Electromagnetic Exploration Systems

Syllabus

Industrial Organization Engineering Degree

Academic year 2013-2014

1. Course details

Name	Electromagnetic Exploration Systems				
Course field	Electromagnetic Exploration Systems				
Code	511103011				
Degree Course	Industrial Organization Engineering Degree				
Programme	2009 (Decreto 269/2009 de 31 de julio)				
Faculty	University Centre of Defense at the Spanish Air Force Academy				
Type	Elective				
Duration	Four-month course (1 semester)			**Year**	4^{th}
Language	English				
ECTS	7.5	**Hours / ECTS**	25	**Total workload (hours)**	187.5

Lectures Timetable	Monday 16:05-17:50 Tuesday 17:55-18:45 Thursday 17:00-18:45	**Room**	Seminar CUD
Classes/Labs/Seminars timetable	-	**Building**	CUD

2. Teaching Staff contact details

Head of the course	Nina Skorin-Kapov		
Department	Integrated Areas		
Area of expertise	Telecommunications		
Office location	Office 7 @ CUD building		
Phone	+34.968. 189 911	**Fax**	+34.968188780
E-mail	nina.skorinkapov@cud.upct.es		
URL / WEB	Aula Virtual UPCT		
Office hours (for consultations)	To be defined		
Office hours location (for consultations)	Office 7 @ CUD building		
Teaching and Research Profile	Doctor of Electrical Engineering, Field Telecommunications. Associate Professor of Telecommunications.		

Teaching Experience	10 years Courses taught: Heuristic Optimization Methods, Information Theory, Photonic Telecommunication Networks, Photonic Communication Technologies, Algorithms and Optimization Methods, Computer Science, Teletraffic Theory, Transmission Systems, Logical Algebra, Information Networks, Reliability of Telecommunications Systems, Digital Logic, Telecommunication Systems and Networks
Research Areas	Optimization and planning in telecommunications, WDM wide-area optical networks, (meta)-heuristic algorithms, network security and attack management
Professional Experience	Member of the Advisory Board of the Institute of Telemedicine of the Republic of Croatia, (2009 – 2012) Associate Editor of the CIT - Journal of Computing and Information Technology

3. Course outline

3.1. Presentation

The course "*Electromagnetic Exploration Systems (EES)*" is an elective course in the 4th year of the undergraduate program in Industrial Organization offered at the University Centre of Defence (CUD) as part of the formation of future Air Force officers at the Spanish Air Force Academy (AGA). Specifically, the main objective is for students to learn the basic theoretical and practical concepts of radar and radionavigation systems, and thus, develop the skills needed to apply them in their future professional practice.

Radar systems apply the concepts of electromagnetic wave propagation to detect objects (targets) and determine their distance (range). Modern radar systems can be used to track, identify, and image targets, and have numerous military and civilian applications, such as aircraft and missile detection and tracking, fire control, weather radar, and airport surveillance. The first part of this course covers the basic elements of radar systems, their underlying principles of operation, design issues and applications. It develops upon the basic concepts on radar systems introduced in course Security and Defense Technology.

In addition to the aforementioned radar applications, exploiting the properties of electromagnetic wave propagation is widely used in navigation systems to determine the position of moving objects with respect to a reference, referred to as radionavigation. The second part of this course covers a wide range of air radionavigation aids, including both terrestrial systems (point source systems, aircraft landing systems, and hyperbolic systems) and satellite systems.

The complex and practical character of the course will also be aimed at developing skills such as teamwork, independent learning, quality concern and critical thinking.

Huella Digital acHQKfpoZnrCTpMq2lwxEOxIdCw=
Código seguro de verificación 8ToDtOfI2lmJ7kohOclrPUVZf

3.2. Year and duration within the degree programme

The subject "Electromagnetic Exploration Systems" will be taught in the fourth year (Spring semester) of the Industrial Organization Engineering Degree.

