NAME:	CLASS:	INDEX NO:

QUEENSWAY SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2023

SECONDARY 4 EXPRESS

Parent's Signature:

PHYSICS **6091/01**

Paper 1 Multiple Choice

13 September 2023

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and index number on the Answer Sheet in the spaces provided.

There are **forty** questions on this paper. Answer **all** questions. For each question, there are four possible answers, **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

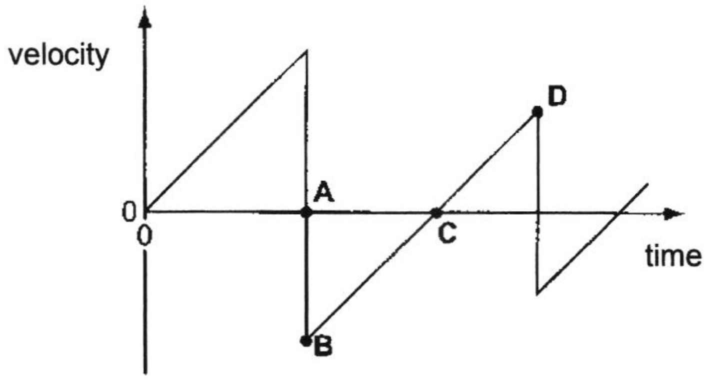
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

1 Which row states the correct SI unit for temperature and amount of substance?

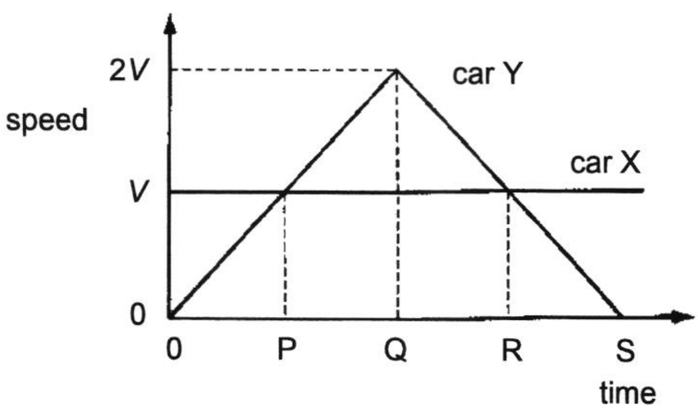
	temperature	amount of substance
A	°C	kg
B	°C	mol
C	K	kg
D	K	mol

2 A ball is released from rest above a horizontal surface. The graph shows how the velocity of the bouncing ball varies with time.

At which point on the graph does the ball reach its maximum height after the first bounce?



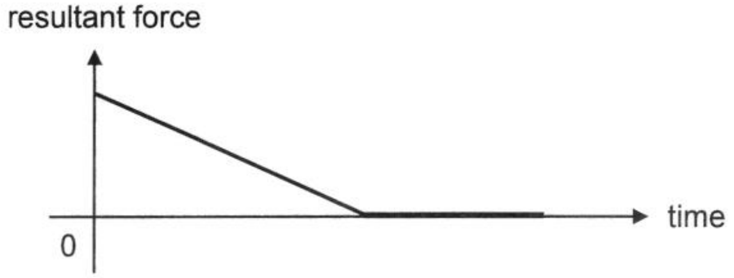
3 Car X travels at a constant speed V along a straight road. At time = 0 s, it passes car Y which immediately accelerates uniformly from rest to speed $2V$. Car Y then decelerates uniformly to rest in the same amount of time that it takes to accelerate from rest.



Which statement is correct?

A At time Q, car Y has travelled twice as far as car X.
B At time R, both cars have the same acceleration.
C Both cars have the same average speed from time = 0 s to S.
D The average speed of car Y is greater than car X from time = 0 s to S.

4 The diagram shows how the resultant force acting on a rocket varies with time.



Which of the following describes how the velocity of the rocket changes with time?

A It decreases and then becomes zero.
B It decreases and then remains constant (non-zero).
C It increases and then becomes zero.
D It increases and then remains constant (non-zero).

5 An elevator of mass 250 kg is moving downwards with a constant deceleration of 2.0 m/s^2. The gravitational field strength is 10 N/kg.

What is the tension in the cable of the elevator?

A 750 N **B** 2000 N **C** 2500 N **D** 3000 N

6 An alloy consists of 25% metal P and 75% metal Q by volume. The densities of P and Q are ρ and 0.5ρ, respectively.

What is the density of the alloy?

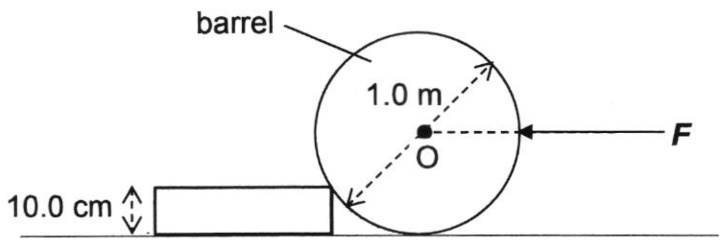
A 0.25ρ **B** 0.50ρ **C** 0.63ρ **D** 0.75ρ

7 An object of mass 20 kg weighs 400 N on Planet P. The gravitational field strength on Planet P is five times that on Planet Q.

What is the mass and weight of the object on Planet Q?

	mass of object on Planet Q / kg	weight of object on Planet Q / N
A	4	20
B	4	80
C	20	20
D	20	80

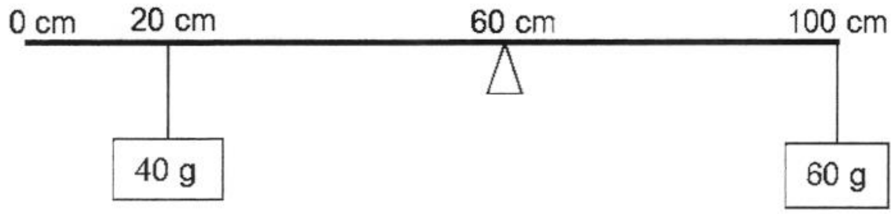
8 A barrel of weight 100 N and diameter 1.0 m is rested against a step of height 10.0 cm as shown in the diagram. O is the centre of the barrel.



What is the smallest horizontal force ***F*** needed to push the barrel over the step?

A 25 N **B** 40 N **C** 75 N **D** 100 N

9 The diagram shows a **non-uniform** 100 cm rod of mass 40 g pivoted at the 60 cm mark, and kept in equilibrium by two suspended masses of 40 g and 60 g respectively.



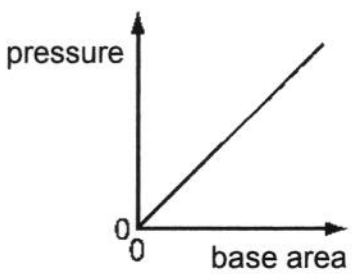
Where is the centre of gravity of the rod?

A at the 20 cm mark
B at the 40 cm mark
C at the 60 cm mark
D at the 80 cm mark

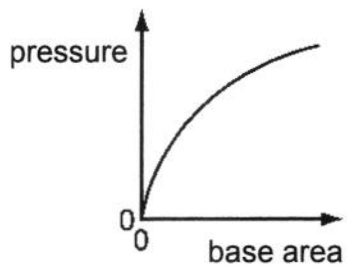
10 A piece of plasticine resting on a table exerts a pressure on the table. The plasticine can be remoulded into different shapes, each with a different base area resting on the table.

Which graph shows the relationship between pressure exerted by the plasticine on the table and its base area?

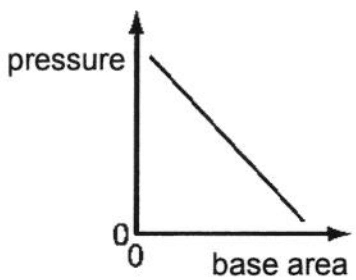
A



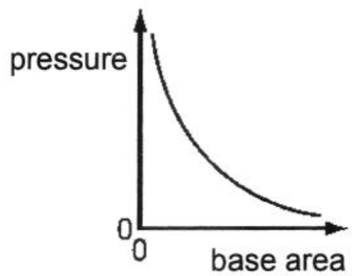
B



C



D

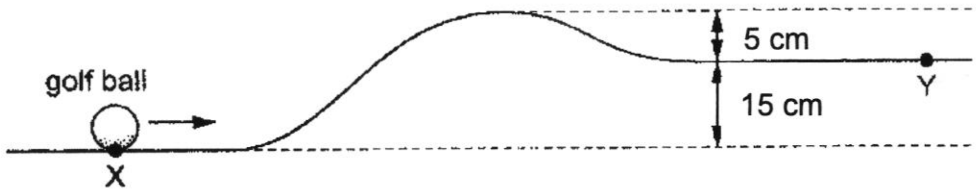


11 Two mercury barometers X and Y are placed beside each other in a room. The height of the mercury column in X is slightly lower than that in Y.

What is a possible reason for the difference in height of the mercury columns?

A The atmospheric pressure is different.
B There is air in the space above liquid X.
C The diameter of the tube of X is larger than that of Y.
D Barometer X is slightly tilted while barometer Y is upright.

12 A golf ball travels horizontally in the direction shown.

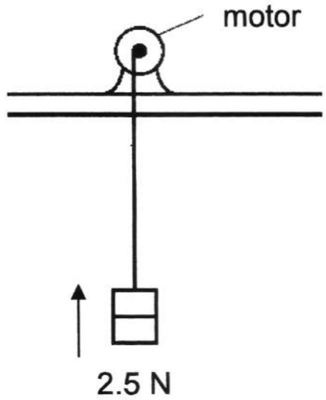


Assume that no kinetic energy is transferred to thermal energy or sound, and the gravitational field strength is 10 N/kg.

What is the minimum speed the golf ball must have at point X to enable it to reach point Y?

A 1.0 m/s **B** 1.4 m/s **C** 1.7 m/s **D** 2.0 m/s

13 An electric motor is used to raise a weight of 2.5 N through a vertical height of 40 cm in a time of 2.0 s.



The motor has an efficiency of 40%.

What is the electrical power supplied to the motor?

A 0.20 W **B** 1.3 W **C** 80 W **D** 500 W

14 A substance consists of particles that are close together and moving past each other at random. The average speed of the particles is gradually decreasing.

Which statement best describes the substance?

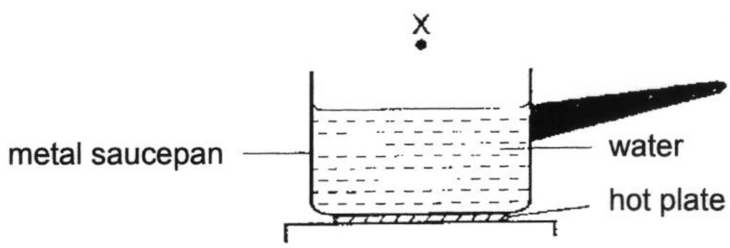
A a solid melting
B a solid being cooled
C a liquid freezing
D a liquid being cooled

15 Air is pumped slowly into a car tyre to increase the pressure in the car tyre. The temperature of the air in the car tyre does not change.

