CCClassical Mechanics
Groups B & B2

UNIVERSIDAD COMPLUTENSE MADRID

BACHELOR IN PHYSICS

Fernando Ruiz
Department of Theoretical Physics
Fall Semester 2024/25

Syllabus

1. (Review of) Newtonian mechanics. Newton's laws: inertial frames, covariance, validity of the third law. Motion of a particle in one dimension: conservative forces, equilibrium points, harmonic oscillations. Constants of motion. Systems of particles.

2. Motion in a central potential. The two-body problem and its reduction to the equivalent one-particle problem. Conserved quantities. Equations of motion. The Kepler problem and planetary motion. Scattering: cross section and Rutherford's formula.

3. Lagrangian mechanics. Introduction to the calculus of variations. The principle of stationary action: Lagrangian, action and Euler-Lagrange equations. Constraints and generalized coordinates. Properties of the Lagrangian formulation. Noether's theorem.

4. Hamiltonian mechanics. The Legendre transform, the Hamiltonian and phase space. Hamilton's equations. The principle of stationary action. Poisson brackets.

5. Motion relative to a non-inertial frame. Rotating frames: velocity and acceleration. Dynamics in a rotating frame. Motion of a particle relative to the (rotating) Earth. Foucault's pendulum

6. Motion of rigid bodies. Degrees of freedom, angular momentum and kinetic energy. The inertia tensor. Equations of motion of a rigid body. The symmetric dtop.

7. Introduction to special relativity. The principles of special relativity. Lorentz transformations and the invariant interval. Four-dimensional formulation. Relativistic collisions and conservation of energy and momentum. Relativistic dynamics.

References

Basic

- S. T. Thornton and J. B. Marion, *Classical dynamics of particles and systems*, 5th edition, Brooks/Cole (2004).
- L. Hand and J. Finch, *Analytical mechanics*, Cambridge University Press (1998).
- J. R. Taylor, *Classical Mechanics*, University Science Books (2005).

Complementary

- H Goldstein, C. Poole and J. Safko, *Classical mechanics*. Last edition, Pearson (2013). Previous, Addison-Wesley (2002).
- L. Landau and E.Lifshitz, *Mechanics*, 3rd edition, Elsevier (1976).
- F. Scheck, *Mechanics: From Newton's laws to deterministic chaos*, Graduate Texts in Physics, Elsevier (2010).

Learning outcomes

By the end of the course the student should:
- Understand and use with confidence the Lagrangian formulation of classical dynamics.
- Understand the principle of stationary action and Noether's theorem.
- Be able to work with ease in different coordinate systems.

Grading

Final exam grade = F
Other activities grade (may include problems solved individually by students either at home or in-class, a midterm exam, ...) = M.
Course grade = CG = $\max\left(0.3\times \mathrm{M} + 0.7\times \mathrm{F},\ \mathrm{F}\right)$.