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L6 Scholarship Paper

March 2025

Subject: PHYSICS

Time: 1 Hour

Attempt all Questions Candidates answer on the question paper	**Total Marks** **60**

Instructions

- Fill the boxes at the top of this page with your name.
- There are 16 questions in this paper.
- Answer all questions in the spaces provided. There may be more space than needed

Information

- The total mark for this paper is **60**
- Any rough working should be done on this question paper.
- Where necessary, use acceleration due to gravity on Earth, g = 10 m/s^2

FORMULAE

You may find the following formulae useful.

energy transferred = current × voltage × time $E = I \times V \times t$

$$\text{frequency} = \frac{1}{\text{time period}} \qquad f = \frac{1}{T}$$

$$\text{power} = \frac{\text{work done}}{\text{time taken}} \qquad P = \frac{W}{t}$$

$$\text{power} = \frac{\text{energy transferred}}{\text{time taken}} \qquad P = \frac{W}{t}$$

$$\text{orbital speed} = \frac{2\pi \times \text{orbital radius}}{\text{time period}} \qquad v = \frac{2 \times \pi \times r}{T}$$

(final speed)^2 = (initial speed)^2 + (2 × acceleration × distance moved)

$$v^2 = u^2 + (2 \times a \times s)$$

pressure × volume = constant $p_1 \times V_1 = p_2 \times V_2$

$$\frac{\text{pressure}}{\text{temperature}} = \text{constant} \qquad \frac{p_1}{T_1} = \frac{p_2}{T_2}$$

$$\text{force} = \frac{\text{change in momentum}}{\text{time taken}} \qquad F = \frac{(mv - mu)}{t}$$

$$\frac{\text{change of wavelength}}{\text{wavelength}} = \frac{\text{velocity of a galaxy}}{\text{speed of light}} \qquad \frac{\lambda - \lambda_0}{\lambda_0} = \frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$$

change in thermal energy = mass × specific heat capacity × change in temperature

$$\Delta Q = m \times c \times \Delta T$$

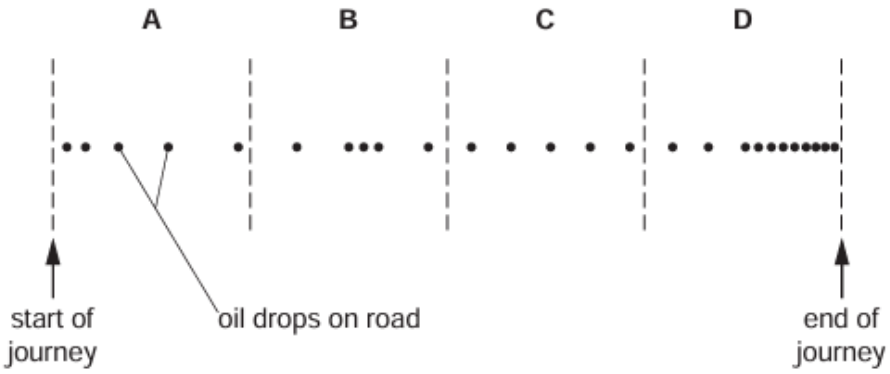
Where necessary, assume the acceleration of free fall, $g = 10\ \text{m/s}^2$.

SECTION A

There are ten questions on this Section. Answer all questions.

*• For each question there are four possible answers **A, B, C** and **D**. Choose the one you consider correct and circle it using a soft pencil.*

1 A car is dripping oil at a steady rate on a straight road.
The road is divided into four sections **A**, **B**, **C**, and **D**.



Which section of the road shows the car travelling at a constant speed?

2 Which two quantities are related in Hubble's law?

A Distance and mass of galaxies.

B Velocity and intensity of galaxies.

C Distance and velocity of galaxies.

D Distance and red shift of stars in our galaxy.

3 A sound wave travels from air into water.

Which quantity stays the **same**?