Which row is correct?

	average speed	frequency of collisions with walls
A	increases	decreases
B	increases	increases
C	unchanged	decreases
D	unchanged	increases

16 The diagram shows a metal saucepan containing water and placed on a hot plate. After some time, the air at point X becomes hot.



What are the main ways by which thermal energy travels through the different mediums?

	through the base of the saucepan	through the water	through the air
A	conduction	convection	convection
B	conduction	radiation	convection
C	radiation	convection	conduction
D	radiation	convection	convection

17 Two metal blocks are placed beside each other. Block X has a temperature of 500 °C while block Y is at room temperature.

Which method can increase the rate of heat transfer between the blocks through radiation?

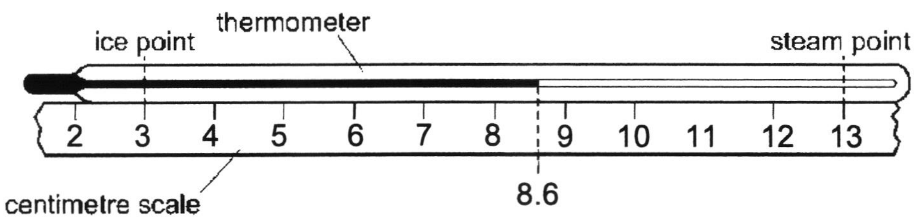
A connect the blocks using a copper rod
B paint block X black
C paint block Y white
D remove all the air between the blocks

18 A mercury-in-glass thermometer and a resistance thermometer are both calibrated using the same fixed points of 0 °C and 100 °C.

When the thermometers are used to measure the temperature of a body, the temperatures measured on both thermometers will be exactly the same

A for all temperatures between 0 °C and 100 °C only.
B for any temperature.
C only at room temperature.
D only at the fixed points.

19 A centimetre scale is fixed next to an unmarked mercury-in-glass thermometer. The ice point and the steam point are marked.

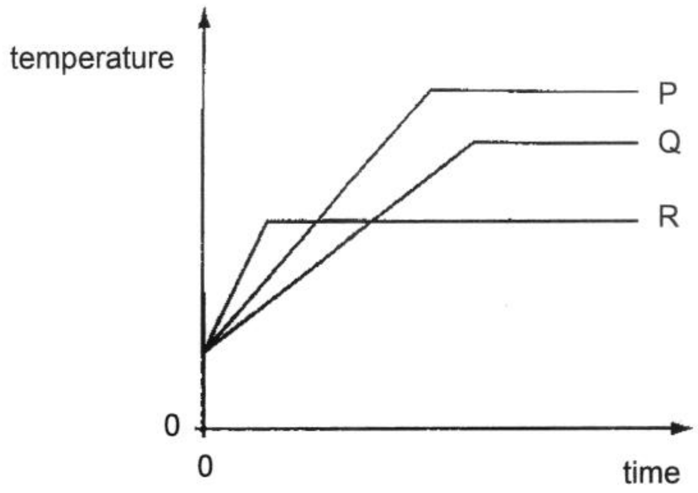


What is the temperature shown on the thermometer?

A 44 °C **B** 56 °C **C** 66 °C **D** 86 °C

20 Equal masses of three liquids P, Q and R are heated from room temperature. Each liquid is supplied with heat at the same rate.

The graph shows how the temperature of each liquid varies with time after heating starts.



What can be deduced from the graph?

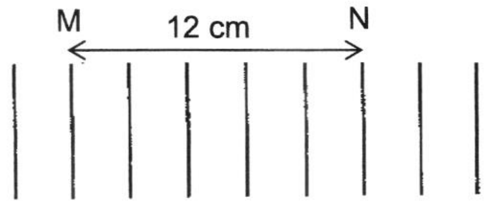
A P has the highest melting point.
B Q has the largest specific heat capacity.
C R gains the least internal energy.
D R has the smallest specific latent heat of vaporisation.

21 Which of the following could increase the rate of evaporation of a liquid?

1 decreasing the humidity surrounding the liquid
2 decreasing the surface area of the liquid
3 increasing the mass of the liquid
4 increasing the temperature of the liquid

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

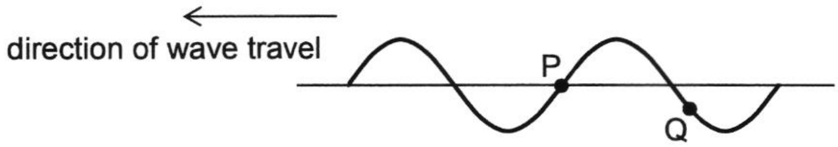
22 The wavefronts of a wave are shown below.



If the wavefront at position M takes 2.0 s to travel to position N, what are the wavelength and frequency of the wave?

	wavelength / cm	frequency / Hz
A	2.4	2.5
B	2.4	3.0
C	4.8	3.0
D	4.8	2.5

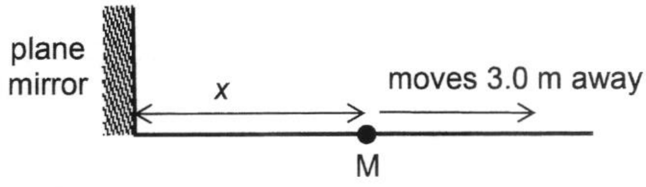
23 The diagram shows a transverse wave on a rope at a particular instant. The wave is travelling from right to left.



Which of the following describes the direction of motion of the points P and Q at this instant?

	point P	point Q
A	downward	downward
B	downward	upward
C	upward	downward
D	upward	upward

24 The diagram shows a man standing at position M in front of a plane mirror.

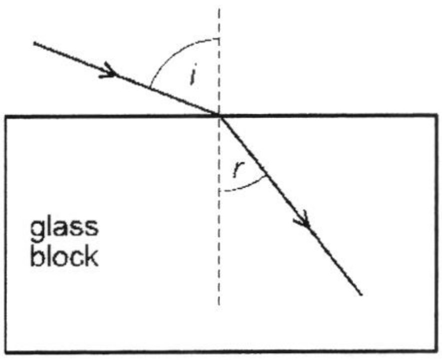


If the man moves 3.0 m away from the mirror, the new distance between the man and his image is 12.0 m.

What is the value of *x*?

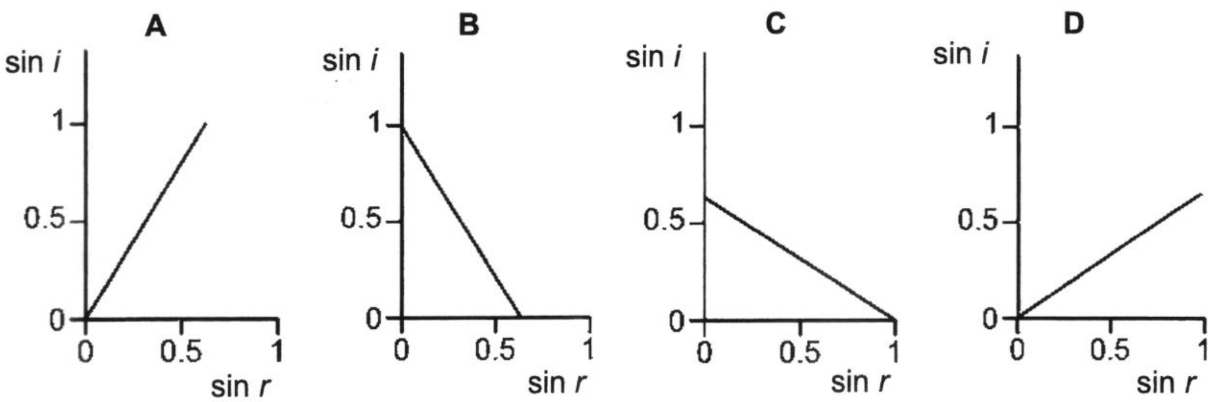
A 1.0 m **B** 2.0 m **C** 3.0 m **D** 4.0 m

25 A ray of light enters a glass block at an angle of incidence *i* and has an angle of refraction *r* in the glass.



Different values of *i* and *r* are measured, and a graph of sin *i* against sin *r* is plotted.

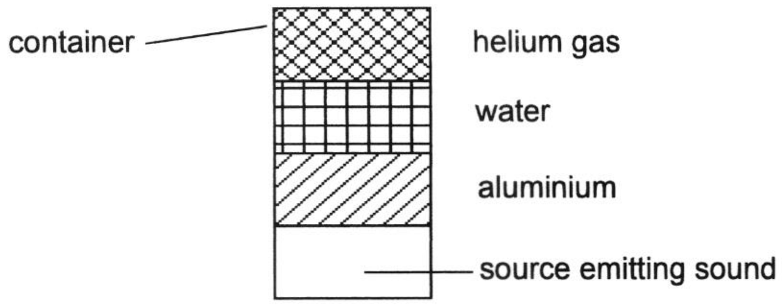
Which graph is correct?



26 Which one of the following is **not** a correct use of the stated electromagnetic wave?

	electromagnetic wave	use
A	X-rays	detection of cracks in buildings
B	radio waves	optical fibres
C	infra-red radiation	intruder alarm
D	ultraviolet radiation	sterilisation

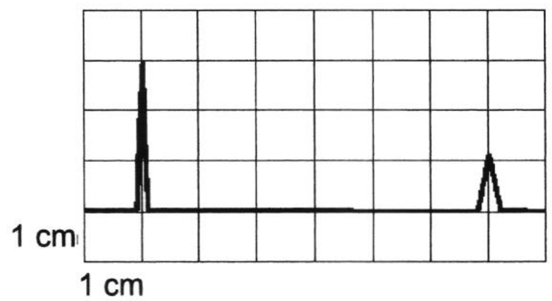
27 A sealed container contains three different substances as shown: helium gas, water and aluminium. A source which emits sound waves is located at the base of the container.



Which of the following is true?

A The sound waves travel with the same amplitude in all the substances.
B The sound waves travel with the same frequency in all the substances.
C The sound waves travel with the same speed in all the substances.
D The sound waves travel with the same wavelength in all the substances.

28 An ultrasound is transmitted vertically downwards onto the seabed and reflected back. The diagram shows the pulses captured on a cathode ray oscilloscope (c.r.o.).

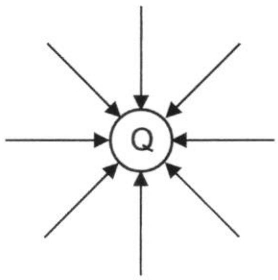


The time base of the c.r.o. is set at 400 ms/cm and the speed of the ultrasound in water is 1500 m/s.

What is the depth of the sea?

