACTIVITIES

ANX-PR/CL/001-01
LEARNING GUIDE

ETSIT UPM

E.T.S. de Ingenieros de
Telecomunicacion

3.4. Techniques for bandwidth improvement

3.5. Contoured-beam reflectarrays

3.6. Dual-reflector configurations

3.7. Appications: Automotive radar, base station antennas, sub-mm waves, space antennas

3.8. Terahertz reflectarrays

3.9. New capabilities: filtering and non-reciprocal response

3.10. Reconfigurable and beam-scanning reflectarrays

3.11. Example: Practical design of reflectarray antennas

4. Planar array antennas

4.1. Overview of planar array antennas

4.2. Phased array antennas

4.3. Example: Practical design of planar array antennas

5. Antenna measurement techniques

5.1. Overview of antenna measurement systems

5.2. Far-field and Near-field measurement techniques

5.3. Source reconstruction and post-processing techniques

5.4. Laboratory with Matlab

6. Schedule

6.1. Subject schedule*

Week	Face-to-face classroom activities	Face-to-face laboratory activities	Distant / On-line	Assessment activities
1	**Presentation and objectives of the course and Antenna project topics proposal** Duration: 01:00 Additional activities **Topic 1: Printed antennas, overview of printed antennas** Duration: 01:00 Lecture	**Introduction and getting started with electromagnetic software** Duration: 02:00 Laboratory assignments		
2	**Topic 1: Printed antennas, overview of printed antennas** Duration: 02:00 Lecture	**Introduction and getting started with electromagnetic software** Duration: 02:00 Laboratory assignments		
3	**Topic 1: Printed antennas, wideband and multiband antennas** Duration: 02:00 Lecture	**Example: Practical design of printed antenna** Duration: 02:00 Laboratory assignments		**Delivery at the end of the laborartory of a short report+files of printed antenna design** Individual work Continuous assessment Presential Duration: 00:00
4	**Topic 2: Aperture antennas, overview of advanced horn antennas** Duration: 02:00 Lecture	**Example: Practical design of wideband or multiband antenna** Duration: 02:00 Laboratory assignments		**Delivery at the end of the laboratory of a short report+files of wideband or multiband antenna design** Individual work Continuous assessment Presential Duration: 00:00
5	**Topic 2: Aperture antennas, overview of reflector antennas** Duration: 02:00 Lecture	**Example: Practical design of horn antenna** Duration: 02:00 Laboratory assignments		**Meeting with tutors for 1ºphase intermediate antenna project presentation+report** Group presentation Continuous assessment Presential Duration: 00:00 **Delivery at the end of the laboratory of a short report+files of horn antenna design** Individual work Continuous assessment Presential Duration: 00:00

6	**Topic 3: Reflectarray and Transmitarray antennas, overview of reflectarray and transmitarray antennas, techniques for bandwidth improvement** Duration: 02:00 Lecture	**Example: Practical design of reflector antenna** Duration: 02:00 Laboratory assignments		**Delivery at the end of the laboratory of a short report+files of reflector antenna design** Individual work Continuous assessment Presential Duration: 00:00
7	**Topic3: Reflectarray antennas, reconfigurable and beam scanning reflectarrays, Terahertz reflectarrays** Duration: 02:00 Lecture	**Intrduction to reflectarrays antenna design with MRADANT-UPM** Duration: 02:00 Laboratory assignments		
8	**Topic 4: Planar array antennas, overview of planar array antennas, phased array antennas** Duration: 02:00 Lecture	**Example: Practical design of reflectarray antennas** Duration: 02:00 Laboratory assignments		**Delivery at the end of the laboratory of a short report+files of reflectarray antenna design** Individual work Continuous assessment Presential Duration: 00:00
9	**1º and 2ºphase intermediate antenna project presentation+report** Duration: 04:00 Additional activities			**1º and 2ºphase intermediate antenna project presentation+report** Group presentation Continuous assessment Presential Duration: 00:00
10		**Example: Practical design of planar array antenna with Matlab** Duration: 04:00 Laboratory assignments		**Delivery at the end of the laboratory of a short report+files of planar array antenna with Matlab** Individual work Continuous assessment Presential Duration: 00:00
11		**Example: Practical design of planar array antenna with CST** Duration: 04:00 Laboratory assignments		**Delivery at the end of the laboratory of a short report+files of planar array antenna with CST** Individual work Continuous assessment Presential Duration: 00:00
12	**Topic 5: Antenna measurement techniques, overview of antenna measurement systems, Far-field and near-field measurement techniques** Duration: 02:00 Lecture	**Visit to anechoic chamber LEHA from ETSIT-UPM** Duration: 02:00 Laboratory assignments		
13	**Topic 5: Antenna measurement techniques, source reconstruction techniques and post-processing techniques** Duration: 02:00 Lecture	**Example: laboratory with Matlab** Duration: 02:00 Laboratory assignments		**Delivery at the end of the laboratory of a short report+files of measurement techniques** Individual work Continuous assessment Presential Duration: 00:00
14	**3ºphase final antenna project presentation+report** Duration: 04:00 Additional activities			**3ºphase final antenna project presentation+report** Group presentation Continuous assessment Presential Duration: 00:00

