

**PHYSICS  
 STANDARD LEVEL  
 PAPER 2**

Thursday 2 May 2002 (afternoon)

1 hour

Name

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Number

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**INSTRUCTIONS TO CANDIDATES**

- Write your candidate name and number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: Answer all of Section A in the spaces provided.
- Section B: Answer one question from Section B in the spaces provided.
- At the end of the examination, indicate the number of the Section B question answered in the box below.

QUESTIONS ANSWERED		EXAMINER	TEAM LEADER	IBCA
SECTION A	ALL	/25	/25	/25
SECTION B	.....	/25	/25	/25
		TOTAL /50	TOTAL /50	TOTAL /50

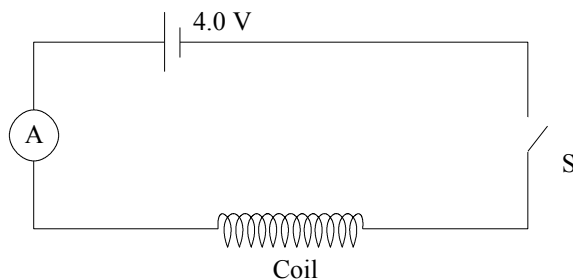
**SECTION A**

Candidates must answer **all** questions in the spaces provided.

**A1.** This question is about the growth of an electric current in a coil.

When a coil is connected to a d.c. power supply the current in the coil does not change instantaneously but takes a finite time to reach a steady value. For a given supply the final, steady value of the current is determined by the resistance ( $R$ ) of the coil.

In the diagram below a coil is connected to a d.c. supply of emf 4.0 V.

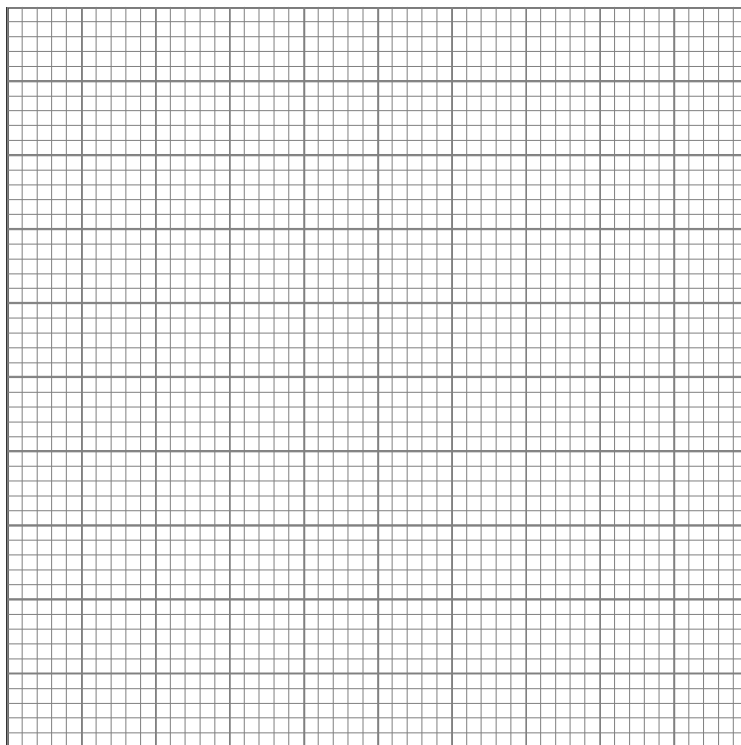


When the switch S is closed an electronic timer is started and the current  $I$  is recorded at different values of the time  $t$ . The results are shown in the table below. (Uncertainties in measurement are not shown.)

$t/s$	0	0.2	0.6	1.0	1.4	1.8	2.0
$I/A$	0	0.8	1.6	1.9	2.0	2.0	2.0

(a) Plot a graph of current against time.