A 1800 m **B** 3600 m **C** 3750 m **D** 600 000 m

29 The diagram shows the direction of electric field lines around an isolated point charge Q.



If a charged object R is placed in the position shown, it experiences a force to the right.

What are the charges of Q and R?

	Q	R
A	negative	negative
B	negative	positive
C	positive	negative
D	positive	positive

30 A wire has a resistance of 8 Ω. A second wire, made of the same material, has half the length and twice the diameter.

What is the resistance of the second wire?

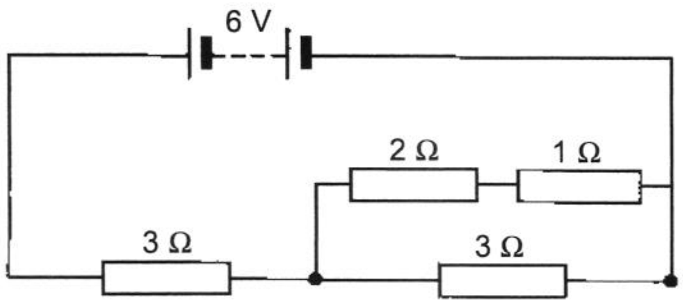
A 1 Ω **B** 2 Ω **C** 8 Ω **D** 16 Ω

31 A driver parks his car but forgets to turn off the car headlights. The 12 V car battery stores a total charge of 3.4×10^5 C and the power of the headlights is 95 W.

How long does it take for the battery to lose all its charge?

A 1.1×10^3 s **B** 3.6×10^3 s **C** 4.3×10^4 s **D** 2.7×10^4 s

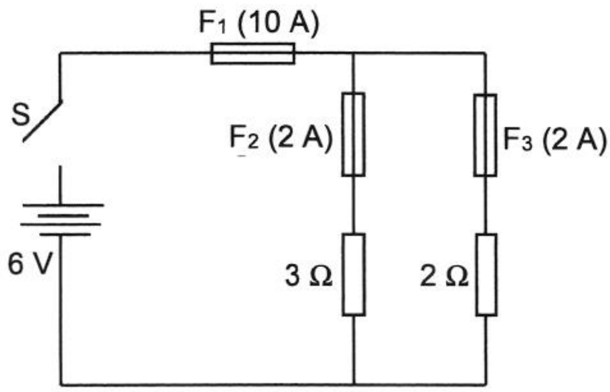
32 Four resistors are arranged in a circuit as shown.



What is the potential difference across the 2 Ω resistor?

A 1.33 V **B** 2.00 V **C** 2.66 V **D** 3.00 V

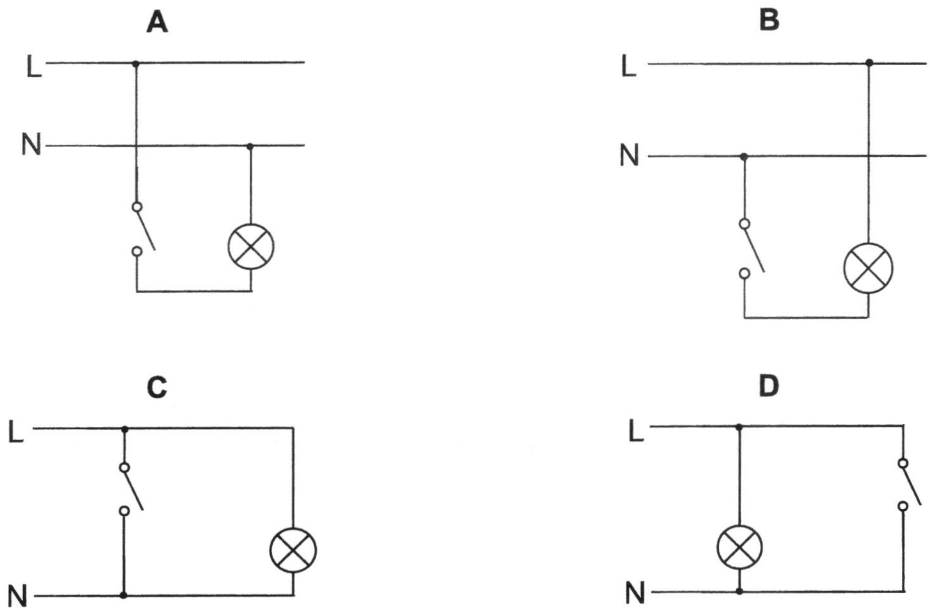
33 A student sets up a circuit, complete with fuses, as shown below. F_1 has a rating of 10 A while F_2 and F_3 each has a rating of 2 A.



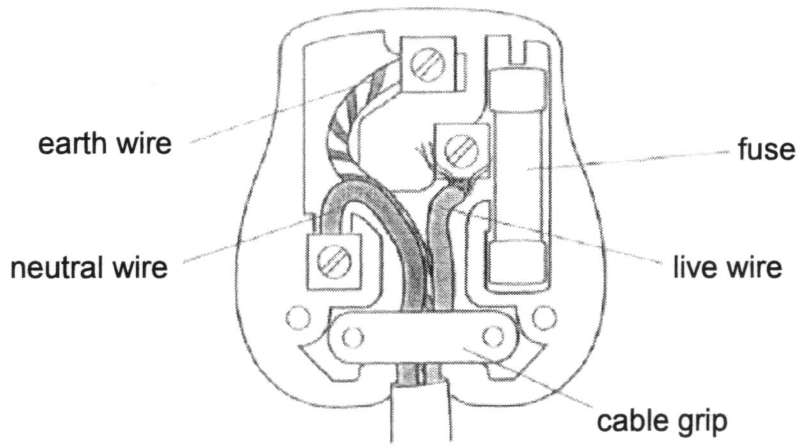
If switch S is closed, which fuse(s) in the circuit will melt?

A F_2 only **B** F_3 only **C** F_2 and F_3 only **D** F_1 , F_2 and F_3

34 Which circuit shows how a lamp and a switch should be connected in a household lighting circuit?



35 The following shows a three-pin plug of a kettle whose live wire has not been connected properly.

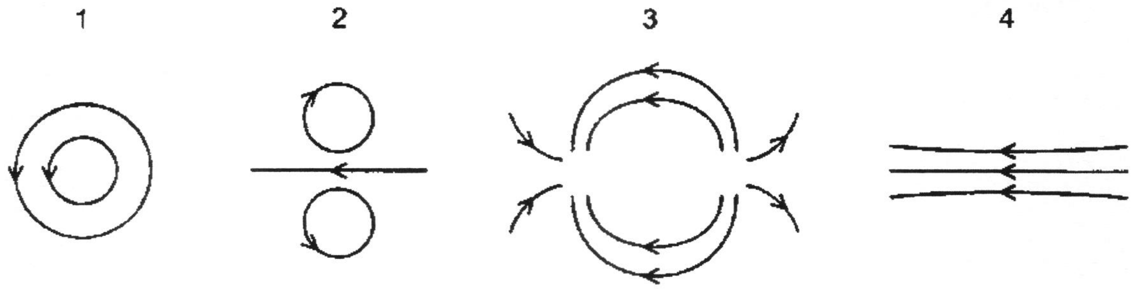


The exposed copper wires of the live wire touch the neutral pin.

Which of the following will occur?

A The metal casing of the kettle will be at a high potential and poses an electrical hazard.
B The current increases and the fuse will blow to prevent any electrical hazard.
C The live wire will divert the high current to the ground to prevent any electrical hazard.
D The neutral wire will divert the high current to the ground to prevent any electrical hazard.

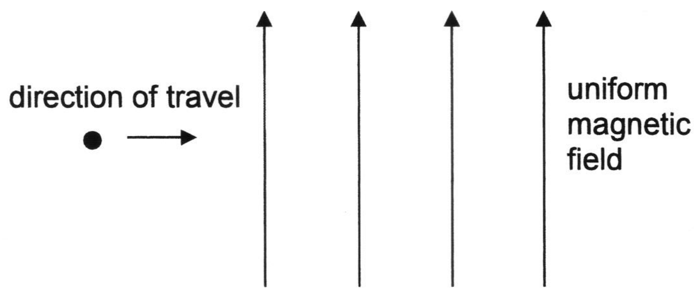
36 Four magnetic fields are shown.



Which row shows the objects that matches these fields?

	1	2	3	4
A	flat circular coil	bar magnet	solenoid	long straight wire
B	flat circular coil	solenoid	bar magnet	long straight wire
C	long straight wire	flat circular coil	bar magnet	solenoid
D	long straight wire	solenoid	bar magnet	flat circular coil

37 The diagram shows a negatively charged particle moving towards the right and entering a uniform magnetic field.

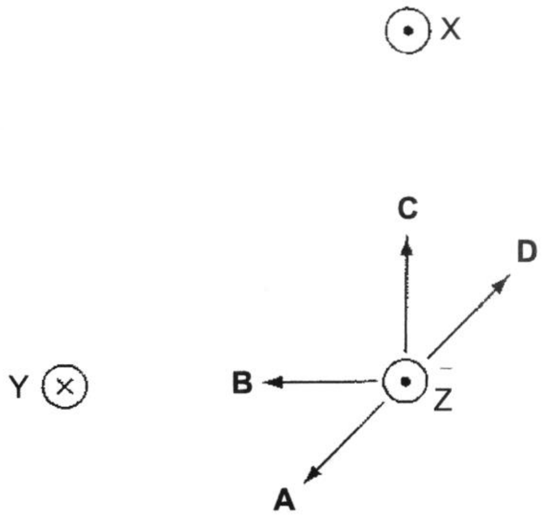


What is the direction of the magnetic force on the particle?

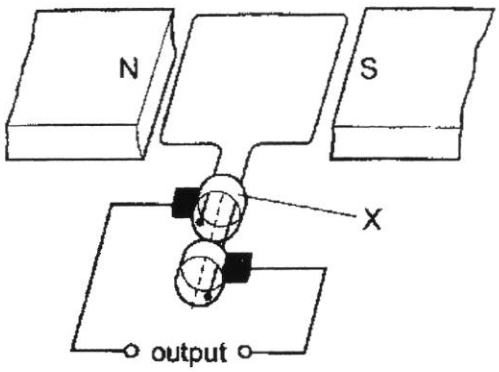
A upwards
B downwards
C into the diagram
D out of the diagram

38 Three parallel wires X, Y and Z are fixed at three corners of a square. They carry the same current in the directions shown.

In which direction is the force on wire Z?



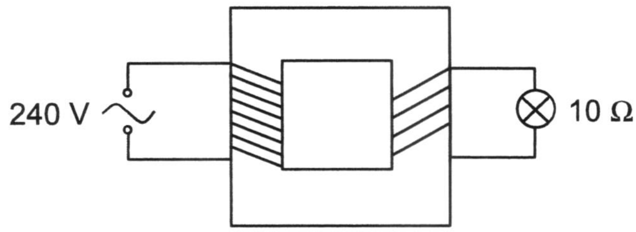
39 The diagram shows an experimental set-up.



