1 For which quantity is the magnitude a reasonable estimate?

	quantity	magnitude
A	diameter of an atom	50 μm
B	Earth's gravitational field strength	9.0 N/kg
C	refractive index of glass	0.93
D	wavelength of radio waves	5.0 m

2 Which expression with only SI base units is equivalent to the newton?

A J/m **B** $kg\,m/s^2$ **C** $kg\,m^2/s$ **D** $kg\,m^2/s^2$

3 Which group of quantities contains only vectors?

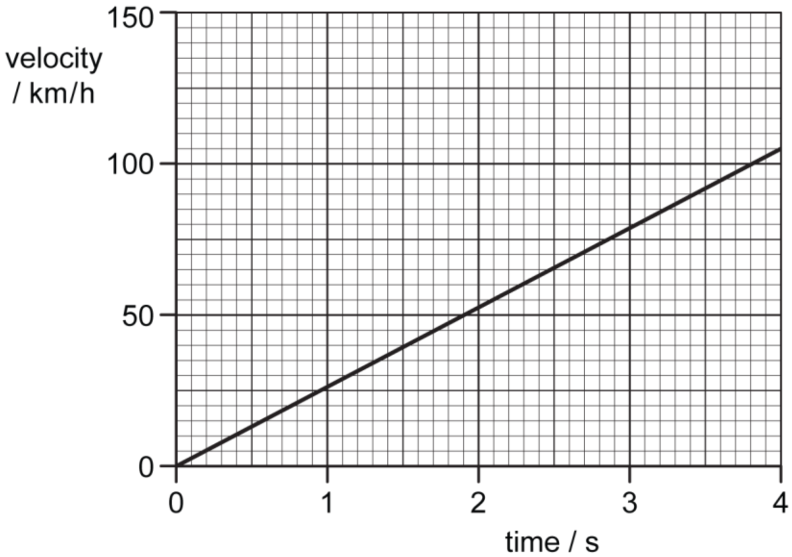
A acceleration, displacement, speed

B acceleration, gravitational field strength, work done

C displacement, force, velocity

D gravitational field strength, force, power

4 The variation of velocity with time of a car is shown in the diagram.



What is the acceleration of the car?

A $190\,m/s^2$ **B** $53\,m/s^2$ **C** $26\,m/s^2$ **D** $7.3\,m/s^2$

5 On Mars, the gravitational field strength is 38% of that on Earth.

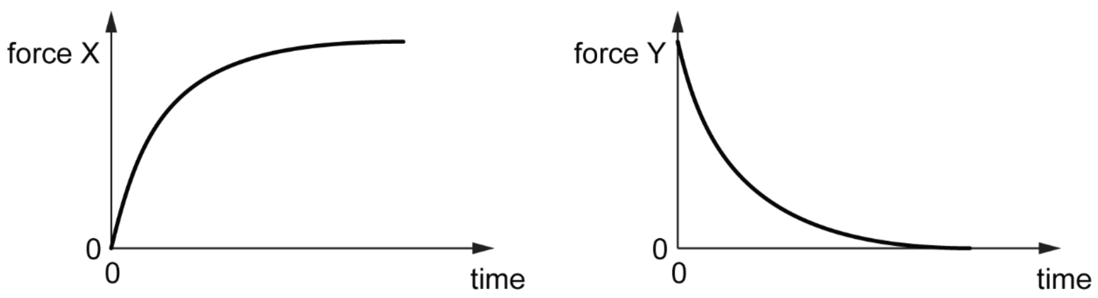
A body has a mass of 2.5kg and weight of 25N on Earth.

What are the mass and weight of this body on Mars?

	mass on Mars / kg	weight on Mars / N
A	0.95	9.5
B	0.95	66
C	2.5	9.5
D	2.5	66

6 A ball falls from rest through air and eventually reaches terminal velocity.

For this fall, forces X and Y acting on the ball vary with time as shown.

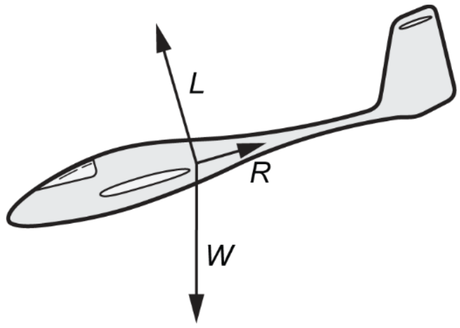


What are forces X and Y?

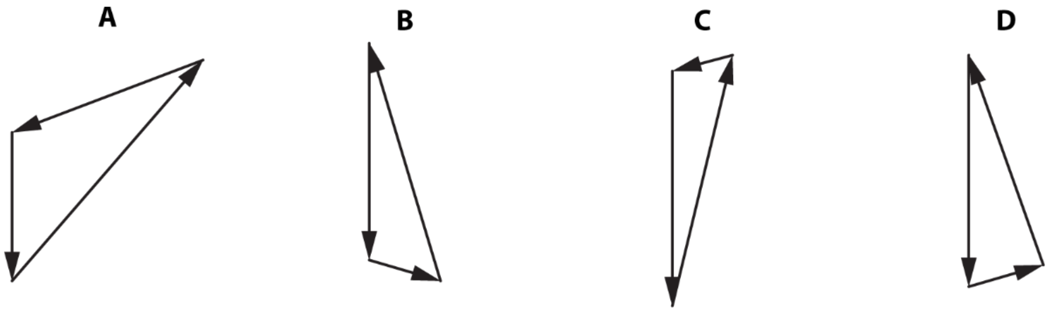
	force X	force Y
A	air resistance	resultant force
B	air resistance	weight
C	resultant force	air resistance
D	resultant force	weight

7 A model plane is descending at constant speed at an angle to the horizontal.

The diagram shows the directions of the lift *L*, air resistance *R* and weight *W* acting on the plane.



Which vector diagram could represent the forces acting on the glider?



8 A book rests on a table.

What is the reaction to the weight of the book?

A the pull of the book by the Earth

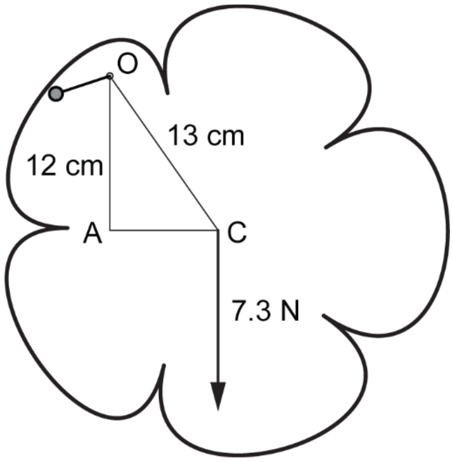
B the pull of the Earth by the book

C the push of the book on the table

D the push of the table on the book

9 A piece of cardboard with uniform thickness is freely suspended from point O, where OC = 13 cm.

The weight of the cardboard is 7.3 N and its centre of gravity is at C.



When the lamina is displaced to the position with OA = 12 cm, what is the moment of the force (due to the weight) about point O that causes the lamina to swing?

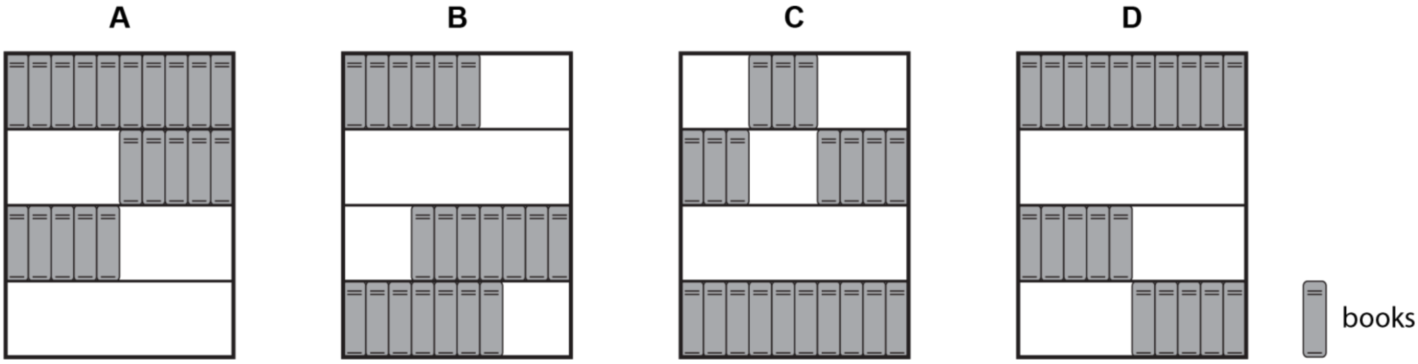
A 7.3 N cm anticlockwise

B 37 N cm clockwise

C 88 N cm clockwise

D 95 N cm anticlockwise

10 Similar sets of books are placed in identical bookcases.



Which bookcase is most likely to fall backward if pushed sightly from the front?

11 A volume of $1.5\,m^3$ of water is mixed with $0.50\,m^3$ of alcohol. The density of water is $1000\,kg/m^3$ and the density of alcohol is $800\,kg/m^3$.

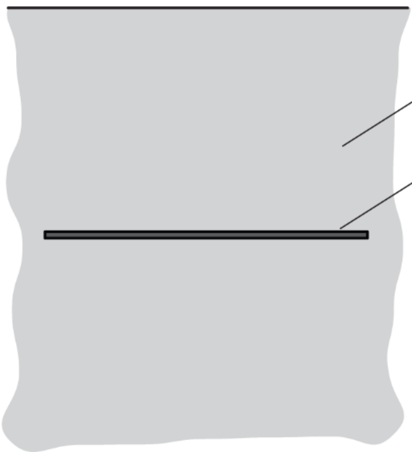
The volume of the mixture is $2.0\,m^3$.

What is the density of the mixture?

A $850\,kg/m^3$ **B** $900\,kg/m^3$ **C** $940\,kg/m^3$ **D** $950\,kg/m^3$

12 A horizontal plate of area $0.036\,m^2$ is placed beneath the surface of a liquid of density $930\,kg/m^3$.

The force acting on the plate due to the pressure of the liquid is 290 N.



The gravitational field strength is 10 N/kg.

The effect of atmospheric pressure is negligible.

