Cambridge Assessment International Education

Cambridge O Level

CANDIDATE NAME

CENTRE NUMBER | CANDIDATE NUMBER

6454401533

PHYSICS **5054/22**

Paper 2 Theory **October/November 2023**

1 hour 45 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS
- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units
- Take the weight of 1.0 kg to be 9.8 N (acceleration of freefall = 9.8 m / s^2).

INFORMATION
- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **16** pages.

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[Turn over

1 Velocity is a vector quantity but speed is a scalar quantity.

(a) State how a vector quantity differs from a scalar quantity.

....

.... [1]

(b) Underline **all** the vector quantities in the list.

acceleration **distance** **energy** **mass** **momentum** **temperature** [1]

(c) Fig. 1.1 shows a passenger running across a large ship at right angles to the direction in which the ship is moving.

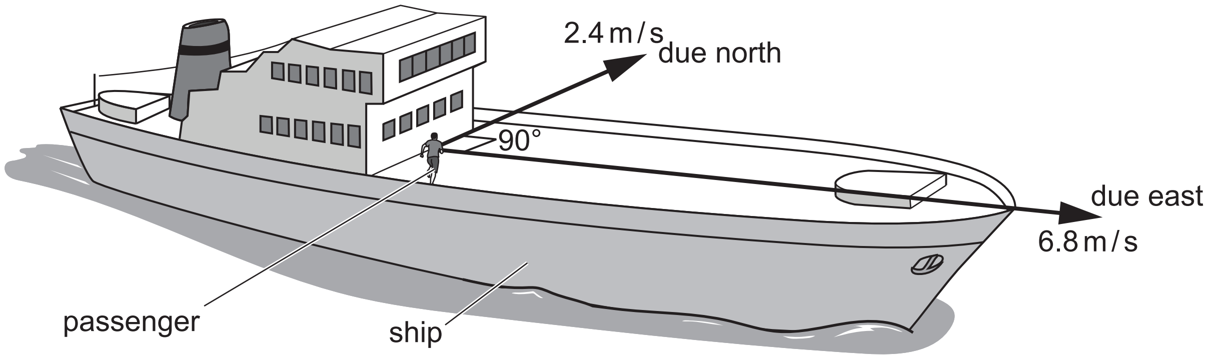

Fig. 1.1 (not to scale)

The passenger runs across the ship at 2.4 m / s due north.

The large ship is travelling due east at 6.8 m / s.

Determine, either graphically or by calculation, the resultant velocity of the passenger. Give the direction in which the passenger is moving relative to due north.

Show how the answer is obtained.

velocity = ... m / s at .... ° from due north [4]

[Total: 6]

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2 A spacecraft of mass 300 kg is moving in a straight line in space, at a speed of 8000 m/s.

(a) Calculate the momentum of the spacecraft.

momentum = ... kg m/s [2]

(b) The fuel on the spacecraft explodes and the spacecraft splits into two parts. The direction in which the parts move does not change.

(i) After the explosion, the speed of the front part increases to 9000 m/s. It has a mass of 150 kg.

Calculate the speed of the rear part after the explosion.

speed = ... m/s [3]

(ii) The total kinetic energy of the two parts after the explosion is greater than the original kinetic energy of the spacecraft.

State the energy transfer that occurs in the explosion.

....

.... [1]

(iii) The explosion lasts for 0.20 s.

Calculate the average force on the front part during this time.

force = ... N [3]

[Total: 9]

3 A plane, irregular lamina has a mass of 50 g. It hangs from a nail that passes through a small hole H near to the edge of the lamina.

The nail acts as a pivot and the lamina can swing about it. The lamina is held in the position shown in Fig. 3.1, a small distance above a horizontal bench.