3.3. Description of the course

Radar systems have extensive military applications, including target tracking, surveillance, and reconnaissance missions, as well as military and civilian applications in air traffic control and weather detection. Thus, knowledge of the underlying principles of operation of radar systems is critical for military officers with direct responsibilities in the areas mentioned. Furthermore, understanding the foundations of various radionavigation systems, specifically air navigation aids, including both terrestrial and satellite systems, form an integral part of the formation of future Air Force officers. This course is meant to provide the fundamental knowledge needed to understand the theoretical workings and design of radar and radionavigation systems, and thus prepare the students with a solid theoretical background to face their practical training within the Spanish Air Force.

3.4. Related courses. Prerequisites and recommendations

As a prerequisite to the course, student should have basic knowledge of electromagnetic fields and circuit theory. These topics are covered in the following subjects:

- Physics (1st year): block 3 (Electricity and Magnetism).
- Electrical Technology (2nd year)

The course further develops concepts introduced in course Security and Defense Technology (3rd year), Block II, and also complements the course Networks and Communications Services (3rd year).

3.5. Special measures

Special measures will be taken to allow for successful completion of the students´ military & aeronautical training activities which run in parallel to the course. Specifically, working groups will be formed to promote cooperative learning for students with limited availability; scheduled tutoring activities will be available and lecture notes will be provided on the course website.

4. Competences

4.1. Specific competences of the course

Adequate knowledge and applied engineering of air navigation systems and radio determination systems; the needs of the onboard and ground equipment for proper operation

4.2. Generic and transversal competences

INSTRUMENTAL COMPETENCES

- ☒ T1.1 Analytical and summary skills
- ☒ T1.3 Oral and written communication skills in their mother tongue
- ☒ T1.7 Problem solving skills

PERSONAL COMPETENCES

- ☒ T2.2 Teamwork

SYSTEMIC COMPETENCES

- ☒ T3.1 Ability to apply theory to practice
- ☒ T3.2 Learning ability
- ☒ T3.7 Ability to work autonomously

4.3. General aims/ Degree specific competences

PROFESSIONAL COMPETENCES

E 2.8."Ability to organize, control, protection and use of units responsible for force protection, control systems, control and operational support to air operations"

4.4. Learning objectives

The main objective of the course is to gain understanding of the underlying principles of operation of modern radar and radionavigation systems. Specifically the student should be able to:

- Understand the principles of electromagnetic wave propagation and radio detection
- Know the basic elements of radar systems and subsystems
- Understand the problematics associated with radar system design
- Distinguish between different types of radar and modern radar applications
- Explain positioning methods used in radionavigation
- Know the basic principles of hyperbolic radionavigation systems
- Understand the principles of operation of point-source and aircraft landing systems
- Know the basic principles of satellite navigation systems

5. Contents

5.1. Contents according to the Degree programme

Radio determination. Air navigation aids. Ground equipment. Onboard equipment. Radar.

5.2. Lectures programme

BLOCK I. RADAR SYSTEMS

Unit 1: Introduction and basic concepts

1.1. Historical background
1.2. Review of electromagnetic waves
1.3. Radio detection and the radar concept; Basic radar system block diagram
1.4. Classifications and configurations
1.5. Applications

Unit 2: The Radar Range Equation

2.1. Introduction
2.2. Received power – target properties and radar characteristics
2.3. Signal-to-Noise ratio
2.4. Tracking vs Search equations
2.5. Summary of Losses

Unit 3: Radar Subsystems and External factors

3.1. Propagation effects
3.2. Target Cross Section
3.3. Detection of Signals in Noise
3.4. Pulse Compression
3.5. Radar antennas
3.6. Clutter
3.7. Signal Processing - MTI and Pulse Doppler Techniques
3.8. Tracking and Parameter Estimation
3.9. Transmitters and Receivers