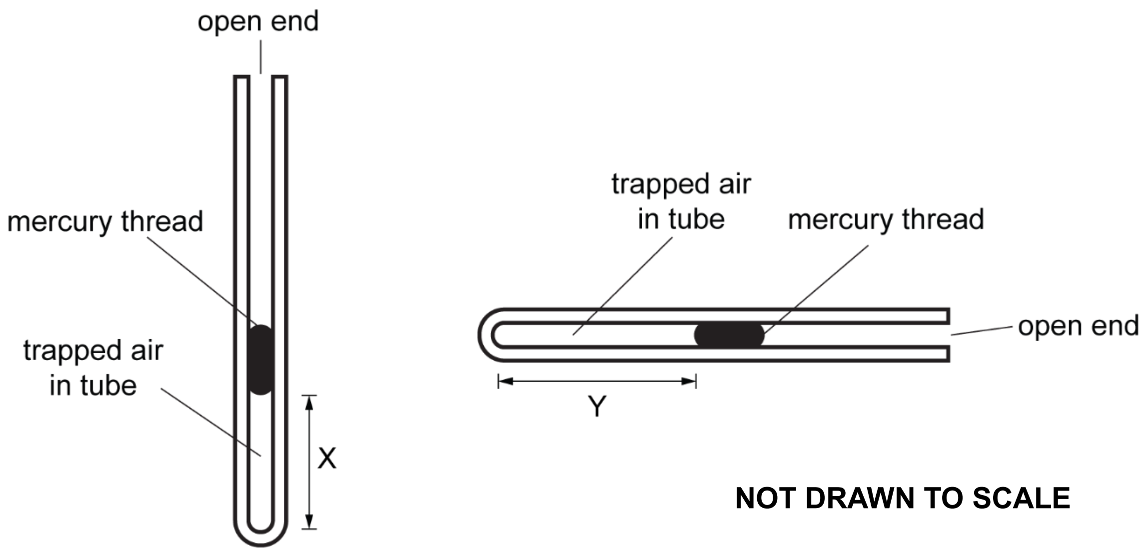
What is the depth of the plate beneath the surface of the liquid?

A 0.87 m **B** 1.13 m **C** 8.7 m **D** 9.1 m

13 A thin tube contains a short thread of mercury, trapping a column of air at one end. The other end of the tube is open to the atmosphere.

When the tube is held vertically, the length of the trapped air column is X.

When the tube is placed horizontally, the length of the trapped air column is Y.



Which statement correctly describes the relationship between lengths X and Y?

A X may be greater or smaller than Y, depending on atmospheric pressure.

B X is always greater than Y, due to increased pressure from the mercury thread.

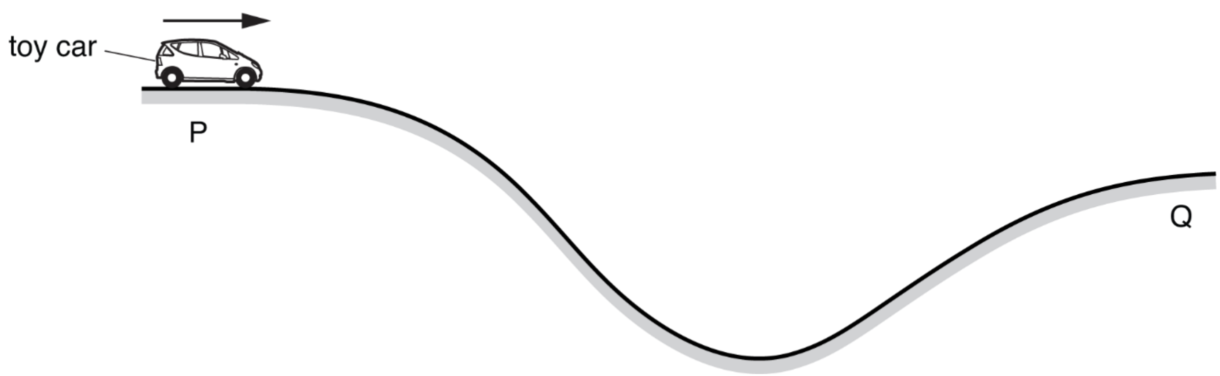
C X is always smaller than Y, due to increased pressure from the mercury thread.

D X is always equal to Y, as atmospheric pressure remains constant.

14 A toy car travels fom P to Q along a track. P is higher than Q.

At P, the car has 8.0 kJ of energy in its kinetic store.

At Q, its gravitational potential store has 35 kJ less energy than that at P.

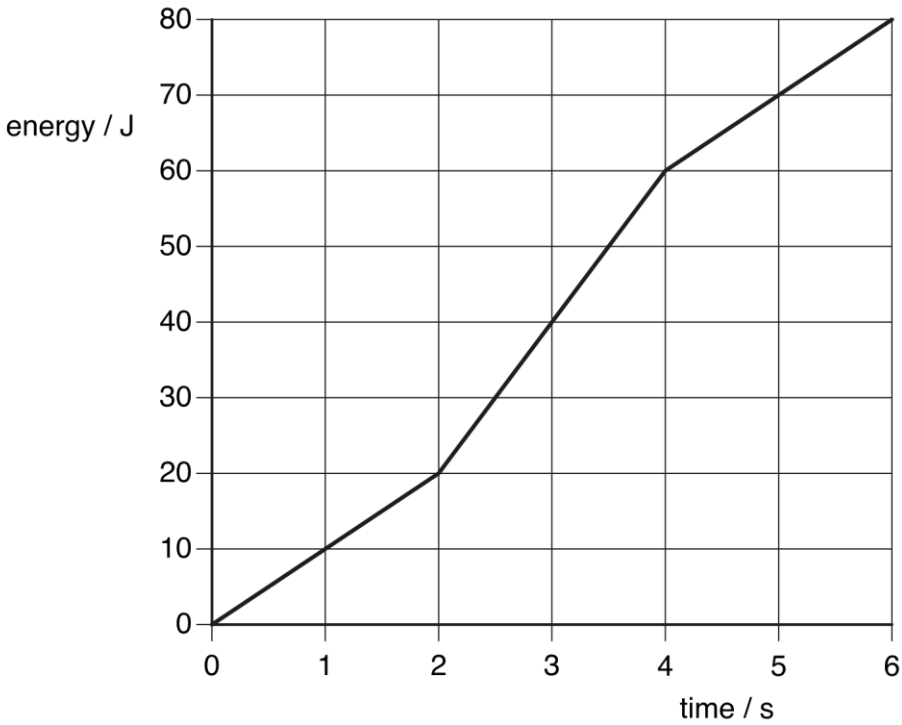


Between P and Q, 10 kJ of work is done against friction.

What is the minimum energy in the car's kinetic store at Q?

A 33 kJ **B** 45 kJ **C** 53 kJ **D** 65 kJ

15 An electrical heater is turned on at time zero. The total thermal energy transferred by the heater during the first 6 seconds is shown in the graph.



What is the maximum power output of the heater at any instant during these 6 seconds?

A 10 W **B** 20 W **C** 30 W **D** 40 W

16 What are the energy changes in nuclear power production?

A chemical → thermal → electrical

B electrical → thermal → nuclear

C nuclear → chemical → electrical

D nuclear → thermal → electrical

17 When energy is continuously removed from the thermal store of a substance at a steady rate, its temperature decreases but occasionally remains constant for a period of time.

What is happening to the substance when its temperature remains constant temporarily?

A The substance is losing thermal energy faster.

B The substance is undergoing a change in physical state.

C The substance is experiencing an increase in internal energy.

D The substance has reached thermal equilibrium with its surroundings.

18 Why does the pressure inside a sealed container of gas increase when the gas is heated?

A The gas molecules collide more frequently with each other.

B The gas molecules expand when heated.

C The gas molecules move faster and collide with the walls of the container more frequently.

D There are more gas molecules present to collide with the walls of the container.

19 What is meant by the *internal energy* of an object?

A The energy related to the object's motion through space.

B The energy due to the random motion of molecules in the object.

C The energy arising from the forces of attraction between the molecules.

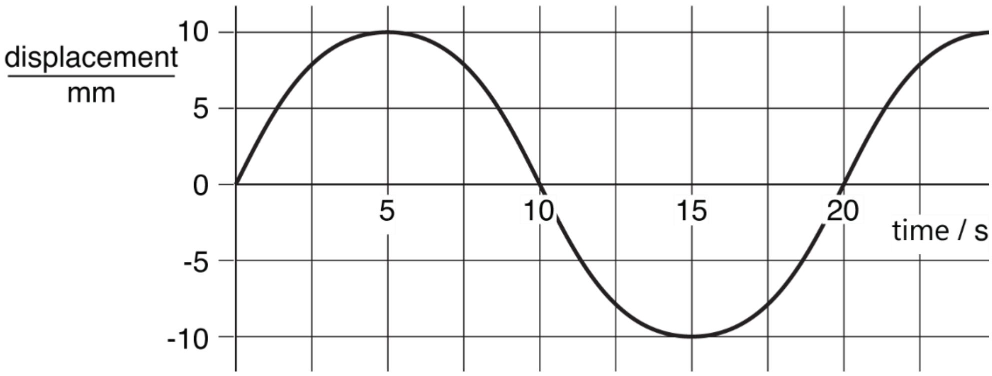
D The total of all the kinetic and potential energies of the molecules in the object.

20 A 0.10 kg block of copper requires 1160 J of thermal energy to increase its temperature from 10 °C to 40 °C.

What is the numerical value of the ratio $\dfrac{\text{specific heat capacity of copper}}{\text{heat capacity of the copper block}}$?

A $\dfrac{1}{30}$ **B** $\dfrac{1}{10}$ **C** 10 **D** 30

21 The graph shows how the displacement of a particle in a wave varies with time.



The wave has an amplitude of

A 10 mm and could be either transverse or longitudinal.

B 10 mm and must be transverse.

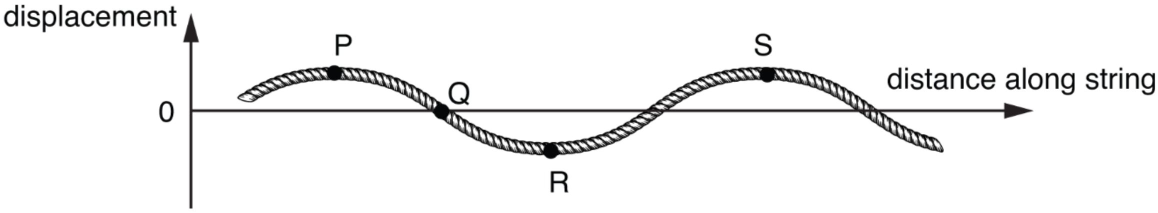
C 20 mm and could be either transverse or longitudinal.

D 20 mm and must be transverse.

22 The diagram shows the shape of part of a transverse wave travelling along a rope at a particular instant.

P, Q, R and S are four different points on the rope.

The wave is travelling towards the right.



Which statement is correct?

A P and Q are moving to the right.

B P and R are moving downward.

C Q and R are moving upward.

D Q and S are moving to the left.

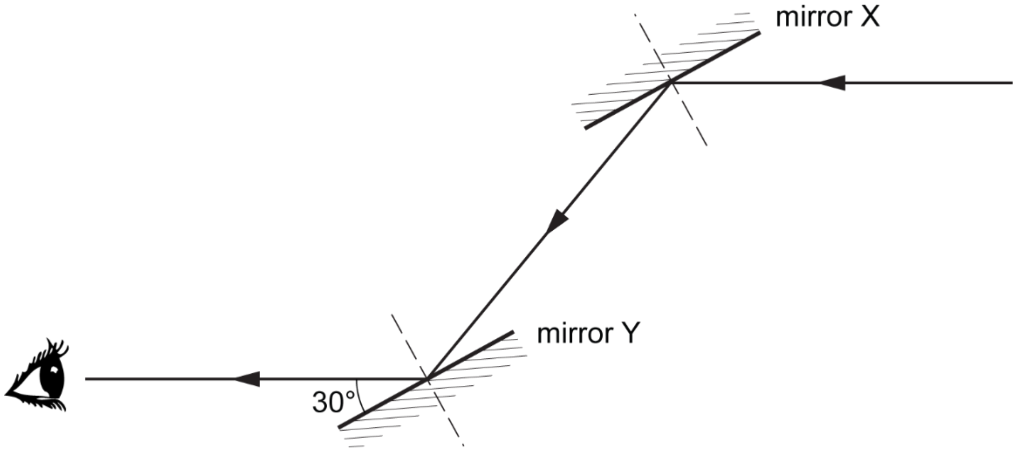
23 A radar system sends out a pulse of radio waves which reflects off an aircraft and returns to the receiver after 240 μs.

