Course guide
270171 - FDM - Physics of Memory Devices

Last modified: 30/01/2024

Unit in charge:	Barcelona School of Informatics
Teaching unit:	748 - FIS - Department of Physics.

Degree:	BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer:	GEMMA SESE CASTEL
Others:	Segon quadrimestre: JORDI MARTÍ RABASSA - 10 GEMMA SESE CASTEL - 10

PRIOR SKILLS

1. General knowledge : Physics and Mathematics at the level of Initial Phase at FIB.

2. Specific knowledge : analytical mathematical formalism and elementary notions of vector calculus .

3. Capacity : learning, problem solving, information search, abstraction and use of mathematical language .

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CT1.1A. To demonstrate knowledge and comprehension about the fundamentals of computer usage and programming, about operating systems, databases and, in general, about computer programs applicable to the engineering.
CT1.1B. To demonstrate knowledge and comprehension about the fundamentals of computer usage and programming. Knowledge about the structure, operation and interconnection of computer systems, and about the fundamentals of its programming.
CT1.2A. To interpret, select and value concepts, theories, uses and technological developments related to computer science and its application derived from the needed fundamentals of mathematics, statistics and physics. Capacity to solve the mathematical problems presented in engineering. Talent to apply the knowledge about: algebra, differential and integral calculus and numeric methods; statistics and optimization.
CT1.2B. To interpret, select and value concepts, theories, uses and technological developments related to computer science and its application derived from the needed fundamentals of mathematics, statistics and physics. Capacity to understand and dominate the physical and technological fundamentals of computer science: electromagnetism, waves, circuit theory, electronics and photonics and its application to solve engineering problems.
CT1.2C. To use properly theories, procedures and tools in the professional development of the informatics engineering in all its fields (specification, design, implementation, deployment and products evaluation) demonstrating the comprehension of the adopted compromises in the design decisions.
CT8.1. To identify current and emerging technologies and evaluate if they are applicable, to satisfy the users needs.
CT8.4. To elaborate the list of technical conditions for a computers installation fulfilling all the current standards and normative.

Generical:
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

TEACHING METHODOLOGY

The theoretical content will be worked out in lectures followed by practical sessions were problems and exercises will be discussed and solved. There will be two laboratory practices and one directed practice of numerical simulation, all of them performed by pairs.

LEARNING OBJECTIVES OF THE SUBJECT

1.Understanding the operation of new technologies for data storage in computers, phones, cameras, tablets, etc.
2.Understanding the magnetic field and its interactions
3.Understanding the phenomenon of magnetic induction and its applications to technology
4.Understanding the properties of electromagnetic waves and their applications
5.Understanding of the basic principles of Quantum Physics and its applications
6.Comprensió del làser i les seves característiques
7.Understanding the operation of electronic and optoelectronic devices
8.Using especific instruments from electronics, magnetism and optics laboratories (oscilloscope, digital multimeter, measuring magnetic fields-Hall probe, laser, etc.)
10.Performing data analysis and use of a wide variety of information' sources

STUDY LOAD

Type	Hours	Percentage
Guided activities	6,0	3.97
Self study	85,0	56.29
Hours large group	60,0	39.74

Total learning time: 151 h

CONTENTS

1. MAGNETIC FIELD

Description:
1.1. Magnetism in nature. Oersted experiment.
1.2. Magnetic forces on charges and currents: Lorentz force.
1.3. Hall effect. Hall effect sensors.
1.4. Field lines.

2. MAGNETIC INDUCTION

Description:
2.1. Induction phenomena.
2.2. Law of magnetic induction.
2.3. Eddy currents.
2.4. Magnetic Energy.
2.5. Diamagnetic, paramagnetic and ferromagnetic materials.
2.6. Magnetic memories. Ferroelectric memories. Motor drives.

3. ELECTROMAGNETIC WAVES

Description:

3.1. Electromagnetic spectrum.

3.2. Propagation. Laws of reflection and refraction. Optical fibers.

3.3. Polarization (absorption, reflection and dispersion). Birefringence. Optical instruments.

3.4. Interference. Diffraction. Diffraction gratings.

3.5. Magnetooptical and optical memories. Holographic memories.

4. QUANTUM PHYSICS

Description:

4.1. Introduction: photoelectric effect and Compton effect, ideas about special relativity, atomic spectra, Bohr model

4.2 Wave properties of particles

4.3 Principle of uncertainty of Heisenberg

4.4 Schrödinger equation

4.5 Tunnel effect: Scanning Tunneling Microscope, tunnel effect diode

4.6 Atomic quantum theory: hydrogen atom, electron spin, periodic table of elements

4.7 Applications: Giant magnetoresistence, Nuclear Magnetic Resonance

5. LASER

Description:

5.1. Incandescence and luminescence

5.2. Einstein's quantum theory of radiation

5.3. Essential elements of a laser

5.4. Characteristics of laser light

5.5. Classification of lasers

5.6. General applications of lasers

6. ELECTRONIC ANDI OPTOELECTRONIC DEVICES

Description:

6.1. Theory of conductivity: semiconductors.

6.2. MOSFET transistors.

6.3. Flash memory Memory circuits Scaling theory. Manufacture of integrated circuits.

6.4. Direct and indirect gap semiconductors. LED. Laser diode

6.5. Photoconductivity. Photodiodes. Solar cells CCD sensors and MOS sensors

6.6. DRAM cells. Miniaturization

ACTIVITIES

1. Magnetic Field

Description:
Development of the chapter 1 of the course: Analysis of properties and effects of magnetic fields. Calculation of magnetic fields and magnetic forces.