[5]



(This question continues on the following page)

(Question A1 continued)

(b) What is the steady state value of the current? [1]

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(c) Determine the value of the resistance  $R$  of the coil. [1]

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(d) By drawing a tangent to the curve at the point (0, 0) on your graph, determine the time it would take for the current to reach its steady state value if it were to continue changing at its initial rate. (This time is known as the **time constant** of the coil.) [2]

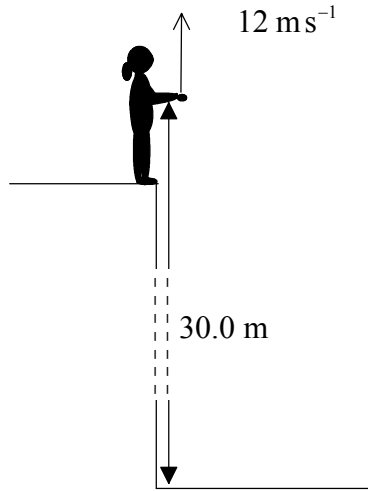
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(e) The initial rate at which the current in the coil changes is determined by a property of the coil known as its inductance ( $L$ ). If the time constant of the coil is given by the expression  $\frac{L}{R}$  determine the value of the inductance  $L$  of the coil. [1]

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A2. This question is about vertical motion under gravity.

A girl stands on the edge of a vertical cliff and throws a stone vertically upwards. The stone eventually lands in the sea below. The stone leaves her hand with a speed of  $12 \text{ m s}^{-1}$  at a height of  $30.0 \text{ m}$  above the sea.



Taking the acceleration due to gravity to be  $10 \text{ m s}^{-2}$  and ignoring air resistance determine

(a) the maximum height, measured from sea-level, reached by the stone. [2]

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(b) the time that it takes the stone to hit the sea after leaving the girl's hand. [5]

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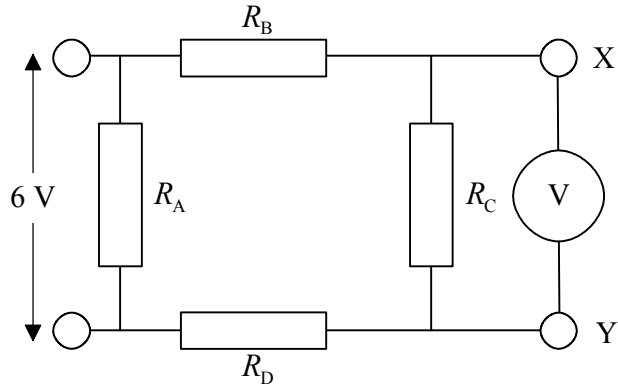
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*(Question A2 continued)*

- (c) In the space provided below sketch a graph to show how the **speed** of the stone varies with time from the moment it leaves her hand to just before it hits the sea. *(Note that this is a sketch graph; you do not need to add values to the axes.)* [2]

A3. This question is about testing an electrical circuit.

The diagram below shows an electrical circuit consisting of four identical resistors  $R_A$ ,  $R_B$ ,  $R_C$ , and  $R_D$ . The resistance of each resistor is  $10\text{ k}\Omega$ .



- (a) Commercial resistors sometimes fail in one of two ways. They can go “open-circuit” in which the resistance of the resistor becomes infinite **or** they can go “short-circuit” in which the resistance becomes zero.

In order to test the circuit a technician connects a high resistance voltmeter between the terminals X and Y and applies a potential difference of 6 V across the resistor  $R_A$ .

- (i) What voltage will the voltmeter read if all the resistors are functioning normally? [2]

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- (ii) What would the voltmeter read if **either** resistor  $R_B$  **or**  $R_D$  were to short-circuit? [1]

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- (iii) If the electrician were to note a reading on the voltmeter that suggested **either**  $R_B$  **or**  $R_D$  had short-circuited how could he test which **one** of these had in fact short-circuited using only the voltmeter? [2]

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- (b) Identify a possible fault with the circuit that would produce a reading of 6 V on the voltmeter when it is connected between X and Y. [1]

