Course guide
230467 - MEC - Mechanics

Last modified: 19/06/2023

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

Degree: BACHELOR'S DEGREE IN ENGINEERING PHYSICS (Syllabus 2011). (Compulsory subject).

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

LECTURER

Coordinating lecturer: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura

Others: Consultar aquí / See here: https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Ability to solve problems in thermodynamics, heat transfer and fluid mechanics, in the fields of physics, aerodynamics, geophysics and engineering.

Generical:
1. ABILITY TO IDENTIFY, FORMULATE, AND SOLVE PHYSICAL ENGINEERING PROBLEMS. Planning and solving physical engineering problems with initiative, making decisions and with creativity. Developing methods of analysis and problem solving in a systematic and creative way.

Transversal:
2. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.
3. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.

TEACHING METHODOLOGY

There are two types of lectures: theoretical and practical. The main concepts and the fundamental results along with some examples and practical applications are discussed in the theoretical lectures. The practical lessons are devoted to solving exercises and a more active participation of the students is expected. Additional examples and applications are also discussed in the practical lectures.

LEARNING OBJECTIVES OF THE SUBJECT

- Ability to identify the freedom degrees and generalized coordinates of a system of particles and rigid bodies.
- Ability to write de Lagrange and Hamilton equations of motion for any mechanical system.
- Knowledge of the concepts of equilibrium, stability and linearization of the equations of motion.
- Ability to linearize the equations of motion and write the equations for the eigenfrequencies and normal modes.
- Ability to pose dynamical problems for 2D and 3D rigid bodies.
- Being able to identify problems of kinematics and dynamics in which the relativistic corrections are relevant.
- being able to formulate and solve some problems of relativistic kinematics and dynamics.

STUDY LOAD

Type	Hours	Percentage
Self study	85,0	56.67
Hours large group	65,0	43.33

Total learning time: 150 h

CONTENTS

1.- Introduction to relativity.

Description:
1.1 Principle og Galilean Relativity
1.2 Galilean transformations
1.3 Waves
1.4 Electromagnetism
1.5 Michelson-Morley experiment

Full-or-part-time: 6h 55m
Theory classes: 3h
Self study : 3h 55m

2.- Postulates of Special Relativity and Lorentz transformations

Description:
2.1 Postulates
2.2 Lorentz transformations
2.3 Some consequence of Lorentz transformations
2.4 General Lorentz transformations

Full-or-part-time: 16h 10m
Theory classes: 4h
Practical classes: 3h
Self study : 9h 10m

3.- Relativistic kinematics

Description:
3.1 Transformation of velocities
3.2 Transformation of accelerations
3.3 Proper acceleration in rectilinear movement

Full-or-part-time: 6h 55m
Theory classes: 2h
Practical classes: 1h
Self study : 3h 55m

4.- Space-time and 4-vectors

Description:
4.1 4-vectors
4.2 Proper time
4.3 4-velocity
4.4 4-acceleration
4.5 Classification of intervals
4.6 Classification of 4-vectors

Full-or-part-time: 4h 37m
Theory classes: 1h
Practical classes: 1h
Guided activities: 2h 37m

Relativistic dynamics

Description:
5.1 Fundamental postulate of the Relativistic Dynamics
5.2 Classification of collisions
5.3 Photons
5.4 The zero moment RS
5.5 The 4-force and the relativistic 3-force
5.6 Example: Lorentz 4-force
5.7 3-forces and accelerations in some relevant cases
5.8 Transformation of the 3-force

Full-or-part-time: 11h 33m
Theory classes: 3h
Practical classes: 2h
Self study : 6h 33m

6.- Complements of Newtonian Mechanics

Description:
6.1 Changes of reference frame. Accelerations of d'Alembert, centrífuga i de Coriolis. Forces d'inèrcia.
6.2 Kinematics of a rigid body. Instantaneos axis of rotation and sliding and imnstantaneous center of rotations in the 2D case.
6.3 Angular momentum and energy of a rigid body. Tensor and moments of inertia.
6.4 Dynamics of a rigid body. Euler's equations. Examples: free rigid body, precession, etc.

Full-or-part-time: 34h 39m
Theory classes: 10h
Practical classes: 5h
Self study : 19h 39m

7. Lagrangian formulation of Mechanics.

Description:
7.1. Holonomic constraints. Virtual work principle.
7.2. Generalized coordinates and equations of motion. Lagrange equations.
7.3. Generalized potentials.
7.4. Examples: central forces and gravitation.
7.5. Variational equations and action principle.

Full-or-part-time: 23h 06m
Theory classes: 6h
Practical classes: 4h
Self study : 13h 06m

8. Small oscillations.

Description:
8.1. Linearization at an equilibrium point. Stability.
8.2 Eigenvalue equation. Diagonalization of T and V.
8.3. Normal modes of motion. Examples.
8.4. Forced oscillations and resonance.
8.5. Nonlinear oscillations.

Full-or-part-time: 23h 06m
Theory classes: 6h
Practical classes: 4h
Self study : 13h 06m

9. Hamilton formulation.

Description:
9.1. Generalized moments and Hamilton function.
9.2. Poisson brackets.
9.3. Liouville's theorem.
9.4. Conservation laws. Noether's theorem.
9.5 Example: central forces.

Full-or-part-time: 23h 06m
Theory classes: 6h
Practical classes: 4h
Self study : 13h 06m

GRADING SYSTEM

The grading process consists of two partial exams (EP1, EP2) and a final exam (EF). The first partial exam will be held at mid semester and both the final exam and the second partial exam will be held the same day at the end of the semester.
The final grade will be: max{EF,0.5*EP1+0.5*EP2}

BIBLIOGRAPHY

Basic:
- Llosa, J.; Molina, A. Relativitat especial amb aplicacions a l'electrodinàmica clàssica. Barcelona: Universitat de Barcelona, 2004. ISBN 9788447528158.
- Rindler, W. Relativity. Oxford: Oxford University Press, 2001. ISBN 9780198508366.
- Taylor, J.R. Classical mechanics. Sausalito, California: University Science Books, 2005. ISBN 189138922X.
- Symon, K.R. Mechanics. 3rd ed. Reading, Massachusets: Addison Wesley, 1971. ISBN 0201073927.
- Goldstein, H.; Poole, C.; Safko, J. Classical mechanics. International ed. Pearson, 2014. ISBN 9781292026558.
- Hand, L.N.; Finch, J.D. Analytical mechanics. Cambridge: Cambridge University Press, 1998. ISBN 052157572.

RESOURCES

Other resources:
Notes of the subject and list of exercises to solve.