What is the application of the set-up and component X?

	application	component X
A	a.c. generator	slip ring
B	a.c. generator	split-ring commutator
C	d.c. motor	slip ring
D	d.c. motor	split-ring commutator

40 An ideal transformer is connected to a 240 V a.c. supply. The primary coil has 1000 turns while the secondary coil has 50 turns. The output voltage is connected to a lamp of resistance 10 Ω.



What is the current passing through the lamp?

A 1.2 A **B** 24 A **C** 48 A **D** 120 A

END OF PAPER

NAME:	CLASS:	INDEX NO:

QUEENSWAY SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2023

SECONDARY 4 EXPRESS

Parent's Signature:

PHYSICS **6091/02**

Paper 2 Theory

12 September 2023

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and index number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A:
Answer **all** questions.

Section B:
Answer **all** questions. Question 14 has a choice of parts to answer.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

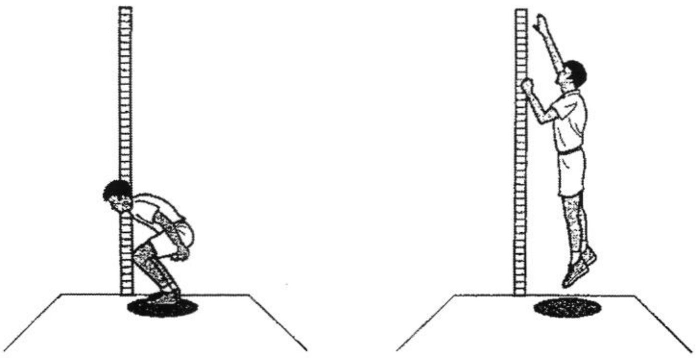
The number of marks is given in brackets [ ] at the end of each question or part question.

	For Examiner's Use	
	Section A	**/50**
	Q12	**/10**
	Q13	**/10**
E / O	**Q14**	**/10**
	TOTAL	**/80**

SECTION A

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

1 Fig. 1.1 shows a man of mass 70 kg jumping vertically upwards. He takes a time of 0.50 s to rise from his lowest position and leaves the ground with a speed of 1.2 m/s.



man at lowest position   man just leaves the ground

Fig. 1.1

The gravitational field strength is 10 N/kg.

(a) Determine the average acceleration of the man during this time.

acceleration = ...[1]

(b) Hence, determine the average force acting on the man by the ground.

force = ...[2]

(c) The force in **(b)** and the weight of the man are **not** an action-reaction pair.

Describe the other force that is a part of the action-reaction pair with the force in **(b)**, and state the body on which it acts.

....

.... [1]

2 A submarine of mass of 2.2×10^6 kg descends from the surface of the sea to a depth of 500 m.

The density of sea water is 1025 kg/m^3 and atmospheric pressure is 1.0×10^5 Pa. The gravitational field strength is 10 N/kg.

(a) Calculate the increase in pressure on the submarine due to the seawater at 500 m below the surface of the sea.

increase in pressure = ... [1]

(b) A hatch cover on the submarine has an area of 2.5 m^2. Calculate the **total** force exerted on the cover when the submarine is at a depth of 500 m below the surface of the sea.

total force = ... [2]

(c) In reality, the temperature, salinity and density of seawater varies with depth as shown in Fig. 2.1.

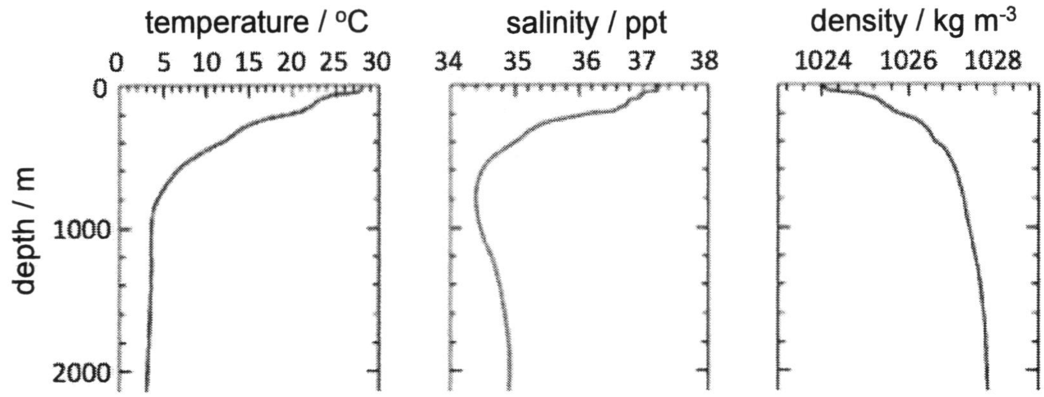


Fig. 2.1

Without further calculation, suggest, with a reason, how the information shown in Fig. 2.1 would affect your answer to **(b)**.

....

.... [1]

3 **(a)** Fig. 3.1 shows a uniform metre rule of mass 0.15 kg pivoted at the 60 cm mark. A 4.0 N weight is suspended from one end of the rule, causing the rule to rotate about the pivot.

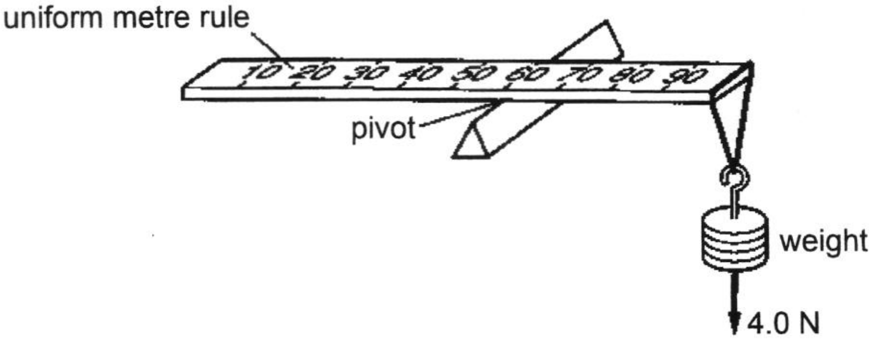


Fig. 3.1

Determine the resultant moment about the pivot, at the instant when the rule is horizontal. The gravitational field strength is 10 N/kg.

resultant moment = ... [2]

(b) A block is placed on a ramp as shown in Fig 3.2.

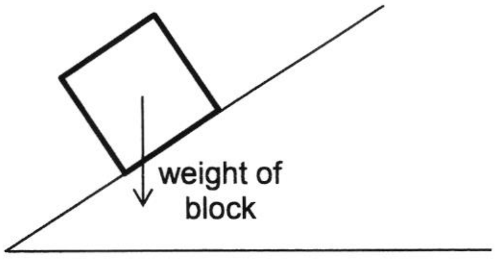


Fig. 3.2

At the position shown in Fig. 3.2, the block is at rest.

(i) State two other forces acting on the block in Fig 3.2.

.... [1]

(ii) Using the concept of moments, explain why the block topples when the ramp is tilted further.

....

.... [1]

4 Fig. 4.1a and Fig. 4.1b show a female gymnast of mass 50 kg on a trampoline. At position A in Fig. 4.1a, the gymnast is at her lowest position and starts to rise.

She passes position B in Fig 4.2b with a speed of 8.0 m/s and reaches her maximum height at position C.

The gravitational field strength is 10 N/kg.

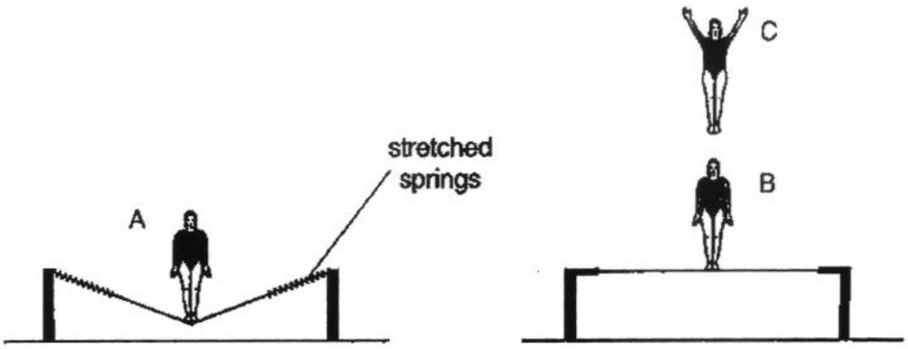


Fig. 4.1a **Fig. 4.1b**

(a) State the form of energy stored in the stretched springs shown in Fig. 4.1a.

.... [1]

(b) The gymnast moves through a height of 0.30 m from A to B.

By considering the changes in energy, determine the energy stored in the stretched springs at A.

energy = ...[2]

(c) Calculate the distance moved by the gymnast from B to C.

distance = ...[2]

(d) Another male gymnast of a **greater mass** uses the trampoline. He also passes B with a speed of 8.0 m/s and reaches his maximum height at C'.

State and explain whether the distance moved by the male gymnast from B to C' is different from your answer to **(c)**.

....

.... [1]

5 A cylinder that contains a fixed amount of gas is shown in Fig. 5.1.

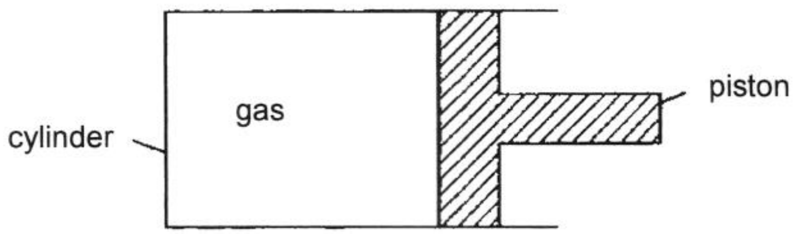


Fig. 5.1

The cylinder is fitted with a piston that **moves freely**.

(a) Explain how the gas molecules create a pressure.

....

....

.... [2]

(b) The gas is heated to a higher temperature.

Explain, using the kinetic model of matter, how the gas pressure can remain constant as the gas is heated.

....

....

....

....

....

....

....

....

.... [3]

6 Fig. 6.1 shows the positions of particles in a medium at a particular instant when a sound wave, travelling from left to right, passes through the medium. Before the wave arrives, the particles are equally spaced at their original undisturbed positions as indicated by the vertical lines.

The speed of sound in the medium is 1500 m/s.

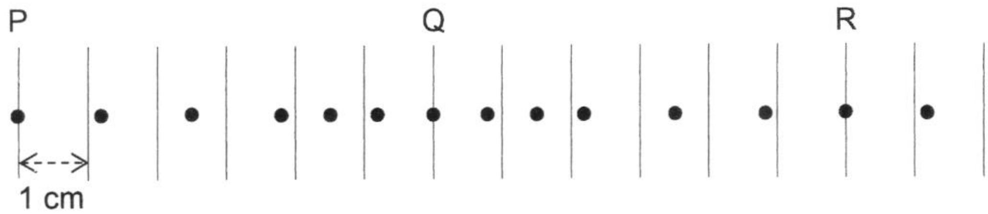


Fig. 6.1

(a) Explain how Fig. 6.1 shows that sound wave is a longitudinal wave.