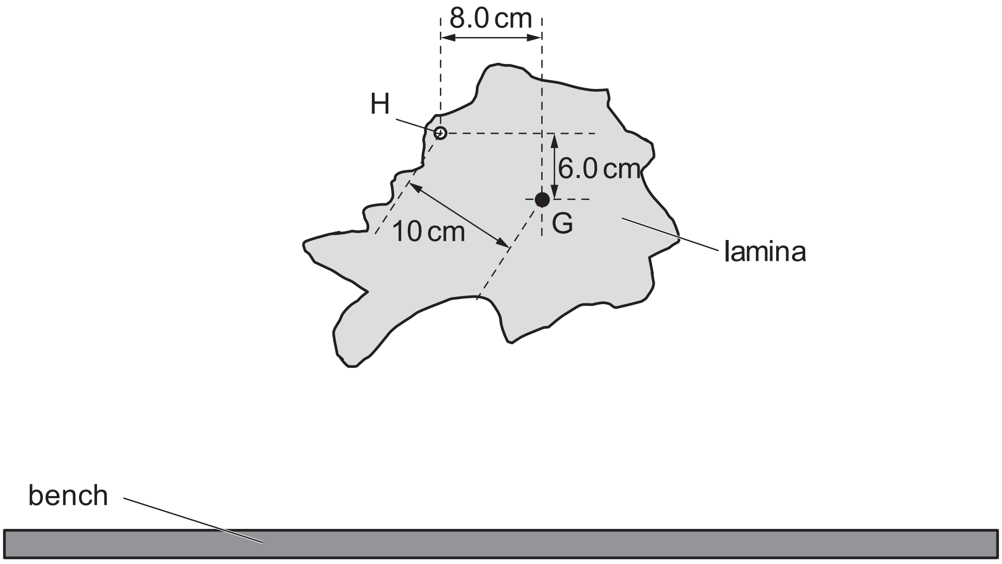

Fig. 3.1 (not to scale)

The centre of gravity of the lamina is at G.

(a) The weight of the lamina is a force that acts downwards.

(i) Explain why the lamina experiences this downward force.

....

.... [1]

(ii) Calculate the weight of the lamina on Earth.

weight = ... N [2]

(b) The weight produces a moment about the pivot through H.

(i) Using Fig. 3.1, calculate the moment of the weight about the pivot.

moment = ... N m [2]

(ii) The lamina is now released from the position shown in Fig. 3.1.

Describe what happens to the lamina from the time it is released until it stops moving.

....

....

....

.... [3]

[Total: 8]

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4 Fig. 4.1 shows a long vertical tube, sealed at the base and open at the other end.

The tube is 1.0 m long.

The cross-sectional area of the tube is $4.0 \times 10^{-4}\,m^2$.

It is filled with a liquid of density $1.4 \times 10^4\,kg/m^3$.

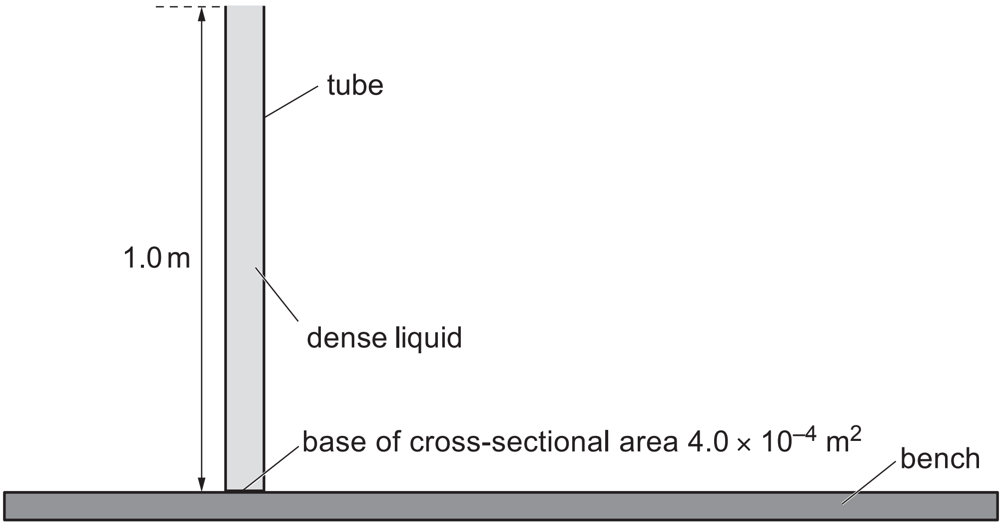

Fig. 4.1 (not to scale)

The atmospheric pressure is $1.0 \times 10^5\,Pa$.

