Physics 3.4 : Demonstrate understanding of mechanical systems

Level 3 Credits 6

This achievement standard involves knowledge and understanding of phenomena, concepts, principles and/or relationships related to translational; circular and rotational; and simple harmonic motion; and the use of appropriate methods to solve related problems.

Translational Motion
Centre of mass (1 and 2 dimensions); conservation of momentum and impulse (2 dimensions only).

Circular and Rotational Motion
Velocity and acceleration of, and resultant force on, objects moving in a circle under the influence of 2 or more forces, e.g. banked corners, vertical circles; Newton's Law of gravitation, satellite motion.

Rotational motion with constant angular speed and with constant angular acceleration; torque; rotational inertia; angular momentum; rotational kinetic energy; conservation of angular momentum; conservation of energy.

Simple Harmonic Motion (SHM)
Displacement; velocity; acceleration; time and frequency of a particle undergoing SHM; forced SHM; resonance; the reference circle; phasors; conservation of energy.

Relationships:

$d = r\theta$ $\quad v = r\omega$ $\quad a = r\alpha$

$\omega = \frac{\Delta\theta}{\Delta t}$

$\alpha = \frac{\Delta\omega}{\Delta t}$ $\quad \omega = 2\pi f$ $\quad E_{K(ROT)} = \frac{1}{2}I\omega^2$

$\omega_f = \omega_i + \alpha t$ $\quad \theta = \frac{(\omega_i + \omega_f)}{2}t$ $\quad \omega_f^{\,2} = \omega_i^{\,2} + 2\alpha\theta$

$\theta = \omega_i t + \frac{1}{2}\alpha t^2$

$\tau = I\alpha$ $\quad L = mvr$ $\quad L = I\omega$

$F_g = \frac{GMm}{r^2}$

$T = 2\pi\sqrt{\frac{l}{g}}$ $\quad T = 2\pi\sqrt{\frac{m}{k}}$

$y = A\sin\omega t$ $\quad v = A\omega\cos\omega t$ $\quad a = -A\omega^2\sin\omega t$

$a = -\omega^2 y$

$y = A\cos\omega t$ $\quad v = -A\omega\sin\omega t$ $\quad a = -A\omega^2\cos\omega t$

MECHANICS: translation motion

By the end of this unit students should be able to:

- ❑ Describe translational motion using graphs, equations and words.
- ❑ Use free-body force diagrams to find resultant forces
- ❑ Calculate the centre of mass for a multibody system
- ❑ Analyse interactions by applying the idea of centre of mass.
- ❑ Describe the conservation of momentum with reference to the motion of the centre of mass of a system, when the motion of the particles is in one dimension
- ❑ Apply the principle of conservation of linear momentum in one and two dimensions including the use of vectors
- ❑ Understand the relationship between rate of change of momentum and force in one and two dimensions (Impulse)

MECHANICS: rotational motion

By the end of this unit students should be able to:

- ❑ Understand Newton's laws of Gravitation, including the force on a satellite in a circular orbit
- ❑ Analyse circular motion in terms of centripetal force, centripetal acceleration, period and frequency
- ❑ Define a gravitational field in terms of the force on a unit mass.
- ❑ Use Newton's law of Universal Gravitation to analyse the motion of satellites in circular orbit
- ❑ Analyse the Velocity and acceleration of , and resultant force on, objects orbiting under the influence of two or more forces (eg. Conical pendulums, banked corners)
- ❑ Describe and analyse rotational motion with constant angular acceleration and constant angular speed using angular quantities and rotational Kinematic equations
- ❑ Use rotational motion equations to solve problems (with constant angular acceleration)
- ❑ Describe torque as two equal and opposite forces producing rotational motion.
- ❑ Define Torque, rotational inertia, and the relationship between torque and angular acceleration
- ❑ Apply the principle of conservation of angular momentum to systems with no external torque.
- ❑ Apply the principle of conservation of energy to situations involving rotations to include rotational kinetic energy, conservation of gravitational potential energy, and rotational and translational kinetic energy.

MECHANICS: Simple harmonic motion

By the end of this unit students should be able to:

- ❑ Investigate the features of Simple Harmonic Motion
- ❑ Describe Motion with a restoring force or torque proportional to displacement from an equilibrium position in systems such as mass-spring, pendulums, buoys
- ❑ Apply the equations describing SHM to calculate unknown physical quantities for displacement, velocity, acceleration and frequency of a particle undergoing simple harmonic motion.
- ❑ Use equations of motion for cases when the displacement at time zero is either maximum or zero (equilibrium position).
- ❑ Analyse real life situations of SHM including the use of the reference circle to analyse simple harmonic motion.
- ❑ Identify the kinetic and potential energies present at various positions/times of SHM (Conservation of energy)
- ❑ Understand the factors that determine resonant frequencies in physical systems.
- ❑ Describe situations involving Damped and forced oscillations; resonance