....

.... [1]

(b) On Fig. 6.1, indicate the amplitude of the wave by drawing an arrow from the equilibrium position of one of the particles to its maximum displacement. [1]

(c) Calculate time taken for the wave at position Q to travel to position R.

time taken = ... [2]

(d) A softer sound with a lower pitch now passes through the medium.

Describe how the movement of the particle at position P will change, if at all.

....

.... [1]

7 Fig. 7.1 shows a converging lens AB with principal focus F. XY is an object placed in front of the lens.

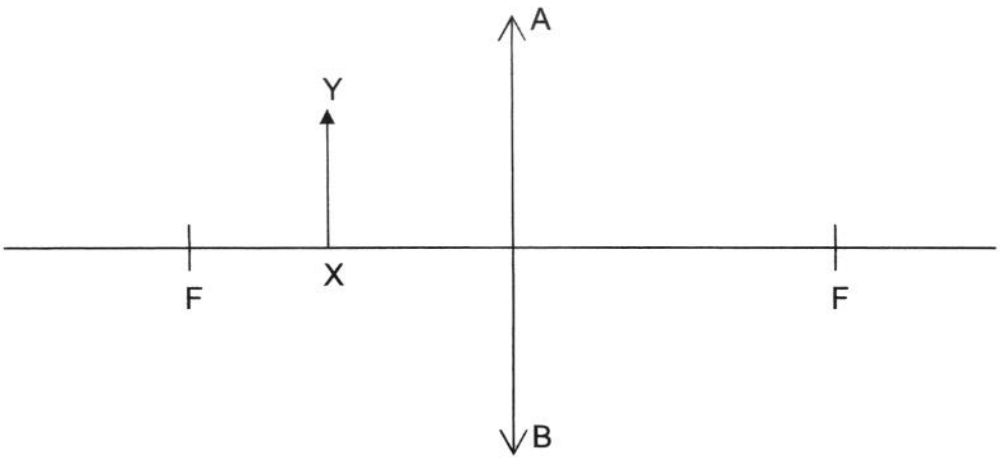


Fig. 7.1

(a) On Fig. 7.1, draw a ray diagram to locate the position of the image of XY. Label the image ***I***.

[2]

(b) State the properties of the image obtained.

....

.... [1]

8 A plastic rod becomes negatively charged after it is rubbed with a cloth.

The charged plastic rod is placed on an insulator on top of a balance. The balance shows a reading of 32.8 g.

An uncharged metal rod is then held above the plastic rod but not touching it, as shown in Fig. 8.1. The hand provides an earthing mechanism for the metal rod.

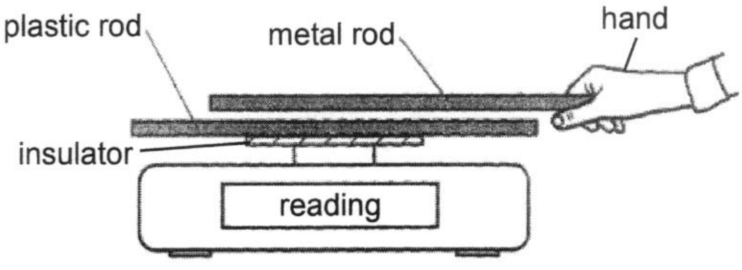


Fig. 8.1

(a) Explain why the plastic rod becomes negatively charged after it is rubbed with the cloth.

....

.... [1]

(b) State and explain the charge on the metal rod, if any, when it is held above the plastic rod as shown in Fig. 8.1.

....

....

....

....

....

.... [2]

(c) Hence, state and explain how the reading on the balance will change from its initial value of 32.8 g, when the metal rod is held above it.

....

....

....

.... [1]

9 Fig. 9.1 shows an electrical setup for an alarm bell. Assume that the alarm bell draws negligible current from the circuit.

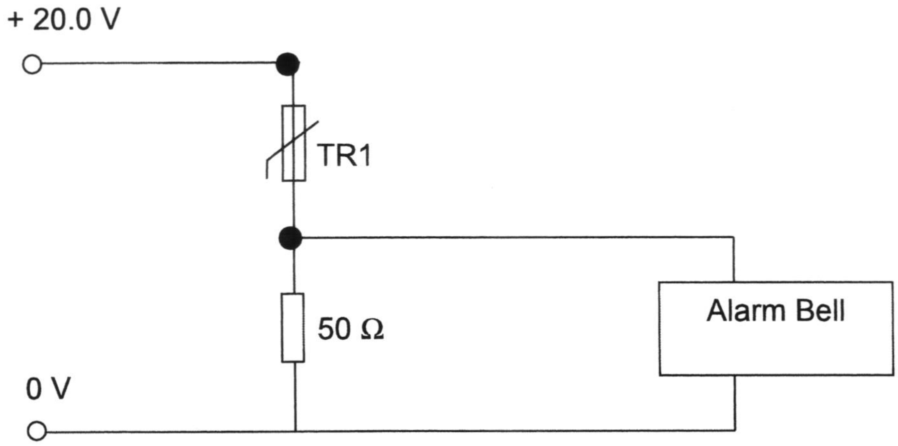


Fig. 9.1

Fig. 9.2 shows the variation of the resistance of the thermistor TR1 with temperature.

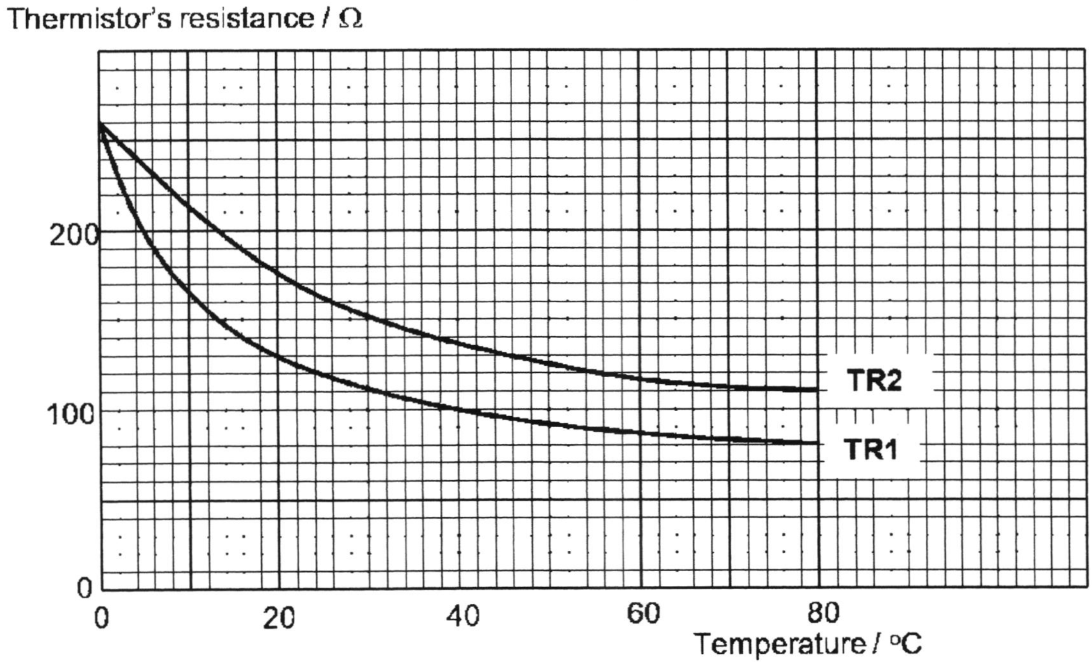


Fig. 9.2

(a) If the thermistor TR1 is at a temperature of 45 °C, determine

(i) the resistance of the thermistor,

resistance = ... [1]

(ii) the current in the thermistor.

current = ... [1]

(b) The alarm bell is triggered when the potential difference across it is greater or equal to 5.0 V.

Determine the temperature range that will trigger the alarm bell.

temperature range = ... [2]

(c) The thermistor TR1 is replaced by thermistor TR2, whose resistance-temperature graph is shown in Fig. 9.2.

State how your answer to **(b)** would change.

....

.... [1]

10 Fig. 10.1 shows a d.c. motor with a rectangular coil ABCD mounted on an axle and placed between the poles of a permanent magnet. The coil is rotating clockwise, as seen by the observer.

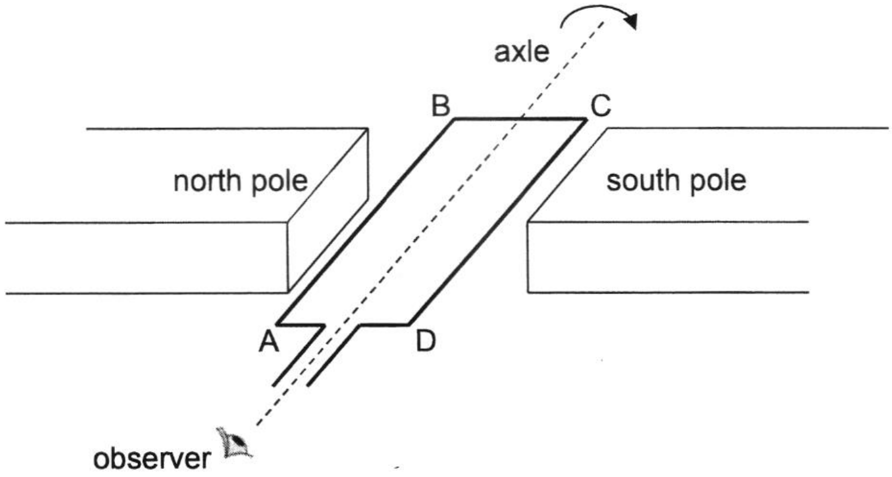


Fig. 10.1

(a) On Fig. 10.1, draw the direction of current flowing through sides AB and CD of the coil. [1]

(b) The coil is able to rotate about the axle continuously because of a split-ring commutator, which is not shown on Fig. 10.1.

With reference to side AB of the coil, explain how the split-ring commutator ensures that the rotation continues.

....

....

....

....

.... [2]

(c) The coil rotates from the position shown in Fig. 10.1 by 90°.

State and explain how the moment experienced by the coil changes.

....

....

....