The speed of radio waves in air is 3.0×10^8 m/s.

What is the distance between the radar and the aircraft?

A 3.6 km **B** 7.2 km **C** 36 km **D** 72 km

24 A ray of light is reflected by two parallel plane mirrors X and Y.



Which statement is correct?

A The angle of incidence at mirror X is 30°.

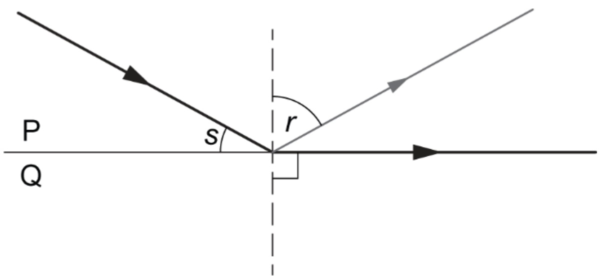
B The angle of reflection at mirror X is 60°.

C The angle of reflection at mirror Y is 30°.

D The angle of incidence at mirror Y is 120°.

25 The diagram shows a ray of light incident on the boundary between two mediums, P and Q.

The mediums have different refractive indexes.



Some of the incident light is reflected back into medium P

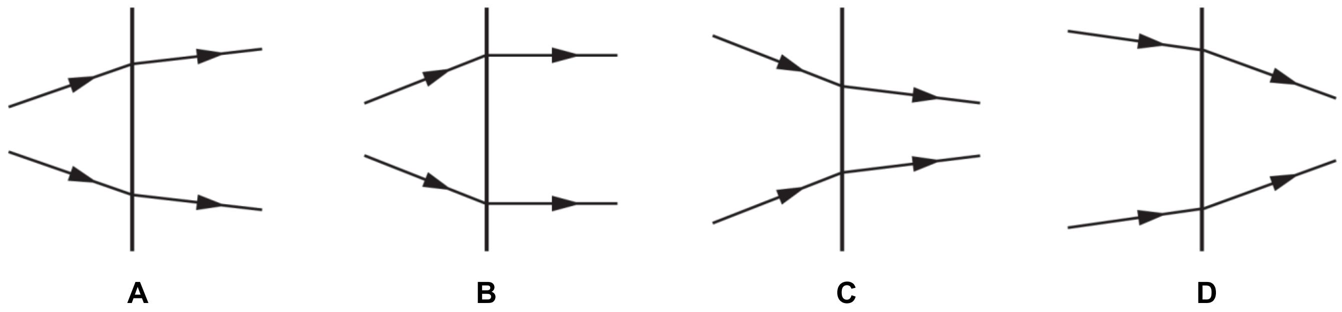
Some light travels exactly along the boundary between the two mediums.

Angle *r* is greater than angle *s*.

Which angle is the critical, and which medium has the greater refractive index?

	critical angle	medium with greater refractive index
A	*r*	P
B	*r*	Q
C	*s*	P
D	*s*	Q

26 Which diagram show light rays passing through a diverging lens.



27 The table shows the wavelengths of five electromagnetic waves.

Which row is correct?

	increasing wavelength →				
A	gamma ray	x-ray	infra-red	microwave	radio wave
B	radio wave	microwave	infra-red	x-ray	gamma ray
C	radio wave	microwave	ultraviolet	infra-red	x-ray
D	x-ray	infra-red	ultraviolet	microwave	radio wave

28 When the flash on a camera is used, a charge of 1.2 C flows for 0.0025 s through the flash lamp.

The average voltage across the flash lamp is 300 V.

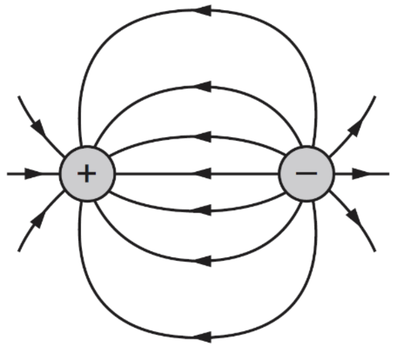
What is the electrical energy and power supplied to the flash lamp?

	energy / J	power / kW
A	300	120
B	300	144
C	360	120
D	360	144

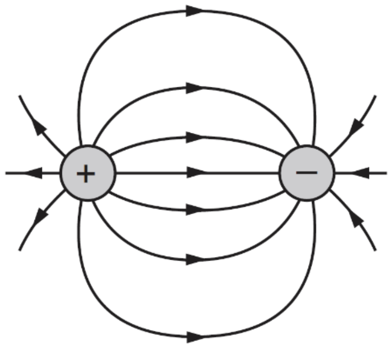
29 A positive charge and a negative charge of equal magnitude are placed a short distance apart.

Which diagram best represents the associated electric field?

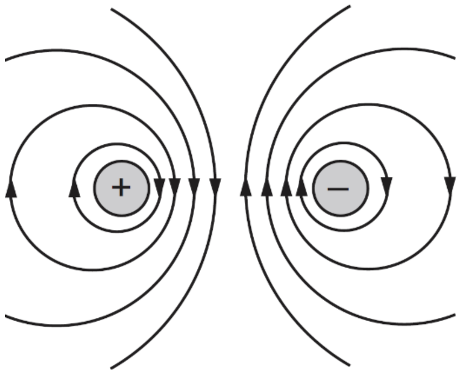
A



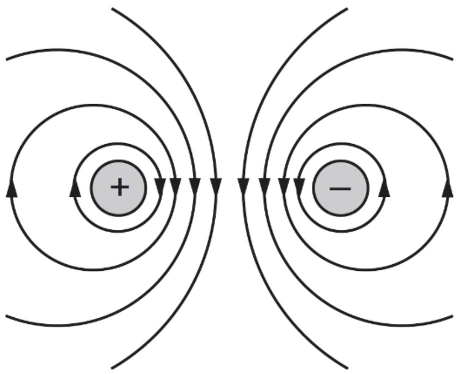
B



C



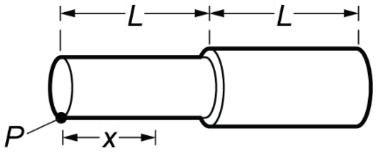
D



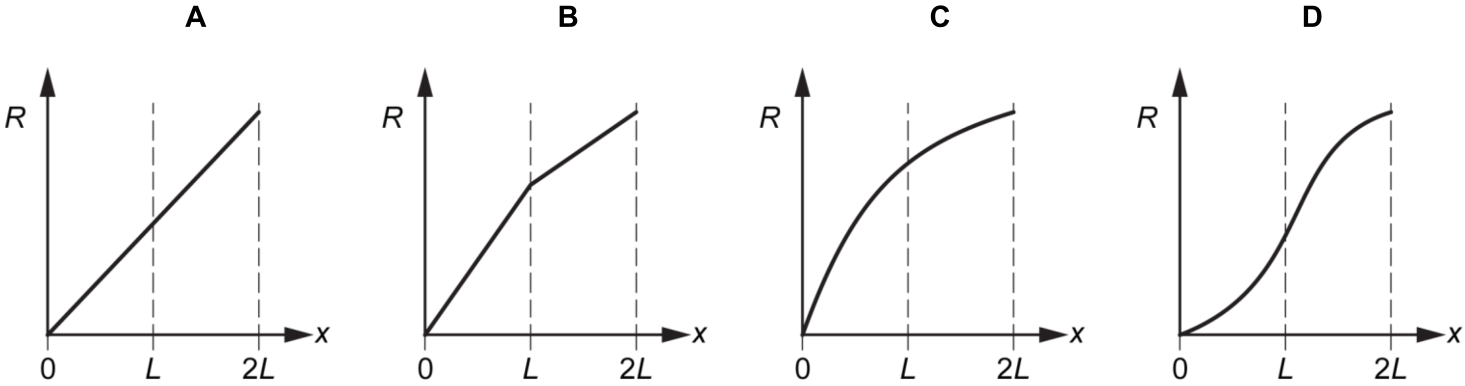
30 A resistor is constructed from two cylindrical metal conductors of identical material.

Each cylinder is of length L and uniform diameter.

The two cylinders are joined end-to-end as shown.



Which graph best shows how the resistance of the resistor varies with distance x from end P?



31 Four statements about potential difference and electromotive force are given below:

1 It involves converting electrical energy into other forms of energy.

2 It involves converting other forms of energy into electrical energy.

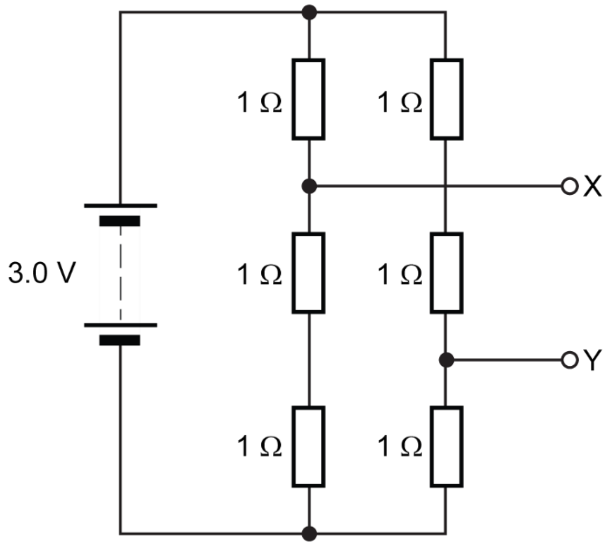
3 It is the energy per unit charge required to move charge completely around a circuit.

4 It is the work done per unit charge by the charge in moving from one point to another.

Which statements describe potential difference, and which describe electromotive force?

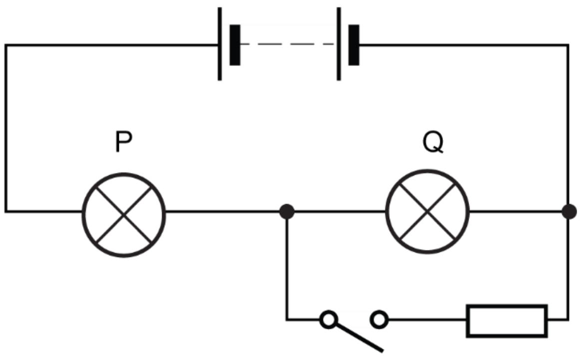
	potential difference	electromotive force
A	1 and 3	2 and 4
B	1 and 4	2 and 3
C	2 and 3	1 and 4
D	2 and 4	1 and 3

32 What is the potential difference between terminals X and Y?



A 0V **B** 1.0V **C** 2.0V **D** 3.0V

33 Two identical lamps, P and Q, and one resistor are connected in the circuit shown.



Initially, the switch is open and both lamps glow with normal brightness.

