



Bachelor in Physics (Academic Year 2021-22)

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	67.5	37	30.5

Learning Objectives (according to the Degree's Verification Document)
<ul style="list-style-type: none"> • 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	Artemio González López			Dept.	FT
	Room	29 (2 nd West)	e-mail	artemio@ucm.es	

Theory/Exercises – Schedule and Teaching Staff								
Group	Lecture Room	Day	Time	Professor	Period/ Dates	Hours	T/E	Dept.
B	10	Mo, We, Th	10:30-12:00 09:00-11:00 09:00-10:30	Artemio González López	Full term	67.5	T/E	FT

T: Theory, E: Exercises

Office hours				
Group	Professor	Schedule	E-mail	Location
B	Artemio González López	M: 10:30-13:00 V: 11:00-13:00-14:30-16:00	artemio@ucm.es	29 (2 nd West)

Syllabus

- 1. Review of Newtonian mechanics**
Inertial systems and Galilean relativity. Kinematics of a point particle. 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. 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. Special relativity**
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-energy equivalence. 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 (<http://jacobi.fis.ucm.es/artemio/Notas%20de%20curso/CM.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
On-campus teaching 100% (Scenario 0)
<p>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.</p> <p>The instructor will answer both theoretical and problem-related questions from the students during his office hours.</p>
Semi-online teaching (Scenario 1)
<p>The course will basically follow option A from the document "Medidas Extraordinarias de planificación y organización docente para el curso 2020-21" (https://fisicas.ucm.es/info-coronavirus-fisicas_ucm). Lectures will take place at their scheduled time and classroom attended by a subgroup of the class, which will rotate on a weekly basis. The lectures will be taped and broadcast live via Google Meet, so that the students not able to attend them in person can interact with the instructor and ask questions. The recorded lectures, as well as other didactic material such as lecture notes, solved problems, solved exams from past courses, Mathematica or Maple notebooks, etc., will be available to the students through the UCM's intranet ("Campus Virtual").</p>
Online teaching (Scenario 2)
<p>Lectures will be broadcast live via Google Meet at their scheduled hours and recorded. The recorded lectures, as well as other didactic material such as lecture notes, solved problems, solved exams from past courses, Mathematica or Maple notebooks, etc., will be available to the students through the UCM's intranet ("Campus Virtual"). Office hours will take place individually by email or, when necessary, in Google Meet sessions.</p>

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%
Two or three times during the course, exercises similar to those discussed in problem-solving sessions will be proposed to the class to be individually solved in writing by the students during lecture hours.		
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).		