.... [2]

11 Fig. 11.1 shows high voltage cables being used to transmit electrical energy.

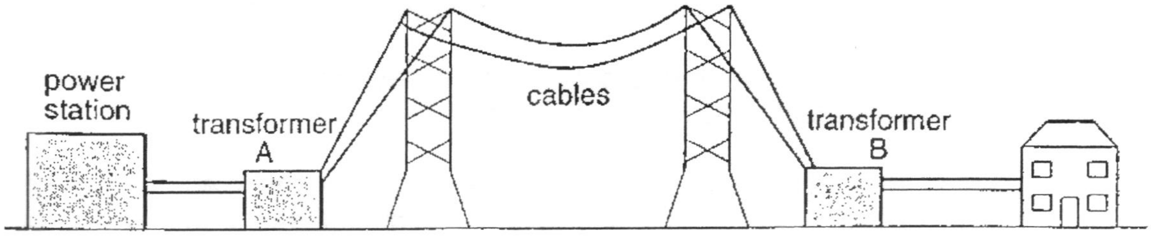


Fig. 11.1

(a) State the function of transformer B.

.... [1]

(b) Explain why high voltages are used to transmit electrical power.

....

....

.... [2]

(c) Fig. 11.2 shows a transformer.

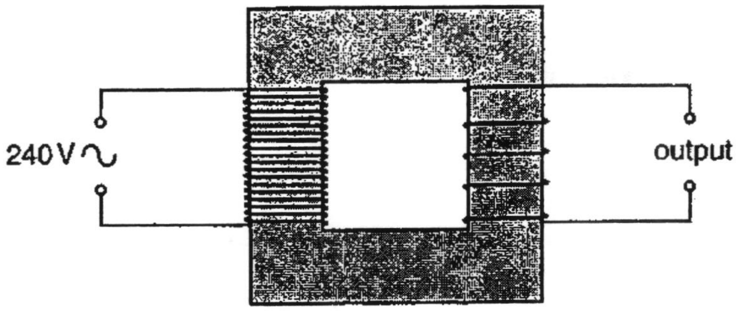


Fig. 11.2

Explain how an e.m.f. is induced in the secondary coil.

....

....

....

....

.... [2]

SECTION B

Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 14**.

12 Fig. 12.1 shows an experimental setup used to determine the specific heat capacity and specific latent heat of vaporisation of liquid X.

A data logger, equipped with voltage sensors, is connected to the thermocouple comprising hot and cold junctions. The hot junction of the thermocouple is placed inside an insulated copper container filled with liquid X. The cold junction is placed inside another container of melting ice, kept at a steady temperature of 0 °C.

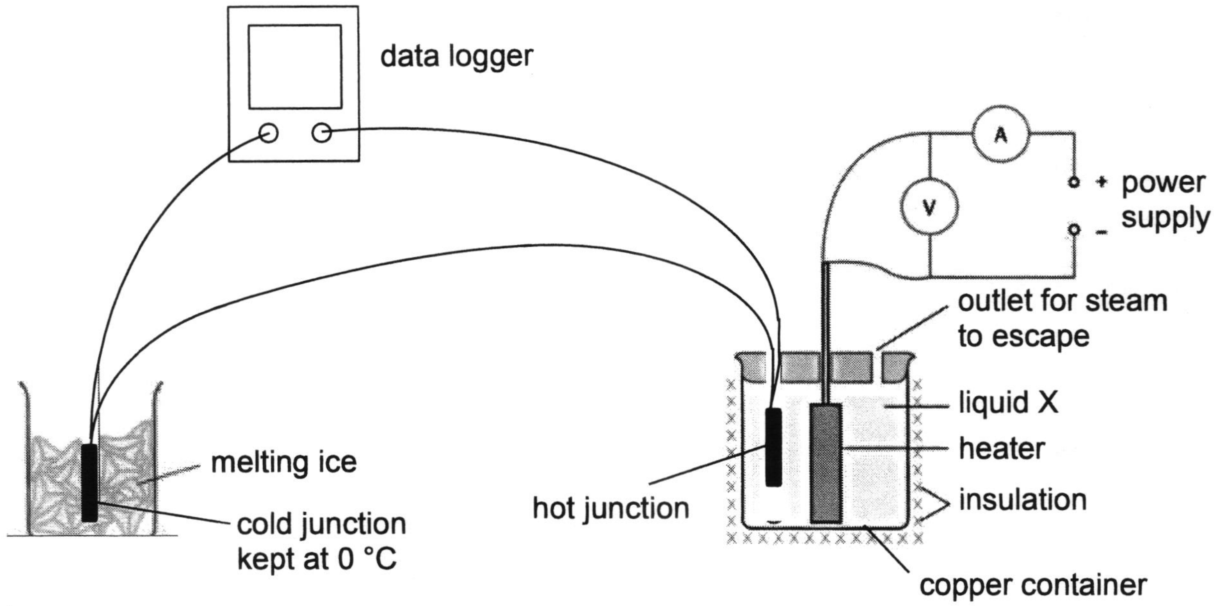


Fig. 12.1

Table 12.2 shows the data relevant to the setup.

Table 12.2

power of heater	800 W
initial mass of liquid X	0.50 kg
mass of copper container	0.80 kg
specific heat capacity of copper	400 J kg^{-1} °C^{-1}
voltage reading shown on data logger when the hot junction is placed in pure steam and the cold junction is placed in melting ice at 0 °C	8.0 mV

Fig. 12.3 shows the variation with time t of the voltage V recorded on the data logger when the heater is switched on at t = 0 s. Both the copper container and liquid X are initially at the same temperature.

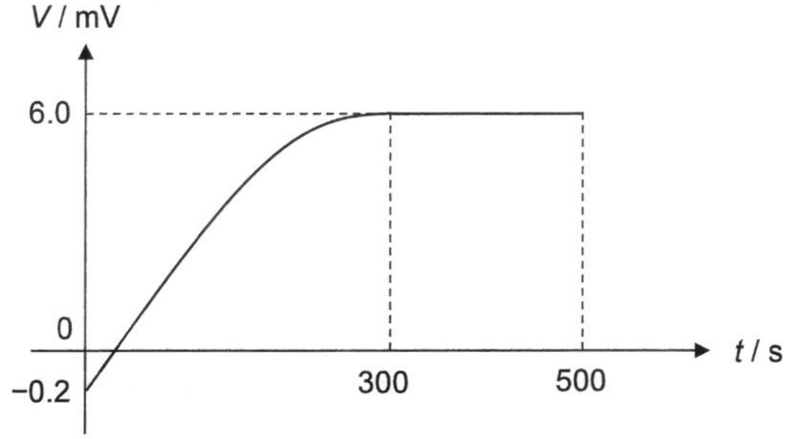


Fig. 12.3

(a) Show that the temperature of liquid X at t = 0 s is −2.5 °C.

[2]

(b) (i) At t = 300 s, liquid X starts to boil at 75 °C.

Calculate the specific heat capacity of liquid X.

specific heat capacity = ...[3]

(ii) At t = 500 s, the heater is switched off and the mass of the liquid X left in the copper container is found to be 0.30 kg.

Calculate the specific latent heat of vaporisation of liquid X.

specific latent heat of vaporisation = ...[2]

(iii) State one assumption you made in your calculations for **(i)** and **(ii)**.

....

.... [1]

(c) Explain why the temperature of liquid X does not rise from 300 s to 500 s, even though thermal energy is still being supplied by the heater.

....

....

.... [2]

13 A student stands near the edge of a cliff. He throws a ball upwards with a velocity of 4.0 m/s, at a height of 1.0 m from the top of the cliff, as shown in Fig. 13.1. The ball rises vertically over a short distance and then falls.

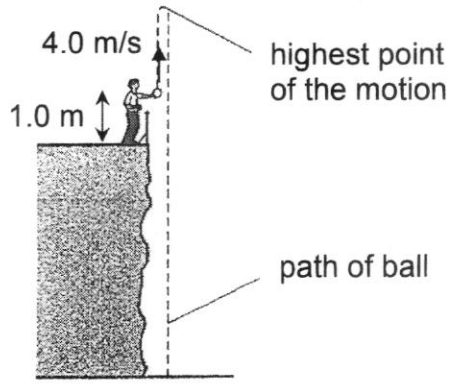


Fig. 13.1

Fig. 13.2 shows the displacement-time graph and Fig. 13.3 shows the velocity-time graph of the ball for the first 1.0 s of the motion. Air resistance is negligible in the first 1.0 s of the motion. The gravitational field strength is 10 N/kg.

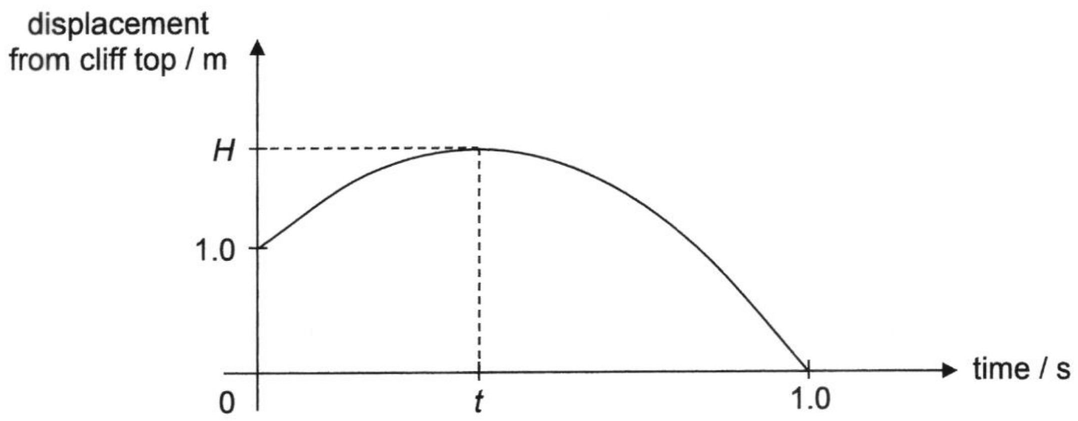


Fig. 13.2

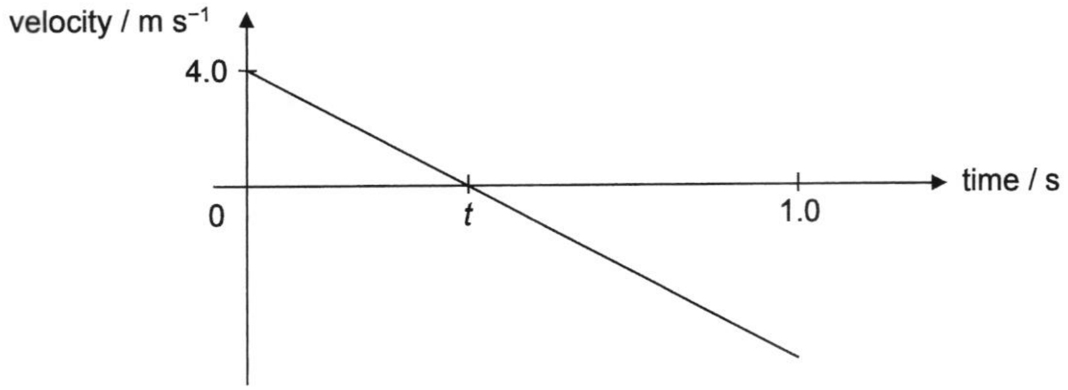


Fig. 13.3

(a) At time t, the ball reaches its maximum height H from the cliff top.