What happens to the brightness of lamps P and Q when the switch is closed?

	lamp P	lamp Q
A	brighter	brighter
B	brighter	dimmer
C	dimmer	brighter
D	dimmer	dimmer

34 An electric lamp is marked "230 V, 1 kW" and is connected to a main circuit with a maximum rating of 30 A.

Which fuse rating is most suitable to use in series with the lamp to protect it?

A 1 A **B** 3 A **C** 7 A **D** 13 A

35 Which of the following best describes induced magnetism?

A A bar magnet attracts a piece of soft iron when placed near to it.

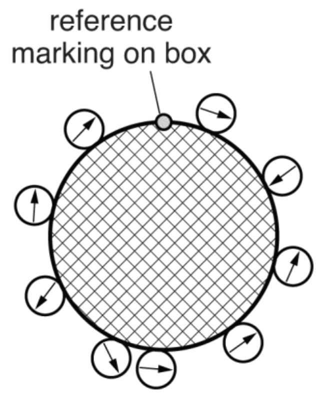
B A bar magnet loses its magnetism after being repeatedly dropped.

C A bar magnet aligns itself with the Earth's magnetic field when freely suspended.

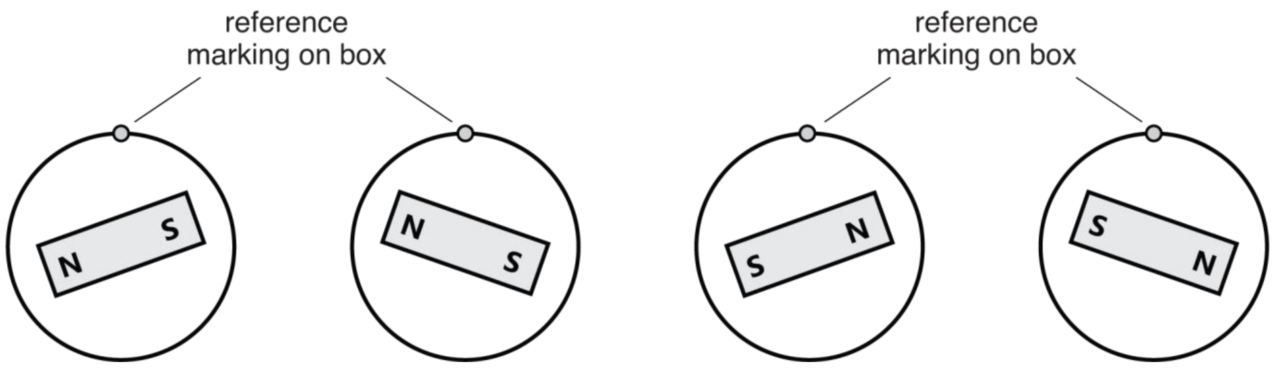
D Two North poles repel each other, while a North pole attracts a South pole.

36 The diagram shows a box containing a hidden bar magnet. A reference marking is made on the surface of the box.

Compasses are placed around the outside of the box, and their needles align as shown in the diagram.

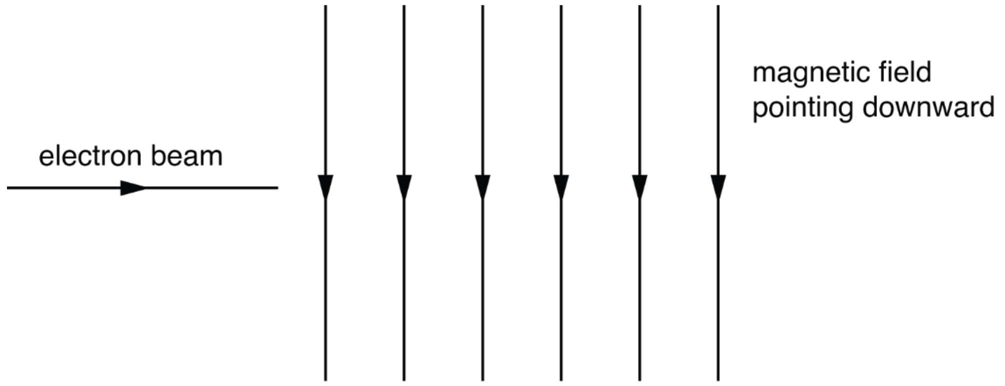


Which diagram best shows the position and orientation of the bar magnet inside the box, relative to the reference mark?



A **B** **C** **D**

37 The diagram shows a beam of electrons about to enter a magnetic field. The direction of the field is downward.



What will be the direction of the deflection, if any, as the beam passes through the field?

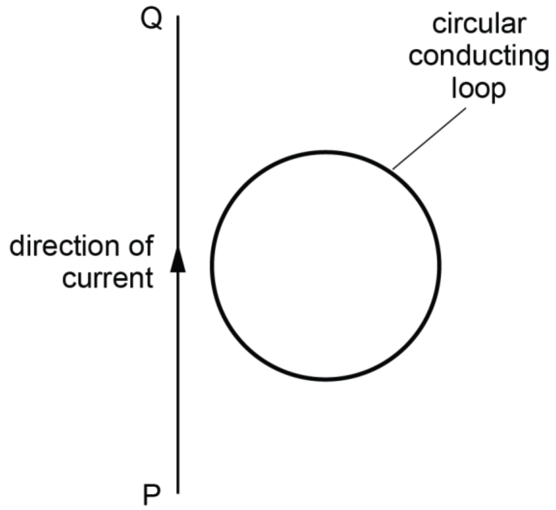
A towards the bottom of the page

B towards the top of the page

C into the page

D out of the page

38 A circular conducting loop is placed near a current-carrying straight wire PQ, as shown in the diagram.



Which action will result in an induced current in the circular loop?

A Move the circular loop horizontally to the right, increasing its distance from the wire PQ.

B Move the circular loop vertically downward.

C Rotate the circular loop anticlockwise around the wire PQ, using the wire as the axis of rotation.

D Rotate the circular loop clockwise around the wire PQ, using the wire as the axis of rotation.

39 Which statement about the ionising powers of alpha, beta and gamma radiation is correct?

A Alpha radiation has the greatest ionising power.

B Beta radiation has the greatest ionising power.

C Gamma radiation has the greatest ionising power.

D Alpha, beta and gamma radiation have equal ionising powers.

40 The following represents a sequence of radioactive decays involving two α-particles and one β-particle.

$$^{217}_{85}\text{At} \xrightarrow{\alpha} \text{V} \xrightarrow{\alpha} \text{W} \xrightarrow{\beta} \text{X}$$

What is nuclide X?

A $^{213}_{85}\text{At}$ **B** $^{215}_{77}\text{Ir}$ **C** $^{209}_{82}\text{Pb}$ **D** $^{217}_{81}\text{Tl}$

End of Paper

Section A

Answer **all** the questions in this section.

1 A small parcel is lifted vertically upwards by a drone, as illustrated in Fig. 1.1.

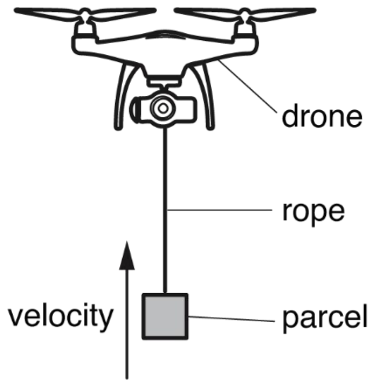


Fig. 1.1

When the parcel is in motion, the rope connecting it to the drone snaps at $t = 0$.

The parcel continues moving upwards initially before descending and eventually hitting the ground at time $t = 0.80\,s$.

Fig. 1.2 show the velocity-time graph of the parcel.

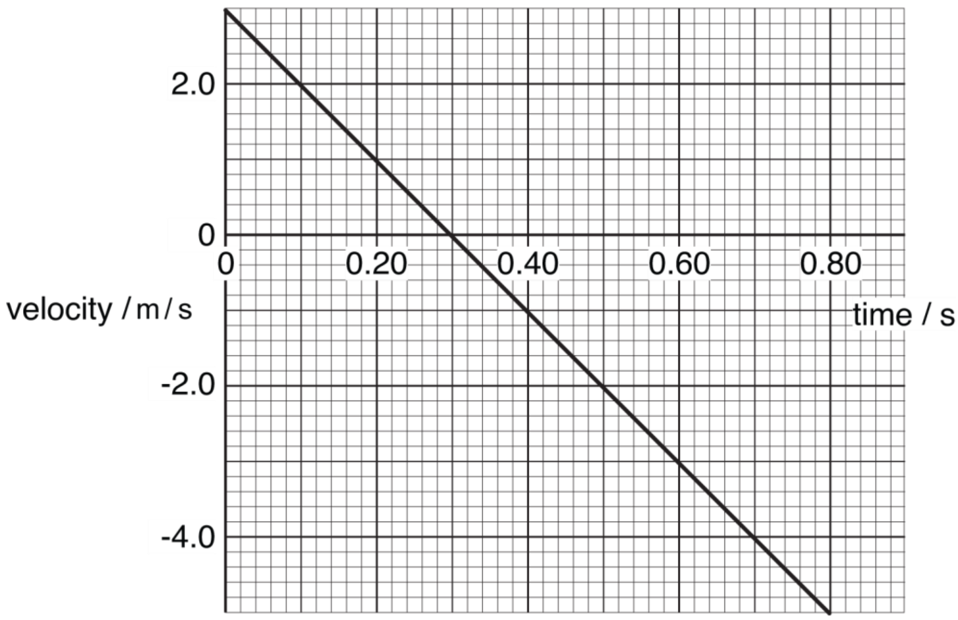


Fig. 1.2

Assume air resistance is negligible.

(a) State how Fig. 1.2 shows the parcel has a constant acceleration.

....[1]

(b) Use Fig. 1.2 to determine

(i) the maximum height of the block above the ground,

height: ....[2]

(ii) the height rises by the block before falling back.

height: ....[2]

(c) On Fig. 1.3, sketch a line to show the variation of the distance moved by the block with time *t* from *t* = 0 to *t* = 0.30 s. Numerical values of distance are not required

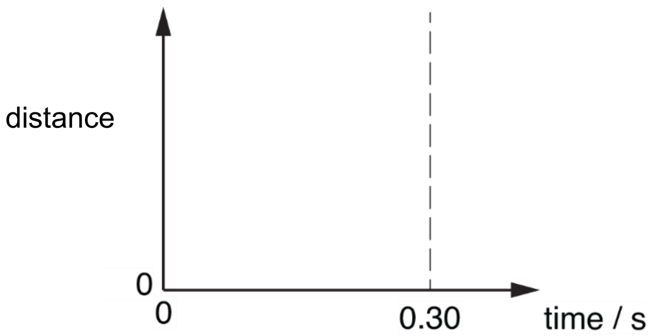


Fig. 1.3

[2]

[Total: 7]

2 **(a)** Define *pressure*.

....

....[1]

(b) Fig. 2.1 shows a liquid in a cylindrical container.