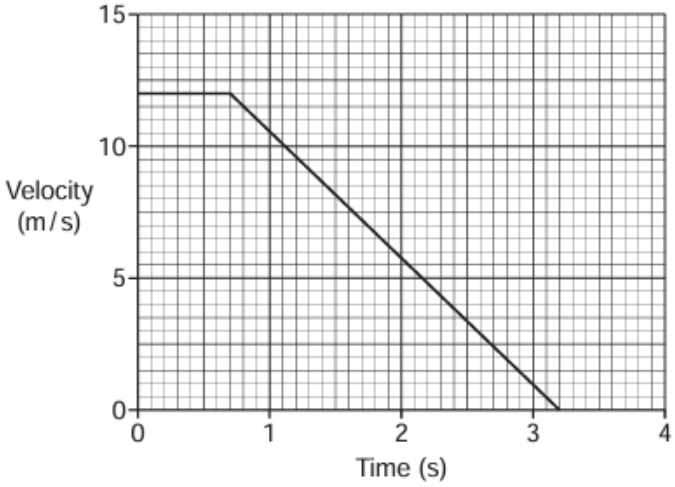
A Amplitude

B Frequency

C Speed

D Wavelength

4 The velocity–time graph shows how the velocity of a car changes after the driver sees a hazard in the road.



What is the braking distance of the car?

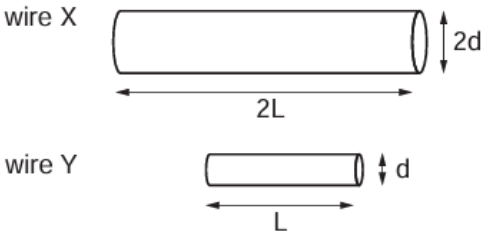
A 8.4 m

B 15.0 m

C 17.5 m

D 23.4 m

5 The diagram shows the relative lengths and diameters of two copper wires, labelled wire X and wire Y.



What is the ratio of the resistivity of wire Y to wire X?

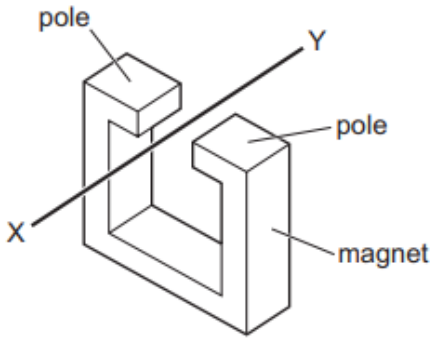
A 1 : 1

B 1 : 2

C 1 : 4

D 1 : 8

6 When wire XY is moved downwards between the poles of a stationary magnet, an e.m.f. is produced across X and Y.



Which action produces an e.m.f. across X and Y in the opposite direction?

A Move both the wire and the magnet upwards at the same speed.

B The wire is kept stationary and the magnet is moved upwards.

C The wire is moved downwards and the magnet is moved upwards.

D The wire is moved upwards and the magnet is kept stationary.

7 A transformer has 5500 turns on the primary coil and 500 turns on the secondary coil.

The output of the secondary coil is 110 V a.c. and is connected to a heater. The transformer is 100% efficient.

The heater produces a power of 132 W.

What is the current in the primary coil?

A 0.11 A **B** 0.12 A **C** 11 A **D** 12 A

8 A scientist was asked to separate the following equations into two categories: nuclear fission and nuclear fusion.

1 $^{239}_{94}Pu \rightarrow {}^{112}_{46}Pd + {}^{124}_{48}Cd + 3{}^{1}_{0}n$

2 $^{3}_{2}He + {}^{3}_{2}He \rightarrow {}^{4}_{2}He + {}^{1}_{1}H + {}^{1}_{1}H$

3 $^{14}_{7}N + {}^{1}_{1}H \rightarrow {}^{15}_{8}O$

4 $^{235}_{92}U \rightarrow {}^{90}_{36}Kr + {}^{143}_{56}Ba + 2{}^{1}_{0}n$

Which equations show nuclear fission?

A 1 and 2 **B** 1 and 3 **C** 1 and 4 **D** 2 and 4

9 Which quantity can be determined using the brightness of a supernova in a distant galaxy?

A the speed at which the galaxy is moving away from the Earth

B the distance of the galaxy from the Earth

C the Hubble constant

D the age of the Universe

10 An electric fire is connected to a 240 V supply and transfers energy at a rate of 1.0 kW.

How much charge passes through the fire in 1.0 h?