(i) State the velocity of the ball at time t and explain how this value can be derived from the graph in Fig. 13.2.

....

.... [1]

(ii) By drawing a free-body diagram of the ball, show that the magnitude of its acceleration at time t is 10 m s^{-2}.

[2]

(iii) Using Fig. 13.3 and your answer to **(ii)**, determine time t.

t = ...[2]

(iv) Hence, determine the maximum height H from the cliff top.

H = ...[2]

(b) The ball continues to fall after 1.0 s. The effect of air resistance becomes significant and the ball eventually falls at terminal velocity.

(i) Explain, in terms of forces acting on the ball, how the acceleration of the ball changes from time = 1.0 s until terminal velocity is reached.

....

....

....

....

.... [2]

(ii) The mass of the ball is 15 g.

Determine the maximum air resistance acting on the ball.

maximum air resistance = ...[1]

14 EITHER

(a) Fig. 14.1 shows the path of a ray of blue light as it passes through a glass prism.

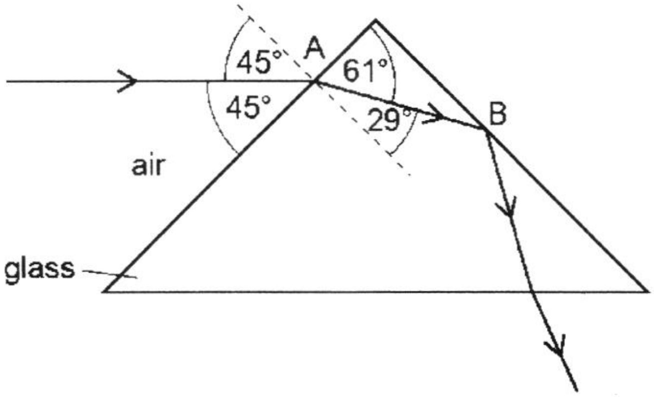


Fig. 14.1

(i) Determine the critical angle.

critical angle = ... [2]

(ii) Explain why the light ray does not emerge from the prism at B.

....

....

.... [1]

(iii) Suggest and explain what would be observed if the ray of blue light is replaced with white light.

....

....

....

.... [2]

(iv) Fig. 14.2 shows a second ray of blue light striking the prism at point C. The second ray of light is parallel to the first ray.

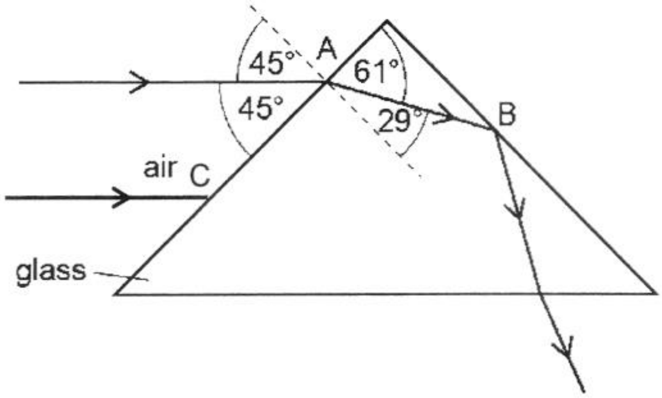


Fig. 14.2

On Fig. 14.2, continue the path of the second ray through and out of the glass prism.

[2]

(b) The ultraviolet region of the electromagnetic spectrum contains two sections, UVA and UVB. The wavelength range of UVA radiation is from 320 nm to 400 nm and the wavelength range of UVB radiation is from 280 nm to 320 nm.

(i) UVA radiation is used in sunbeds.

Suggest why the amount of ultraviolet radiation used is carefully controlled.

....

.... [1]

(ii) Calculate the lowest frequency of UVA radiation.

lowest frequency = ... [1]

(iii) Name another region in the electromagnetic spectrum which has frequencies higher than those of UVB radiation.

.... [1]

14 OR

(a) When the switch S is closed as shown in Fig. 14.3, the ammeter reading is 2.0 A.

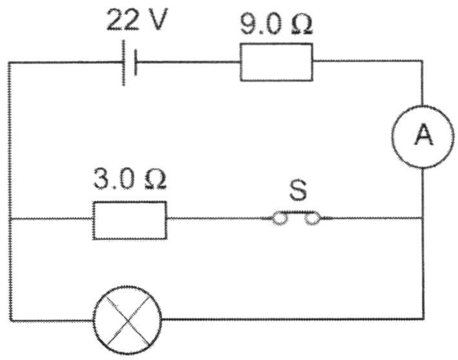


Fig. 14.3

(i) Calculate the potential difference across the 9.0 Ω resistor.

potential difference = ... [1]

(ii) Determine the current in the 3.0 Ω resistor.

current = ... [2]

(iii) Determine the resistance of the lamp.

resistance = ... [2]

(iv) Switch S is now opened.

State and explain how the brightness of the lamp will change.

....

....

.... [2]

(b) All refrigerators sold in Singapore must carry energy labels which will show the number of "Green Ticks" awarded to them. A fridge with more Green Ticks is more energy-efficient than one with fewer Green Ticks.

Table 14.4 shows some data of fridges and the number of Green Ticks that they are awarded. The Annual Energy Consumption is the amount of energy the fridge would consume if it is used continuously for an entire year.

Table 14.4

Fridge	Green Ticks	Volume / litre	Annual Energy Consumption / kWh
A	2	200	508
B	3	200	452
C	2	400	697
D	3	400	549

(i) Calculate the power, in W, consumed by Fridge **A** in a year.

power = ... W [1]

(ii) Agnes is considering buying either Fridge **C** or Fridge **D**. Fridge **D** costs $200 more than Fridge **C**.

Assuming that the lifespan of each fridge is 8 years and the cost of electricity is $0.29 per kWh, determine which fridge Agnes should buy in order to save cost in the long term, and state the total cost saving over 8 years if she buys that particular fridge over the other one.

fridge to buy = ...

total cost saving = ... [2]

END OF PAPER

2023 4E Physics Prelim Exam Solution

Paper 1

Multiple Choice Questions [40 marks]

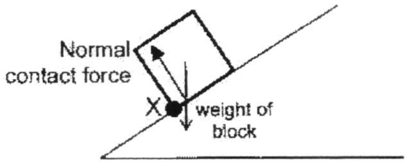
1	D	11	B	21	B	31	C
2	C	12	D	22	A	32	A
3	C	13	B	23	C	33	B
4	D	14	D	24	C	34	A
5	D	15	D	25	A	35	B
6	C	16	A	26	B	36	C
7	D	17	B	27	B	37	C
8	C	18	D	28	A	38	D
9	B	19	B	29	A	39	A
10	D	20	B	30	A	40	A

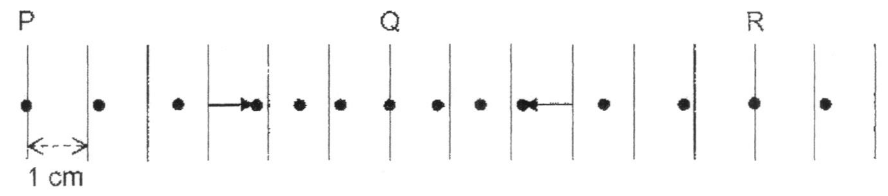
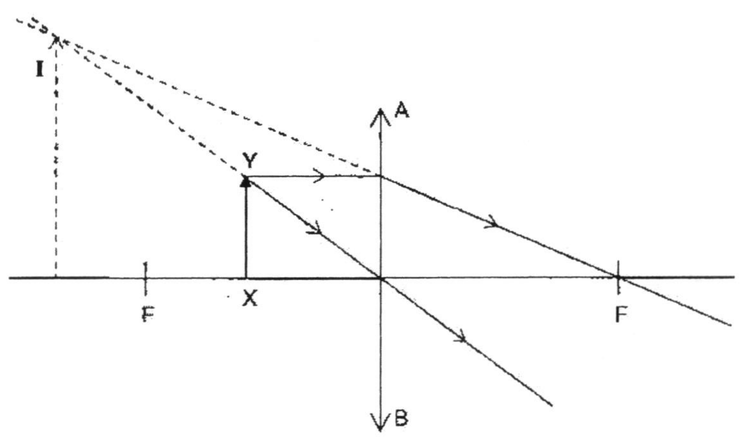
Paper 2

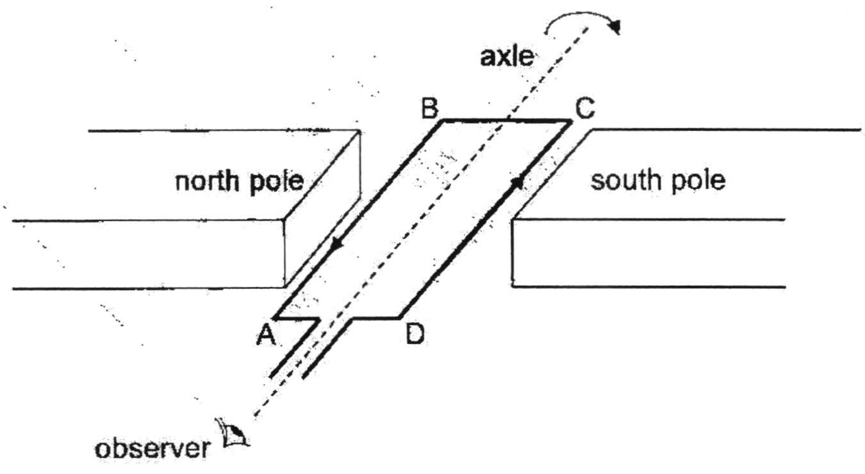
Note:
Deduct one mark overall for incorrect significant figures.
Deduct one mark overall for no unit or incorrect unit.

