NAME:	CLASS:	INDEX NO:

QUEENSWAY SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2024

SECONDARY 4 EXPRESS

Parent's Signature:

PHYSICS **6091/02**

Paper 2 Theory **22 August 2024**

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class 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. Write your answers in the spaces provided.

Section B:
Answer **one** question. Write your answers in the spaces provided.

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	/70
Q	/10
TOTAL	/80

Section A

Answer **all** questions.

1 Two forces, 100 N and 50 N, act on an 8.0 kg box as shown in Fig. 1.1. The box is initially at rest.

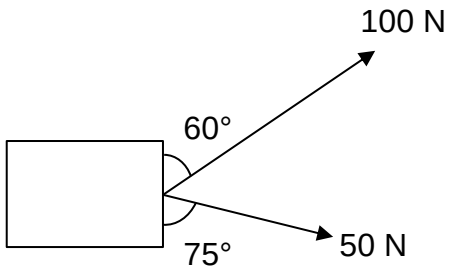

Fig. 1.1

(a) By using a suitable scale diagram, determine the magnitude of the resultant force acting on the box.

resultant force = ... [2]

(b) Hence, determine the acceleration of the box.

acceleration = ... [1]

(c) Calculate the speed of the box after 6.0 s.

speed = ... [1]

[Total: 4]

2 **(a)** A cyclist applies a vertical force *F* of 110 N on a pedal of her bicycle, as shown in Fig. 2.1.

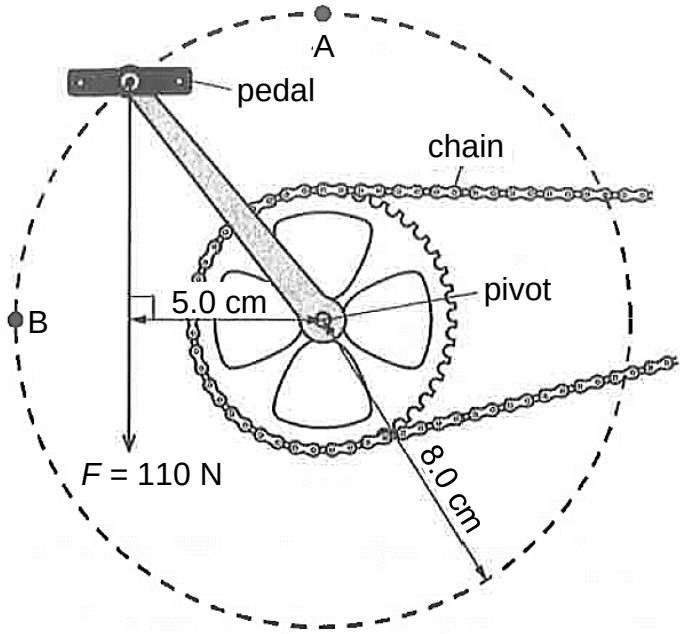

Fig. 2.1

As she travels along, the pedal moves through a circle of radius 8.0 cm. For the pedal in the position shown in Fig. 2.1, the line of action of the force *F* is 5.0 cm from the pivot.

(i) Calculate the moment of force *F* about the pivot.

moment = ... [2]

(ii) The pedal moves from position A to position B, as shown in Fig. 2.1.

Explain, in terms of moments, why the downward force *F* applied at A will have a different effect from the same force applied at B.

.....

.....

..... [1]

(b) A boy stands with his right foot and right shoulder touching a wall, and his centre of gravity as shown in Fig. 2.2.

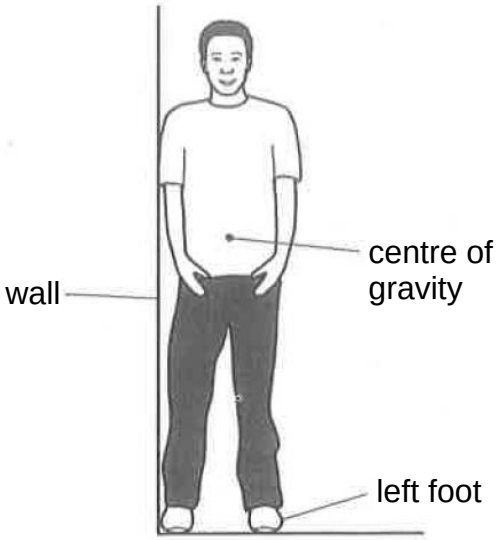

Fig. 2.2

Explain why the boy cannot raise his left foot off the ground without losing his balance.

……

……

…… [1]

[Total: 4]

