Vibrations and Waves — Course description

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Aims:

To give students an understanding of oscillations and waves and an appreciation of their importance in the study of physics; to introduce the mathematical tools used in their analysis.

Objectives:

- understand and describe simple harmonic motion (SHM), be able to derive the equations of motions for physical systems that undergo SHM and solve;
- be able to use the complex notation for analysing vibrations and waves;
- be able to adapt the general SHM solution for specific initial conditions;
- understand why small oscillations are harmonic and the general consequences of non-linear restoring forces;
- be able to derive the velocity and acceleration of SHM and the kinetic, potential and total energy of a mechanical system undergoing SHM;
- understand the concept of coupled oscillators, derive and solve the equations of motion for simple systems and describe motion of coupled oscillators in terms of normal mode solutions;
- understand the principle of linear superposition and the phenomenon of beating;
- understand and be able to derive and solve the equations for the damped oscillator in the over damped, critically damped and under damped regimes;
- understand and be able to derive and solve the equations for a forced oscillator; understand the concept of resonance and the response of a system (amplitude and phase, power dissipation) as a function of driving frequency and the effects of transients;
- understand and be able to calculate the quality factor Q for damped and driven oscillators;
- understand a wave as a travelling oscillation; understand the concepts of and the differences between transverse and longitudinal waves; know the non-dispersive wave equation and be able to derive it for transverse waves on a string; understand superposition of waves, wave groups and harmonic waves;
- understand and be able to calculate reflection, transmission and absorption of travelling waves;
- understand refraction and know Snells law;
- understand the concept and consequences of wave dispersion and be able to identify normal and anomalous dispersion;
- understand the concepts of phase and group velocities and be able to calculate these quantities;
- understand standing waves as counter-propagating travelling waves, the concepts of nodes and anti-nodes and how boundary conditions lead to normal modes and harmonics;
- understand and analyse the Doppler effect;
- understand diffraction and interference of waves; understand the importance of relative phase and be able to analyse the summation of waves from two point sources;