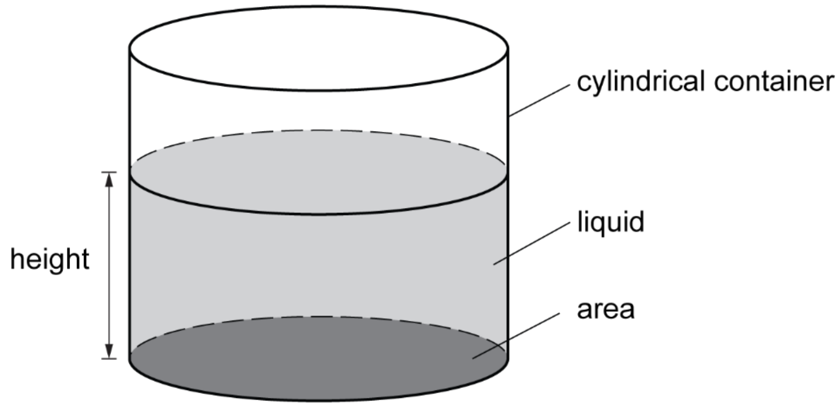


Fig. 2.1

Describe how to calculate the pressure due to the liquid, in pascals, acting on the base of the cylinder, using:

- the density of the liquid,
- the height of the liquid in the container, and
- the gravitational field strength.

....

....

....[2]

(c) Fig. 2.2 shows how the total pressure *P* of a point in the liquid varies with the height *h* above the base of the liquid.

The maximum height of the liquid is 1.7 m.

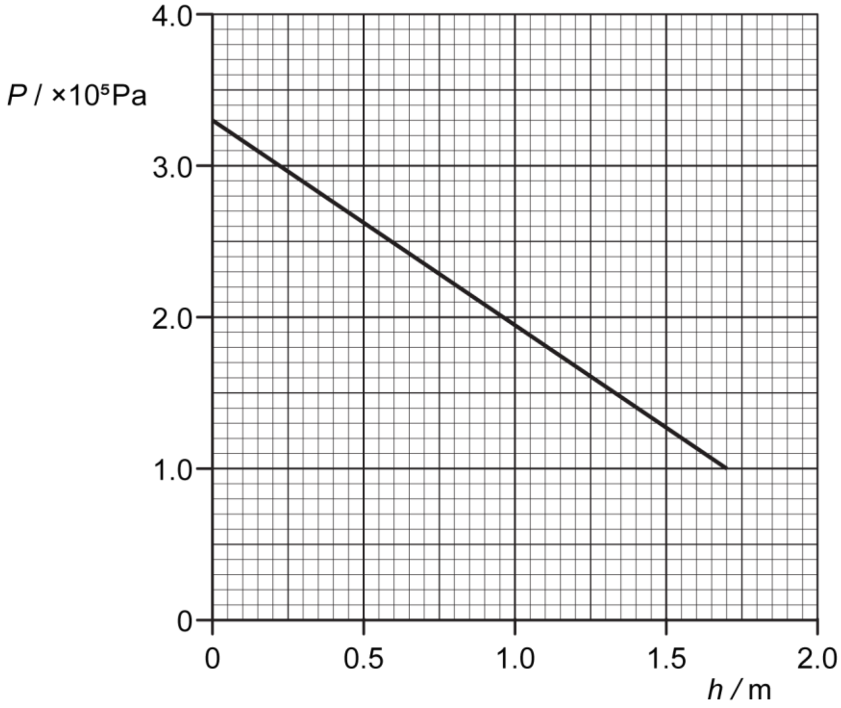


Fig. 2.2

(i) Explain why the total pressure *P* in Fig. 2.2. is not zero when the height of the liquid is 1.7 m.

....

....[1]

(ii) Use data from Fig. 2.2 to calculate the density of the liquid in the cylinder.

Gravitational field strength = 10 N/kg.

density of liquid: ....[2]

[Total: 6]

3 A girl slides down a snow-covered slope on a sled as shown in Fig. 3.1.

The girl and the sled have a combined mass of 55 kg. A constant resistive force *F* acts on the sled as it slides down the slope.

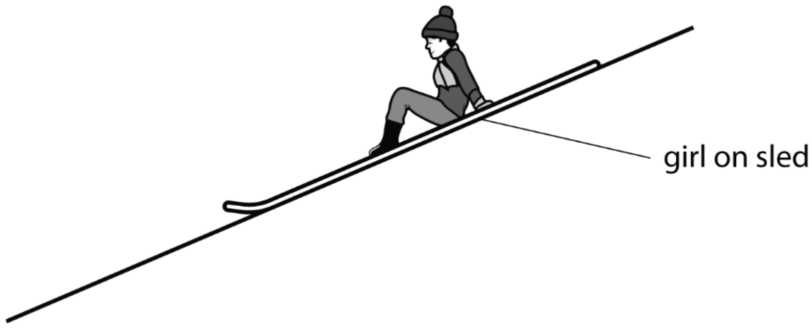


Fig. 3.1

(a) Write a **word equation** that relates the work done by the resistive force *F* to the transfers in energy in the gravitational potential and kinetic stores of the girl and the sled.

....

....

....[2]

(b) The sled starts from rest, and its velocity varies with time as shown in Fig. 3.2.

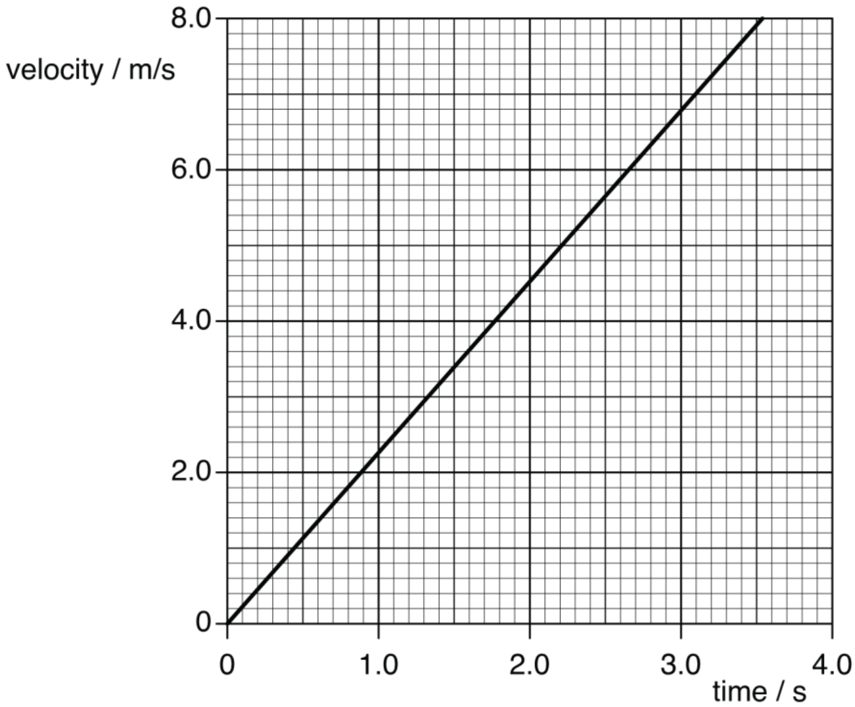


Fig. 3.2

Calculate for the girl and the sled, during the time interval between t = 0s and 2.5s,

(i) gain in energy in the kinetic store.

gain in energy: ....[2]

(ii) the loss in energy in the gravitational potential store. Given the change in height is 3.5 m.

(gravitational field strength = 10N/kg)

loss in energy: ....[2]

(c) Use your results in **(b)** to calculate the resistive force *F* acting on the sled.

resistive force *F*: ....[2]

[Total: 8]

4 A solar power plant uses a large curved mirror to reflect sunlight onto a black metal container filled with 2.0 kg of molten salt. The salt is heated from 300 °C to 500 °C by the reflected sunlight.

The specific heat capacity of the molten salt is 1500 J/(kg °C).

The area of the mirror is 1.5 m². The average solar energy incident on each square metre of the mirror is 600 J in one second.

(a) Calculate

(i) the energy needed to raise the temperature of the molten salt from 300 °C to 500 °C.

energy needed: ....[2]

(ii) the minimum time required to heat the molten salt. Assuming all the energy from the mirror is transferred to the salt.

time taken: .... s [2]

(b) Fig. 4.1 shows how the temperature of the molten salt changes over time.

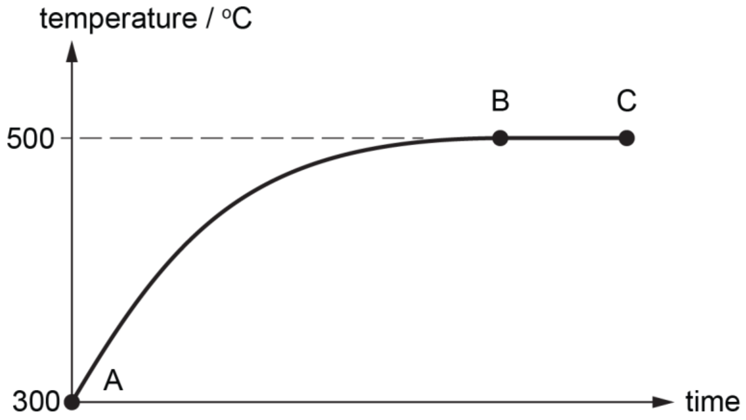


Fig. 4.1

Explain the shape of section AB and BC of Fig. 4.1.

AB: ....

....

BC: ....

....[2]

(c) Explain why the container containing the molten salt is made of metal and painted black.

....

....

....

....[2]

[Total: 8]

5 **(a)** Define the *focal length* of a converging lens.

....

....[1]

(b) Fig. 5.2 shows an object O placed upright and perpendicular to the principal axis of a converging lens. The lens is not shown in the diagram.

A real, inverted image of the **same size** as the object is formed.

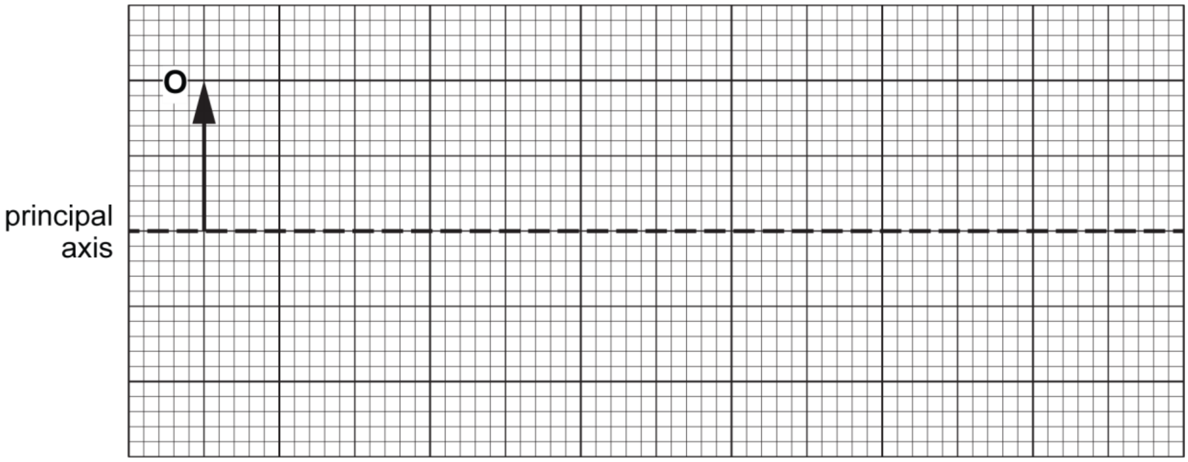


Fig. 5.2

On Fig. 5.2,

- draw and label the converging lens in a suitable position,
- mark one focal point of the lens with the letter F,
- draw **two** rays of light from the top of the object to the image. [3]

(c) Using your drawing on Fig. 5.2, determine the ratio

$$\frac{\text{distance between optical centre of lens and the image}}{\text{focal length of lens}}.$$

Express your answer to an appropriate number of significant figures.

ratio: ....[2]

[Total: 6]

6 In Fig. 6.1, sphere L is a large conducting sphere connected to the positive terminal of a high-voltage supply with a switch. A small, light conducting sphere S is hanging from an insulating thread.