Specific objectives:
2, 8, 10

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 23h
Theory classes: 4h 30m
Practical classes: 4h
Laboratory classes: 2h 30m
Self study: 12h

2. Magnetic induction

Description:
Development of the second topic of the course: Description of the phenomenon of induction, Eddy's currents and their main applications in data storage: magnetic memories

Specific objectives:
1, 3, 10

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 20h
Theory classes: 4h
Practical classes: 4h
Self study: 12h

3. Electromagnetic waves

Description:
Development of the third issue of the course: Description of properties of electromagnetic waves in connection with the subject "Physics". Study of interference and diffraction, liquid crystals and their main applications in data storage: optical, magneto optical and holographic memories

Specific objectives:
1, 4, 8

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 22h 30m
Theory classes: 4h 30m
Practical classes: 4h
Laboratory classes: 2h
Self study: 12h

4. Quantum Physics

Description:
Development of the fourth issue of the course: Introduction to the main phenomena and quantum equations: duality, uncertainty, Schrödinger equation, spin. Application to magnetoresistance.

Specific objectives:
1, 5, 10

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 24h
Theory classes: 5h 30m
Practical classes: 6h 30m
Self study: 12h

5. Laser

Description:
Development of the fifth issue of the course: Description of Einstein's theory of radiation, lasers and their properties and applications.

Specific objectives:
1, 6, 8

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 8h
Theory classes: 3h
Practical classes: 2h
Self study: 3h

6. Electronic and optoelectronic devices

Description:
Development of the 6th. topic of the programme: Review and extension of the theory of semiconductors and MOSFET transistors. Applications to flash memory, sensors, solar cells.

Specific objectives:
1, 7, 10

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 21h 30m
Theory classes: 5h
Practical classes: 4h 30m
Self study: 12h

Partial exam

Description:
Written test after teaching the first three issues of the programme.

Specific objectives:
1, 2, 3, 4

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 2h
Guided activities: 2h

Final exam/second partial exam

Description:
Exam on the contents of the course. Students who have passed the first partial test may take an exam on the last three issues.

Specific objectives:
1, 2, 3, 4, 5, 6, 7

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 2h
Guided activities: 2h

Simulation exercise

Description:
Public Presentation of a numerical simulation project

Specific objectives:
4, 5, 10

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 24h
Guided activities: 3h
Self study: 21h

Assessment revision with feedback

Specific objectives:
4, 5, 10

Related competencies :
G9. PROPER THINKING HABITS: capacity of critical, logical and mathematical reasoning. Capacity to solve problems in her study area. Abstraction capacity: capacity to create and use models that reflect real situations. Capacity to design and perform simple experiments and analyse and interpret its results. Analysis, synthesis and evaluation capacity.

Full-or-part-time: 3h
Guided activities: 3h

GRADING SYSTEM

The evaluation is based on a midterm and a final exam, assessment of the problems done in class, the practical activities made at the laboratory and the rating of a simulation work.

Approximately at half of the semester there will be an exam, covering the first half of the syllabus. The final exam will test both the first and the second part. The first half is optional for those students who have passed the first part. The rating of the first part will be the maximum of two notes.

The final grade is calculated as follows:

NF = 0.50*NT + 0.25*NSim + 0.10*NPrac + 0.15*NPro

Where:

NF = Final mark
NT = [max (Npar, NEx1) NEx2 +] / 2
NPar = partial exam
NEx1 = 1st half of the final exam
NEx2 = 2nd half of the final exam
NSim = Mark of the simulation work
NPrac = Average of laboratory practices
NPro = mark of problems made at the classroom

The grade of the transversal ability G9 will be determined from exams (NE) and problems
(NPro) with marks : A (excellent) , B (good) , C (enough) , D (not passed) .

BIBLIOGRAPHY

Basic:

- Tipler, P.A.; Mosca, G. Física per a la ciència i la tecnologia. Barcelona: Reverté, 2010. ISBN 9788429144314.
- Giro, A. Física per a estudiants d'informàtica. Barcelona: Editorial Universitat Oberta de Catalunya, 2005. ISBN 8497881443.
- Pedrotti, F.L.; Pedrotti, L.S.; Pedrotti, L.M. Introduction to optics. 3rd ed. Pearson Prentice-Hall, 2007. ISBN 0131499335.
- Millman, J.; Halkias, C.C. Electronic devices and circuits. McGraw-Hill Book Co., 1967. ISBN 0070423806.

Complementary:

- Halliday, D.; Resnick, R.; Walker, J. Fundamentals of physics. 10th ed. John Wiley & Sons, 2013. ISBN 1118230728.
- Streetman, B.G.; Banerjee, S.K. Solid state electronic devices. 7th ed., global ed. Essex: Pearson, 2016. ISBN 9781292060552.
- Palais, J.C. Fiber optic communications. Prentice-Hall, 2005. ISBN 0138954429.
- Hecht, E. Optics. 5th ed, global ed. Pearson, 2017. ISBN 9781292096933.

RESOURCES

Hyperlink:

- http://cataleg.upc.edu/record=b1460877~S1*cat