Unit 4: Selected Radar Applications

4.1. Ground Radar
4.2. Airborne Radar

BLOCK 2. RADIONAVIGATION SYSTEMS

Unit 5: Introduction and basic concepts

5.1. Historical background
5.2. Maps and coordinates
5.3. Positioning, Radio determination
5.4. Overview of on-board and ground air navigation aids

Unit 6: Terrestrial systems

6.1. Introduction

Hyperbolic Systems

1.1. Loran C

1.2. DECCA, OMEGA

Point source systems:

1.3. Direction Finding

1.4. Nondirectional Beacons (NDB)

1.5. VHF Omnidirectional Range (VOR)

1.6. Distance Measuring Equipment (DME)

1.7. Tactical Air Navigation (Tacan)

Aircraft Landing Systems

1.8. Instrument Landing System (ILS)

1.9. Microwave Landing System (MLS)

Unit 7: Satellite Systems

2.1. Introduction

2.2. Global Positioning System (GPS)

2.3. Global Orbiting Navigation Satellite System (GLONASS), Galileo

5.3. Classes/Seminars/practicals/tutorials programme

Laboratory sessions:

Four lab sessions will be realized to familiarize the students with the basic technologies used in radar and radio-navigation systems. The lab sessions will include exercises using software tools aimed to deepen understanding of the concepts covered in the lectures, as well as familiarization with equipment subject to availability.

The learning objectives are to:

- Apply the theoretical knowledge acquired in the lectures to practical problems
- Gain knowledge of the main aspects of laboratory work and acquire the capacity to organize, plan and solve problems
- Understand the need for numerical simulations and experiments
- Understand the difficulties encountered when dealing with real problems.
- Learn to work in a team and prepare project/lab reports

The lab sessions will be organized in 2 blocks following the course outline:

Block I:

Radar system design

Block II:

Radionavigation systems

6. Teaching methodology

6.1. Learning activities

Activity	Lecturer role	Student role	ECTS
Lectures	Presentation and explanation of the course material. Resolving doubts. Special emphasis will be made on the fundamental and more complex theoretical aspects of the course.	Attendance: Active attendance and class participation. Taking notes. Questions.	**2.2**
		Non-attendance: Individual study.	**1.8**
Problem solving classes	Solving problems in the classroom and/or presenting case studies.	Attendance: Active attendance. Questions and problem solving.	**0.4**
		Non-attendance: Individual study. Problem solving.	**0.6**
Laboratory sessions	Explaining the laboratory exercises. Supervising and leading the laboratory classes. Evaluating student knowledge and participation.	Attendance Individual and/or cooperative work in the laboratory under lecturer supervision. Active participation.	**0.4**
		Non-attendance Cooperative and individual pre-lab preparation; Lab report preparation.	**0.8**
Continuous assessment/Midterm	Preparing an individual, partial written examination covering the first part of the course (Block 1)	Attendance Attending and taking the midterm exam	**0.06**
		Non-attendance: Individual or group study and exam preparation	**0.4**
Individual and/or group consultation and tutorials	Resolving student questions and doubts related to the course	Attendance Actively participating in resolution of their questions/doubts.	**0.18**
Course assessment/Final Exam	Preparing a final individual written examination at the end of the term consisting of 2 parts covering Blocks 1 and 2, respectively.	Attendance. Attending and taking the final exam.	**0.1**
		Non-attendance: Individual or group study and exam preparation	**0.56**
TOTAL			**7.5**

7. Assessment

7.1. Assessment system

Methods	Criteria	Weighting	Generic competences
Midterm Exam (60%) (*)	A written exam consisting of theoretical and theoretical-practical questions and problems will be given at the end of Block 1 (Radar systems) to evaluate the acquired knowledge.	60%(*)	T1.1, T1.3, T1.7, T2.2, T3.1, T3.2, T3.7
Final Exam (40/100%) (*)	PART 1: The first part of the final written exam will consist of theoretical and/or practical questions and problems aimed at evaluating the acquired knowledge of the material covered in Block 1 (Radar systems), i.e. pre-Midterm content	60%(*)	T1.1, T1.3, T1.7, T2.2, T3.1, T3.2, T3.7
	PART 2: The second part of the final written exam will consist of theoretical and/or practical questions aimed at evaluating the acquired knowledge of the material covered in Block 2 (Radionavigtion systems), i.e., Post-Midterm content	40%	