(a) Calculate:

(i) the total pressure in the liquid at the bottom of the tube

total pressure = ... Pa [3]

(ii) the force exerted on the inside surface of the bottom of the tube.

force = ... N [2]

(b) A small sheet of glass is placed over the open end of the tube.

The tube is inverted in a container of the dense liquid.

The open end of the tube and the sheet of glass are a short distance below the surface of the liquid.

Fig. 4.2 shows the arrangement.

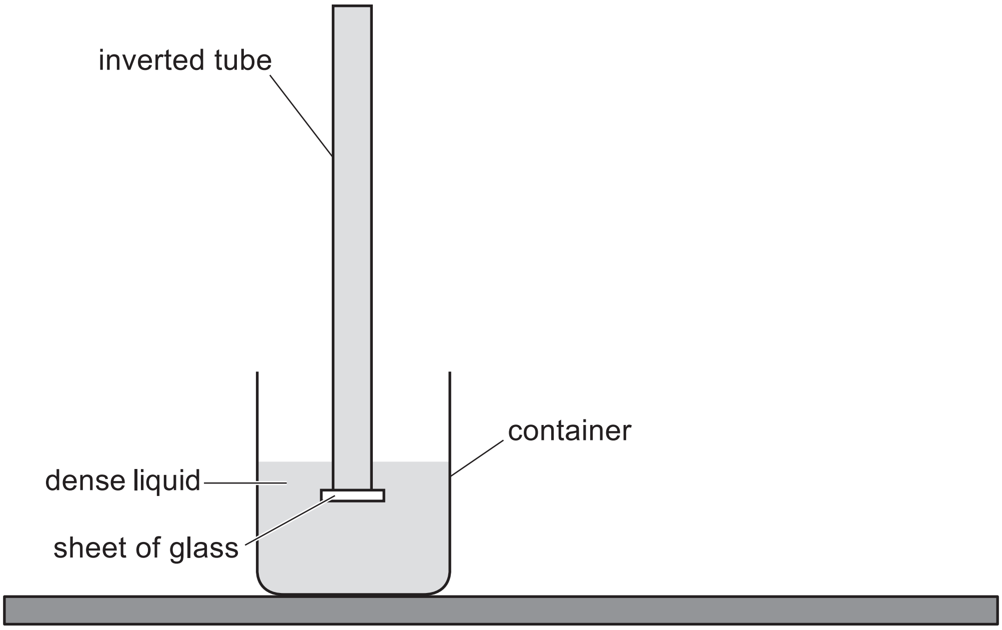

Fig. 4.2 (not to scale)

The sheet of glass seals the open end of the inverted tube.

(i) Describe what happens in the inverted tube when the sheet of glass is removed.

....

....

....

....

.... [3]

Question 4 continues over the page.

(ii) This equipment is used to make a measurement that is used to calculate atmospheric pressure.

Describe the measurement made and then used in the calculation of atmospheric pressure.

You may draw a diagram to help your description.

....

....

.... [2]

[Total: 10]

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5 Fig. 5.1 shows a device that cools the air in a room by evaporation.

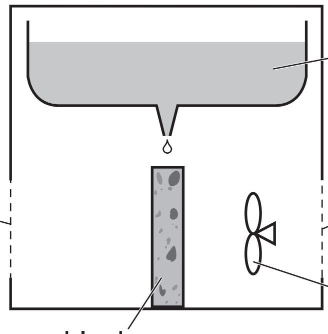

Fig. 5.1

Water drips from the container into the sponge block and keeps it wet.

Air flows in through one grille and out through the other.

As the air flows through the wet sponge block, the water in the sponge block evaporates.

(a) When the water evaporates, the temperature of water remaining in the sponge block decreases.

(i) Explain, in terms of the movement of particles, why this decrease in temperature occurs.

....

....

....

.... [2]

(ii) Explain why energy is needed when the water evaporates.

....

.... [1]

(b) State **two** ways in which evaporation differs from boiling.

