Diploma Programme
Programme du diplôme
Programa del Diploma

Physics
Standard level
Paper 2

Thursday 3 November 2022 (afternoon)

Candidate session number

1 hour 15 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **physics data booklet** is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

8822 – 6505

Answer **all** questions. Answers must be written within the answer boxes provided.

1. A raindrop falls vertically from rest.

(a) State the initial acceleration of the raindrop. [1]

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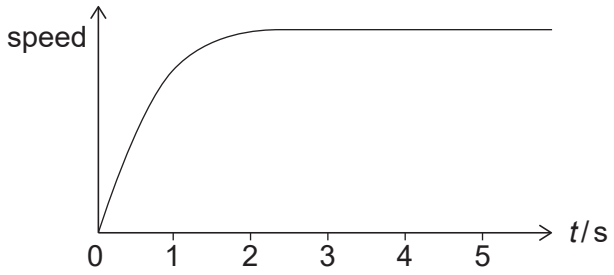
The graph shows how the speed of the raindrop varies with time *t*.



(b) Explain, by reference to the vertical forces, how the raindrop reaches a constant speed. [3]

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(Question 1 continued)

(c) During the first 3.0 s of motion, the raindrop falls a distance of 21 m and reaches a speed of 9.0 m s^{-1}. The mass of the raindrop is 34 mg. The temperature of the raindrop does not change.

(i) Determine the energy transferred to the air during the first 3.0 s of motion. State your answer to an appropriate number of significant figures. [3]

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(ii) Describe the energy change that takes place for $t > 3.0$ s. [1]

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2. A solar heating panel is placed on the roof of a house in order to heat water in a storage tank. The rest of the roof is covered with tiles.

(a) On a certain day, the intensity of the solar radiation that is incident perpendicular to the surface of the panel is $680\,W\,m^{-2}$.

The following data are available.

Mass of the water in the tank = 250 kg

Initial temperature of the water in the tank = 15 °C

Specific heat capacity of water = $4200\,J\,kg^{-1}\,K^{-1}$

Overall efficiency of the heating system = 0.30

Albedo of the roof tiles = 0.20

Emissivity of the roof tiles = 0.97

(i) Determine the minimum area of the solar heating panel required to increase the temperature of all the water in the tank to 30°C during a time of 1.0 hour. [3]

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(ii) Estimate, in °C, the temperature of the roof tiles. [3]

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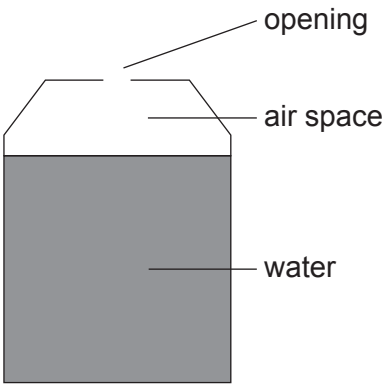
(Question 2 continued)

(b) There is an air space above the water in the storage tank with an opening to the atmosphere. Assume that air behaves like an ideal gas.



(i) State **one** way in which a real gas differs from an ideal gas. [1]

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The air space is always at constant atmospheric pressure and constant volume, as the water level is kept constant. The air-space temperature and water temperature are the same.

(ii) The water is heated. Explain why the quantity of air in the storage tank decreases. [2]

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(c) Another method of harnessing solar energy involves the use of photovoltaic cells.

Distinguish between photovoltaic cells and solar heating panels. [1]

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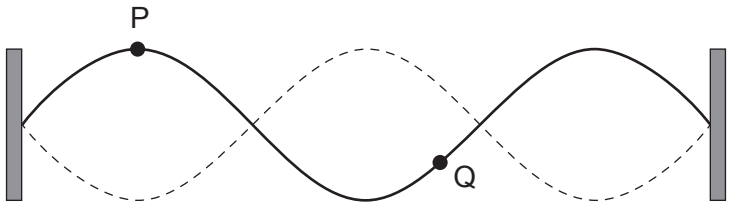
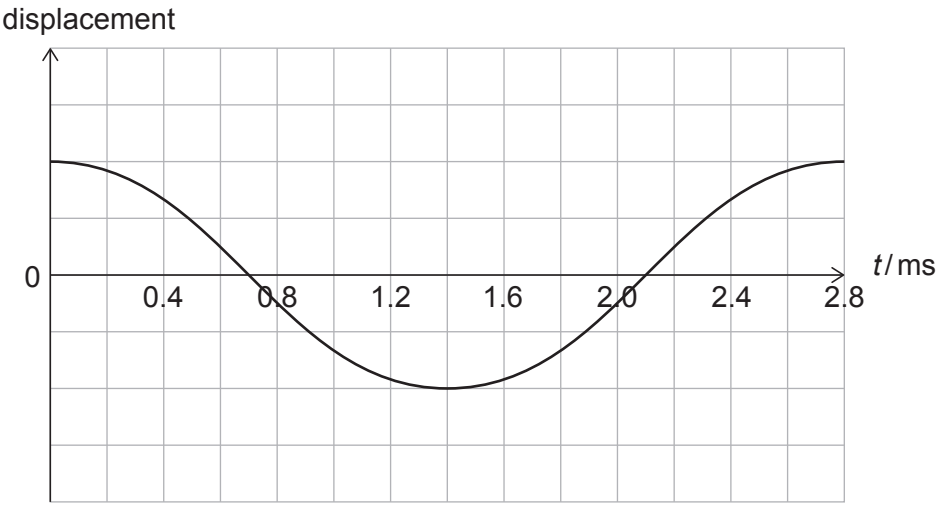
3. A string of length 0.80 m is fixed at both ends. The diagram shows a standing wave formed on the string. P and Q are two particles on the string.



