COURSE GUIDE
DEGREE

DEGREE: MEDICINE
ACADEMIC YEAR 2016/2017

COURSE: Biophysics and Physical Fundamentals of Imaging

Course Title
Diagnostic and Therapeutic Procedures

<table>
<thead>
<tr>
<th>ECTS</th>
<th>Type</th>
<th>Period</th>
<th>Calendar</th>
<th>Pre-requisites</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Basic</td>
<td>Obligatory</td>
<td>Optional</td>
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<tr>
<td>6</td>
<td>X</td>
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</tbody>
</table>

Course Language
Spanish | Valencian | English | French |

Department
Physics, Mathematics and Computer Science
Specific Area of knowledge
Applied Physics

Course Coordinator and other Professors
Name
Ignasi Rosell Escribà
Office / Faculty
Office 35 - Technical School of Design, Architecture and Engineering (ESET)
Email
rosell@uch.ceu.es
Student appointment schedule
Available on the Internet

Introduction to the Course
The main motivation of the syllabus of this course is twofold. First of all, we introduce some basics of Biophysics, which are convenient for a good development as a physician. On the other hand, we try to introduce the physical principles of diagnostic techniques based on medical imaging. Although we do not suppose prior knowledge in this subject, some concepts and mathematical techniques studied in high school are very desirable.

Without forgetting that this course is introductory, some concepts and proceedings of the scientific method are used. In any case, we try to apply most of the results to the health sciences in general and to medical physics in particular. Each unit is presented firstly in the physical world in general, but the application to the humans is fundamental in order to motivate and understand the different topics.

Humans are part of the physical world and, therefore, are affected by general laws governing the behaviour of
Introduction to the Course

Any physical system. Thus, it is difficult to understand deeply the way our bodies work without studying the physical processes in which their operation is based.

Pre-requisites

Not pre-requisites required.

Course Objectives

- Fundamentals of biomechanics
- Fluid dynamics
- Radiation physics
- Interaction of radiation with the body
- Physical fundamentals of diagnostic imaging techniques

General and Specific Skills Offered by the Course

General Skills

General Skill 1 Knowledge Acquisition
Building on the foundations laid during their secondary education and with the support of advanced textbooks, the students will be able to demonstrate a levels of knowledge and understanding equivalent to those at the forefront of their field of study.

General Skill 2 Application of Knowledge
Students will be able to apply their knowledge to their work or vocation in a professional manner and possess the skills typically demonstrated through devising and sustaining arguments and solving problems within epidemiology and public health.

General Skill 3 Collect and Interpret and Analyse Relevant Data
Students will gain the ability to gather and interpret relevant data to inform judgments that include reflection on social scientific and ethical issues.

General Skill 4 Communication
Students will gain the opportunity to improve their communication skills via dissemination of information, ideas, problems and solutions to both specialist and non-specialist audiences.

General Skill 5 Independent Learning
Students will be required to develop learning skills necessary to undertake in depth, detailed studies with a high degree of autonomy

Specific Skills

- Understand the fundamentals of the interaction of radiation with the human body.
- Know the radiographic image.
- Know the basic radiographic signs of different organ systems.
- Know how to interpret through systematic reading a radiological image.
- Know other techniques for obtaining diagnostic image.
- Learn to assess the indications and contraindications of radiological studies.
- Have the ability to apply the criteria for radiation protection procedures in diagnostic and therapeutic irradiation.

Course Contents

- Biomechanics
- Fluid dynamics
- Thermodynamics
### Course Contents

- Waves
- Radiations
- Medical imaging

### Course Structure and Design

- Lectures
- Seminars
- Laboratory
- Workshops
- Assessment
- Independent study
## Estimation of Student Workload

