AS91524: Demonstrate understanding of mechanical systems

Level 3 Credits 6

This achievement standard involves demonstrating understanding of mechanical systems.

Achievement Criteria

Achievement	Achievement with Merit	Achievement with Excellence
• Demonstrate understanding of mechanical systems.	• Demonstrate in-depth understanding of mechanical systems.	• Demonstrate comprehensive understanding of mechanical systems.

Assessment is limited to a selection from the following:

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

Circular Motion and Gravity
Velocity and acceleration of, and resultant force on, objects moving in a circle under the influence of 2 or more forces, Newton's Law of gravitation, satellite motion.

Rotating Systems
Rotational motion with constant angular acceleration; torque; rotational inertia; conservation of angular momentum; conservation of energy.

Oscillating Systems
The conditions for Simple Harmonic Motion, angular frequency, variation of displacement, velocity and acceleration with time, phasor diagrams, reference circles, damped and driven systems, resonance, conservation of energy.

Relationships

$d = r\theta$ $\quad v = r\omega$ $\quad a = r\alpha$ $\quad \omega = \dfrac{\Delta\theta}{\Delta t}$

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

$\omega_f = \omega_i + \alpha t$ $\quad \theta = \dfrac{(\omega_i + \omega_f)}{2}t$ $\quad \omega_f{}^2 = \omega_i{}^2 + 2\alpha\theta$ $\quad \theta = \omega_i t + \frac{1}{2}\alpha t^2$

$\tau = I\alpha$ $\quad L = mvr$ $\quad L = I\omega$ $\quad F_g = \dfrac{GMm}{r^2}$

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

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

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

$$x_{COM} = \frac{m_1x_1 + m_2x_2}{m_1 + m_2}$$

Achievement criteria

1 *Demonstrate understanding* involves showing an awareness of how simple facets of phenomena, concepts, or principles relate to a given situation.

Demonstrate in-depth understanding involves giving explanations for phenomena, concepts, or principles that relate to a given situation.

Demonstrate comprehensive understanding involves connecting concepts or principles that relate to a given situation.

2 *Mechanical systems* include mathematical solutions and/or written descriptions. Written descriptions may include graphs or diagrams.

This achievement standard replaced unit standard 6397 and AS90521.

Achievement

Make sure you can:

- Identify or describe aspects of phenomena, concepts, or principles.
- Solve problems involving a single process. The relevant concept or principle will be transparent, the method will be straightforward (a formula will need no more than a simple rearrangement), and the information will be directly usable.
- Recognise correct concept/phenomenon/principle and give a simple descriptive answer in both written and diagrammatic form, for example:
    - How the simple harmonic motion (SHM) restoring force is always directed towards an equilibrium position.
    - The natural period of a pendulum is related only to its length and the gravitational acceleration.
    - How energy loss reduces amplitude of an SHM but has no effect on its period.
    - The nature of the centripetal force that causes orbital motion around planets.
    - How mass distribution about the axis affects rotational inertia.
    - How angular momentum is conserved when a diver rotates in the air.
- Recognise the correct concept and apply reasonable mathematical skills, for example:
    - The frequency of an SHM.
    - The maximum acceleration of a pendulum relates to the amplitude of its motion.
    - The angular momentum of a rotating body relates to the angular speed.

Achievement with Merit

Make sure you can:

- Meet criteria for Achievement.
- Give accurate explanations in terms of phenomena, concepts, principles, and/or relationships.
- Solve problems where the relevant concept or principle is not immediately obvious, the method involves the use of a complex formula or rearrangement, or the information is not directly usable or immediately obvious. It may involve using a complex formula or rearrangement or some deduction as to the relevant concept or principle.

- Use physics terminology to demonstrate a higher level of understanding of physics concepts, for example:
    - Connection between circular motion and gravitation.
    - Relationship between free-fall and weightlessness.
    - Difference between gravitational force and acceleration due to gravity.
    - Difference between circular motion and SHM.

Achievement with Excellence

Make sure you can:

- Meet criteria for Merit.
- Give concise and accurate explanations that show clear understanding in terms of phenomena, concepts, principles, and/or relationships. Your answers will typically have minimal irrelevancies. In other words, you cannot include any explanations that are not relevant. Do not guess!
- Solve complex problems that involve more than one process. The recognition of at least two different concepts must be involved
- Show numerical accuracy and correct rounding and use SI units in answers.
- Understand fully the physical situations and questions asked for that concept, that is, present a multi-step mathematical solution that links to the required physics concept/principle, and successfully apply it to the context given.

Translation motion

You 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.
- ❑ Describe and explain the relationship between rate of change of momentum and force in one and two dimensions (Impulse).

Circular motion

You should be able to:

- ❑ Describe and explain circular motion (constant speed with one resultant force only providing centripetal force).
- ❑ 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 (e.g. conical pendulums, banked corners).

Rotational motion

You should be able to:

- ❑ 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.

Simple harmonic motion

You should be able to:

- ❑ Describe 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).
- ❑ Describe the factors that determine resonant frequencies in physical systems.
- ❑ Describe situations involving Damped and forced oscillations; resonance.

Advice from previous years

(Thanks to http://www.studyit.org.nz/)

- Understand that a physics problem involves a process(es) to find a physical quantity.
- Show all working of your calculations including any rearrangement of formulae.
- Be aware of the appropriate use of significant figures and units. You may use both negative index (for example, m s^{-2}) and slash notation (for example, m/s^2) when writing units. However, the examination paper will supply data using negative index notation.
- Know when to use each form of the simple harmonic motion (SHM) formulae.
- Remember that f=1/T in SHM.
- Know how to find the position and velocity of the centre of mass of a system of objects (no formulae for these will be given).
- Remember that conservation of linear momentum requires no external **forces**; with angular momentum, no external **torques**.
- Always attempt all questions: you will get credit for progress towards the answer, not just for a completely correct answer.