1 ....

....

2 ....

....

[2]

[Total: 5]

6 The loudspeaker shown in Fig. 6.1 produces a sound of frequency 800 Hz.

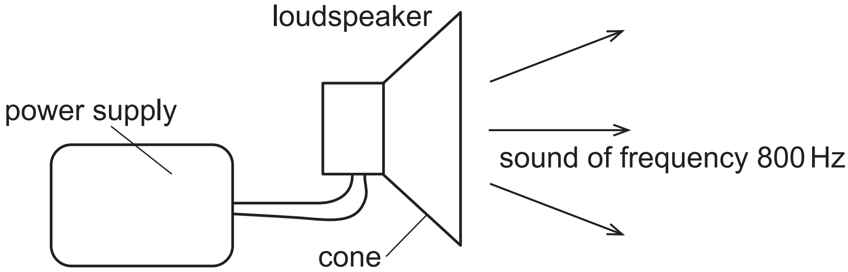

Fig. 6.1

(a) State what is meant by 'frequency'.

....

.... [2]

(b) Explain whether the sound produced by the speaker is audible to a human with healthy hearing.

....

.... [1]

(c) Describe the motion of the cone in Fig. 6.1 and explain how this causes the production of sound.

....

....

....

....

.... [3]

(d) The Sun is a very large and extremely violent ball of gas. Electromagnetic radiation from explosions on the surface of the Sun reaches the Earth.

Explain why sound from explosions on the surface of the Sun does **not** reach the Earth.

....

....

.... [2]

[Total: 8]

7 An electric circuit contains a battery, a fixed resistor R, a voltmeter and a thermistor.

Fig. 7.1 is an incomplete circuit diagram of the arrangement.

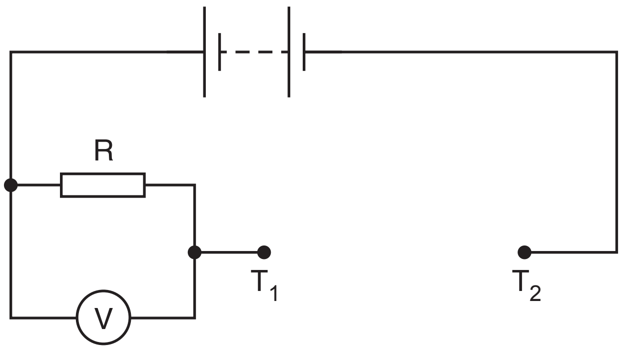

Fig. 7.1

The thermistor is connected between terminals T_1 and T_2.

(a) Complete Fig. 7.1 by drawing the circuit symbol for a thermistor connected between T_1 and T_2. [1]

(b) The resistance of R is 2.5 Ω. The reading on the voltmeter is 0.40 V.

Calculate:

(i) the current in R

current = ... A [2]

(ii) the power transferred in R.

power = ... W [2]

(c) The temperature of the thermistor increases.

Explain what happens to the reading on the voltmeter.

....

....

.... [2]

[Total: 7]

