PHYS326: CLASSICAL MECHANICS AND SYMMETRY PRINCIPLES

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ASSESSMENT:

Final examination (65%)
Test (15%) [Monday, 30 March, 12:00-12:55 pm, Psyc/Soc 252]
5 problem sets (I will count the best 4 of the 5) (20%)

TIMETABLE:

Lectures: Mon 12pm, Tue 2 pm Psyc/Soc 252; **Tutorials:** Wed 10 am, A7
Note: Tutorial slot in week 1 will be a lecture

LEARNING OUTCOMES:

In this course students will embark on a voyage of discovery of the deep theoretical principles that underlie Newtonian and relativistic mechanics, and to appreciate why the laws of physics are the way they are. They will learn new ways of thinking about the physical world which allow deeper appreciation of the links between the classical and quantum regimes.
Armed with the powerful techniques of Lagrangian and Hamiltonian dynamics, and Cartesian tensors, students will have the tools to simplify complex mechanical problems to their basic elements. With elegant symmetry principles such as Noether's theorem they will understand the deep connection between symmetries of spacetime and conservation laws, seeing how, for example, Kepler's second law follows from rotational symmetry and conservation of angular momentum. They will apply this new understanding to a variety of physical systems, from coupled oscillators to particles moving in electromagnetic fields. Finally they will discover how the symmetries of special relativity are most succinctly described with the language of 4-vectors, and derive the Lorentz group from the Principle of Relativity.
This course is the basis for all advanced courses in theoretical physics.

OUTLINE

* Dynamical systems – definitions. Constrained systems. Lagrange's equations.
* Principle of least action. Euler-Lagrange equations.
* Symmetries, conservation laws and Lie groups. Noether's theorem.
* Oscillations: linearization. The linear chain.
* Hamiltonian formulation. Legendre's transformation.
* Transformation theory. Canonical transformations. Generating functions. Poisson brackets.
* Hamilton-Jacobi method. Physical applications: (e.g. wave mechanics and Schrödinger's equation).
* Special relativity: Kinematics, symmetries and Lagrangian formulation

RECOMMENDED TEXT: [†] H. Goldstein, C. Poole and J. Safko, *Classical Mechanics*, 3rd ed. (Addison-Wesley, 2002)

Other useful references:

[1] T.L. Chow, *Classical Mechanics*, (Wiley, New York, 1995)

[2] L. Landau and E. Lifschitz, *Mechanics*, 3rd ed. (Pergamon, 1976)

[3] I. Percival and D. Richards, *Introduction to Dynamics* (Cambridge University Press, 1982)

[4] V.I. Arnold, *Mathematical Methods of Classical Mechanics*, 2nd ed. (Springer, Berlin, 1989)

[5] E.J. Saletan and A.H. Cromer, *Theoretical Mechanics* (Wiley, New York, 1971)

[6] D.E. Bourne and P.C. Kendall, *Vector Analysis and Cartesian Tensors*, 3rd ed., (CRC Press, 2002), chapter 8, [for Orthogonal Transformations in §3 only].

[7] D.W. Jordan and P. Smith, *Nonlinear Ordinary Differential Equations*, 4th ed. (Oxford University Press, 2007) chapters 1,2 [for §4. Oscillations only]

[8] N.A. Doughty, *Lagrangian Interaction*, (Addison Wesley, Sydney, 1990), chapters 12,13 [for §6. Special Relativity only].

General information:

General course information for Physics and Astronomy students can be found at
`https://apps.canterbury.ac.nz/1/science/phys-chem/PHYS%20-%20Course%20Outlines/General.PDF`