PR/CL/001
COORDINATION PROCESS OF
LEARNING ACTIVITIES

ANX-PR/CL/001-01
LEARNING GUIDE

ETSIT UPM
E.T.S. de Ingenieros de Telecomunicacion

15				
16				
17				**Final exam for students with Non continuous assessment: theory and practical laboratory exam. The theory exam could be an oral exam if required by the professors. The practical laboratories are face-to-face activities carried out in the laboratory.** Written test Final examination Presential Duration: 03:00 **Individual antenna project presentation+report for students with Non continous assessment** Individual presentation Final examination Presential Duration: 01:00

Depending on the programme study plan, total values will be calculated according to the ECTS credit unit as 26/27 hours of student face-to-face contact and independent study time.

* The schedule is based on an a priori planning of the subject; it might be modified during the academic year, especially considering the COVID19 evolution.

7. Activities and assessment criteria

7.1. Assessment activities

7.1.1. Continuous assessment

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
3	Delivery at the end of the laborartory of a short report+files of printed antenna design	Individual work	Face-to-face	00:00	5%	5 / 10	CB09 CT01 CT03 CE02 CT04 CE01 CE03 CT05
4	Delivery at the end of the laboratory of a short report+files of wideband or multiband antenna design	Individual work	Face-to-face	00:00	5%	5 / 10	CT01 CB07 CT03 CT04 CE03 CT05
5	Meeting with tutors for 1ºphase intermediate antenna project presentation+report	Group presentation	Face-to-face	00:00	20%	5 / 10	CT01 CT03 CE02 CT04 CT05
5	Delivery at the end of the laboratory of a short report+files of horn antenna design	Individual work	Face-to-face	00:00	5%	5 / 10	CT01 CT03 CB06 CT04 CT05 CB10
6	Delivery at the end of the laboratory of a short report+files of reflector antenna design	Individual work	Face-to-face	00:00	5%	5 / 10	CT03 CB06 CT04 CT05
8	Delivery at the end of the laboratory of a short report+files of reflectarray antenna design	Individual work	Face-to-face	00:00	5%	5 / 10	CB07 CT03 CT04 CT06 CT05 CB10

PR/CL/001
COORDINATION PROCESS OF
LEARNING ACTIVITIES

ANX-PR/CL/001-01
LEARNING GUIDE

ETSIT UPM

E.T.S. de Ingenieros de
Telecomunicacion

9	1º and 2ºphase intermediate antenna project presentation+report	Group presentation	Face-to-face	00:00	20%	5 / 10	CB09 CT01 CT03 CE02 CT04 CT06 CE03 CT05 CB10
10	Delivery at the end of the laboratory of a short report+files of planar array antenna with Matlab	Individual work	Face-to-face	00:00	5%	5 / 10	CB08 CT01 CT03 CB06 CE02 CT04 CT06 CE03 CB10 CT05
11	Delivery at the end of the laboratory of a short report+files of planar array antenna with CST	Individual work	Face-to-face	00:00	5%	5 / 10	
13	Delivery at the end of the laboratory of a short report+files of measurement techniques	Individual work	Face-to-face	00:00	5%	5 / 10	CB07 CT03 CB06 CT04 CE01 CT06 CT05 CB10
14	3ºphase final antenna project presentation+report	Group presentation	Face-to-face	00:00	20%	5 / 10	CB08 CB09 CT01 CB07 CT03 CB06 CE02 CT04 CE01 CT06 CE03 CT05 CB10

7.1.2. Final examination

Week	Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills

PR/CL/001
COORDINATION PROCESS OF
LEARNING ACTIVITIES

ANX-PR/CL/001-01
LEARNING GUIDE

ETSIT UPM

E.T.S. de Ingenieros de
Telecomunicacion

		Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
17		Final exam for students with Non continuous assessment: theory and practical laboratory exam. The theory exam could be an oral exam if required by the professors. The practical laboratories are face-to-face activities carried out in the laboratory.	Written test	Face-to-face	03:00	50%	5 / 10	CE01 CT06 CE03 CT05 CB08 CB09 CB07 CT03 CB06 CE02 CT04
17		Individual antenna project presentation+report for students with Non continous assessment	Individual presentation	Face-to-face	01:00	50%	5 / 10	CB09 CT01 CB07 CT03 CB06 CE02 CT04 CT06 CE03 CT05 CB10