3 Fig. 3.1 shows part of the braking system of a car.

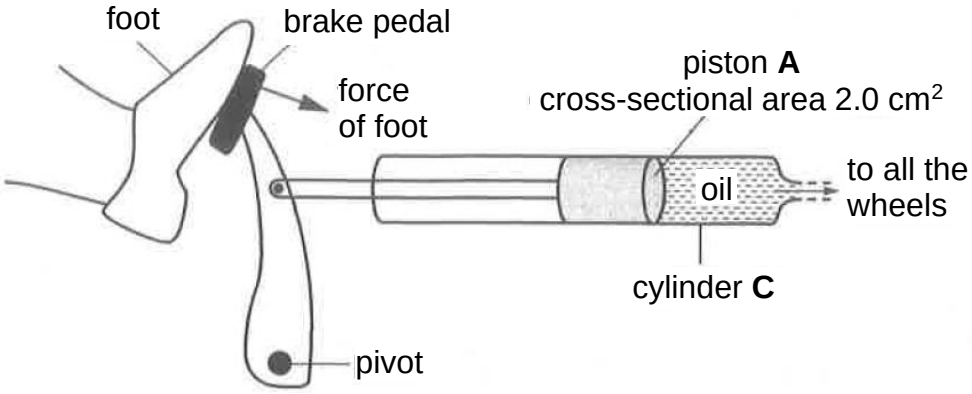

Fig. 3.1

The brake pedal is connected to a piston **A** that can move in cylinder **C** filled with oil. The driver's foot presses on the brake pedal, causing piston **A** to exert a force of 640 N on the oil in the cylinder. The cross-sectional area of piston **A** and cylinder **C** is 2.0 cm^2.

(a) Calculate the pressure in the oil due to the force exerted by piston **A**, giving your answer in the unit pascal.

pressure = …… Pa [2]

(b) The cylinder at the brake pedal is connected by pipes containing oil to cylinders at each wheel. Fig. 3.2 shows cylinder **D** and piston **B** at one of the wheels. The cross-sectional area of piston **B** is 15 cm^2.

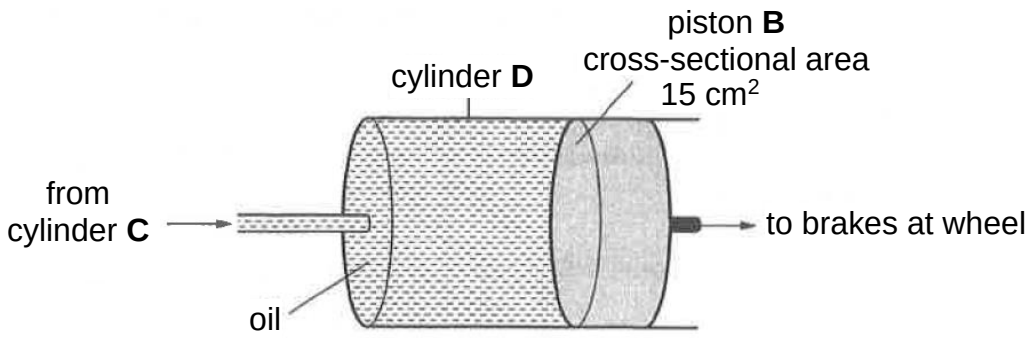

Fig. 3.2

Determine the force exerted by the oil on piston **B**.

force = …… [2]

(c) A student suggests changing the size of cylinder **D** to a cross-sectional area of less than 2.0 cm^2, so that it is less bulky and takes up less space.

State and explain whether you agree with the student's suggestion.

……

……

……

…… [2]

[Total: 6]

4 Fig. 4.1 shows a 1.2 kg ball rolling down a rough track from position A, which is 7.5 m above the ground, with an initial speed v_0. The ball leaves the incline at position B, travels upward and reaches a maximum height of 10 m above the ground.

The motion of the ball along the track produces a total of 25 J of thermal energy. The gravitational field strength is 10 N/kg.

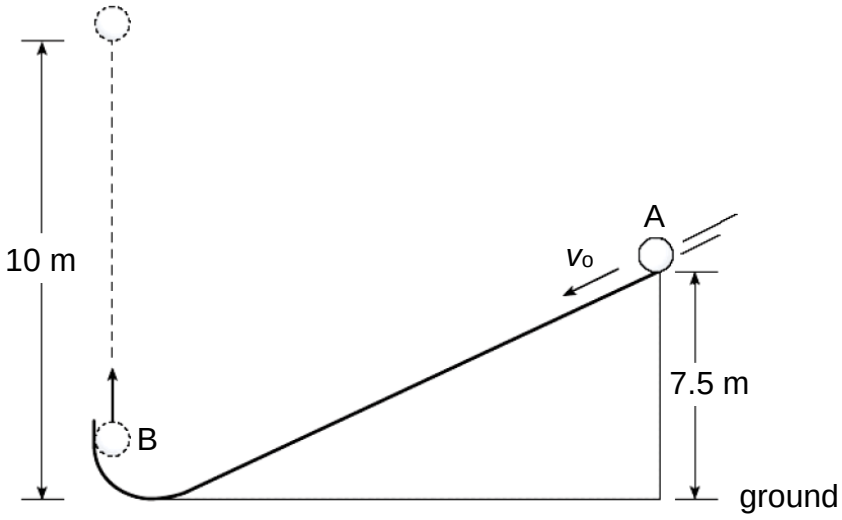

Fig. 4.1

(a) Calculate the gravitational potential energy of the ball at A.

gravitational potential energy = ... [2]

(b) Determine the initial speed v_0 of the ball.

v_0 = ... [3]

(c) State an assumption made in your answer to **(b)**.

.....

..... [1]

[Total: 6]

5 Sonar waves emitted from a surface vessel are used to determine the depth of the sea. After a sonar wave is sent downward from the vessel, it takes 0.75 s for the signal reflected from the sea-bed to be detected. The speed of sound in water is 1200 m/s.

(a) Calculate the depth of the sea.

depth = ... [2]

(b) Explain how sound energy is transferred through the water.

.....

.....

.....

.....

.....

.....

..... [2]

(c) The dots in Fig. 5.1a represent the positions of equally spaced water particles before a sound wave passes through the water.

