200171 - MMF - Mathematical Models in Physics

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 748 - FIS - Department of Physics
Academic year: 2018
Degree: BACHELOR'S DEGREE IN MATHEMATICS (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits: 7.5
Teaching languages: Spanish

Teaching staff
Coordinator: ALVARO MESEGUER SERRANO
Others: Segon quadrimestre:
BLAS ECHEBARRIA DOMINGUEZ - A
ALVARO MESEGUER SERRANO - A

Prior skills
The course "Mathematical Models of Physics" is the second general physical content and the first block of matter "modeling" Math Grade FME. This subject is based on the knowledge of the subject of Physics in Q4 and expands its own theoretical formulations of classical mathematical physics using mathematical tools, mainly from multivariable calculus, that the student knows at this point. The course should also provide a base to discuss real systems such as in "Mathematical models of technology" and in different subjects as "Dynamical systems and analysis" and "Numerical methods and engineering."

Degree competences to which the subject contributes

Specific:
1. CE-1. Propose, analyze, validate and interpret simple models of real situations, using the mathematical tools most appropriate to the goals to be achieved.
2. CE-2. Solve problems in Mathematics, through basic calculation skills, taking into account tools availability and the constraints of time and resources.
3. CE-3. Have the knowledge of specific programming languages and software.
4. CE-4. Have the ability to use computational tools as an aid to mathematical processes.

General:
5. CB-1. Demonstrate knowledge and understanding in Mathematics that is founded upon and extends that typically associated with Bachelor's level, and that provides a basis for originality in developing and applying ideas, often within a research context.
6. CB-2. Know how to apply their mathematical knowledge and understanding, and problem solving abilities in new or unfamiliar environments within broader or multidisciplinary contexts related to Mathematics.
7. CB-3. Have the ability to integrate knowledge and handle complexity, and formulate judgements with incomplete or limited information, but that include reflecting on social and ethical responsibilities linked to the application of their knowledge and judgements.
8. CB-4. Have the ability to communicate their conclusions, and the knowledge and rationale underpinning these to specialist and non-specialist audiences clearly and unambiguously.
9. CG-1. Show knowledge and proficiency in the use of mathematical language.
10. CG-2. Construct rigorous proofs of some classical theorems in a variety of fields of Mathematics.
11. CG-3. Have the ability to define new mathematical objects in terms of others already known and ability to use these
The general objective of the course is that students assume that mathematics is the real language of physics, and it is not a collection of tricks difficult to justify, and that, starting from certain postulates, it is possible to derive rigorous laws, so that if the results make conflicting predictions with experiment, the postulates must be changed.

The central objective is to familiarize with the basic ideas of four fields of classical physics and their mathematical formulations. The student will have the conceptual tools to enter independently in these fields and to interact with physicists and engineers.

The mechanical part concerns with the Euler-Lagrange and Hamilton equations, and the principles of symmetry and its relation with conservation laws. The block of Electromagnetism presents the Maxwell equations in integral and differential form, and discuss their Lorentz invariance to link it with special relativity. Finally, the part of Continuous Media, besides of introducing the concept of balance of various quantities and the material derivative, focuses on fluid mechanics, culminating in the Navier-Stokes equation and some of its solutions and their stability.

The more detailed objectives are:

- Understanding the Lagrangian and Hamiltonian formulation of mechanics.
- To use the calculus of variations to introduce the variational principles of mechanics.

Transversal:

- EFFICIENT ORAL AND WRITTEN COMMUNICATION. Communicating verbally and in writing about learning outcomes, thought-building and decision-making.
- SUSTAINABILITY AND SOCIAL COMMITMENT. Being aware of and understanding the complexity of social and economic phenomena that characterize the welfare society.
- TEAMWORK. Being able to work as a team player, either as a member or as a leader.
- EFFECTIVE USE OF INFORMATION RESOURCES. Managing the acquisition, structure, analysis and display of information from the own field of specialization.
- SELF-DIRECTED LEARNING. Detecting gaps in one's knowledge and overcoming them through critical self-appraisal.

Learning objectives of the subject

The course is designed for a total of 65 teaching hours (13 weeks) in 39 hours of theory sessions and 26 hours of practical sessions (problems). Both in the theoretical and, above all, in the practice sessions, we try to involve the students in their development, inviting them to solve the problems proposed and even to develop a theoretical section. In the sessions of problems, besides the exercises to be discussed in class, other ones will be delivered to the students. Some of them will be required, and the others could be delivered voluntarily. These exercises would be discussed in the tutorial hours or, exceptionally, in class.

Another objective is to habituate the students to use English bibliography. Catalan and spanich will be both used in the courses.

Teaching methodology

The course is designed for a total of 65 teaching hours (13 weeks) in 39 hours of theory sessions and 26 hours of practical sessions (problems). Both in the theoretical and, above all, in the practice sessions, we try to involve the students in their development, inviting them to solve the problems proposed and even to develop a theoretical section. In the sessions of problems, besides the exercises to be discussed in class, other ones will be delivered to the students. Some of them will be required, and the others could be delivered voluntarily. These exercises would be discussed in the tutorial hours or, exceptionally, in class.

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The more detailed objectives are:

- Understanding the Lagrangian and Hamiltonian formulation of mechanics.
- To use the calculus of variations to introduce the variational principles of mechanics.
To apply the Lagrangian and Hamiltonian formulations for complex mechanical problems.

To describe Electromagnetism with Maxwell's equations in integral and differential form.

To obtain the wave equations of Electromagnetism.

To describe the Lorentz transformations.

Understanding the Lorentz invariance of Maxwell's equations.

To apply the equations of Special Relativity to simple kinematic problems.

Understanding the Eulerian formulation of fluid mechanics.

Understanding the development of various conservation laws of fluid mechanics, in differential and integral form.

Understanding the application of the Navier-Stokes equation and its solutions.

To apply the equations of fluid mechanics to systems and problems.

### Study load

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group: 45h</th>
<th>24.00%</th>
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</thead>
<tbody>
<tr>
<td>Total learning time: 187h 30m</td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Hours small group: 30h</td>
<td>16.00%</td>
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<td></td>
<td>Guided activities: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study: 112h 30m</td>
<td>60.00%</td>
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<tr>
<td>Content</td>
<td>Learning time:</td>
<td>Theory classes:</td>
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<tr>
<td>----------------------------------------</td>
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</tr>
<tr>
<td><strong>CLASSICAL MECHANICS</strong></td>
<td>15h</td>
<td>9h</td>
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<tr>
<td><strong>Description:</strong></td>
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<tr>
<td><strong>ELECTROMAGNETIC FIELD AND SPECIAL RELATIVITY</strong></td>
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<td>10h</td>
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<tr>
<td><strong>Description:</strong></td>
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<tr>
<td><strong>FLUID DYNAMICS</strong></td>
<td>32h</td>
<td>19h</td>
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<td><strong>Description:</strong></td>
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<td>4. Hydrodynamic stability: numerical computation</td>
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Qualification system

At the end of the first two parts of the course there is a first partial exam, with a 45% weight in the final qualification of the subject.

After finishing the course, students can choose to perform a second partial exam of the two remaining parts, weighting 45% of the final grade, or a final exam of the entire course, whose value would be, in this case, 90% of the final grade. The remaining 10% will come from the correction of the problems submitted by the students during the course.

An extra exam will take place on July for students that failed during the regular semester.

Bibliography

Basic:


Complementary:


Goldstein, Herbert ; Safko, Joh ; Poole, Charles P. Classical mechanics. 3rd ed. San Francisco [etc.]: Addison-Wesley, cop. 2002. ISBN 0201657023.