270171 - FDM - Physics of Memory Devices

Coordinating unit: 270 - FIB - Barcelona School of Informatics
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2019
Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Teaching unit Optional)
ECTS credits: 6
Teaching languages: Catalan

Teaching staff

Coordinator: - Jordi Martí Rabassa (jordi.marti@upc.edu)
Others: - Gemma Sese Castel (gemma.sese@upc.edu)

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.

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.
270171 - FDM - Physics of Memory Devices

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 specific instruments from electronics, magnetism and optics laboratories (oscilloscope, digital multimeter, measuring magnetic fields-Hall probe, laser, etc.)
9. Performing data analysis and use of a wide variety of information sources

Study load

<table>
<thead>
<tr>
<th>Total learning time: 151h</th>
<th>Hours large group: 27h</th>
<th>17.88%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours medium group:</td>
<td>27h</td>
<td>17.88%</td>
</tr>
<tr>
<td>Hours small group:</td>
<td>4h</td>
<td>2.65%</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>8h</td>
<td>5.30%</td>
</tr>
<tr>
<td>Self study:</td>
<td>85h</td>
<td>56.29%</td>
</tr>
</tbody>
</table>
# 270171 - FDM - Physics of Memory Devices

## Content

### 1. MAGNETIC FIELD

**Degree competences to which the content contributes:**

**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

**Degree competences to which the content contributes:**

**Description:**
- 2.1. Induction phenomena.
- 2.2. Law of magnetic induction.
- 2.3. Eddy currents.
- 2.5. Diamagnetic, paramagnetic and ferromagnetic materials.

### 3. ELECTROMAGNETIC WAVES

**Degree competences to which the content contributes:**

**Description:**
- 3.1. Electromagnetic spectrum.
- 3.5. Magneto-optical and optical memories. Holographic memories.

### 4. QUANTUM PHYSICS

**Degree competences to which the content contributes:**

**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 magnetoresistance, Nuclear Magnetic Resonance
5. LASER

**Degree competences to which the content contributes:**

**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 AND OPTOELECTRONIC DEVICES

**Degree competences to which the content contributes:**

**Description:**
- 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
Planning of activities

| 1. Magnetic Field | Hours: 26h  
Theory classes: 4h  
Practical classes: 4h  
Laboratory classes: 2h  
Guided activities: 1h  
Self study: 15h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Development of the chapter 1 of the course: Analysis of properties and effects of magnetic fields. Calculation of magnetic fields and magnetic forces.</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>2, 8, 10</td>
</tr>
</tbody>
</table>

| 2. Magnetic induction | Hours: 20h  
Theory classes: 4h  
Practical classes: 4h  
Laboratory classes: 0h  
Guided activities: 0h  
Self study: 12h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>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</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>1, 3, 10</td>
</tr>
</tbody>
</table>

| 3. Electromagnetic waves | Hours: 28h  
Theory classes: 5h  
Practical classes: 4h  
Laboratory classes: 2h  
Guided activities: 1h  
Self study: 16h |
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Development of the third issue of the course: Description of properties of electromagnetic waves in connection with the subject &quot;Physics&quot;. Study of interference and diffraction, liquid crystals and their main applications in data storage: optical, magneto optical and holographic memories</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>1, 4, 8</td>
</tr>
<tr>
<td>4. Quantum Physics</td>
<td>Hours: 30h 30m</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 6h</td>
</tr>
<tr>
<td>Development of the fourth issue of the course: Introduction to the main phenomena and quantum equations: duality, uncertainty, Schrödinger equation, spin. Application to magnetoresistance.</td>
<td>Practical classes: 6h 30m</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td>1, 5, 10</td>
<td>Guided activities: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study: 17h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Laser</th>
<th>Hours: 13h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 3h</td>
</tr>
<tr>
<td>Development of the fifth issue of the course: Description of Einstein’s theory of radiation, lasers and their properties and applications.</td>
<td>Practical classes: 2h</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td>1, 6, 8</td>
<td>Guided activities: 0h</td>
</tr>
<tr>
<td></td>
<td>Self study: 8h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Electronic and optoelectronic devices</th>
<th>Hours: 26h 30m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 5h</td>
</tr>
<tr>
<td>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.</td>
<td>Practical classes: 4h 30m</td>
</tr>
<tr>
<td><strong>Specific objectives:</strong></td>
<td>Laboratory classes: 0h</td>
</tr>
<tr>
<td>1, 7, 10</td>
<td>Guided activities: 1h</td>
</tr>
<tr>
<td></td>
<td>Self study: 16h</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Partial exam</th>
<th>Hours: 2h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Guided activities: 2h</td>
</tr>
<tr>
<td>Written test after teaching the first three issues of the programme.</td>
<td>Self study: 0h</td>
</tr>
</tbody>
</table>
### Final exam/ second partial exam

**Hours:** 2h  
Guided activities: 2h  
Self study: 0h

**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

### Simulation exercise

**Hours:** 2h  
Guided activities: 2h  
Self study: 0h

**Description:**  
Doing and explaining of results of a numerical simulation practical exercise

**Specific objectives:**  
1, 10
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:

\[ NF = 0.50 \times NT + 0.25 \times NSim + 0.10 \times NPrac + 0.15 \times NPro \]

Where:

- **NF** = Final mark
- **NT** = \([\text{max (Npar, NEx1)} \text{ NEx2 } +] / 2\)
- **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:


Complementary:


Others resources:

Hyperlink

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