The dots in Fig. 5.1b represent the positions of the same water particles at one particular instant of time as the sound wave passes through.

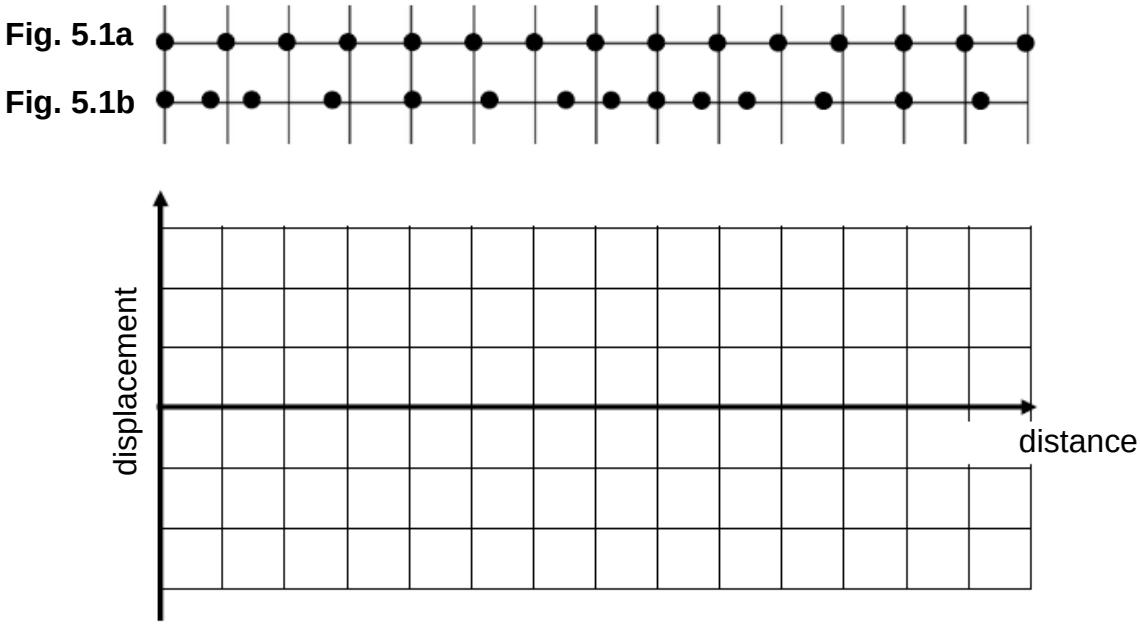

Fig. 5.2

(i) On Fig. 5.1b, mark out the wavelength of the sound wave and label it λ.

[1]

(ii) On Fig. 5.2, sketch the displacement-distance graph of the sound wave. Assume that positive displacement is to the right.

[1]

[Total: 6]

6 A student performs an experiment to demonstrate the refraction of light in a rectangular glass block.

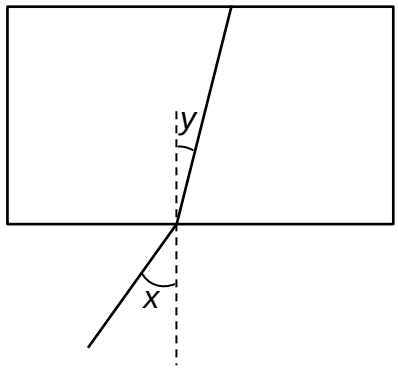

Fig. 6.1

He repeats the experiment with the incident ray at different angles. The values obtained for the angle of incidence *x* and the angle of refraction *y*, as shown in Fig. 6.1, are given in Table 6.2.

Table 6.2

x / °	0	10	20	30	40	50	60	70	80
y / °	0	7	13	20	26	31	36	39	42

(a) On Fig. 6.3, plot a graph of *y* against *x*. Draw the best fit curve through your points.

