Bachelor in Physics
(Academic Year 2025-26)

Classical Mechanics		**Code**	800498	**Year**	2nd	**Sem.**	1st
Module	General Core	**Topic**	Classical Physics	**Character**	Obligatory		

	Total	**Theory**	**Exercises**
ECTS Credits	7.5	4.5	3
Semester hours	69	39	30

Learning Objectives (according to the Degree's Verification Document)

- Write the Lagrangian and Hamiltonian of a dynamical system in different types of generalized coordinates, and derive from them the corresponding equations of motion.
- Learn how to apply conservation laws to analyzing the motion of a mechanical system.
- Study the motion of a particle in a central potential.
- Learn the elementary kinematics and dynamics of rigid bodies.
- Study in greater depth the fundamentals of special relativity.

Brief description of contents

Review of Newtonian mechanics. Motion in a central force field. Introduction to analytical mechanics. Non-inertial reference frames. Rigid body motion. Complements on special relativity.

Prerequisites

Calculus, linear algebra, vector algebra and calculus, general physics.

Coordinator	Luis Manuel González Romero		**Dept.**	FT
	Room	02.320.0	**e-mail**	mgromero@ucm.es

Theory/Problems – Schedule and Teaching Staff

Group	**Lecture Room**	**Day**	**Time**	**Professor**	**Period/ Dates**	**Hours**	**T/E**	**Dept.**
B	10	Mo W Th	10:30 – 12:00 9:00 – 11:00 9:00 – 10:30	Fernando Ruiz Ruiz	Full term	69	T/E	FT

T: Theory, E: Exercises

Office hours				
Group	**Professor**	**Schedule**	**E-mail**	**Location**
B	Fernando Ruiz Ruiz	Tu, We, Th: 11:30 - 13:30	ferruiz@fis.ucm.es	0.315.0

Syllabus

1. **Review of Newtonian mechanics**
   Kinematics of a point particle. Inertial systems and Galilean relativity. Motion in a one-dimensional potential. Dynamics of a system of particles. Constants of motion.

2. **Motion in a central potential**
   Reduction of the equivalent two-body problem. Constants of motion. Integration of the equations of motion. Bounded orbits. The Kepler problem. Scattering by a central potential. Rutherford's formula.

3. **Fundamentals of Lagrangian and Hamiltonian mechanics**
   Introduction to the calculus of variations. Hamilton's principle for unconstrained systems. Constraints and generalized coordinates. Lagrange's equations. Constants of motion and Nöther's theorem. Small oscillations. Hamilton's canonical equations. Poisson brackets.

4. **Motion relative to a non-inertial frame**
   Three-dimensional rotations. Relative angular velocity of two orthonormal frames. Equations of motion in a non-inertial frame. Motion relative to the rotating Earth. Foucault's pendulum.

5. **Rigid body motion**
   Angular momentum and kinetic energy of a rigid body. Inertia tensor. The equations of motion of a rigid body. Euler's equations. Inertial motion of a symmetric top. Lagrange's top.

6. **Introduction to relativistic mechanics**
   Einstein's postulates. Lorentz transformations and their physical consequences. Relativistic addition of velocities.Four-velocity and four-momentum. Relativistic energy. Conservation of the four-momentum. Mass-energyequivalence. Relativistic collisions. Particles of zero mass. Relativistic dynamics.

Bibliography

Basic:

- S.T. Thornton and J.B. Marion, *Classical Dynamics of Particles and Systems,* 5th edition, Brooks/Cole, 2004.
- J.R. Taylor, *Classical Mechanics,* University Science Books, 2005.
- E.F. Taylor and J.A. Wheeler, *Spacetime Physics,* Freeman, 1992.
- A.P. French, *Special Relativity* (M.I.T. Introductory Physics), 1st edition, W. W. Norton & Company, 1968.
- A. González López, Lecture Notes on Classical Mechanics, 2020 (https://teorica.fis.ucm.es/artemio/Notas%20de%20curso/MC.pdf).

Complementary:

- F. Gantmacher, *Lectures in Analytical Mechanics,* MIR Publications, 1975.
- H. Goldstein, C. Poole, J. Safko, *Classical Mechanics,* 3rd edition, Addison Wesley, 2002.
- L.D. Landau, E.M. Lifshitz, *Mechanics* (Course of Theoretical Physics, vol. 1), 3rd edition, Butterworth-Heinemann, 1976.
- L. Meirovitch, *Methods of Analytical Dynamics,* Dover, 2010.
- F.A. Scheck, *Mechanics: From Newton's Laws to Deterministic Chaos,* 4th edition, Springer, 2005.
- W. Rindler, *Introduction to Special Relativity,* Oxford, 1991.

Online Resources

Material and announcements related to the course will be posted in UCM's "Campus Virtual".

Methodology

Lectures will consist of theoretical explanations (including examples) and problem solving sessions. The corresponding problems will be made available to the students in advance through UCM's "Campus Virtual" at the beginning of each topic.

The instructor will answer both theoretical and problem-related questions from the students during his office hours.

Evaluation Criteria

Exams	Weight:	70%

The final exam will consist of a number of practical problems similar in difficulty to those solved during the lectures.

Other Activities	Weight:	30%

Exercises solved individually by students during lecture hours similar to those discussed in problem-solving sessions.

Final Mark

The final grade will be computed according to the formula

$$G = \max(E, 0.7\,E + 0.3\,A),$$

where E and A are respectively the "Exams" and "Other activities" grades (both in the range 0-10).

The grade obtained in the "Other activities" category in the first semester term will be carried over to the second semester evaluation (when applicable).