PHYS 5310
Fall 2022
Classical Mechanics

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The following text is required by UTRGV authorities:
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Course Description: This is an introduction to Classical Mechanics at a graduate level. It does require a knowledge of Calculus of Multiple Variables, some knowledge of differential equations and a knowledge of Classical mechanics at the undergraduate level.

1 Learning Objectives for this course

This is probably the most fundamental course in the education of a professional physicist. Developed fundamentally in the XVIII century, systematizing the fundamental work of Kepler, Galileo and Newton, it laid the theoretical foundation of physics in general. Fundamental concepts like physical system, energy, momentum, angular momentum, physical interactions and mathematical constructions like Lagrangian and Hamiltonian of as system in electromagnetism, statistical mechanics, quantum mechanics and modern physics (including nuclear physics and relativity) in general, stand on the foundations developed by the mechanics rationalists of the XVIII century.
A solid command of these concepts and the ability to formulate physical problems in general using this framework of rational mechanics is the major expected outcome of successful completing this course.

WARNING: the topics in the layout below are tentative. There is no guarantee that we will be able to cover all of them. I will prioritize in depth understanding by the majority of the students over amount of topics covered.

2 Course layout

2.1 THE PRINCIPLE OF LEAST ACTION AND THE EQUATIONS OF MOTION

1. Generalized Coordinates.
2. The principle of least action.
3. Galileo's relativity's principle.
4. The Lagrangian for a free particle.
5. The Lagrangian for a system of particles.

2.2 CONSERVATION LAWS

6. Energy.
7. Momentum.
8. Centre of Mass.
9. Angular momentum.
10. Mechanical similarity and the Virial Theorem.
11. Noether's theorem.

2.3 INTEGRATION OF THE EQUATIONS OF MOTION

12. Motion in 1-dimension.
13. Potential energy and period of oscillation.
14. Reduced mass.
15. Motion in a central field.
16. Kepler's problem.

2.4 COLLISIONS BETWEEN PARTICLES

17. Disintegration of particles.
18. Elastic collisions.
19. Scattering.
20. Ruthersford's formula.
21. Small angle scattering.

2.5 SMALL OSCILLATIONS

22. Free oscillations in 1-D.
23. Forced oscillations.
24. Oscillations with several degrees of freedom.
25. Vibrations.
26. Damped oscillations.
27. Parametric resonance.
28. Anharmonic oscillations.
29. Motion in a rapidly oscillating field.

2.6 MOTION OF A RIGID BODY

30. Angular velocity.
31. The inertia tensor.
32. Angular momentum of a rigid body.
33. The equations of motion of a rigid body.
34. Eulerian angles.
35. Euler's equations.
36. The asymmetrical top.
37. Rigid bodies in contact.
38. Motion in a non-inertial frame of references.

2.7 THE CANONICAL EQUATIONS

39. Hamilton's equations.
40. The Routhian.
41. Poisson brackets.
42. The action as a function of the coordinates.
43. Maupertuis' principle.
44. Canonical transformations.
45. Liouville's theorem.
46. The Hamilton-Jacobi equation.
47. Separation of variables.
48. Adiabatic invariants
49. Canonical variables.

3 Evaluation

Evaluation will be through delivery of the homework assigned (40%) and three exams (20% each) given equally spaced through the semester. the exams will be based on the HW assigned.

4 Bibliography

I will be following very closely **Mechanics** by L. Landau and E. M. Lifshitz (Pergamon Press).
It is not necessary to buy the book, but if you want to buy one I definitely recommend it. I will be providing notes which will be following the book format but also elaborating more on certain topics and presenting others that not every student could have necessarily been exposed to.
A good book as a resource is Goldstein, Herbert (1980). Classical Mechanics (2 ed.). Addison-Wesley. ISBN 0201029189.

Other quite famous books are Arnol'd, Vladimir (1978). Mathematical Methods of Classical Mechanics. Springer-Verlag. ISBN 0387968903.
Abraham, Ralph; Marsden, Jerrold (1978). Foundations of Mechanics. Addison-Wesley.
Lanczos, Cornelius (1986). The Variational Principles of Mechanics (4th ed.). Dover Publications. ISBN 0486650677. Whittaker, E. T. (1999). A treatise on the analytical dynamics of particles and rigid bodies : with an introduction to the problem of three bodies (4th ed.). Cambridge University Press. ISBN 0-521-35883-3.
Sommerfeld, Arnold (1952). Mechanics: lectures on theoretical physics. New York: Academic Press Inc. ISBN 978-0-12-654670-5. OCLC 803152309.
Fetter, Alexander L; Walecka, John Dirk (1980). Theoretical mechanics of particles and continua. New York: McGraw-Hill. ISBN 978-0-07-020658-8. OCLC 6110997.