Huella Digital acHQKfpoZnrCTpMq2lwxEOxIdCw=
Código seguro de verificación 8ToDtOfI2lmJ7kohOclrPUVZf

Laboratory work (PASS/FAIL)	Participation and successful completion of the laboratory classes is compulsory for passing the course. Evaluation based on participation, oral questioning and/or lab reports.	PASS/FAIL	T1.1, T1.3, T1.7, T2.2, T3.1, T3.2, T3.7

(*) There will be an individual written Midterm examination at the end of Block 1 which will cover the first part of the course (Block 1: Radar Systems). Students that obtain a global score greater or equal to 5 out of 10 have the option to skip Part 1 of the final exam.

The Final examination will consist of two parts: Part 1 covering pre-Midterm content (i.e., Block 1: Radar Systems) and Part 2 covering post-Midterm content (i.e., Block 2: Radionavigation Systems), each carrying a maximum of 10 points. The final exam will be held as follows: Part 1 of the final exam covering pre-Midterm material (Block 1) will be taken by those students who did not pass the Midterm exam (received a grade <5) or by students who wish to try to improve upon their Midterm grade. Then, Part 2 of the exam covering post-Midterm material (Block 2) will be taken by all of the students.

Note: Students who decide to take Part 1 the final exam to try to improve upon their Midterm grade, permanently renounce the grade received on the Midterm, irrespective of the result they obtain on the final exam.

The final grade is based on the grades received for each Part (Part 1 and Part 2). To pass the course it is necessary to obtain a minimum score of 4 out of 10 for each Part (Part 1 and Part 2), and obtain an overall minimum score of 5 out of 10 for the Final Grade. The grade for Part 1 can be obtained either though the Midterm (if the grade is >=5) or Part 1 of the Final Exam as outlined above. The grade for Part 2 can only be obtained via the Final Exam.

The final grade will then be calculated as:

Final grade= 60%(Part 1 grade)+40%(Part 2 grade)

To pass the course the student must obtain a Final grade >= 5.0, such that Part 1 grade >= 4 and Part 2 grade >= 4

7.2. Learning process monitoring

Learning process monitoring will be realized through the following activities:

- Posing questions/problems and monitoring student participation in the classroom.
- Monitoring student work in the laboratory sessions.
- Individual and/or group tutorials
- Individual written midterm and final examinations

8. Results, learning activities and assessment

8.1. Learning objectives/learning activities/results assessment

Learning objectives (4.4)	Lectures	Problem solving classes	Laboratory sessions	Consultations/Tutorials	Continuous assessment / Midterm	Course Assessment / Final Exam
Understand the principles of electromagnetic wave propagation and radio detection	X	X		X	X	X
Know the basic elements of radar systems and subsystems	X	X	X	X	X	X
Understand the problematics associated with radar system design.	X	X	X	X	X	X
Distinguish between different types of radar and modern radar applications	X	X	X	X	X	X
Explain positioning methods used in radionavigation	X	X		X	X	X
Know the basic principles of hyperbolic radionavigation systems	X	X		X	X	X
Understand the principles of operation of point-source and aircraft landing systems	X	X	X	X	X	X
Know the basic principles of satellite navigation systems	X	X	X	X	X	X

10. SCHEDULE

AH: ATTENDANCE HOURS.
CAH: CONVENTIONAL ATTENDANCE HOURS.
NCAH: NON-CONVENTIONAL ATTENDANCE HOURS.
NAH: NON-ATTENDANCE HOURS.