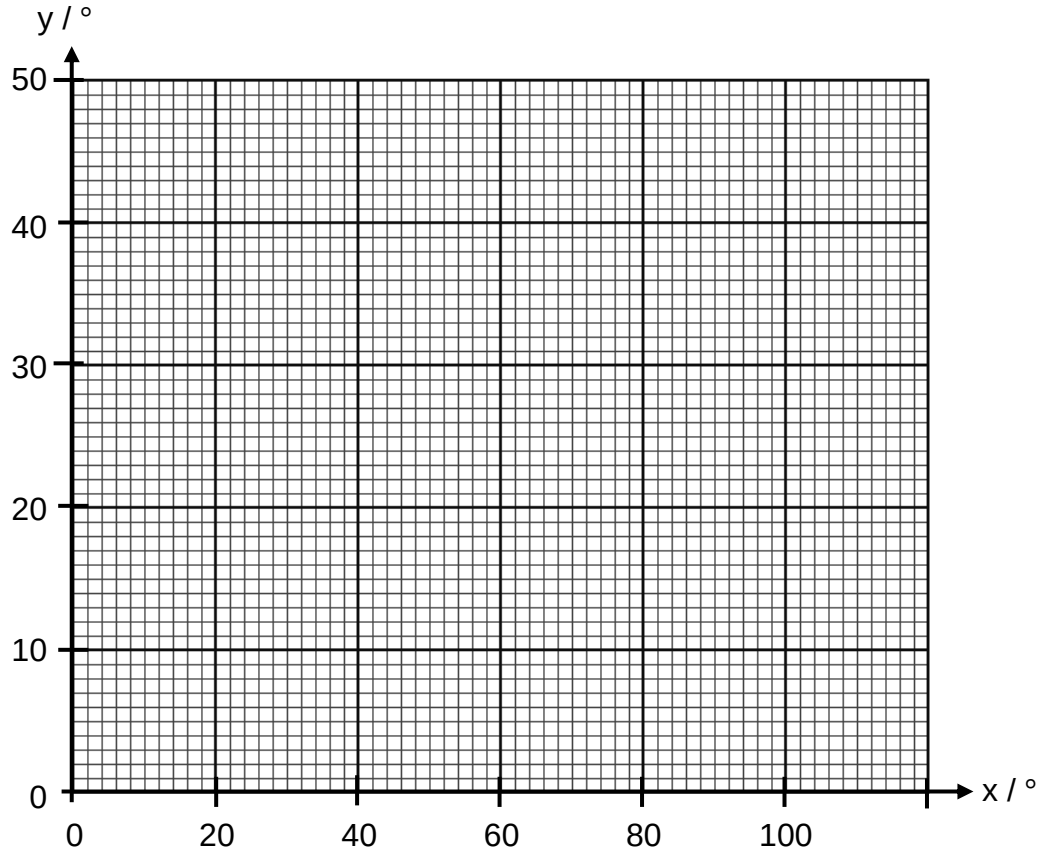

Fig. 6.3

[2]

(b) **Use your graph** to estimate the critical angle for glass. Explain how you obtained your result.

……

……

…… [2]

(c) The glass block used in the experiment is replaced by one having a larger refractive index. The experiment is repeated and a second graph is plotted.

(i) Predict how the second graph would look like, compared to the graph obtained in **(a)**.

……

…… [1]

(ii) Compare the value of the critical angle obtained from the second graph with that obtained in **(b)**.

……

…… [1]

[Total: 6]

7 Fig. 7.1 shows two vertical metal plates mounted on insulating stands placed a short distance apart. A high voltage d.c. power supply is used to charge the plates.

A charged conducting ball is suspended between the plates by a nylon thread clamped at Y. The rest position of the ball and thread is such that the thread makes an angle 15 ° with the vertical.

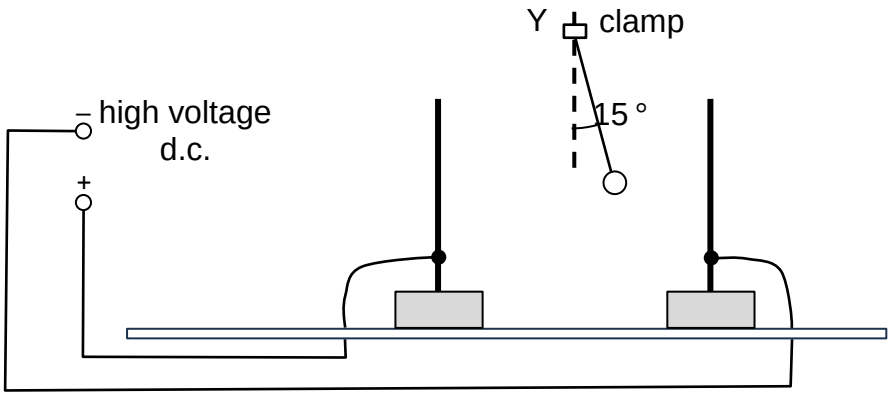

Fig. 7.1

(a) State and explain whether the charge on the ball is positive or negative.

……

…… [1]

(b) The plates are moved closer together until the plate on the right touches the ball, as shown in Fig. 7.2.

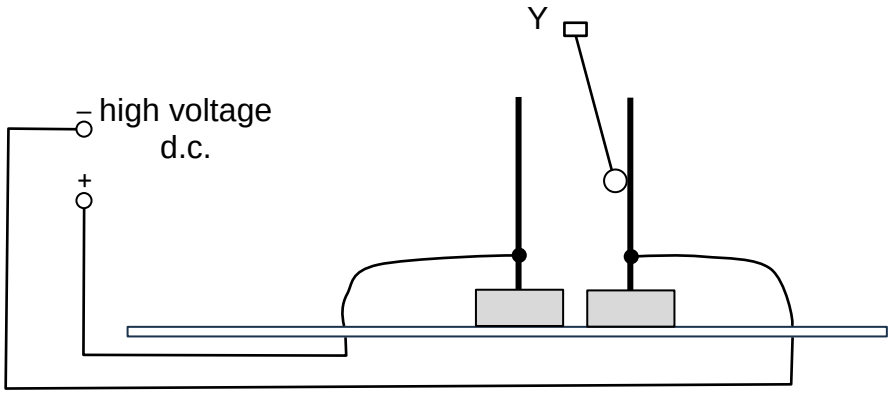

Fig. 7.2

Explain the subsequent motion of the ball.

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……

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……

…… [3]

[Total: 4]

8 Fig. 8.1 shows the structure of a circuit-breaker that uses an electromagnet. The circuit-breaker operates when the current in the circuit is 10 A.