**Biophysics and Physical Fundamentals of Imaging**

| ECTS: | 6 |

### Breakdown of Student Work Hours

<table>
<thead>
<tr>
<th>Formative Activity</th>
<th>Contact Hours (A)</th>
<th>Independent Study (B)</th>
<th>Total Work Hours (C)</th>
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</thead>
<tbody>
<tr>
<td><strong>TAUGHT CLASSES</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Presentation</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Theory Classes</td>
<td>34</td>
<td>20</td>
<td>54</td>
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<tr>
<td>Debates</td>
<td></td>
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<tr>
<td>Feedback and Review of Assignments</td>
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<tr>
<td>Others</td>
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<tr>
<td><strong>PRACTICAL CLASSES</strong></td>
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<tr>
<td>Problem Solving</td>
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<tr>
<td>Debates</td>
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<tr>
<td>Feedback and Review of Assignments</td>
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<tr>
<td>Simulations</td>
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<tr>
<td>Laboratory</td>
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<tr>
<td>Practical Sessions in the Computer Lab</td>
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<tr>
<td>Visits</td>
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<tr>
<td>Presentation and discussion about coursework assignments</td>
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<tr>
<td>Other</td>
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<tr>
<td><strong>SEMINAR CLASSES</strong></td>
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<tr>
<td>Problem Solving</td>
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<tr>
<td>Debates</td>
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<tr>
<td>Feedback and Review of Assignments</td>
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<tr>
<td><strong>WORKSHOPS</strong></td>
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<tr>
<td>Feedback and Review of Assignments</td>
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<tr>
<td>Oral Presentations</td>
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<tr>
<td>Practical Sessions in the Computer Lab</td>
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<td><strong>COURSEWORK</strong></td>
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<tr>
<td>Preparation time required</td>
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<tr>
<td><strong>EXAMS AND ASSESSMENTS</strong></td>
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<tr>
<td>Exam preparation time</td>
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<tr>
<td>Exams and Tests</td>
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<tr>
<td>Others</td>
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<tr>
<td>TOTAL</td>
<td>90</td>
<td>60</td>
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</table>

### Relationship Between Work Hours and ECTS Credits

|                | 25 |

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*Medicine / Biophysics and Physical Fundamentals of Imaging / 2016-2017*
Assessment Criteria

The final grade is obtained through a continuous assessment that the professor performs in the classroom, in the laboratory and in the computer room. The continuous assessment follows the table below.

The final grade is obtained by considering the results of the continuous assessment and the final exam. To pass the course students must get at least 50% of the final grade and at least 40% of the final exam. Note that the continuous assessment can be recovered only in the extraordinary call.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Seminars (assignments 7.5% + small exams 7.5%)</td>
<td>15%</td>
</tr>
<tr>
<td>Laboratory (work in the lab 7.5% + lab exam 7.5%)</td>
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<tr>
<td>Workshops (oral presentations)</td>
<td>5%</td>
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<td>Exams during the course (2 exams x 7.5%)</td>
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<tr>
<td>Final exam</td>
<td>50%</td>
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Course Program

LECTURES & SEMINARS

UNIT 0. INTRODUCTION
UNIT 1. BIOMECHANICS
UNIT 2. FLUIDS
UNIT 3. THERMODYNAMICS
UNIT 4. WAVES
UNIT 5. IONIZING RADIATIONS
UNIT 6. MEDICAL IMAGING

SEMINARS

SEMINAR 1. INTRODUCTION
SEMINAR 2. BIOMECHANICS I
SEMINAR 3. BIOMECHANICS II
SEMINAR 4. FLUIDS
SEMINAR 5. THERMODYNAMICS
SEMINAR 6. WAVES
SEMINAR 7. IONIZING RADIATIONS

LABORATORY

LAB 1. MEASURING DENSITIES. UNCERTAINTIES
LAB 2. MEASURING VISCOSITIES. INTERPOLATION
LAB 3. MEASURING SURFACE TENSIONS. LINEAR REGRESSION
LAB 4. THE SIMPLE PENDULUM
LAB 5. ELECTRICITY

WORKSHOPS

WORKSHOPS 1, 2 & 3. WORKING WITH OSIRIX.
## Detailed Course Contents

### UNIT 0. INTRODUCTION (≈ 1 WEEK)

- 0.1. VECTORS
- 0.2. UNITS
- 0.3. DIMENSIONAL ANALYSIS

### UNIT 1. BIOMECHANICS (≈ 4 WEEKS)

1.1. KINEMATICS
   - 1.1.1. POSITION AND DISPLACEMENT
   - 1.1.2. VELOCITY
   - 1.1.3. ACCELERATION

1.2. DYNAMICS
   - 1.2.1. NEWTON’S LAWS
   - 1.2.2. FORCE IN ANIMALS
   - 1.2.3. CONSERVATION OF LINEAR MOMENTUM
   - 1.2.4. THE CENTRE OF MASS
   - 1.2.5. FUNDAMENTAL AND NON-FUNDAMENTAL FORCES