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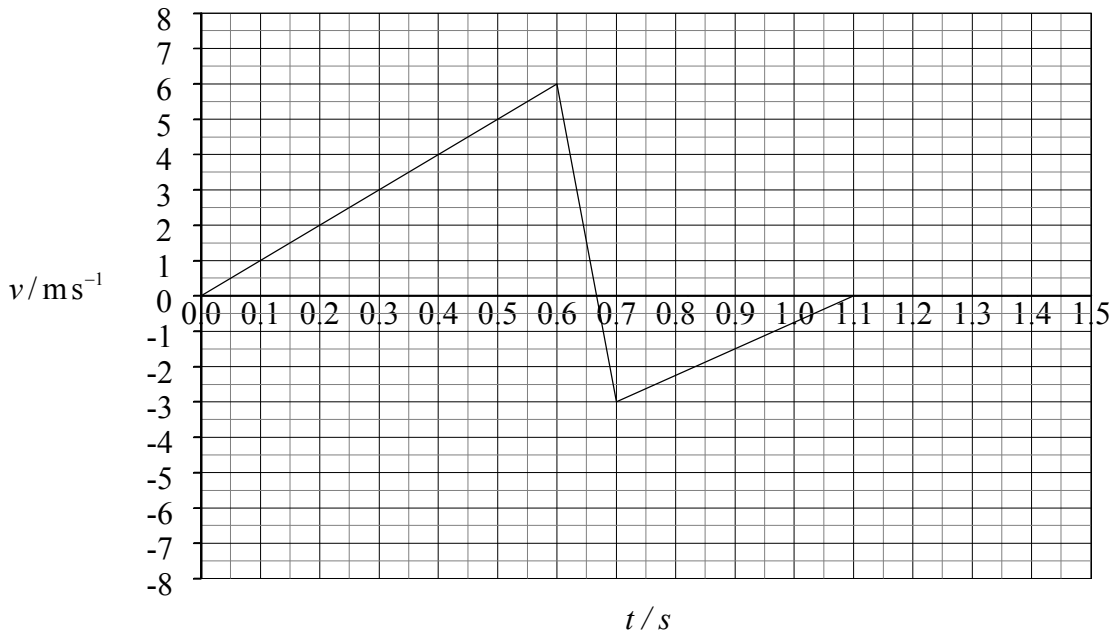
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**SECTION B**

This section consists of three questions: B1, B2 and B3. Answer **one** question in this section.

**B1.** This question is about a bouncing ball.

A soft rubber ball of mass 0.20 kg is dropped from rest on to a flat horizontal surface and it is caught at its maximum height of rebound. A sonic data logger is used to record the velocity of the ball as a function of time. The graph below shows how the velocity of the ball varies with time  $t$  from the instant it is released to the instant that it is caught.



(a) Mark on the graph above the time  $t_1$  where the ball hits the surface and the time  $t_2$  where it just loses contact with the surface. [2]

(b) Use data from the above graph to determine

(i) the acceleration due to gravity. [3]

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(ii) the height to which the ball rebounds. [3]

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(Question B1 continued)

- (c) Use data from the graph opposite to find the change in momentum of the ball between  $t_1$  and  $t_2$ . [3]

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- (d) Determine the magnitude of the average force that the ball exerts on the surface. [4]

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- (e) Explain how the collision between the ball and the surface is consistent with the principle of momentum conservation. [2]

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- (f) Is the magnitude of the force that the surface exerts on the ball greater than, smaller than **or** equal to the force that the ball exerts on the surface? Explain. [3]

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- (g) A hard rubber ball of the same mass as the soft rubber ball is dropped from the same height as that from which the soft rubber ball was dropped.

Given that the hard rubber ball exerts a greater force on the surface than the soft rubber ball, sketch on the graph opposite how you think the velocity of the hard rubber ball will vary with time. (Note that this is a sketch graph; you do not need to add any values.) [5]

**B2.** This question is in **two** parts. **Part 1** is about the behaviour of an ideal gas and **Part 2** is about magnetic forces.