A 42 C **B** 250 C **C** 1.5×10^4 C **D** 2.4×10^5 C

Continue to page 7

SECTION B

Write your answers in the spaces provided after every question

11 Fig. 1.1 shows the speed–time graph for a car travelling on a straight horizontal road.

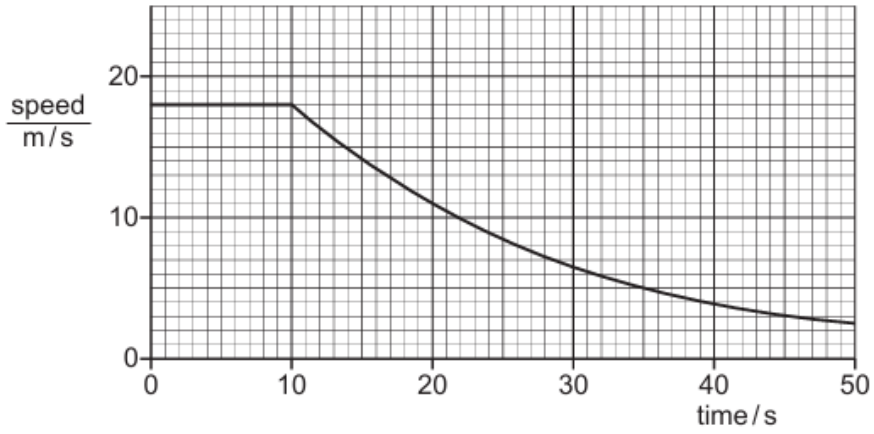


Fig. 1.1

(a) Describe the motion of the car shown in Fig. 1.1.

.....

.....

.....

..... [2]

(b) At time t = 10 s the engine of the car is switched off. The brakes are not applied.

(i) Name **two** forces that act on the car to cause the change in motion after t = 10 s.

1 .....

2 .....

[1]

(ii) Suggest why Fig. 1.1 is a curve after t = 10 s.

.....

.....

..... [1]

(c) Between $t = 10\,s$ and $t = 20\,s$ the speed of the car changes from $18\,m/s$ to $11\,m/s$.

The mass of the car is $1200\,kg$.

(i) Calculate the change in momentum of the car in this time.

Give the unit of your answer

momentum change = ... unit ..... [2]

(ii) Calculate the average resultant force exerted on the car during this time.

average resultant force = ... N [2]

[Total: 8]

12 A child's toy consists of a flexible track and a model car.

Fig. 2.1 shows a diagram of the toy.

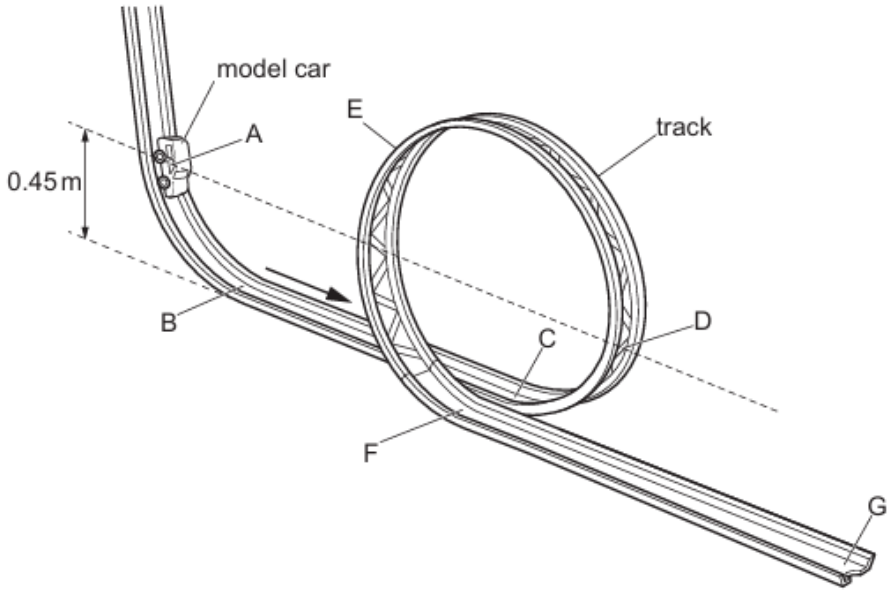


Fig. 2.1

Fig. 2.1

The child first holds the car stationary at point A which is 0.45 m above the horizontal sections of track BC and FG. The mass of the car is 0.12 kg.