7.1.3. Referred (re-sit) examination

Description	Modality	Type	Duration	Weight	Minimum grade	Evaluated skills
Final exam: theory and practical laboratory exam. The theory exam could be an oral exam if required by the professors. The practical laboratories are face-to-face activities carried out in the laboratory.	Written test	Face-to-face	03:00	50%	5 / 10	CB09 CB06 CT04 CT06 CE03 CB10
Individual antenna project presentation+report	Individual presentation	Face-to-face	01:00	50%	5 / 10	CB08 CT01 CB07 CT03 CB06 CT04 CT05 CB10

PR/CL/001
COORDINATION PROCESS OF
LEARNING ACTIVITIES

ANX-PR/CL/001-01
LEARNING GUIDE

ETSIT UPM
E.T.S. de Ingenieros de
Telecomunicacion

7.2. Assessment criteria

Students will be qualified through continuous evaluation by default. According to the Normativa de Evaluación del Aprendizaje de la Universidad Politécnica de Madrid, students willing to renounce to continuous evaluation must complete the Moodle task entitled "Renounce to continuous evaluation" before week 4 of the course (deadline will be announced in Moodle).

Evaluation will assess if students have acquired all the competences of the subject. Thus evaluation through final assessment will be carried out considering all the evaluation techniques used in continuous evaluation (EX, ET, TG, etc.), and will be celebrated in the exam period approved by Junta de Escuela for the current academic semester and year. Evaluation activities that assess learning outcomes that cannot be evaluated through a single exam can be carried out along the semester.

Extraordinary examination will be carried out exclusively by the final assessment method.

Continuous evaluation:

- 40% Report+files delivery at the end of each design laboratory. It is mandatory to realize all the laboratories. If a student does not complete all the labs, he or she will fail the course.
- 60% Antenna project: 20% phase 1, 20% phase 2, 20% phase 3. The cross-evaluation among the team members is MANDATORY. The student who does not evaluate their classmates among the team members via Moodle will have a zero.

Final assessment and extraordinary examination:

- 50% Final exam: theory and practical laboratory. The theory exam could be an oral exam if required by the professors. The practical laboratories are face-to-face activities carried out in the laboratory.
- 50% Individual antenna project presentation+report.

8. Teaching resources

8.1. Teaching resources for the subject

Name	Type	Notes
Design book	Bibliography	Antenna Theory: Analysis and Design, C. Balanis, John Wiley & Sons, 4th Edition, 2016.
Microstrip antenna book	Bibliography	Handbook of Microstrip Antennas, J.R. James, P.S. Hall, Peter Peregrinus Ltd, 1989.
Printed antenna book	Bibliography	Advances in Microstrip and Printed Antennas, K. Fong Lee, W. Chen, Wiley, 1997.
Horns book	Bibliography	Microwave Horns and Feeds, A.D. Oliver, P.J. Claricoats, A.A. Kishk, L. Shafai, IEE Electromagnetic Waves Series 39, 1994.
Reflectors book	Bibliography	Modern Antenna Design, T.A. Milligan, IEEE Press, John Wiley & Sons, 2005.
Reflectarray design book	Bibliography	Reflectarray Antennas, J. Huang and J.A. Encinar, IEEE Press, 2008.
Arrays book	Bibliography	Phased Array Antenna Handbook, R.A. Mailloux, Artech House, 2005.
Measurement systems	Equipment	Anechoic chamber LEHA from Universidad Politécnica de Madrid
CST Studio Suite	Others	Analysis and design of antenna software
Matlab	Others	Mathematical software
MOOC Videos on Antennas	Web resource	Massive Open Online Courses on Antennas available in the web (http://www.gr.ssr.upm.es/index.php/es/).

9. Other information

9.1. Other information about the subject

Students are recommended to download some software applications available in the UPM repository and in particular Matlab.

This subject can contribute to increase the awareness and training of our students in relation to the United Nations Agenda 2030 and its Sustainable Development Goals (SDGs). Some problems will show how various mathematical and electromagnetic tools are used in antenna modeling, which will allow students to become familiar with antennas for communications.

More generally, the applied concepts are used extensively in engineering and, in particular, will touch on everything related to telecommunication infrastructures (ODS 9). The course will also contribute to sub-objectives 4.4: To significantly increase the number of people with the professional and technical skills needed to access employment and entrepreneurship; and 4.7: To ensure that all students acquire the necessary theoretical and practical knowledge to promote sustainable development.

The course is prepared to move to a fully virtual format if necessary.