8 Fig. 8.1 shows a permanent magnet attached to one end of an unstretched spring and held at rest just above a solenoid.

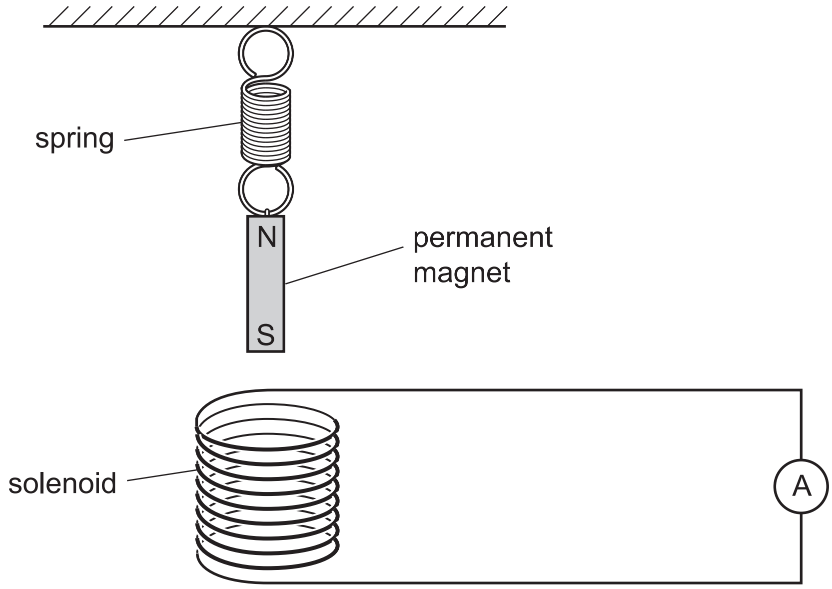

Fig. 8.1

The solenoid is connected to a sensitive ammeter.

(a) State the name of a substance from which permanent magnets are made.

.... [1]

(b) The magnet is released and moves downwards towards the solenoid.

The ammeter shows that there is a current in the solenoid when the magnet moves.

(i) Explain why there is a current in the solenoid.

....

....

....

....

.... [3]

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(ii) The current causes the top end of the solenoid to become the S pole of an electromagnet.

The bottom end of the permanent magnet is an S pole.

Explain why the top end of the solenoid becomes an S pole as the magnet moves downwards towards the solenoid.

....

....

.... [2]

(c) The magnet oscillates up and down.

Describe what happens to the current in the solenoid.

....

....

.... [2]

[Total: 8]

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

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

....

....

.... [2]

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

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

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

....

.... [1]

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

....

.... [1]

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

$$^{3}_{1}H \longrightarrow \, ^{.....}_{.....}\beta \; + \; ^{.....}_{.....}He$$

[2]

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

....

....

....

....

.... [3]

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

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

....

.... [1]

[Total: 10]

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10 The isotope iodine-131 emits two types of nuclear radiation. Gamma radiation is one of the types emitted.

A sample of iodine-131 produces a narrow beam of radiation which passes into a magnetic field.

Fig. 10.1 shows some of the paths taken in the magnetic field by the radiation emitted from the sample.

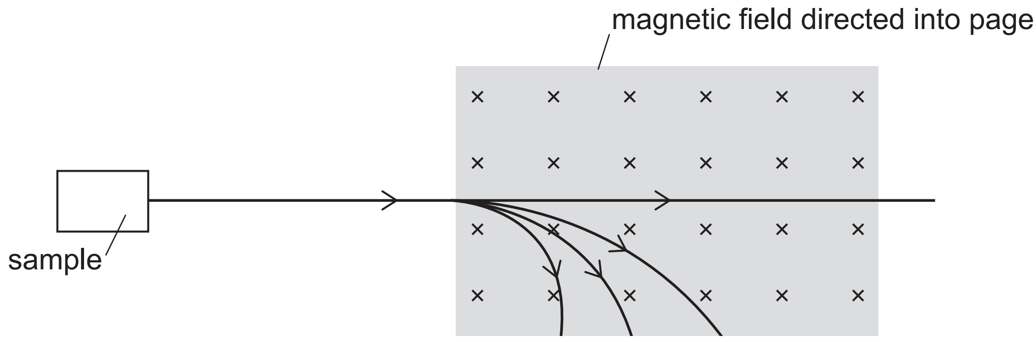

Fig. 10.1

(a) The direction of the magnetic field is into the page.

(i) On Fig. 10.1, mark with a gamma symbol (γ) any of the paths taken by the gamma radiation. [1]

(ii) Determine the other type of radiation emitted by iodine-131.

Explain how you obtain your answer.

type of radiation ....

explanation ....

....

....

.... [4]

(iii) In another experiment, the beam of radiation from the sample is incident on a 5 mm thick sheet of lead.

State what happens to the two types of radiation in the beam.

....

....

.... [2]

Question 10 continues over the page.

(b) The gamma radiation produced has a frequency of 8.8×10^{19} Hz.

The speed of electromagnetic radiation in a vacuum is 3.0×10^{8} m / s.

Calculate the wavelength of this gamma radiation in a vacuum.

wavelength = ... m [2]

[Total: 9]

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