The child then releases the car which travels towards point B. Both air resistance and friction between the car and the track are negligible.

The gravitational field strength g is 10 N / kg.

(a) Calculate the change in gravitational potential energy (g.p.e.) of the car as it travels from A to B.

change in g.p.e. = ... [2]

(b) Calculate the speed of the car when it reaches B.

speed = ... [3]

(c) After releasing it, the child expects the car to follow the track along the route ABCDEFG. In fact, the model car does not reach F.

(i) Explain, in terms of energy, why the car does not go past D, which is also 0.45 m above the horizontal track.

.....

..... [1]

(ii) Immediately after being released at A, the car travels to B, to C and then to D.

Describe the motion of the car after it reaches D.

.....

..... [1]

[Total: 7]

13 A filament lamp is arranged above a shiny metal surface, as shown in Fig. 8.1.

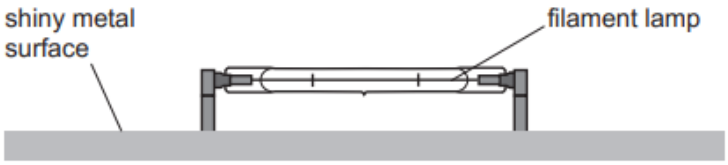


Fig. 8.1

A student reads in a textbook that a light-emitting diode (LED) is more efficient than a filament lamp.

(a) (i) State what is meant by 'efficiency'.

.....

.....

..... [1]

(ii) Suggest why the efficiency of a filament lamp is very low.

.....

.....

..... [1]

(b) The student considers replacing the filament lamp shown in Fig. 8.1 with an LED of the same brightness.

Data about the filament lamp and a suitable LED are shown in Table 8.1.

Table 8.1

	input power / W	energy efficiency
filament lamp	120	6.2%
LED	15	–

The LED emits the same amount of visible light as the filament lamp.

Using this information and the data in Table 8.1, determine the efficiency of the LED.

efficiency = ... % [2]

(c) The filament lamp is connected to the live and neutral wires in the mains supply.

The earth wire in the mains supply is connected to the shiny metal surface shown in Fig. 8.1.

There is a fuse in the live wire.

By accident, the live wire touches the shiny metal surface.

(i) Describe what then happens.

.....

.....

.....

..... [2]

(ii) In another similar lamp, the fuse is wrongly connected into the earth wire.

Explain why a person is **not** protected when the live wire touches the shiny metal surface.

.....

.....

.....

..... [2]

[Total: 8]

Continue to page 11

14 Fig. 9.1 shows a simple a.c. generator.

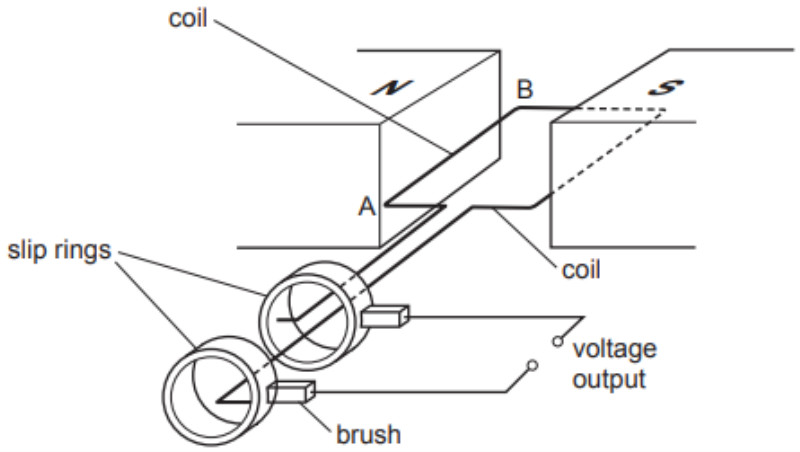


Fig. 9.1

(a) Explain why there is a voltage induced in the coil when the coil is turned.

