SECTION A

A1. C

A2. B

A3. C

A4. D

A5. C

A6. B

A7. C

A8. B

A9. D

A10. A

A11. A

A12. D

A13. C

A14. B

A15. A

A16. C

A17. C

A18. B

A19. A

A20. D

SECTION B

B1. (a) (i) The reading is 20.30mm

(ii) One use of a micrometer screw gauge is to measure the diameter of small objects or the thickness of thin materials with high precision. Micrometer screw gauges can provide very accurate measurements, often to within one-thousandth of an inch (0.001") or one-hundredth of a millimeter (0.01 mm), depending on the gauge.

B2. (a) The weight of the stone in the air is 60 N

(b) Upthrust, also known as buoyancy, is a force exerted by a fluid that opposes the weight of an immersed object. It is the reason why objects feel lighter when submerged in a fluid. The upthrust is equal to the weight of the fluid that the object displaces.

(c) Given that the weight of the stone in air (W) is 60 N and g is 10 N/kg, the mass (m) is:

$$m = \frac{60N}{10N/kg} = 6kg$$

B3. (a) Thermal expansion is the tendency of matter to change in volume in response to a change in temperature.

(b)(i) E is the bulb of the thermometer which contains a reservoir of the liquid.

F is the capillary tube through which the liquid expands when temperature increases.

(ii) Mercury is a common liquid used in thermometers for measuring temperature. Alternatively, colored alcohol can also be used.

(iii) One way to improve the sensitivity of the thermometer is by using a liquid with a high coefficient of thermal expansion, which means it expands significantly with temperature. Another way is to make the capillary tube narrower, so even a small expansion of liquid results in a larger movement along the tube.

B4. (a)(i) To calculate the speed (v) of the wave, we can use the formula:

$$v = \frac{d}{t}$$

where d is the distance and t is the time. Plugging in the given values:

$$v = \frac{1.8m}{0.3s}$$

$$v = 6m/s$$

(ii) To find the distance covered by the wave in 2 minutes, we first convert the time to seconds:

2 minutes = 2 × 60 seconds = 120 seconds

Then, we multiply the speed of the wave by the total time:

Distance = Speed × Time

Distance = 6m/s ×120s

Distance = 6m/s × 120s

Distance = 720m

Distance = 720m

(b)(i) To calculate the frequency f of a sound wave, you use the equation:

$$f = \frac{v}{\lambda}$$

where:

v is the speed of the wave, which is 340 m/s,

and λ (lambda) is the wavelength, which is 0.5 m.

$$f = \frac{340m/s}{0.5m}$$

$$f = 680\ Hz$$

So the frequency of the sound wave is 680 Hz

(ii) Yes, this sound with the frequency calculated in b(i) can be heard.

(iii) The range of human hearing is typically between 20 Hz to 20,000 Hz (20 kHz). Since 680 Hz falls within this range, it can be heard by the average human ear.

B5. (a)(i) Infrared: Used for thermal imaging cameras to detect heat leaks in buildings and to see in the dark.

Radio waves: Used for communication purposes, such as broadcasting television and radio signals.

(ii) Both are types of electromagnetic radiation which can travel through a vacuum.

(iii) Prolonged exposure to high levels of electromagnetic radiation can lead to health issues such as cancer.

(b) Sound waves require a medium (like air, water, or solid) to travel through, whereas electromagnetic waves can travel through the vacuum of space.

(c) The amplitude of the sound wave; larger amplitudes result in louder sounds.

(d) To calculate how far the lightning is from the learner, we can use the speed of sound in air and the time it takes for the sound to reach the learner.

The formula to calculate the distance (d) is:

$d = speed \times time$

Given:

Speed of sound in air $= 340 \text{ m/s}$

Time $= 4.5$ s

$d = 340m/s \times 4.5s$

$d = 1530m$

So the lightning is 1530 meters, or 1.53 kilometers, away from the learner.

B6 (a) Neutral point

(b) Q: North Pole, **P:** South Pole

B7 (a) (i) 2 Volts

(ii) At 4 hours

(iii) 9 volts

(b) Charge (Q) is calculated by the formula $Q = I \cdot t$, where I is current and t is time. Given that the current (I) is 0.6 0.6 amperes (A), and the time (t) is 2 hours, we can calculate the charge as follows:

$Q = 0.6A \times 2h$

$Q = 1.2A \cdot h$

Since 1 A·h is equivalent to 3600 Coulombs (C), the charge accumulated in 2 hours is:

$Q = 1.2A \cdot h \times 3600C/A \cdot h$

$Q = 4320C$

(ii) Power (P) is calculated by the formula = $P = I \cdot V$, where I is the current and V is the voltage. To find the power when the phone is fully charged, we use the maximum charge voltage and the current:

$P = 0.6A \times 9V$

$P = 5.4W$

The power of the phone when fully charged is 5.4 watts.

