13 Unit Physics 3

At the beginning of each sub-section, activities are stated which develop candidates' skills, knowledge and understanding of how science works. Details are then given of the substantive contexts in which these skills, knowledge and understanding should be set. It is expected that, where appropriate, teachers will adopt a practical approach enabling candidates to develop skills in addition to procedural knowledge and understanding.

13.1 How do forces have a turning effect?

Even if the forces acting on a body are balanced in the sense that they do not cause the body to change speed, they can still make the body turn.

Candidates should use their skills, knowledge and understanding of how science works:

- to describe how to find the centre of mass of a thin sheet of a material

HT ❖ to calculate the size of a force, or its distance from an axis of rotation, acting on a body that is balanced

HT ❖ to analyse the stability of bodies by considering their tendency to topple.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- The turning effect of a force is called the moment.
- The size of the moment is given by the equation:

moment	=	force	×	perpendicular distance from the line of action of the force to the axis of rotation
(newton metre, Nm)		(newton, N)		(metre, m)

- The centre of mass of a body is that point at which the mass of the body may be thought to be concentrated.
- If suspended, a body will come to rest with its centre of mass directly below the point of suspension.
- The centre of mass of a symmetrical body is along the axis of symmetry.

HT ❖ If a body is not turning, the total clockwise moment must be exactly balanced by the total anticlockwise moment about any axis.

HT ❖ Recognise the factors that affect the stability of a body.

HT ❖ If the line of action of the weight of a body lies outside the base of the body there will be a resultant moment and the body will tend to topple.

13.2 What keeps bodies moving in a circle?

A body remains stationary, or keeps moving at the same speed in a straight line, unless an unbalanced force acts upon it. If a body moves in a circular path there must be an unbalanced force acting upon it all the time.

Candidates should use their skills, knowledge and understanding of how science works:

- to identify which force(s) provide(s) the centripetal force in a given situation
- to interpret data on bodies moving in circular paths.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- When a body moves in a circle it continuously accelerates towards the centre of the circle. This acceleration changes the direction of motion of the body, not its speed.
- The resultant force causing this acceleration is called the centripetal force.
- The direction of the centripetal force is always towards the centre of the circle.
- The centripetal force needed to make a body perform circular motion increases as:
  - the mass of the body increases;
  - the speed of the body increases;
  - the radius of the circle decreases.

13.3 What provides the centripetal force for planets and satellites?

The planets, like the Earth, orbit the Sun. Artificial satellites, which are used for communications and monitoring, orbit the Earth. Gravitational force provides the centripetal force that allows all of these bodies to orbit.

Candidates should use their skills, knowledge and understanding of how science works:

- to interpret data on planets and satellites moving in orbits that approximate to circular paths.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- The Earth, Sun, Moon and all other bodies attract each other with a force called gravity.
- The bigger the masses of the bodies the bigger the force of gravity between them.
- As the distance between two bodies increases the force of gravity between them decreases.
- The orbit of any planet is an ellipse (slightly squashed circle), with the Sun at one focus.
- Gravitational force provides the centripetal force that allows planets and satellites to maintain their circular orbits.
- The further away an orbiting body is the longer it takes to make a complete orbit.
- To stay in orbit at a particular distance, smaller bodies, including planets and satellites, must move at a particular speed around larger bodies.
- Communications satellites are usually put into a geostationary orbit above the equator.

- Monitoring satellites are usually put into a low polar orbit.

13.4 What do mirrors and lenses do to light?

Mirrors and lenses can be used to form images in optical devices such as cameras and magnifying glasses. The most commonly used mirrors and lenses have surfaces with a uniform curvature and these are the only ones which need to be considered. All objects and images will be located vertically on the principal axis.

Candidates should use their skills, knowledge and understanding of how science works:

- to construct ray diagrams to show the formation of images by plane, convex and concave mirrors
- to construct ray diagrams to show the formation of images by diverging lenses and converging lenses
- to explain the use of a converging lens as a magnifying glass and in a camera
- to calculate the magnification produced by a lens or mirror using the formula:

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- The normal is a construction-line perpendicular to the reflecting/refracting surface at the point of incidence.
- The angle of incidence is equal to the angle of reflection.
- The nature of an image is defined by its size relative to the object, whether it is upright or inverted relative to the object and whether it is real or virtual.
- The nature of the image produced by a plane mirror.
- The nature of the image produced by a convex mirror.
- The nature of the image produced by a concave mirror for an object placed at different distances from the mirror.
- Refraction at an interface.
- Refraction by a prism.
- The nature of the image produced by a diverging lens.
- The nature of the image produced by a converging lens for an object placed at different distances from the lens.
- The use of a converging lens in a camera to produce an image of an object on a detecting device (eg film).

13.5 What is sound?

Sounds are mechanical vibrations that can be detected by the human ear. This means they are in the frequency range 20-20 000 Hz.