Both spheres are initially uncharged.

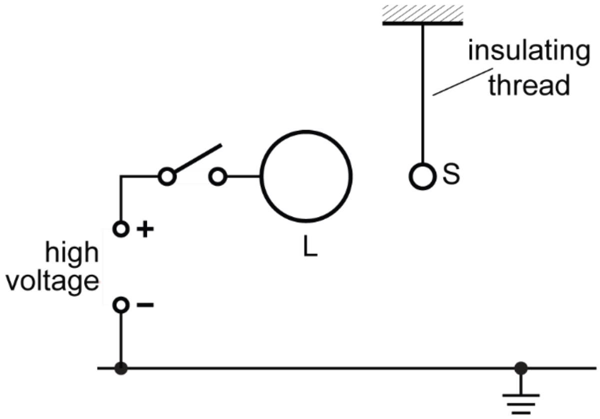


Fig. 6.1

(a) Describe the movement of electrons in sphere L when the switch is closed, resulting in sphere L becoming charged.

....

....

....[2]

(b) Explain the effects the charges on L have on the conducting sphere S.

....

....

....[2]

(c) Sphere S is then connected to earth. Explain the effect this has on

(i) the charge on S,

....

....[1]

(ii) the position of S relative to L.

....

....

....[2]

[Total: 7]

7 The *I*-*V* characteristic of a semiconductor diode is shown in Fig. 7.1.

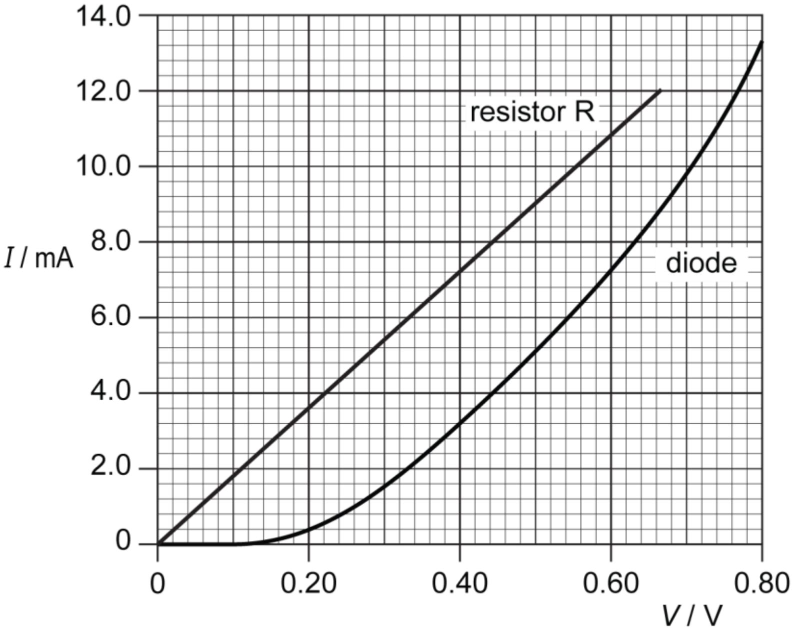


Fig. 7.1

(a) (i) Use Fig. 7.1 to describe how the resistance of the diode changes as *V* increases from zero to 0.80 V.

....

....

....[2]

(ii) Use Fig. 7.1 to determine the resistance of the diode when the potential difference across it is 0.40 V.

resistance: ....[2]

(b) The diode and the resistor R are connected in a circuit, as shown in Fig. 7.2.

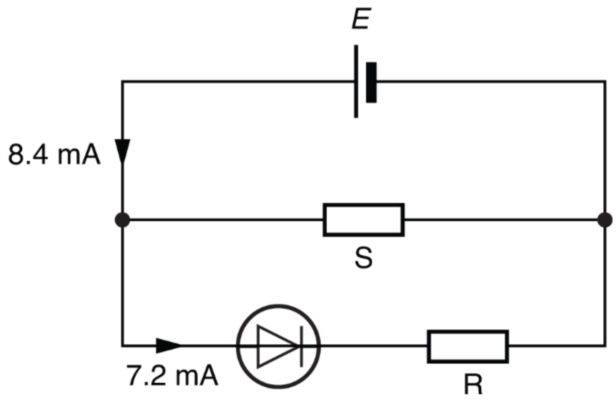


Fig. 7.2

Another resistor S is connected in the circuit with a cell of electromotive force (e.m.f.) *E*.

The current supplied by the cell is 8.4 mA and the current flowing in the diode is 7.2 mA.

(i) Using Fig. 7.1, determine the e.m.f. of the cell.

e.m.f.: ....[1]

(ii) Calculate the resistance of resistor S.

resistance: ....[2]

(iii) Calculate the power dissipated in the diode.

power dissipated: ....[2]

[Total: 9]

8 Carbon dating is a method used to estimate the age of ancient fossils or remains.

It works by measuring the amount of carbon-14, a radioactive isotope of carbon with a *half-life* of 5,700 years, found in all living things.

While an organism is alive, it constantly takes in carbon, so the amount of carbon-14 in its body remains constant.

After the organism dies, it stops taking in carbon, and the carbon-14 in its body undergoes *radioactive decay* to form carbon-12.

By measuring how much carbon-14 is left, scientists can estimate how long ago the organism died.

(a) For carbon-14, explain what is meant by:

(i) radioactive decay,

....

....

....[2]

(ii) half-life of 5,700 years.

....

....

....[2]

(b) A sample of wood from an archaeological site contains only 25% of the carbon-14 it would have had when the tree was alive.

(i) Determine how many half-lives have passed since the tree, which the wood is from, died.

number of half-lives: ....[1]

(ii) Estimate the age of the wood.

age: ....[1]

(c) Suggest one limitation of using carbon dating to determine the age of very old fossils.

....

....[1]

[Total: 7]

9 Electric Vehicles (EVs) are becoming more popular, with Singapore aiming to phase out Internal Combustion Engine (ICE) cars by 2040.

The battery of an EV consists of many smaller units called *cells*. Each cell has its own voltage and current limits. These cells work together in series or parallel arrangements to meet the energy and voltage requirements of the EV battery.

To extend its driving range, an EV can use *regenerative braking*. This works by converting the vehicle's kinetic energy back into electrical energy.

Table 9.1 provides data for a typical EV:

Table 9.1

Parameter of a typical EV	Value
Mass	1900 kg
Battery capacity when fully charged	75 kWh
Maximum terminal voltage of cell in EV battery	3.0 V
Maximum charging current	2.5 A
Range per full charge	450 km

(a) The cost of electrical energy in Singapore is S$0.23 per kWh.

(i) Calculate the cost to travel 1.0 km using the typical EV.

cost: ....[2]

(ii) Given that the cost of refueling an ICE car for 800 km is $80, find the ratio of the cost to travel 1.0 km in an EV to the cost to travel 1.0 km in an ICE car.

ratio: ....[1]

(b) Using the data in Table. 9.1, determine the minimum number of cells required in the EV battery. Given charging time = 1 hour.

number of cells: ....[2]

(c) The battery of an EV is located under the floor of the vehicle as shown in Fig. 9.1.

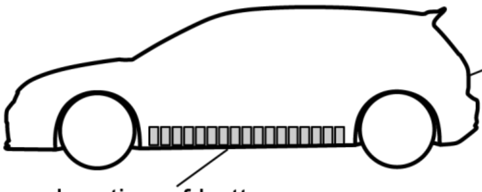


Fig. 9.1

Explain why the battery is located at this position.

....

....[1]

(d) An EV travelling at 90 km/h comes to rest using regenerative braking.

(i) Calculate the change in the EV's kinetic energy in kWh.

Given 1 kWh = 3.6×10^6 J.

change in kinetic energy: ....[3]

(ii) the maximum distance it could travel using the regenerated energy.

distance: ....[1]

(f) Suggest one advantage and one disadvantage of replacing ICE cars with EVs.

Advantage ....

....

Disadvantage ....

....[2]

[Total: 12]

Section B

Answer **one** question from this section.

10 Fig. 10.1 shows a worker of weight 640 N standing on a uniform plank.

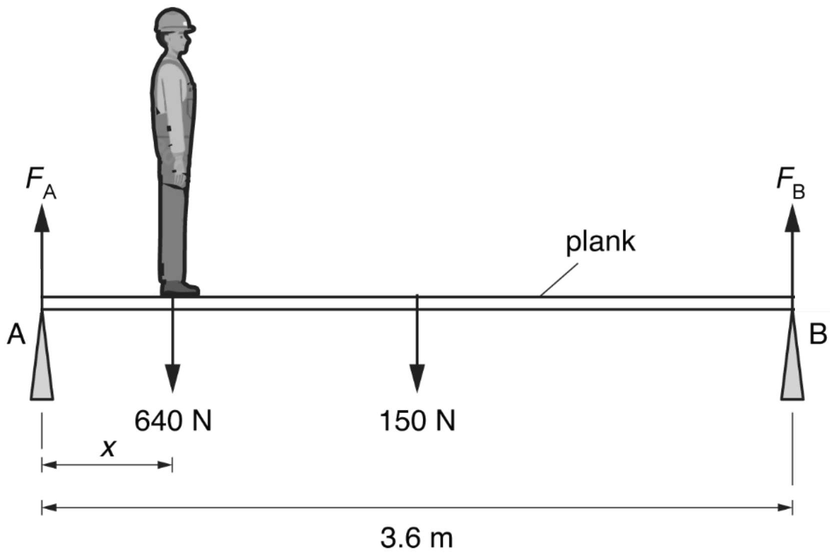


Fig. 10.1

The plank weighs 150 N, 3.6 m in length and is supported by two pivots A and B.

The support exerts a vertical force F_A at pivot A, and the pivot at B exerts a vertical force F_B .

As the worker moves along the plank, the plank remains in equilibrium.

(a) (i) State the conditions required for the plank to remain in equilibrium.

....

....

....[2]

(ii) Explain why the sum of the forces F_A and F_B is always 790 N, no matter where the worker stands on the plank.

....

....[1]

(b) The man stands at a distance x = 0.50 m from end A.