B8 (a) End A is where the **south pole** of the electromagnet

(b) The strength of the electromagnet can be increased by either increasing the number of coils around the core, increasing the current flowing through the coil, or using a core material with better magnetic properties.

(c) (i) The core of an electromagnet is typically made from iron or another ferromagnetic material.

(ii) The justification for using iron or a similar ferromagnetic material is because these materials can be magnetized easily and can significantly increase the magnetic field created by the coil. They have high permeability, which is the ability of a material to support the formation of a magnetic field within itself.

B9 (a) (i) Half-life is the time required for half of the radioactive nuclei in a sample to decay.

(ii) $^{132}_{53}I \rightarrow\ ^{132}_{54}Xe\ +\ \frac{0}{-1}e + \gamma$

(iii) One property of a beta particle:

Beta particles are high-energy, high-speed electrons or positrons that are emitted by certain types of radioactive nuclei such as beta decay.

(b) (i) Mention one medical use of radioactive substances:

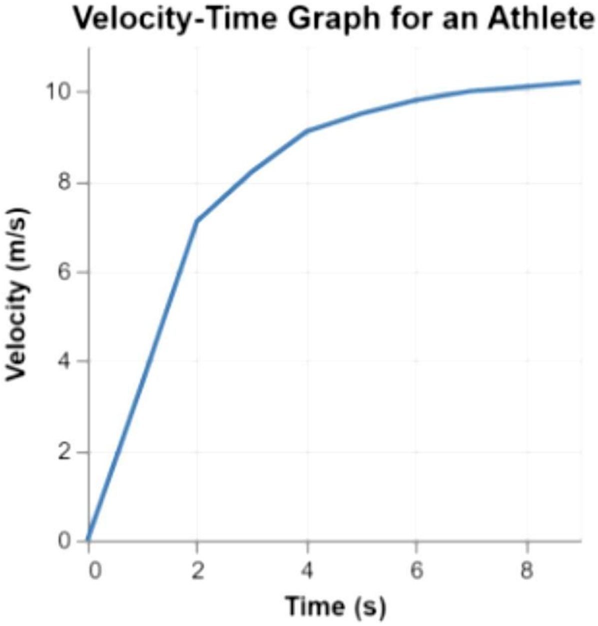
One medical use of radioactive substances is in cancer therapy, where radioactive isotopes are used to target and destroy malignant cells.

(ii) Explain the effect of radioactive substances on the environment:

Radioactive substances can have significant environmental impacts. They can contaminate air, water, and soil; harm plants and wildlife; and pose health risks to humans through exposure to radiation, which can cause cancer and other illnesses.

SECTION C

C1 (a)



(b) Acceleration (a) is defined as the change in velocity (Δv) divided by the change in time (Δt):

$$a = \frac{\Delta v}{\Delta t}$$

From the table, the athlete's velocity at 2 seconds is 7.1 m/s and at 0 seconds is 0.0 m/s. Therefore:

$$a = \frac{7.1m/s - 0.0m/s}{2s - 0s}$$

$$a = \frac{7.1m/s}{2s}$$

$$a = 3.55m/s^2$$

(c) (i) Force (F) can be calculated using Newton's second law, $F = ma$, where m is the mass and a is the acceleration.

The mass of the athlete (m) is 75 kg, and the acceleration (a) is 3.55 m/s^2 from part (b).

$$F = 75kg \times 3.55m/s^2$$

$F = 266.25N$

(ii) Kinetic energy (KE) is given by the formula $=KE = \frac{1}{2}$ is the mass and v is the velocity.

$$KE = \frac{1}{2} \times 75kg \times (7.1m/s)^2$$

$$KE = \frac{1}{2} \times 75kg \times 50.41m^2/s^2$$

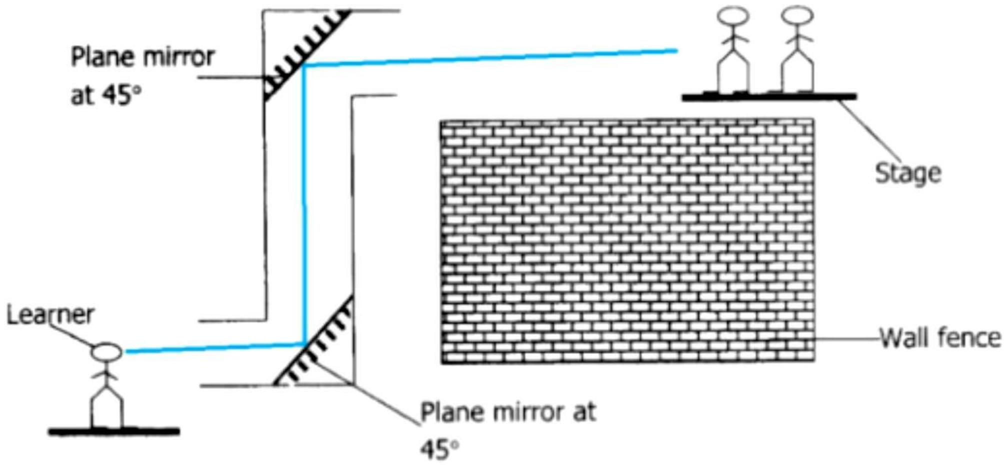
$$KE = 37.5kg \times 50.41m^2$$

$$KE = 1880.375J$$

So, the kinetic energy is 1880.38 Joules (rounded to two decimal places).

