Course content for MT1210, Introduction to Applied Mathematics

Prerequisites:

Aims:
The aim of this course is to provide an introduction to some key ideas and methods of classical mechanics, chaos theory and special relativity. The course covers Newton's equations of motion for a single particle, shows how these equations can give rise to chaotic behaviour, and shows how they need to be modified for velocities close to the speed of light.

Learning outcomes:
On completion of the course, the student should be able to:

- solve Newton's equations of motion for a variety of problems, including the damped, driven harmonic oscillator;
- use Mathematica where a closed solution cannot be found;
- use the conservation laws for energy and momentum;
- work with co-ordinate systems that accelerate or rotate;
- explain how chaos arises for the forced pendulum;
- state Einstein's principle of relativity and explain how it leads to special relativity;
- use the Lorentz transformation and draw Minkowski diagrams.

Course content:
Classical Dynamics: Dimensional analysis, units, forces. Newton's laws, One dimensional motion; Conservation of energy and momentum. Stable and unstable equilibrium points. Simple Harmonic motion, damped and harmonic forced motion. Three dimensional motion. Projectile in the presence of friction. Circular motion. Angular momentum. Numerical solution of Newton's equation, application to planetary motion, Coriolis force.
Chaos: The damped forced pendulum. Limit cycles, attractors. Period doubling. Chaotic motion of three gravitating bodies.
Special Relativity: Galilean invariance. Inertial systems. Einstein's principle of relativity. The Lorentz transformation. Length contraction, time dilation, the twin paradox. The geometry of space-time. Energy-mass equivalence $E = mc^2$.