Classical Mechanics I & II (MA1241 & MA1242)

(2013-14, JF Mathematics and Theoretical Physics, SF TSM)

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Duration: 11 weeks per module – 3 lectures per week.

Lectures:
- Tuesday, 10:00-10:50, Science Lecture Theatre (Chemistry Building)
- Tuesday, 13:00-13:50, East End Building Lecture Theatre 2
- Wednesday, 13:00-13:50, East End Building Lecture Theatre 2

Books on Mechanics:

• The main textbook is:

D. Kleppner and R. J. Kolenkow, *An Introduction to Mechanics*.

The two modules combined will cover chapters 1 to 9 of this book. The first module (MA1241) will cover most of the contents of chapters 1, 2, 3 and 4 and part of chapter 6. The second module (MA1242) will include a few sections from the first chapters and chapters 5, 6, 7 (only a few sections), 8 and 9.

• Other recommended books on Classical Mechanics:

1. C. Kittel *et al.*, *Mechanics*, Berkeley Physics Course Vol. 1.
2. T. W. Kibble, *Classical Mechanics*.
3. R. P. Feynman, *The Feynman Lectures on Physics* (Vol. 1 is on Mechanics).
   These three volumes collect lectures on Mechanics, Electromagnetism and Quantum Mechanics by Richard Feynman, one of the great theoretical physicists of the twentieth century. The lectures provide a very original and stimulating presentation of the topics covered. I strongly recommend that you read these books as a complement to the more traditional textbooks for the courses on Mechanics, Electromagnetism and Quantum Mechanics.

• Other texts on Classical Mechanics (the ones at the bottom of the list are more elementary):

1. K. Symon, *Mechanics*.
2. V. Barger and M. Olsson, *Classical Mechanics: A Modern Perspective*.

3. A. P. French and M. G. Ebison, *Introduction to Classical Mechanics.*
4. A. P. French, *Newtonian Mechanics.*
5. J. Orear, *Physics.*
6. M. Alonso and E. J. Finn, *Fundamental University Physics, Vol. 1.*
7. G. B. Arfken *et al.*, *University Physics.*
8. H. C. Ohanian, *Physics.*
   There is also a companion volume with solutions to the problems in this book.

• Advanced texts:

1. H. Goldstein, *Classical Mechanics.*
2. L. D. Landau and E. M. Lifshitz, *Mechanics.*
3. V. I. Arnold, *Mathematical Methods of Classical Mechanics.*
4. G. Gallavotti, *The Elements of Mechanics.*

Assessment:

- End of year examination. It will consist of problems similar to the ones discussed in lectures and tutorials during the year.
- Homework assignments. Problems will be regularly assigned. Homework papers should be returned and will be graded. The solutions will then be discussed in class. *Homework counts for 20% of the final mark.*

Outline of the courses

Module MA1241:

- Introduction.
  Mechanics as the basis of Physics. What it is, how it works.
  Description of some modern applications of Mechanics and some topics of current research: Non-linear Dynamics and Chaos; Fluid Dynamics and Turbulence; Non-linear phenomena in Astrophysics; structure of the Universe.

- Mathematical preliminaries.
  Vectors and their role in Mechanics. Elements of vector algebra.

- Kinematics.
  Position, velocity, acceleration and how they are related to each other. Polar coordinates. Differentiation and integration of vectors.

- Newton's Laws: the foundations of Classical Mechanics.
  Description of Newton's three laws of dynamics and their analysis through ideal experiments.

- Applications of Newton's laws to elementary physical systems. Examples of forces.

- Gravity.
  Historical background: from Brahe and Kepler to Newton and from Newton to Einstein.
  Newton's law of gravitation. Inertial and gravitational mass. Experimental tests. Limits of validity.
  Applications: elementary systems; astronomical and astrophysical systems.

- Linear momentum.
  Dynamics of multi-particle systems. Conservation of momentum. Impulse. Centre of mass.

- Work and Energy.
  Definition of work and the work-energy theorem. Potential and kinetic energy. Conservative and non-conservative forces. Conservation of energy.

- Angular Momentum.
  Angular momentum of a point-like mass. Torque. Motion with angular momentum. Conservation of angular momentum.

Module 1242:

- Some mathematical aspects of forces and energy. Gradient. Stokes' Theorem.

- More on momentum and energy. Elastic and inelastic collisions. Centre of mass frame.

- Systems with variable mass. Mass flow and momentum transfer. The rocket equation.

- More on angular momentum. Fixed axis of rotation. Motion combining translation and rotation. Moment of inertia. Pendulum motion.

- Rigid body motion.
  Angular velocity and angular momentum as vectors. The gyroscope, precession. Tensor of inertia.

- Central forces.
  Two-body problem, reduced mass. General properties of central force motion. Planetary motion.

- Non-inertial frames and fictitious forces.
  Accelerating, but non-rotating frames. Rotating coordinate systems. Centrifugal and Coriolis forces. Tidal forces. Rotating bucket and Mach's principle. The Equivalence Principle, origins of General Relativity. Galilean transformations. Principle of Relativity.

- Elements of fluid mechanics.