(i) By taking moments about pivot A, calculate the magnitude of F_B .

force F_B : ....[3]

(ii) Determine the magnitude of F_A .

force F_A : ....[2]

(c) As the worker walks along the plank, the variation with distance x of force F_A is shown in Fig. 10.2.

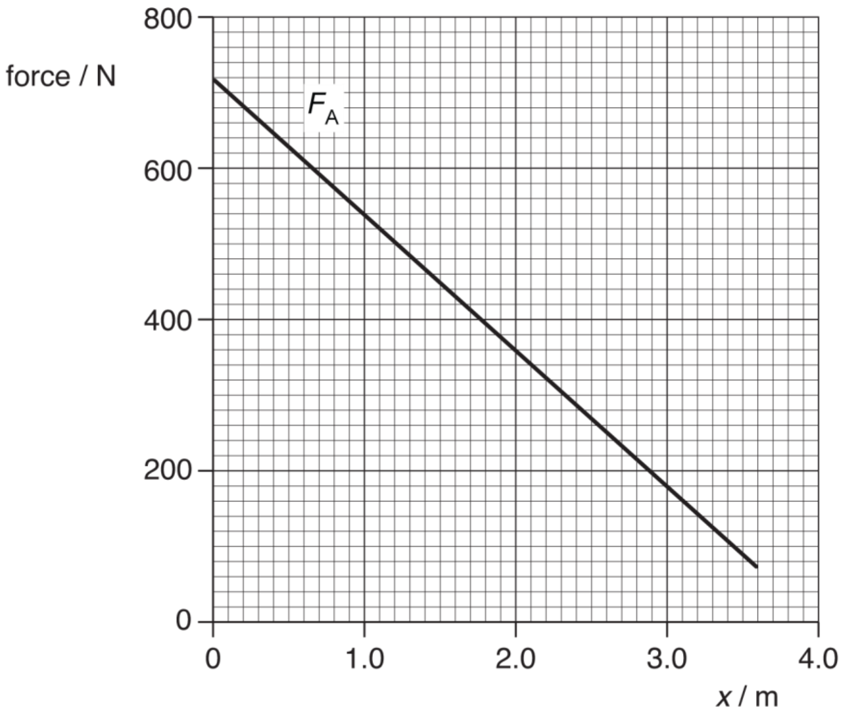


Fig. 10.2

On the axes of Fig. 10.2, sketch a graph to show the variation with x of force F_B . [2]

[Total: 10]

11 A long bar magnet is hung from a spring with one of its poles positioned within a short cylindrical coil, as shown in Fig. 11.1.

The system is set up so that the magnet can oscillate vertically within the coil.

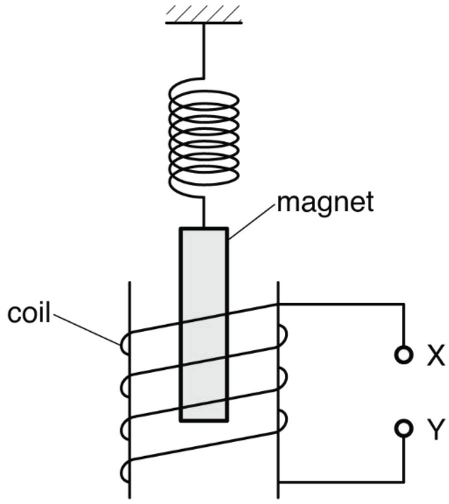


Fig. 11.1

When the magnet is displaced vertically and released, it oscillates within the coil, inducing an electromotive force (e.m.f.) across terminals Xand Y.

(a) **(i)** Explain why an alternate e.m.f. is induced across terminals X and Y.

....

....

....

....

....[2]

(ii) Sketch on Fig. 11.2 how the induced e.m.f. across X and Y varies with time.

On the graph,

Mark a point corresponding to when the magnet is at its equilibrium position (label this point P).

Mark a point corresponding to when the magnet reaches its maximum displacement from the equilibrium position (label this point Q).

[4]

Fig. 11.2

(b) Describe two ways to increase the amplitude of the induced e.m.f. without changing its frequency.

1. ....

....

2. ....

....[2]

(c) A resistor is connected across terminals X and Y.

Describe and explain what happens to the oscillation of the magnet.

....

....

....

....[2]

[Total: 10]

End of Paper

MARK SCHEME
2025 END-OF-YEAR
SECONDARY FOUR EXPRESS
PHYSICS 6091

Paper 1 (A1 × 40**)**

Paper 2

Deduct 1 mark for any mistake in significant figures; however, only 1 mark may be deducted per section in total.

Deduct 1 mark for each wrong or missing unit. If the same unit mistake carries through a question, do not deduct again for it.

Qn	Mark Scheme	Marks	Marks
1	**(a)** straight line with a constant/uniform slope/gradient.	B1	1
	(b) (i) area under the velocity-time graph when the graph is below x-axis. **OR** $\frac{1}{2}\times(0.80-0.30)\times 5.0$ 1.3 m	B1 A1	2
	(b) (ii) area under the velocity-time graph when the graph is above the x-axis **OR**	B1	2

Qn	Mark Scheme	Marks	Marks
	$\frac{1}{2} \times 0.30 \times 3.0$ 0.45 m	A1	
	(c) curve starts from zero and ends at t = 0.30 s	M1	2
	positive gradient decreases to zero at around t = 0.30 s	B1	
		Total	**7**
2	**(a)** pressure is the amount of force exerted per unit area.	B1	1
	(b) Pressure = density × gravitational field strength × height **OR** $P = \rho \times g \times h$	M1	2
	Density in kg/m^3 **AND** gravitational field strength in N/kg AND height in m.	B1	
	(c) **(i)** **atmospheric pressure** acts on the **surface** of the liquid	B1	1
	(ii) pressure due to liquid at base of the cylinder = (3.3 – 1.0) × 10^5	B1	2
	$2.3 \times 10^5 = \rho \times 10 \times 1.7, \rho = 1.4 \times 10^4 \text{ kg/m}^3$	A1	
		Total	**6**
3	**(a)** product of the resistive force F and the distance moved by the sledge is	M1	2
	equal to the gain in kinetic energy and the loss of the gravitational potential energy of the girl and the sled.	B1	
	(b) **(i)** $E_K = \frac{1}{2} \times m \times v^2$ **OR** $\frac{1}{2} \times 55 \times 5.6^2$	B1	2

Qn	Mark Scheme	Marks	Marks
	ecf **(b)(i)** on error in reading *v* from *v-t* graph 860 J	 A1	
	(ii) $E_P = m \times g \times h$ **AND** $55 \times 10 \times 3.5$ 1900 J	B1 A1	2
	(c) WD = 1900 – 860 = 1000 J (ecf **(b)(i)(ii)**) $F \times 7 = 1000$, F = 140 N	B1 A1	2
		Total	**8**
4	**(a)** **(i)** change in temperature = 500 – 200 = 300 ºC $Q = m \times c \times \Delta\theta$ **OR** $2.0 \times 1500 \times 300$ 600,000 J	C1 B1 A1	3
	(ii) total energy incident on mirror in 1 second $600 \times 1.5 = 900$ J time taken = 600000/900 = 670 s	C1 A1	2
	(b) AB: As temperature of the molten salt increases, more energy is needed to increase its temperature. **OR** The higher the temperature of the molten salt, the faster its losses energy to the surrounding. BC: The salt is **changing its state** **OR** the molten salt **reach thermal equilibrium** with the surrounding.	B1 B1	2

Qn	Mark Scheme	Marks	Marks
	(c) Metal allows thermal energy from the sunlight to be transferred quickly and efficiently to the molten salt inside the container. Black surfaces are good **absorbers** of radiation allowing the container to absorb more solar energy.	B1 B1	2
		Total	**9**
5	**(a)** The distance between the **optical centre** of the lens and its **principal focus**.	B1	1
	(b) Correctly drawn vertical lens in the diagram, with optical axis through its centre. Focal point (F) correctly marked on either side of the lens at the correct distance. Two correct rays drawn: One ray parallel to the principal axis, refracted through the focal point on the far side. **AND** One ray through the optical centre, continuing undeviated.	B1 B1 B1	3
	(c) 2.0 (accept 1.8 to 2.2) Answer in 2 sig. fig.	M1 B1	2
		Total	**6**
6	**(a)** When the switch is closed, the high-voltage supply attracts electrons from sphere L and transfer them to the ground Sphere L becomes positively charged as it has excess positive charges.	B1 B1	2
	(b) The positive charge on L induces a charge separation in S.	B1	2

Qn	Mark Scheme	Marks	Marks
	The (left) side of S facing L becomes negatively charged due to the attraction of electrons, while the opposite (or right) side of S becomes positively charged.	B1	
	(c) (i) Electrons flow from the Earth into S to neutralise the positive charge induced on the far (or right) side of S, which leaves sphere S negatively charged.	B1	1
	(c) (ii) The negatively charged sphere S is attracted to the positively charged sphere L. Sphere S moves closer to L.	B1 B1	2
		Total	**7**
7	**(a) (i)** For V < 0.16 V, resistance is extremely large For V > 0.16 V, resistance decreases rapidly	B1 B1	2
	(ii) When V = 0.40 V, I = 3.2 mA, $R = \frac{V}{I}$ **OR** $R = \frac{0.40}{3.2 \times 10^{-3}}$ 130 Ω	B1 B1 A1	3
	(b) (i) $0.40 + 0.60 = 1.00$ V	A1	1
	(b) (ii) $R = \frac{V}{I}$ **OR** $\frac{1.00}{(8.4 - 7.2) \times 10^{-3}}$ 830 Ω (ecf (b)(i))	B1 A1	2
	(b) (iv) $P = VI$ **OR**	B1	2

Qn	Mark Scheme	Marks	Marks
	$0.60 \times 7.2 \times 10^{-3}$ $43\ \text{mW}$ (ecf **(b)(i)**) accept 0.043W	 A1	
		Total	**10**
8	**(a)** **(i)** The **unstable carbon- 14 nucleus** emits radiations change into a the more **stable carbon-12 nucleus**. [-1 mark for not referring to carbon-14 and carbon 12]	B1 B1	2
	(a) **(ii)** The time taken for half of the original carbon-14 nuclei in a sample to decay **OR** the time taken for the count rate (or activity) to fall to half its original value 5700 years. [-1 mark for not referring to 5700 years]	B1 B1	2
	(b) **(i)** 100% →50% → 25% = 2 half-lives	B1	1
	(c) **(ii)** 2 × 5700 = 12 000 years (accept 114 000 years)	B1	1
	(c) Any one valid point such as: For very old fossils, the amount of carbon-14 remaining may be too small to be detected Contamination of the sample can affect the accuracy of results Background radiation not accounted for.	B1	1
		Total	**7**
9	**(a)** **(i)** energy consumed per km travelled with EV $= \frac{75}{450} = 0.17\ \text{kWh/km}$ Cost = $0.167 \times 0.23 = \$0.038$	B1 A1	2
	(a) **(ii)** cost per km travelled with ICE $\frac{80}{800} = \$0.10$ (ecf **(a)(i)**) ratio = 0.38	 A1	1
	(b) energy stored in one cell = $V \times I \times t = 3.0 \times 2.5 \times 1.0 = 7.5\ \text{Wh}$	B1	2