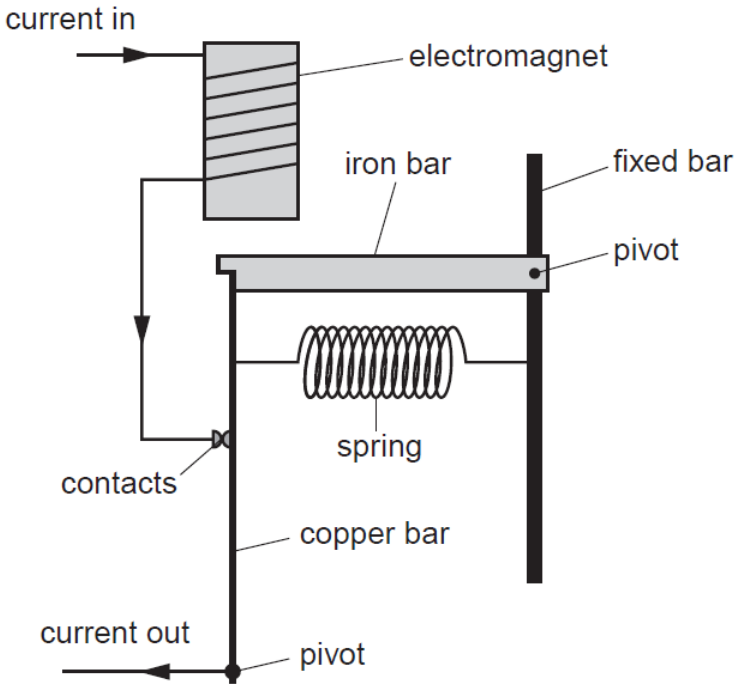

Fig. 8.1

(a) If the current is greater than 10 A, the circuit breaker will disconnect the circuit. Explain how this occurs.

.....

.....

.....

.....

.....

.....

..... [3]

(b) Suggest how the circuit-breaker can be altered so that it can disconnect the circuit when the current is less than 10 A.

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..... [1]

[Total: 4]

9 Fig. 9.1 shows a coil being rotated in the magnetic field between two magnets.

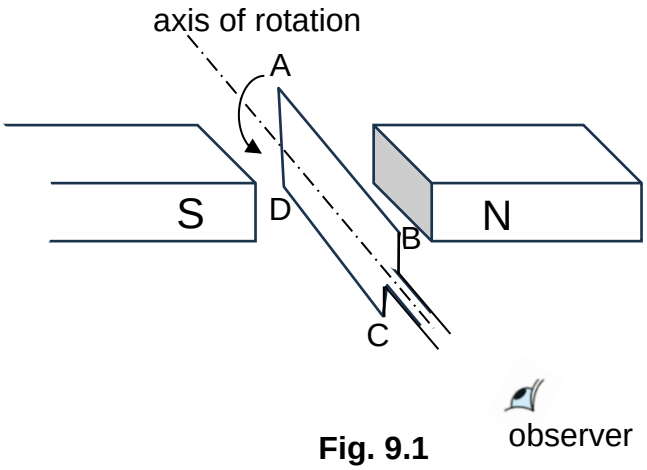

Fig. 9.1

Fig. 9.2 shows how the output voltage across the coil varies when the coil is rotated at a constant speed.

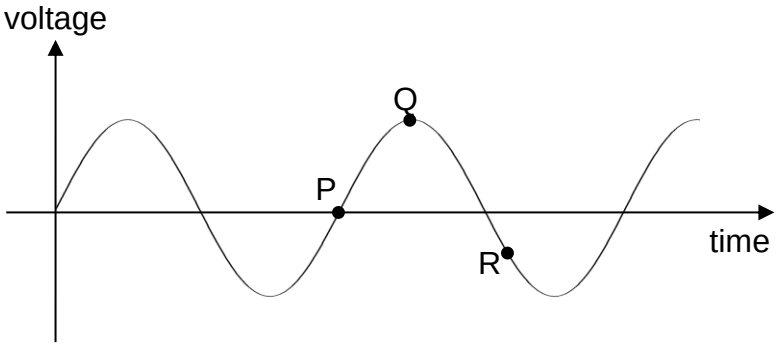

Fig. 9.2

(a) State and explain which of the points on Fig. 9.2, P, Q or R, could represent the voltage when the coil is at the position shown in Fig. 9.1.

.....

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.....

.....

..... [2]

(b) Draw, on Fig. 9.2, the graph of voltage against time if the speed of rotation of the coil is halved.

[2]

[Total: 4]

10 A smoke detector contains a small radioactive source of americium-241 (Am-241). The source emits an alpha-particle to form neptunium (Np) which has an atomic number 93. Americium-241 has a half-life of 430 years.

(a) Write down an equation to represent the decay of americium-241.

…… [1]

(b) Radium-224 is another element that emits alpha-particles. It has a half-life of 3.6 days.

Explain why americium-241 is more suitable as the radioactive source in a smoke detector than radium-224.

……

…… [1]

(c) A smoke detector contains 8.0×10^{11} atoms of americium-241.

Calculate the time taken for the number of atoms of americium-241 to fall to 1.0×10^{11}.

time = …… [2]

(d) When used correctly, the radioactive source in the smoke detector is less harmful than background radiation.

(i) State one harmful effect of background radiation.

……

…… [1]

(ii) A radioactive source is picked up using a long-handled tool. Explain why this is safer than using a short-handled tool.

……

…… [1]

[Total: 6]

11 With a vast range of cookware material to choose from, finding the best cookware for home cooking may seem like a real challenge.

In order for cookware to serve its function well, manufacturers take into consideration factors like thermal conductivity and specific heat capacity. Thermal conductivity measures the rate at which heat can pass through a material.