.....

.....

.....

..... [2]

(b) In Fig. 9.1 the coil is horizontal, with side AB on the left. The output voltage is +6.0 V.

On Fig. 9.2 draw a line from each of the shaded boxes to one of the circled voltages to show the voltage output when the coil is in different positions.

One line has been drawn for you.

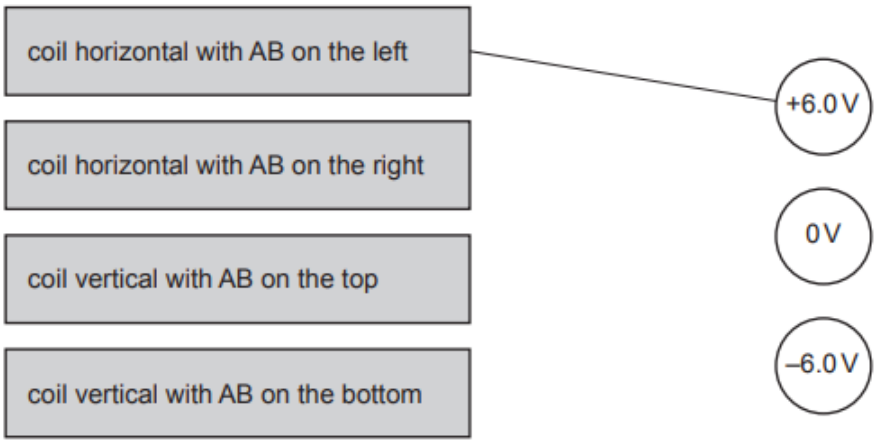


Fig. 9.2

[2]

(c) Both an a.c. generator and a d.c. motor contain a coil and brushes.

(i) Fig. 9.1 shows how the brushes are connected to the coil in an a.c. generator.

Draw a diagram to show how the brushes are connected to the coil in a d.c. motor.

[2]

(ii) State why there are forces on the sides of the coil in a d.c. motor.

.....

..... [1]

[Total: 7]

15 In space, an interstellar cloud of dust and gas collapses to form a protostar. The cloud contains hydrogen.

(a) Describe the energy transfers that take place as the cloud collapses and forms the protostar.

.....

.....

..... [2]

(b) The collapse results in a nuclear reaction in the protostar that involves the isotope hydrogen-3 ($^{3}_{1}H$).

The isotope hydrogen-3 ($^{3}_{1}H$) is radioactive. It decays by beta particle emission.

(i) State how the nuclei of isotopes of the same element are different.

.....

..... [1]

(ii) Explain why hydrogen-3 cannot decay by alpha particle emission.

.....

..... [1]

(iii) Complete the equation for the decay of hydrogen-3 to an isotope of helium (He).

$$^{3}_{1}H \longrightarrow \overset{\cdots\cdots}{\cdots\cdots}\beta + \overset{\cdots\cdots}{\cdots\cdots}He$$

[2]

(iv) Explain how the nuclear reaction in the protostar stops further collapse as the protostar becomes a stable star.

.....

.....

.....

.....

..... [3]

(c) The cloud of dust and gas that collapses also contains atoms of the heaviest elements.

State which part of the life cycle of a star is responsible for the production of the heaviest elements.

.....

..... [1]

[Total: 10]

Continue to page 15

16 **(a)** Table 9.1 shows some properties and values for α-particles, β-particles and γ-radiation.

Complete Table 9.1.

Table 9.1

type of radiation	number of protons	number of neutrons	charge / C	stopped by
α	2		$+ 3.2 \times 10^{-19}$	thin sheet of paper
β		0		thin sheet of aluminium
γ	0			

[3]

(b) State how β-decay changes the nucleus of an atom.

..... [1]

(c) A radiation detector used in a laboratory detects a background count rate of 30 counts / min. A radioactive source is placed in front of the radiation detector. The initial reading on the detector is 550 counts / min. The half-life of the source is 25 minutes.

Calculate the expected reading on the detector after 75 minutes.

reading = ... counts / min [4]

(d) State **two** safety precautions taken when moving, using or storing radioactive sources in a laboratory.

1 .....

2 .....

[2]

[Total: 10]

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