**Part 1.** Ideal gas behaviour

(a) Explain in terms of the microscopic (kinetic) model of an ideal gas

(i) the difference between the temperature of an ideal gas and its internal energy. [4]

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(ii) why the temperature of a gas, contained in a cylinder fitted with a moveable piston, rises when it is compressed rapidly. [2]

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(b) An ideal gas is contained in a cylinder fitted with a moveable piston. The mass of the gas is  $4.0 \times 10^{-3}$  kg and the specific heat of the gas at constant volume is  $3.1 \times 10^3$  J kg<sup>-1</sup> K<sup>-1</sup>. The gas is initially at a temperature of 27 °C and pressure  $1.0 \times 10^5$  Pa.

Diagram 1 shows five of the molecules of the gas and their associated velocity vectors.

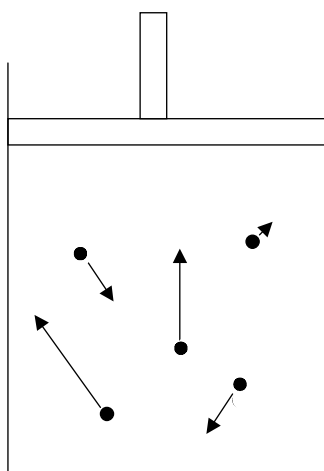


Diagram 1

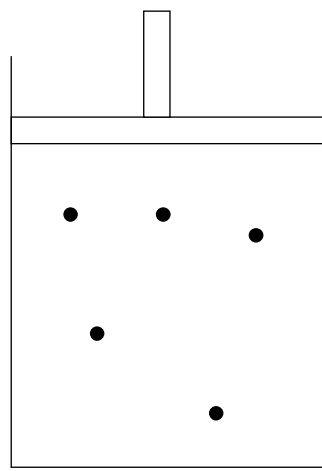


Diagram 2

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*(Question B2 part 1 (b) continued)*

The gas is now heated at constant volume until its pressure becomes  $2.0 \times 10^5$  Pa.

(i) Add velocity vectors to the molecules in Diagram 2 opposite to show how you think that, on average, the velocities of the molecules will have changed from the velocities shown in Diagram 1. [2]

(ii) Calculate the temperature of the gas after it has been heated at constant volume. [2]

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(iii) Determine the thermal energy given to the gas when it is heated. [3]

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(c) The gas is now compressed at constant temperature until its volume is half its original volume. Calculate the pressure of the gas after compression at constant temperature. [3]

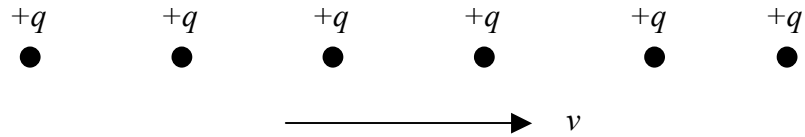
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(Question B2 continued)

**Part 2.** Magnetic forces

The diagram below shows a beam of charged particles moving in a straight line with speed  $v$ . Each particle has a charge  $+q$  and there are  $N$  particles in length  $L$  of the beam.



- (a) How far do the particles travel in time  $\Delta t$ ? [1]

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- (b) How many particles pass a given point in a time  $\Delta t$ ? [2]

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- (c) Using your answers to (a) and (b) above show that the current  $I$  carried by the beam is given by the expression

$$I = \frac{Nvq}{L}. \quad [2]$$

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- (d) When a uniform magnetic field of strength  $B$  is applied at right angles to the direction of motion of the particles each particle experiences a force of magnitude  $Bqv$ .

If the direction of the field is into the plane of the paper show, on the above diagram, the direction of the magnetic force on **one** of the charges. [1]

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*(Question B2 part 2 continued)*

- (e) Show that a force  $Bqv$  on each particle is equivalent to a length  $L$  of the beam experiencing a force of magnitude  $BIL$ .