Table 11.1 gives a comparison of the thermal conductivity and specific heat capacity of some materials.

Table 11.1

material	thermal conductivity / W/(m °C)	specific heat capacity / J/(kg °C)
aluminium	237	897
copper	401	385
cast iron	29.5	449
fiberglass	0.045	840
plastic	0.03	2300
stainless steel	16.3	466

(a) Define the *specific heat capacity* of a material.

……

……

…… [1]

(b) Explain why frying pans are usually made of materials with a low specific heat capacity.

……

……

…… [1]

(c) State which material listed in Table 11.1 is the best conductor of heat.

…… [1]

(d) One manufacturer produced three hot plates made of different materials and with different mass and power ratings. The properties of the hot plates are shown in Table 11.2.

Table 11.2

hot plate	hot plate material	specific heat capacity of material / J/(kg °C)	mass / kg	power / W
A	copper	385	4.0	600
B	aluminium	897	2.5	1200
C	stainless steel	466	3.0	900

The initial temperature of each hot plate is 30 °C. The hot plates are ready to make pancakes when their temperature reach 150 °C.

(i) Calculate the time required for each of the hot plates to reach 150 °C.

time for hot plate A = ... [1]

time for hot plate B = ... [1]

time for hot plate C = ... [1]

(ii) Suggest another property of the hot plate, other than cost and the properties shown in Table 11.1 and Table 11.2, that should be considered when one is buying a hot plate.

.....

..... [1]

(e) Fig. 11.3 shows a saucepan containing water at room temperature placed on a hot plate which is switched on. The saucepan is made of stainless steel with a copper base and has a handle made of plastic.

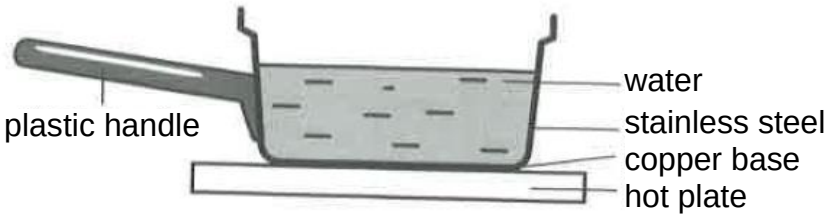

Fig. 11.3

(i) Suggest a reason why this saucepan with a copper base is better than a saucepan that is completely made of stainless steel.

……

…… [1]

(ii) The hot plate is switched off and the water in the saucepan is left to cool. When the saucepan and the water inside it have reached thermal equilibrium with the surrounding, a boy places his left hand on the handle of the saucepan and his right hand on its stainless steel body.

Explain whether the handle or stainless steel body of the saucepan would feel colder to touch, if there is any difference.

……

……

…… [2]

[Total: 10]

12 **(a)** A circuit contains a battery, two identical ammeters A_1 and A_2, and two resistors of resistance 4000 Ω and 2000 Ω respectively, as shown in Fig. 12.1.

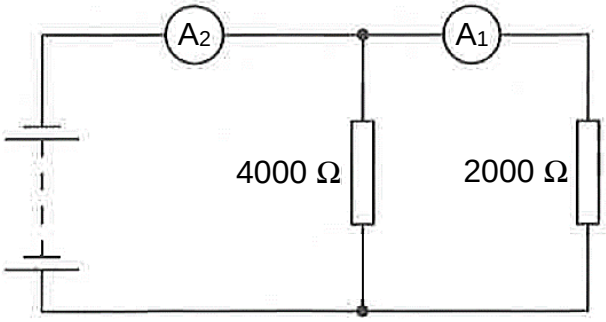

Fig. 12.1

The reading on ammeter A_1 is 2.0 mA.

(i) Determine the e.m.f. of the battery.

e.m.f. = ... [2]

(ii) Calculate the reading on ammeter A_2.

reading = ... [2]

(iii) Calculate the energy transferred in the 2000 Ω resistor in 5.0 minutes.

energy = ... [2]

(b) Component X is connected in series with a resistor Y of resistance 1.0 kΩ and a 12 V battery, as shown in Fig. 12.2.

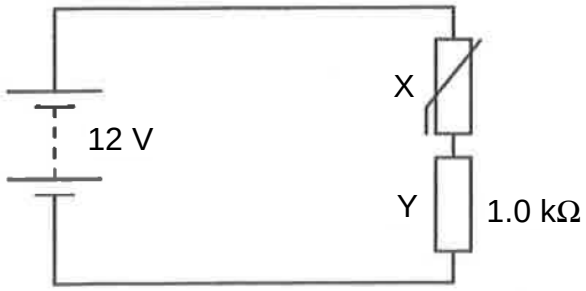

Fig. 12.2

Fig. 12.3 shows the variation with temperature of the resistance of X.