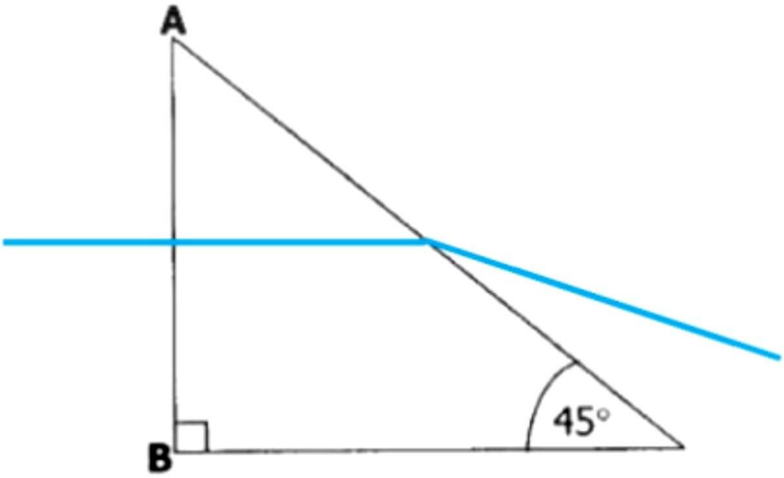
C2 (i) The instrument used in Figure C2.1 is a **periscope**.

(ii)



(b) (i) Critical angle is defined as the angle of incidence above which total internal reflection occurs for light traveling from a medium with a given refractive index to a medium with a lower refractive index. This is the maximum angle at which refraction can occur; at angles greater than the critical angle, all the light is reflected back into the original medium.

(ii)



(iii) The critical angle (c) can be calculated using Snell's Law for the boundary between glass and air, which is:

$n_1 \cdot \sin(c) = n_2 \cdot \sin(90°)$

Where:

n_1 = refractive index of glass = 1.5 (given),

n_2 = refractive index of air ≈ 1 (since air's refractive index is approximately 1),

c = critical angle,

and

$\sin(90°) = 1$

(iv) Two uses of total internal reflection are:

Optical fibers: They use total internal reflection to transmit light over long distances with minimal loss.

Prisms in binoculars: Prisms use total internal reflection to flip the image right-side up as it passes through the binoculars.

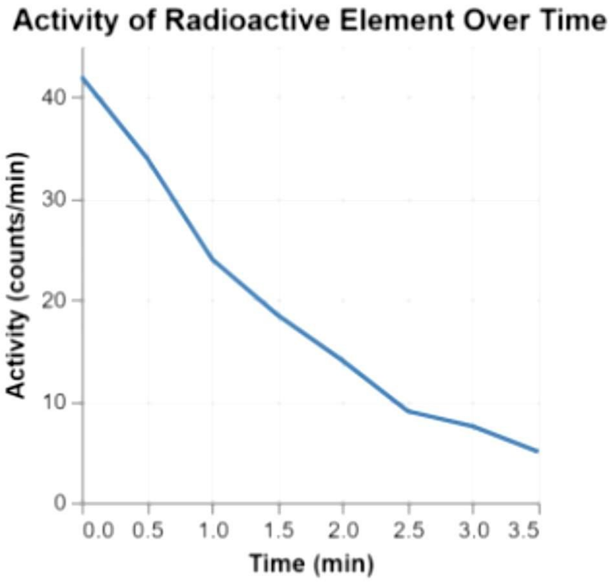
C3 (a) Radioactivity is the spontaneous emission of radiation from the unstable nucleus of an atom. This can include the emission of alpha particles, beta particles, and gamma rays as the nucleus changes into a more stable form.

(b) The decay of radon-222 to form polonium is through alpha decay. Alpha decay is the process of emitting an alpha particle from the nucleus, which is essentially a helium nucleus consisting of two protons and two neutrons. The decay equation can be written as:

$$^{222}_{86}Ra \rightarrow {}^{218}_{84}Po + {}^{4}_{2}He$$

The atomic number decreases by 2 and the mass number decreases by 4 due to the loss of the alpha particle (the helium nucleus).

(c) (ii)



(ii) To determine the half-life from the graph, we find the time at which the activity reduces to half of its original value which is about **1.3 minutes**

(iii) A common source of background radiation is natural environmental radiation, which includes cosmic rays from space and terrestrial sources like radon gas, which is a product of the decay of uranium in the Earth's crust.