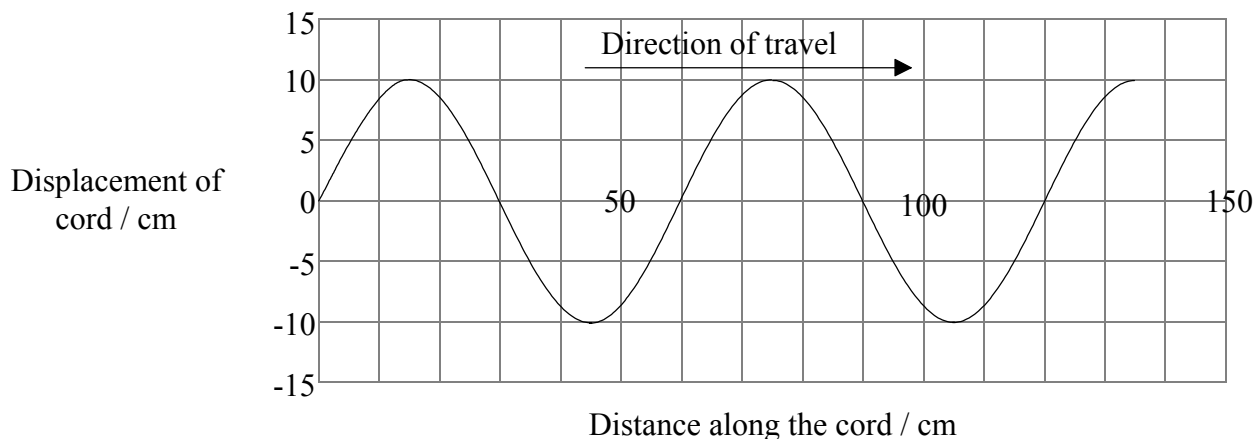
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**B3.** This question is in **two** parts. **Part 1** is about waves in a rubber cord and **Part 2** is about radioactive decay.

**Part 1.** Waves in a rubber cord

The diagram below shows part of a rubber cord along which a wave is travelling.



(a) For this wave determine  
(i) its amplitude. [1]

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(ii) its wavelength. [1]

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(b) The period of the wave is 0.2 s. What is the speed of the wave? [2]

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(c) If the above diagram shows the displacement of the cord at time  $t = 0$ , sketch on the same diagram the displacement of the rubber cord at time 0.1 s later. Explain your sketch. [3]

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*(Question B3 part 1 continued)*

(d) The rubber cord is now stretched between two fixed points 2.5 m apart. If a wave is set up in the cord it travels with a speed of  $10 \text{ m s}^{-1}$ .

(i) On the diagram below sketch the shape of the standing (stationary) wave pattern produced when the cord is set to vibrate at its fundamental frequency. [1]

\_\_\_\_\_ Undisturbed cord

(ii) Calculate the fundamental frequency of vibration. [3]

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(iii) What is the frequency of vibration of the first harmonic of the stretched cord? [1]

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(Question B3 continued)

**Part 2.** Radioactive decay

(a) Explain what is meant by the terms

(i) *isotope*. [2]

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(ii) *half-life*. [1]

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(b) The isotope  $^{220}_{86}\text{Rn}$  (radon) decays by  $\alpha$  emission to an isotope of polonium. For this isotope of **polonium** determine

(i) the atomic number. [1]

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(ii) the number of neutrons in the nucleus. [2]

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(c) Alpha radiation is an ionising radiation. Explain what is meant by the term *ionising radiation*. [2]

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(Question B3 part 2 continued)

(d) A certain sample of radon produces an initial ionisation current in air of  $4.0 \times 10^{-11}$  A.

(i) The radon emits  $\alpha$ -particles. Assuming that when an  $\alpha$ -particle collides with an air molecule it “knocks off” only one electron from the molecule, show that the initial rate at which ion pairs are produced by the  $\alpha$ -particles from this sample of radon is  $2.5 \times 10^8 \text{ s}^{-1}$ . [2]

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(ii) The energy of the emitted  $\alpha$ -particles is 1.5 MeV. If it requires 30 eV of energy to produce one ion pair, how many ions are produced by **one**  $\alpha$ -particle? [1]

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(iii) Calculate the initial activity of the radon. [2]

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