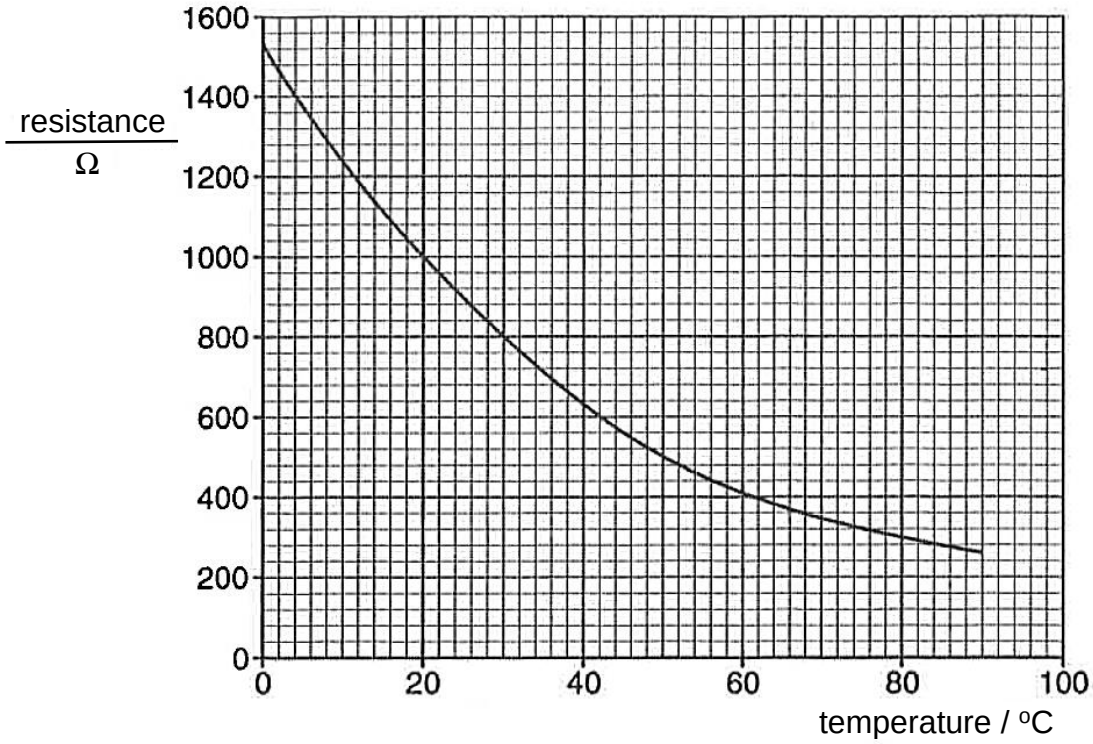

Fig. 12.3

(i) For a temperature of 30 °C, calculate the potential difference across resistor Y.

potential difference = ... [2]

(ii) The temperature rises. Without doing further calculation, state and explain what happens to the potential difference across resistor Y.

……

…… [1]

(iii) When the circuit in Fig. 12.2 is used, a fuse is connected in the circuit.

Explain how the fuse works.

……

…… [1]

[Total: 10]

Section B

Answer **one** question from this section.

13 Ejection seats are important devices in military planes. In an emergency, the pilot is ejected from the plane together with the seat. Fig. 13.1 shows an ejection seat and Fig. 13.2 shows the testing of the ejection process.

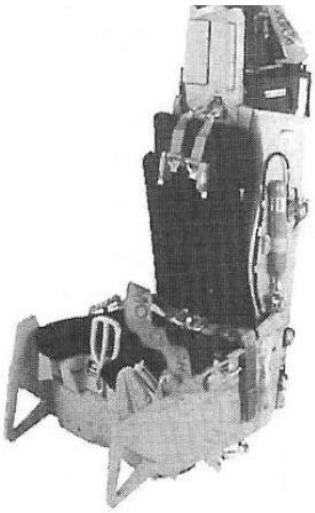

Fig. 13.1

Fig. 13.2

A dummy pilot sitting on the ejection seat is initially placed on the ground.

Fig. 13.3 shows the variation of the velocity v of the dummy with time t during the ejection process, which can be divided into two phases.

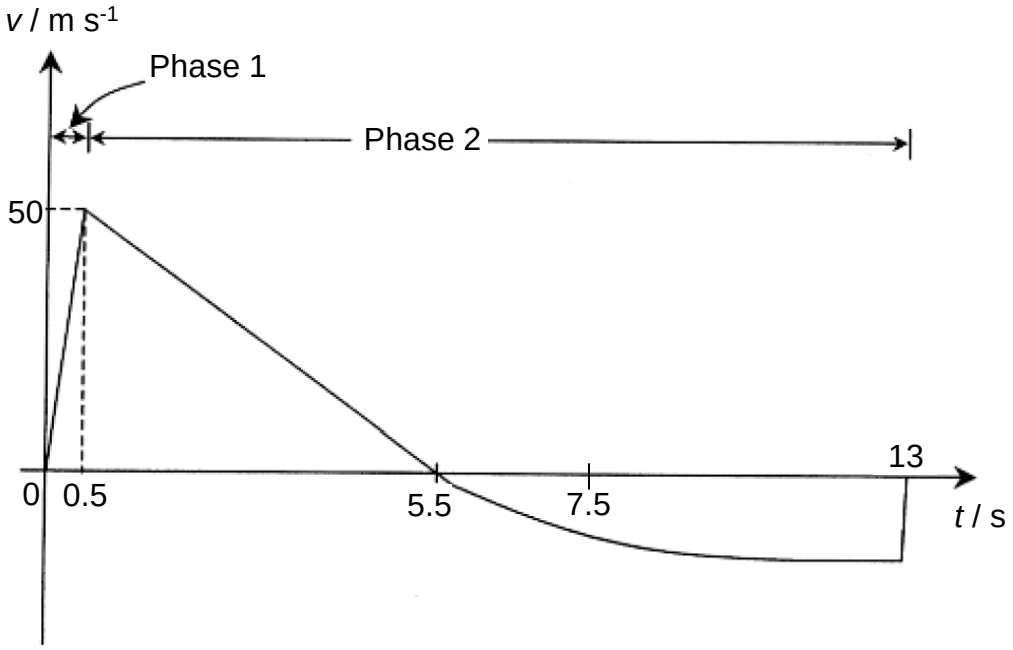

Fig. 13.3

Phase 1:
At t = 0 s, a rocket installed under the seat is ignited and the seat accelerates upward.