		Attendance Activities							Non Attendance Activities			
		Conventional				Non Conventional						
Week	Units or activities	*Lectures*	*Prob. solving classes*	*Lab sessions*	*Total CAH*	*Consultation/Tutorials*	*Midterm and final exam*	*Total NCAH*	*Individual study and exam preparation*	*Group/individual lab preparation and report writing*	*Total NAH*	TOTAL HOURS
1	Overview of the course + Unit 1	5	0	0	**5**	0	0	**0**	3	0	**3**	**8**
2	Unit 2	5	0	0	**5**	0	0	**0**	5	0	**5**	**10**
3	Unit 3	5	0	0	**5**	0	0	**0**	6	0	**6**	**11**
4	Unit 3	5	0	0	**5**	0	0	**0**	6	0	**6**	**11**
5	Unit 3	5	0	0	**5**	0	0	**0**	6	0	**6**	**11**
6	Unit 3	3	2	0	**5**	0	0	**0**	2	5	**7**	**12**
7	Lab Session 1 + Lab Session 2	0	0	5	**5**	0	0	**0**	2	5	**7**	**12**
8	Unit 4	5	0	0	**5**	0	0	**0**	6	0	**6**	**11**
9	Problems and Midterm review	0	5	0	**5**	2	0	**2**	8	0	**8**	**15**
10	Unit 5	5	0	0	**5**	0	1.5	**1.5**	6	0	**6**	**12.5**
11	Unit 6	5	0	0	**5**	0	0	**0**	6	0	**6**	**11**
12	Unit 6	5	0	0	**5**	0	0	**0**	4	3	**7**	**12**
13	Unit 6 + Lab Session 3	2	0	3	**5**	0	0	**0**	5	2	**7**	**12**
14	Unit 7	5	0	0	**5**	0	0	**0**	4	3	**7**	**12**
15	Lab Session 4 + Final Review	0	3	2	**5**	0.5	0	**0.5**	5	2	**7**	**12.5**
	Exam Period	0	0	0	**0**	2	2.5	**4.5**	10	0	**10**	**14.5**
	Other	0	0	0	**0**	0	0	**0**	0	0	**0**	**0**
	TOTAL HOURS	**55**	**10**	**10**	**75**	**4.5**	**4**	**8.5**	**84**	**20**	**104**	**187.5**

11. REFERENCES

11.1. Main References

– M. Richards, J. Scheer, W. Holm, *Principles of Modern Radar: Basic Principles*, SciTech Publishing, 2010

– B. Forsell, *Radionavigation Systems*, Artech House, Inc., 2008

11.2. Additional References

– J. C. Toomay, Paul J. Hannen, *Radar Principles for the Non-Specialist, 3rd Edition*, SciTech Publishing, 2004.

Huella Digital acHQKfpoZnrCTpMq2lwxEOxIdCw=
Código seguro de verificación 8ToDtOfI2lmJ7kohOclrPUVZf

– G. W. Stimson, *Introduction to Airborne Radar*, 2nd *Edition*, SciTech Publishing, 1998

– M. Skolnik*, Introduction to Radar Systems*, New York, McGraw-Hill, 3rd Edition, 2001

– *Radio Navigation, JAA ATPL Training Edition 2*, Jeppesen Sanderson Inc, 2007

– B. Hofmann-Wellenhof, K. Legat, M. Wieser, *Navigation, Principles of Positioning and Guidance*, Springer-Verlag, 2003

– M. Kayton, W.R. Fried, *Avionics Navigation Systems*, John Willey & Sons, Inc., 1997

– L.C. Peña Morán, *Ayudas a la Navegación Aérea*, Diego Marin Librero Editor, 2000

11.3. Network resources

– All material used during the development of this course will be available in Virtual Classroom

– O'Donnell, Robert M. *RES.LL-001 Introduction to Radar Systems, Spring 2007*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu License: Creative Commons BY-NC-SA

Huella Digital acHQKfpoZnrCTpMq2lwxEOxIdCw=
Código seguro de verificación 8ToDtOfI2lmJ7kohOclrPUVZf