(a) The variation with time *t* of the displacement of particle P is shown.



(i) Draw, on the axes, a graph to show the variation with *t* of the displacement of particle Q. [2]

(ii) Calculate the speed of waves on the string. [2]

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(Question 3 continued)

(b) It is suggested that the speed c of waves in the string is related to the tension force T in the string according to the equation $T = ac^2$, where a is a constant.

(i) Determine the fundamental SI unit for a. [2]

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(ii) The tension force on the string is doubled. Describe the effect, if any, of this change on the frequency of the standing wave. [2]

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(c) The standing wave on the string creates a travelling sound wave in the surrounding air.

Outline **two** differences between a standing wave and a travelling wave. [2]

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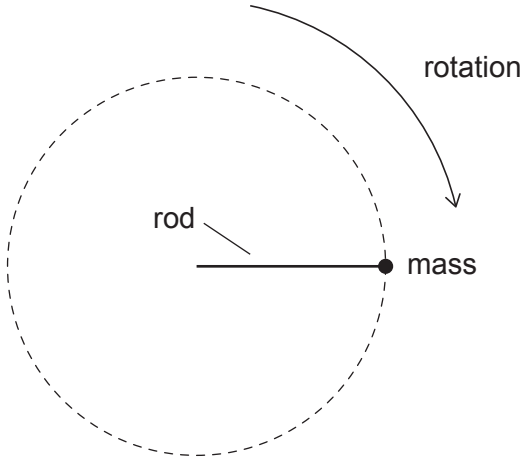
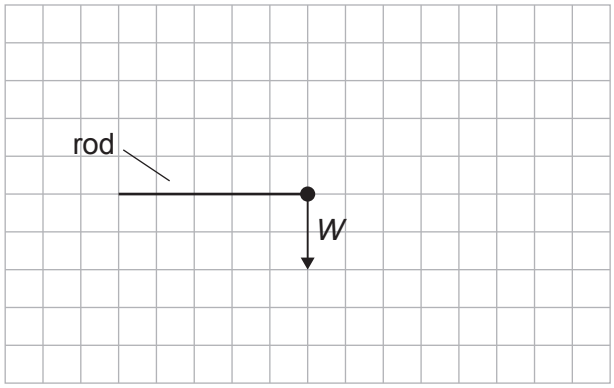
4. A mass is attached to one end of a rod and made to rotate with constant speed in a vertical circle.



(a) The scale diagram shows the weight *W* of the mass at an instant when the rod is horizontal.

Draw, on the scale diagram, an arrow to represent the force exerted on the mass by the rod. [2]



(b) Explain why the magnitude of the force exerted on the mass by the rod is not constant. [3]

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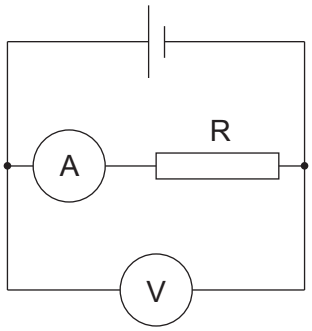
5. Resistor R is connected in a circuit with a cell that has internal resistance.



The ammeter and the voltmeter are ideal.

(a) State what is meant by an ideal voltmeter. [1]

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(b) The cell has an emf of 1.49 V. The resistance of R is 50.0 Ω. The voltmeter reads 1.47 V.

(i) Show that the internal resistance of the cell is about 0.7 Ω. [2]

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(ii) Determine the total power dissipated in the circuit. [2]

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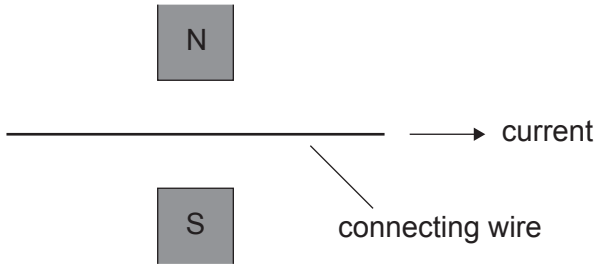
(Question 5 continued)

One of the connecting wires is placed in a magnetic field. The direction of the current in the wire is shown.



(c) (i) Explain, by reference to charge carriers in the wire, how the magnetic force on the wire arises. [2]

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(ii) Every current-carrying wire produces a magnetic field.

Describe **one** piece of evidence that supports this statement. [1]

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6. (a) Outline, by reference to nuclear binding energy, why the mass of a nucleus is less than the sum of the masses of its constituent nucleons. [2]

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Polonium-210 (Po-210) decays by alpha emission into lead-206 (Pb-206).

The following data are available.

Nuclear mass of Po-210 = 209.93676 u

Nuclear mass of Pb-206 = 205.92945 u

Mass of the alpha particle = 4.00151 u

(b) (i) Calculate, in MeV, the energy released in this decay. [2]

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(ii) The polonium nucleus was stationary before the decay.

Show, by reference to the momentum of the particles, that the kinetic energy of the alpha particle is much greater than the kinetic energy of the lead nucleus. [3]

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(Question 6 continued)

(iii) In the decay of polonium-210, alpha emission can be followed by the emission of a gamma photon.

State and explain whether the alpha particle or gamma photon will cause greater ionization in the surrounding material. [2]

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