Phase 2:
The rocket exhausts its fuel. After a while, the seat reaches its maximum height. The seat is then detached from the dummy and a parachute carried by the dummy is opened. The dummy eventually reaches the ground.

Assume that the motion of the dummy is vertical throughout the process, and the effect of air resistance is negligible before the parachute is opened. The gravitational field strength is 10 N/kg.

(a) The mass of the dummy is 80 kg.

Calculate the force exerted by the ejection seat on the dummy in Phase 1.

force = …… [2]

(b) On Fig. 13.3, mark with a cross (X) the point on the graph which corresponds to the instant when the dummy reaches its maximum height above the ground. **Label** this point P.

[1]

(c) Calculate the maximum height above the ground reached by the dummy.

maximum height = …… [2]

(d) **(i)** Describe and explain, in terms of the forces acting, the motion of the dummy from t = 5.5 s to 7.5 s.

……

……

……

……

……

…… [3]

(ii) Explain, in terms of the forces acting, why the dummy eventually falls with a uniform velocity until it reaches the ground at t = 13 s.

……

……

……

…… [2]

[Total: 10]

14 Fig. 14.1 shows a trolley carrying a bar magnet. The trolley is placed on a glass plane. The north pole of the magnet faces a coil wound over the glass plane.

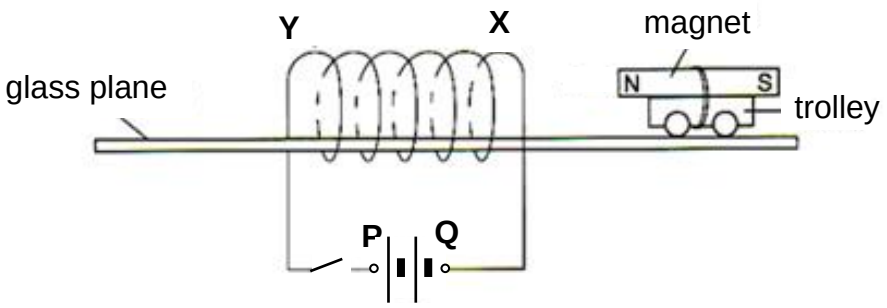

Fig. 14.1

(a) A battery is connected between **P** and **Q**.

State what happens to the trolley when the switch is closed.

…… [1]

(b) Explain your answer to **(a)**.

……

……

…… [2]

(c) State and explain whether there is any difference to the answer to **(a)** when

(i) the positive and negative terminals of the battery are swapped,

……

……

…… [2]

(ii) there are more turns of the coil.

……

……

……

……

…… [2]

(d) The battery is then replaced by a galvanometer, as shown in Fig. 14.2.

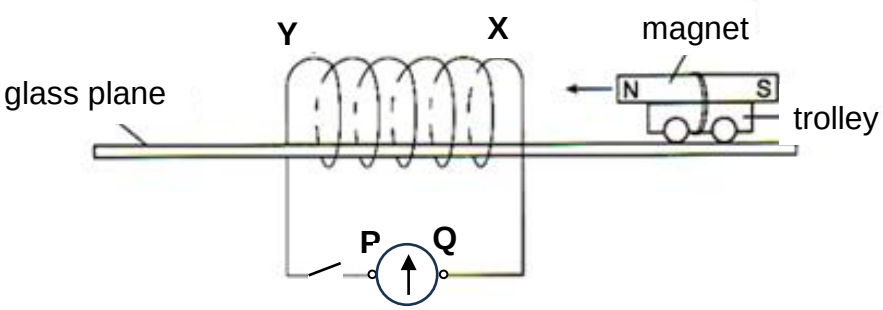

Fig. 14.2

(i) With the switch closed, explain why the galvanometer shows a deflection when the trolley is pushed towards the coil at **X**.

……

…… [1]

(ii) State the polarity at **X** when the trolley approaches the coil.

…… [1]

(iii) On Fig. 14.3, draw arrows to show the direction of the current in the coil when the magnet leaves the coil at **Y**.

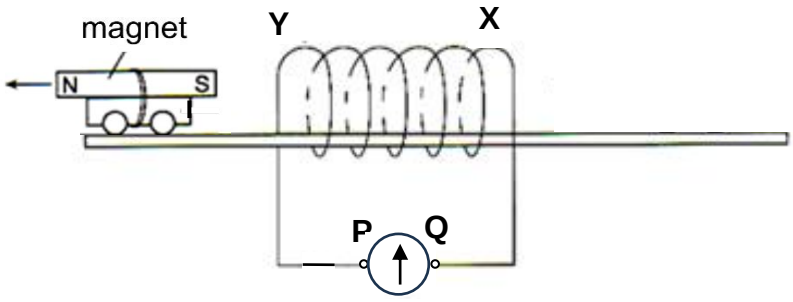

Fig. 14.3

[1]

[Total: 10]

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