Section A: Structured Questions [50 marks]

Qn	Solution	Mark
1(a)	$a=\frac{1.2-0}{0.50}$ $a=2.4\ \text{m s}^{-2}$	[1]
1(b)	$N-W=ma$ $N-(70\times10)=70\times2.4$ $N=868\ \text{N}$	[1] [1]
1(c)	Force on the ground by the man, acting vertically downwards.	[1]
2(a)	Increase in pressure = 500(1025)(10) = 5.13×10^{6} Pa	[1]
2(b)	Total pressure = $5.13\times10^{6}+1.0\times10^{5}$ = 5.23×10^{6} Pa Total force = $(5.23\times10^{6})(2.5)$ = 1.31×10^{7} N	[1] [1]
2(c)	Since the density of seawater increases with depth, the increase in pressure on the submarine at a depth of 500 m would be greater than 5.13×10^{6} Pa. Hence the total force exerted on the hatch cover would be slightly greater.	[1]
3(a)	Resultant moment = 4.0(0.40) – (0.15)(10)(0.10) = 1.45 N m	[1] [1]

3(b)(i)	1. Normal contact force exerted by the ramp on the block 2. Friction exerted by the ramp on the block	[1]
3(b)(ii)	 When the ramp is tilted further, the anticlockwise moment produced by the normal contact force exerted by the ramp on the block about point X is greater than the clockwise moment produced by the weight of the block about X. Hence the block topples.	[1]
4(a)	Elastic potential energy	[1]
4(b)	loss in e.p.e. = gain in k.e. + gain in g.p.e. e.p.e. at A $= (50\times10\times0.30)+\left(\frac{1}{2}\times50\times8.0^2\right)$ e.p.e. at A $=1750$ J	[1] conservation of energy [1]
4(c)	loss in k.e. = gain in g.p.e. $\frac{1}{2}\times50\times8.0^2=50\times10\times h$ $h=3.2$ m	[1] [1]
4(d)	Since loss in k.e. = gain in g.p.e., the factor mass m cancels on both sides of the equation, such that $v^2 = 2gh$. Hence, h only depends on v and so the distance moved is the same.	[1] any reasonable answer
5(a)	The gas molecules collide with the walls of the cylinder and piston, and exert an average force on the walls. The average force per unit area exerted by the gas molecules on the walls is the gas pressure.	[1] [1]
5(b)	As the temperature of the gas increases, the kinetic energy and average speed of the gas molecules increase. Since the force of collision and the rate of collision of the gas molecules with the walls of the cylinder and piston increase, the gas pressure increases beyond atmospheric pressure. A net force is exerted by the gas molecules exerted on the piston, causing the piston to move outward towards the right as the gas expands. This results in a decrease in the number of gas molecules per unit volume. The rate of collision decreases and therefore the pressure of the gas decreases until it reaches its original pressure before it was heated (i.e. atmospheric pressure).	[1] [1] [1]
6(a)	The particles in the medium vibrate in a direction that is parallel to the direction of wave travel.	[1]

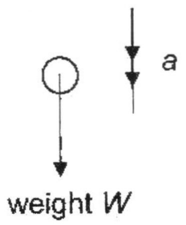
6(b)		[1]
6(c)	Distance from Q to R = 6.0 cm = 0.060 m $\text{Time taken} = \dfrac{\text{Dist}}{\text{Speed}}$ $= \dfrac{0.060}{1500}$ $= 4.0 \times 10^{-5}$ s Or Wavelength = 2 x 6 = 12 cm $v = \dfrac{\lambda}{T}$ $1500 = \dfrac{0.12}{T}$ $T = 8.0 \times 10^{-5}$ s Time taken = $T/2$ = $(8.0 \times 10^{-5})/2$ = 4.0×10^{-5} **s**	[1] [1]
6(d)	The particle will vibrate with a smaller amplitude and more slowly.	[1]
7(a)	 Rays correctly drawn with arrows and extended backwards with dotted lines: [1] Image correctly located, labelled and drawn with dotted lines: [1]	[2]
7(b)	The image is virtual, upright and magnified.	[1]

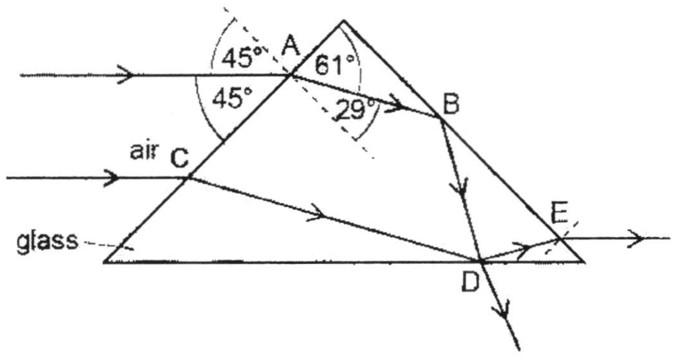
8(a)	The cloth transfers its electrons to the plastic rod during the rubbing process. Hence the plastic rod becomes negatively charged.	[1]
8(b)	When the metal rod is held above the plastic rod, the negative charges in the plastic rod will repel the electrons in the metal rod. These electrons will flow from the metal rod to the earth through the hand, leaving behind the positive charges in the metal rod. Therefore the metal rod will become positively charged.	[1] [1]
8(c)	Attractive forces between the negatively charged plastic rod and the positively charged metal rod will result in an upward force exerted on the plastic rod. Hence the reading on the balance will decrease.	 [1]
9(a)(i)	Resistance = 95 Ω Accept resistance between 95 Ω and 97 Ω.	[1]
9(a)(ii)	Current = 20 / (95 + 50) = 0.138 A	[1]
9(b)	$\frac{50}{50+R} \times 20 = 5$ $R = 150\ \Omega$ From Fig. 9.2, when resistance of thermistor is 150 Ω, its temperature is 13 °C. Hence temperature range is 13 °C and above.	 [1] [1]
9(c)	The alarm bell will be triggered at a temperature range greater or equal to 31 °C. Accept minimum temperature between 30 °C and 31 °C.	[1]
10(a)		[1]

10(b)	The function of the split-ring commutator is to reverse the direction of the current along side AB every half a revolution. This occurs whenever the commutator changes contact from one brush to the other. The force acting on AB will change to downwards, and this ensures that the coil will always turn in one direction.	[1] [1]
10(c)	As the coil turns, the moment decreases from its maximum value to zero. This is because of a decrease in the perpendicular distance from the axle to the line of action of the force.	[1] [1]
11(a)	To step down the voltage.	[1]
11(b)	At high voltages, the current flowing through the transmission cables will be smaller. Hence, the power wasted in the transmission cables will be reduced.	[1] [1]
11(c)	The alternating current in the primary coil creates a changing magnetic field through the soft iron core. The secondary coil hence experiences a change in magnetic flux and so an e.m.f. is induced.	[1] [1]

Section B: Structured Questions [30 marks]

Qn	Solution	Mark
12(a)	$\varepsilon \propto \Delta\theta$ $\frac{\Delta\theta}{\varepsilon} = \frac{\Delta\theta'}{\varepsilon'}$ $\frac{100-0}{8.0} = \frac{\theta - 0}{-0.2}$ $\theta = -2.5$ °C	[1] [1]
12(b)(i)	heat supplied by heater = heat gained by copper container + heat gained by liquid X $800 \times 300 = [0.80 \times 400 \times (75-(-2.5))] + [0.50 \times c \times (75-(-2.5))]$ $c \approx 5550$ J kg^{-1} °C^{-1}	[1] for heat supplied by heater [1] for heat gain by copper container & liquid X [1] answer
12(b)(ii)	Heat supplied by heater = heat gained by liquid X $800 \times 200 = 0.20 \times l_v$ $l_v = 8.0 \times 10^5$ J kg^{-1}	[1] [1]
12(b)(iii)	All heat supplied by the heater is gained by the copper container and liquid X. No heat is lost to the surroundings.	[1]

12(c)	The heat absorbed by liquid X is used to overcome the forces of attraction and separate the particles further. The internal potential increases but the internal kinetic energy remains constant and so the temperature does not change.	[1] [1]
13(a)(i)	The velocity is zero. The gradient of the displacement-time graph at t is zero, which shows that the velocity is zero.	[1]
13(a)(ii)	 $W = ma$ $mg = ma$ $a = g$ $a = 10\ \text{m s}^{-2}$ (shown)	[1] free body diagram [1] use of N2L
13(a)(iii)	gradient = -10 $\frac{4.0-0}{0-t} = -10$ $t = 0.40$ s	**[1] relate gradient to acceleration** [1] time
13(a)(iv)	distance moved upwards = area under graph from 0 s to 0.4 s $= \frac{1}{2} \times 0.4 \times 4.0$ $= 0.80$ m $H = 1.0 + 0.80$ $H = 1.8$ m	 [1] [1]
13(b)(i)	As the ball falls, its velocity increases and air resistance acting on the ball increases. The resultant force acting on the ball decreases and so its acceleration decreases. The weight of the ball and the air resistance acting on it cancel out at some point of its motion. There is no resultant force acting on the ball and it then falls with zero acceleration.	[1] [1]
13(b)(ii)	At terminal velocity, maximum $F_{air} = W$. maximum $F_{air} = \frac{15}{1000} \times 10$ $= 0.15$ N	[1]

14 EITHER		
14(a)(i)	$n = \dfrac{1}{\sin c}$ $\Rightarrow \dfrac{\sin i}{\sin r} = \dfrac{1}{\sin c}$ $\dfrac{\sin 45^\circ}{\sin 29^\circ} = \dfrac{1}{\sin c}$ $c = 43.3^\circ$	[1] [1]
14(a)(ii)	When the light ray hits B, it is travelling from an optically denser medium towards a less dense medium. Since the angle of incidence at B is greater than the critical angle, the light ray undergoes total internal reflection and does not emerge from the prism at B.	[1]
14(a)(iii)	White light comprises light of different colours, each with a different wavelength (or frequency). Light with different wavelengths will travel at different speeds in the glass prism, so they will be refracted at different angles. Hence light rays emerging from the prism will be dispersed into different colours and emerge at different angles.	[1] [1]
14(a)(iv)	 Refracted ray CD is parallel to AB and drawn with arrow, and Reflected ray DE has same angle of reflection as the angle of incidence and drawn with arrow: [1] Refracted ray emerging at E is horizontal and drawn with arrow: [1]	[2]
14(b)(i)	Overexposure to ultraviolet radiation can lead to skin cancer.	[1]
14(b)(ii)	$v = f\lambda$ $3.0\times10^{8} = f(400\times10^{-9})$ $f = 7.5\times10^{14}$ Hz	[1]
14(b)(iii)	X-rays or Gamma rays	[1]

14 OR		
14(a)(i)	V = (2.0)(9) = 18 V	[1]
14(a)(ii)	P.d. across resistor = 22 – 18 = 4.0 V Current in resistor = 4.0/3.0 = 1.33 A	[1] [1]
14(a)(iii)	Current in lamp = 2.0 – 1.33 = 0.67 A Resistance of lamp = 4/0.67 = 6.0 Ω	[1] [1]
14(a)(iv)	When switch S is opened, the potential difference across the lamp will increase (by the potential divider principle). The power dissipated by the lamp is thus greater ($P_{lamp} = \frac{V_{lamp}^2}{R_{lamp}}$). Hence the brightness of the lamp increases.	[1] [1]
14(b)(i)	Power = energy/time $= \frac{508 \times 10^3 \times 3600}{365 \times 24 \times 3600}$ = 58.0 W	[1]
14(b)(ii)	Cost of using Fridge **C** for 8 years = 697 x 0.29 x 8 = $1617.04 Cost of using Fridge **D** for 8 years = 549 x 0.29 x 8 = $1273.68 Hence Agnes should buy Fridge **D**. Total cost saving over 8 years = 1617.04 – 1273.68 – 200 = $143.36 or $143 (3 s.f.)	 [1] [1]