Qn	Mark Scheme	Marks	Marks
	number of cells = $\frac{75000}{7.5} = 10000$	A1	
	(c) Placing the battery under the floor lowers the vehicle's centre of gravity, improving stability and handling during motion.	A1	1
	(d) **(i)** $90 \text{ km/h} = \frac{90 \times 1000}{3600} = 25 \text{ m/s}$ $E_K = \frac{1}{2} \times m \times v^2 = \frac{1}{2} \times 1900 \times 25^2 = 590000 \text{ J}$ $\frac{593750}{3.6 \times 10^6} = 0.16 \text{ kWh}$	B1 B1 A1	3
	(d) **(ii)** distance $= \frac{0.165}{0.167} = 0.99 \text{ km}$ ecf **(a)(i)** and **(d)(i)**	A1	1
	(e) EVs produce zero emissions during operation, reducing air pollution and contributing to a cleaner environment. The availability of public charging stations is still limited, making long-distance travel challenging for EV users.	B1 B1	2
		Total	**12**
10	**(a)** **(i)** The sum of all vertical forces acting on the plank is zero The sum of moments about any point on the plank is zero	B1 B1	2
	(a) **(ii)** The sum of the forces is 790 N because the total upward forces must balance the total downward forces for equilibrium.	B1	1
	(b) **(i)** Taking turning moment about A, clockwise moment = anti-clockwise moment when the plank is in equilibrium $F_B \times 3.6 = (150 \times 1.8) + (640 \times 0.50)$ 160 N	B1 B1 A1	3
	(b) **(ii)** $F_A + 164 = 790$	B1	2

Qn	Mark Scheme	Marks	Marks
	630 N	A1	
	(b) straight line graph starts at *x* = 0 and ends at *x* = 3.6 m y values start at about 70 N and ends at about 720 N	B1 B1	2
		Total	**10**
11	**(a)** **(i)** As the magnet move downwards into the coil, there is an **increase** in the **number of magnetic field line going through the coil with time**, an emf is induced. As the magnet move upwards out of the coil, there is a **decrease** in the **number of magnetic field line going through the coil with time**, an emf is induced. Accept the use of magnetic flux linkage instead of number of magnetic field lines going through the coil Award 1 mark for mentioning changing in magnetic field lines going through the coil with time without the explanation of alternating.	B1 B1	2
	(ii) A sinusoidal (sine/cosine) graph of induced emf against time. Uniform amplitude and period (at least two) any one of peaks of the graph drawn **AND** labelled P. any one of x-intercepts of the graph drawn **AND** labelled Q	M1 B1 B1 B1	4
	(b) Increase the strength of the magnet Increase the number of turns of the coil Any one of the above Any two of the above	 B1 B1	2
	(c) When a resistor is connected, induced current flow to produce a magnetic field that opposes the motion of the magnet.	M1	2

Qn	Mark Scheme	Marks	Marks
	Energy is lost to heat in the resistor, and the oscillations of the magnet gradually decrease in amplitude.	B1	
		Total	**10**

Marking Scheme for 2025 Prelim Exam Pure Physics Paper 3

1ai L_0 = 2.1 cm [1]

Acceptable range : 1.8 - 2.3 cm

Precision of metre rule : 0.1 cm (-1)

1aii L_1 = 7.1 cm [1]

Acceptable range : 6.0 - 8.0 cm

1aiii e_1 = 7.1 -2.1

= 5.0 cm e.c.f [1]

1aiv k = F/e_1

= 1.5 / 5.0

= 0.30 N/cm (2 sf) [1]

Unit: -1

sf : -1

1bi Use a ruler to measure the stretched length of the spring from end to end. [1]

Ensure the ruler is held parallel to the spring and the reading is taken at eye level to minimise parallax error. [1]

Answer " to measure three times ad find average" - awarded 1 mark

1bii L_2 = 9.0 cm [1]

- (range : 8.0 - 10.0 cm)

- ($L_2 > L_1$)

1biii L_3 = 11.0 cm [1]

- $L_3 > L_2$

- difference between L_3 and L_2 < 5.0 cm

1c The difference in L_2 and L_3 is due to the varying amount of clamp circumference in contact with the string. As the contact increases from one-quarter (L_2) to three-quarters (L_3), friction increases [1]

and more horizontal force is redirected into vertical force stretching the spring. This causes the spring to extend more, resulting in $L_3 > L_2$. [1]

2a u = 10.0 cm

h_o= 0.5 cm [1]

- Accepts range 0.4 to 0.6 cm
- Precision of ruler is 0.1 cm

2b h_1 = 0.8 cm [1]

- Accepts range 0.6 to 1.0 cm

2c m $= \frac{2h_1}{h_0}$

= 2(0.8) / 0.5

= 3.2 [1]

- At least 2 SF.

2d f $= \frac{mu}{m-1}$

= (3.2)(10.0) / (3.2 – 1)

= 15 cm (at least 2 sf) [1]

- Units not shown for focal length.
- Follow least SF rule, answer should be 2 SF.

2e The experiment should be conducted using the same lens with the same focal length for all trials.

The object used should be a piece of card with a millimetre scale printed on it, and the observer should always view the image from the same position above the lens.

(At least 2 constant variables with constant physical quantities)[1]

The object distance *u* can be varied by placing the card at different distances from the centre of the lens, such as 80 mm, 90 mm, 100 mm, 110 mm, and 120 mm. Each distance should be measured accurately using a ruler. [1]

(u cannot be greater than 15 cm, as no virtual image will be formed when u>focal length)

To determine the magnification *m*, the apparent image height h_1 of the scale divisions on the card is measured. This is done by comparing the enlarged image to a ruler held above the lens. The magnification is then calculated using the equation $m = \frac{2h_1}{h_0}$, where h_0 is the actual height of the scale division. [1]

 The procedure should be repeated for at least five different values of *u* to gather sufficient data to test the relationship between *u* and *m*. [1]

- A graph of *u* (on the y-axis) against $\frac{1}{m}$ (on the x-axis) should be plotted in order to test if there is a linear relationship. [1]

  (In a **curved u vs m graph**, the slope changes at every point because graph is not linear — steep when m is small, flat when m is large — so there's no single constant to describe the whole relationship.

- In a **linear u vs 1/m graph**, the slope is the same everywhere, so one constant value fully describes the relationship, making it easier to verify proportionality and extract physical constants.)

  1 mark is awarded for students who make an effort to sketch inverse curve. But no marks is awarded for conclusion below.

- If the student's claim is correct, the graph should be a straight line passing through the origin. [1]

3ai V_0 = 2.10 V [1]

[Answer recorded to 2 d.p with unit V **AND** between 2.00 V to 3.00 V]

3aii I = 0.12 A [1]

[Answer recorded to 2 d.p with unit A AND between 0.10 A to 0.20 A]

3aiii R = $\frac{V_0}{I}$

= 2.10 / 0.12

= 18 Ω [1]

[Correct calculation using values from 3(a)(i) and (ii) with unit W AND correct sig. fig. based on the sig. fig. of V and I recorded in 3(a)(i) and (ii)]

3aiv P = 100.0 cm

[Answer recorded to 1 d.p with cm AND between 95 cm to 100 cm]

3av K = $\frac{V_0}{I\,P}$

= 2.10 / (0.12 x 100.0)

= 0.18 Ω/cm (or V/A cm) [1]

[Correct calculation using values from 3(a)(iii) and (vi) with unit W/cm AND correct sig. fig. based on the sig. fig. of V, I and P recorded in 3(a)(i), (ii) and (iv)]

3bi I = 0.10 A

V = 1.4 V [1]

[V and I recorded to the same d.p. and units as those in 3(a)(i) and (ii) AND V is between 1.00 V to 2.00 V AND I is between 0.10 A to 0.20 A]

3bii R = V / I

= 1.4 / 0.10

= 14 Ω [1]

[Correct calculation using values from 3(b)(i) with unit W AND correct sig. fig. based on the sig. fig. of V and I recorded in 3(b)(ii)]

3c Tabulation

p / cm	V / V	I / A	R / Ω
90.0	1.40	0.10	14
80.0	1.30	0.10	13
70.0	1.10	0.10	11
60.0	0.90	0.10	9.0
50.0	0.80	0.10	8.0
40.0	0.60	0.10	6.0

Column Headings [1]
Each column heading must contain a quantity and a unit.
The presentation of quantity and unit must conform to accepted scientific convention of quantity/unit, e.g. p / cm. V / V, I / A and R / W. Do not allow “current / A”

Range [1]
Range of p should be larger than 50.0 cm

Accuracy [1]
Values of V increases with increasing p
Values of I remain constant

Precision (Significant Figures and Decimal Places) [1]
The d.p. of p is 1, the d.p. of V and I is 2; or they are of the same d.p. as those readings recorded in 3(a) and (b)
The values of R calculated should have the same sig. fig. as the V and I which used to derive them.

3di Graph Drawing
Axes [1]
Axes labelled with the quantity/unit that is being plotted.

The starting values of the x and y axes must be clearly marked on the graph.

Sensible scales must be used, no awkward scales (e.g. 3:10) so that all points can be plotted on half a small square.
Scales must be chosen so that the plotted points occupy at least half the graph grid in both x and y directions.

Plotting of point [1]
All observations in the table must be plotted.
All points must be plotted with crosses with size not larger than a small square.

Line of best fit [1]
Judge by balance of all points on the grid about the line drawn (at least 5 points)
There must be an even distribution of points either side of the line along the full length
Allow one anomalous point only if clearly indicated (i.e. circled or labelled)

3dii G = (12.70 – 7.00) / (80.0 – 46.0)

= 5.70 / 34.0

= 0.167 Ω/cm

Gradient drawn on graph [1]
The hypotenuse of the triangle must be at least half the length of the drawn line.
Co-ordinates used for gradient clearly indicated on graph and show it in the calculation.
Both read-offs must be accurate to half a small square in both the x and y directions.
Calculation of Gradient [1]
Correct calculation with values from the graphs AND expressed in Ω/cm.

3diii $R_x = 20 - \frac{RG}{K}$

= 20 – (17.5)(0.17) / 0.18

= 20 – 17

= 3 Ω

Correct substitution of R, G and K [1]
The values of R, G and K correspond to those found earlier.
R expressed in correct sig. fig and unit [1]
Correctly calculated with no d.p. and Ω as unit OR
Correctly calculated with sig. fig . determined by the least sig. fig. of R, G and K.

3iv

1. Instrument Improvements

Check for zero error in ammeter and voltmeter before starting; adjust or record correction.

2. Procedural Improvements

Avoid heating of potentiometer wire by using low currents and switching on the supply only when taking readings.

Ensure tight, clean connections to minimise contact resistance.

For potentiometer measurements, ensure the jockey makes firm, quick contact to avoid sparking or damaging the wire.

Not Accept

Kinks in wires are not accepted as the wire is mounted securely on the potential metre.

Repetition of experiment is not accepted as there is no subjective judgement like finding the sharperst image required.

Avoid using words like “ensure,” as they do not specify the exact actions or changes needed to improve the experiment. Instead, answer suggestions for improvement using clear, direct action statements.