1.3. HUMAN STATICS AND MOTION
   - 1.3.1. ANGULAR MOMENTUM
   - 1.3.2. HUMAN STATICS
   - 1.3.3. MOTION IN HUMAN BEINGS

1.4. WORK AND ENERGY
   - 1.4.1. WORK AND KINETIC ENERGY
   - 1.4.2. ENERGY IN HUMAN BEINGS

### UNIT 2. FLUIDS (≈ 3 WEEKS)

2.1. INTRODUCTION
2.2. FLUID STATICS
   - 2.2.1. ARCHIMEDES’ PRINCIPLE

2.3. MOTION IN FLUIDS I: IDEAL FLUIDS
2.4. MOTION IN FLUIDS II: REAL FLUIDS
   - 2.4.1. VISCOSITY
   - 2.4.2. POISSON L’EQUATION
   - 2.4.3. RESISTANCE AND POWER

2.5. BLOOD CIRCULATION
   - 2.5.1. PRESSURES IN THE CIRCULATORY SYSTEM
   - 2.5.2. RESISTANCE AND POWER IN HEART
   - 2.5.3. THE SPHYGMOMANOMETER

2.6. COHESIVE FORCES
2.7. OSMOSIS

### UNIT 3. THERMODYNAMICS (≈ 2 WEEKS)

3.1. TEMPERATURE, HEAT AND WORK
   - 3.1.1. TEMPERATURE
   - 3.1.2. PRESSURE IN GASES
   - 3.1.3. THE IDEAL GAS
   - 3.1.4. WORK IN GASES
   - 3.1.5. HEAT

3.2. FIRST LAW OF THERMODYNAMICS
   - 3.2.1. HEAT CAPACITY
   - 3.2.2. ADIABATIC PROCESSES
   - 3.2.3. ENTHALPY
   - 3.2.4. ENERGETIC BALANCE IN HUMAN BEINGS
### Detailed Course Contents

**UNIT 4. WAVES (≈ 2 WEEKS)**

4.1. WAVES: MAIN FEATURES  
4.2. HARMONIC WAVES  
4.3. SOUND AND LIGHT  
  4.3.1. SOUND  
  4.3.2. LIGHT  
4.4. BORDERS: REFLECTION AND REFRACTION  
  4.4.1. REFLECTION  
  4.4.2. REFRACTION  
4.5. INTERFERENCE AND DIFFRACTION  
  4.5.1. SUPERPOSITION OF WAVES  
  4.5.2. STANDING WAVES  
  4.5.3. THREE-DIMENSIONAL WAVES  
  4.5.4. INTERFERING WITH LIGHT: YOUNG’S EXPERIMENT  
  4.5.5. DIFFRACTION

**UNIT 5. IONIZING RADIATIONS (≈ 2 WEEKS)**

5.1. A FEW WORDS ABOUT QUANTUM MECHANICS  
  5.1.1. THE NATURE OF LIGHT  
  5.1.2. THE ATOMIC STRUCTURE  
  5.1.3. BOHR MODEL  
  5.1.4. THE DE BROGLIE HYPOTHESIS  
  5.1.5. WAVE-PARTICLE DUALITY  
5.2. ATOMIC NUCLEUS  
5.3. RADIOACTIVITY  
  5.3.1. HALF-LIFE  
5.4. BIOLOGICAL EFFECTS OF IONIZING RADIATION  
  5.4.1. MAIN FEATURES  
  5.4.2. EFFECTS ON LIVING BEINGS

**UNIT 6. MEDICAL IMAGING (≈ 1 WEEK)**

6.1. IMAGING  
6.2. X-RAY AND X-RAY COMPUTED TOMOGRAPHY (CT)  
6.3. POSITRON EMISSION TOMOGRAPHY (PET)  
6.4. TRACERS  
6.5. MAGNETIC RESONANCE IMAGING (MRI)

### Basic Bibliography


### Additional Reading

Other Support Materials

Other key resources for the course will be posted on the Intranet:
- Slides used in the Lectures.
- Assignments for the Seminars.
- Workbook for Laboratory and Workshops.
- Examples of exams (with solutions).

Recommendations to Students Taking This Course

Students should follow the continuous assessment and do all the assignments in the period given for them. Their study should be constant along the whole semester and the use of the office hours if something is not understood is fundamental. The use of the bibliography and the additional reading is very convenient.

Links to On-going Research

This is an introductory course.

Links to the Dental Profession

The fundamentals studied thorough this course are convenient for other courses and specifically for medical imaging.