Candidates should use their skills, knowledge and understanding of how science works:

- to compare the amplitudes and frequencies of sounds from diagrams of oscilloscope traces.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- Sound is caused by mechanical vibrations and travels as a wave.
- Sounds in the range 20-20 000 Hz can be detected by the human ear.
- Sound cannot travel through a vacuum.
- The pitch of a note increases as the frequency increases.
- The loudness of a note increases as the amplitude of the wave increases.
- The quality of a note depends upon the waveform.
- Sound waves can be reflected and refracted.

13.6 What is ultrasound and how can it be used?

Just as there is electromagnetic radiation with frequencies we cannot see, there are "sound" waves with frequencies we cannot hear. These ultrasound waves have several important uses.

Candidates should use their skills, knowledge and understanding of how science works:

- to compare the amplitudes and frequencies of ultrasounds from diagrams of oscilloscope traces

HT ❖ to determine the distance between interfaces in various media from diagrams of oscilloscope traces.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- Electronic systems can be used to produce ultrasound waves which have a frequency higher than the upper limit of hearing for humans.
- Ultrasound waves are partially reflected when they meet a boundary between two different media. The time taken for the reflections to reach a detector is a measure of how far away such a boundary is.
- Ultrasound waves can be used in industry for cleaning and quality control.
- Ultrasound waves can be used in medicine for pre-natal scanning.

13.7 How can electricity be used to make things move?

Electric currents produce magnetic fields. Forces produced in magnetic fields can be used to make things move. This is called the motor effect and is how devices such as the electric motor create movement.

Candidates should use their skills, knowledge and understanding of how science works:

- to explain how the motor effect is used in simple devices.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- When a conductor carrying an electric current is placed in a magnetic field, it may experience a force.
- The size of the force can be increased by:
  - increasing the strength of the magnetic field
  - increasing the size of the current.

- The conductor will not experience a force if it is parallel to the magnetic field.
- The direction of the force is reversed if either the direction of the current or the direction of the magnetic field is reversed.

13.8 How do generators work?

If an electrical conductor 'cuts' through magnetic field lines, an electrical potential difference is induced across the ends of the conductor. This is called the generator effect and is used in generators to produce electricity.

Candidates should use their skills, knowledge and understanding of how science works:

HT
- ❖ to explain from a diagram how an a.c. generator works, including the purpose of the slip rings and brushes.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- If an electrical conductor 'cuts' through magnetic field lines, an electrical potential difference is induced across the ends of the conductor.
- If a magnet is moved into a coil of wire, an electrical potential difference is induced across the ends of the coil.
- If the wire is part of a complete circuit, a current is induced in the wire.
- If the direction of motion, or the polarity of the magnet, is reversed, the direction of the induced potential difference and the induced current is reversed.
- The generator effect also occurs if the magnetic field is stationary and the coil is moved.
- The size of the induced potential difference increases when:
  - the speed of the movement increases
  - the strength of the magnetic field increases
  - the number of turns on the coil increases
  - the area of the coil is greater.

13.9 How do transformers work?

Transformers are used to step-up (increase) or step-down (decrease) a.c. potential differences.

Candidates should use their skills, knowledge and understanding of how science works:

- to determine which type of transformer should be used for a particular application.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- The basic structure of the transformer.
- An alternating current in the primary coil produces a changing magnetic field in the iron core and hence in the secondary coil. This induces an alternating potential difference across the ends of the secondary coil.

HT ❖ The potential difference (p.d.) across the primary and secondary coils of a transformer are related by the equation:

$$\frac{\text{p.d. across primary}}{\text{p.d. across secondary}} = \frac{\text{number of turns on primary}}{\text{number of turns on secondary}}$$

- In a step-up transformer the potential difference across the secondary coil is greater than the potential difference across the primary coil.
- In a step-down transformer the potential difference across the secondary coil is less than the potential difference across the primary coil.
- The uses of step-up and step-down transformers in the National Grid.

13.10 What is the life history of stars?

Astronomers believe that gravitational forces are responsible for the formation of galaxies of stars, and for stars like the Sun having a long stable period.

Candidates should use their skills, knowledge and understanding of how science works:

- to explain how stars are able to maintain their energy output for millions of years

HT ❖ to explain why the early Universe contained only hydrogen but now contains a large variety of different elements.

Their skills, knowledge and understanding of how science works should be set in these substantive contexts:

- Our Sun is one of the many billions of stars in the Milky Way galaxy.
- The Universe is made up of billions of galaxies.
- Stars form when enough dust and gas from space is pulled together by gravitational attraction. Smaller masses may also form and be attracted by a larger mass to become planets.
- Gravitational forces balance radiation pressure to make a star stable.
- A star goes through a life cycle (limited to the life cycle of stars of similar size to the Sun and stars much larger than the Sun).

HT ❖ Fusion processes in stars produce all naturally occurring elements. These elements may be distributed throughout the Universe by the explosion of a star (supernova) at the end of its life.