

**Physics**  
**Standard level**  
**Paper 2**

Thursday 10 May 2018 (afternoon)

Candidate session number

1 hour 15 minutes

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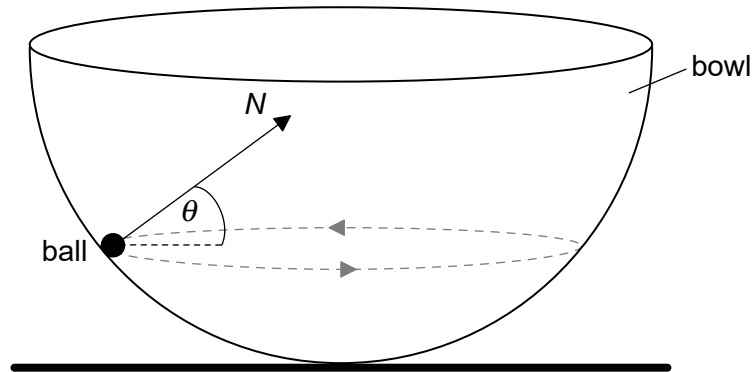
**Instructions to candidates**

- 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]**.



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

1. (a) A small ball of mass  $m$  is moving in a horizontal circle on the inside surface of a frictionless hemispherical bowl.



The normal reaction force  $N$  makes an angle  $\theta$  to the horizontal.

- (i) State the direction of the resultant force on the ball. [1]

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- (ii) On the diagram, construct an arrow of the correct length to represent the weight of the ball. [2]

(This question continues on the following page)



**(Question 1 continued)**

- (iii) Show that the magnitude of the net force  $F$  on the ball is given by the following equation. [3]

$$F = \frac{mg}{\tan \theta}$$

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- (b) The radius of the bowl is 8.0 m and  $\theta = 22^\circ$ . Determine the speed of the ball. [4]

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- (c) Outline whether this ball can move on a horizontal circular path of radius equal to the radius of the bowl. [2]

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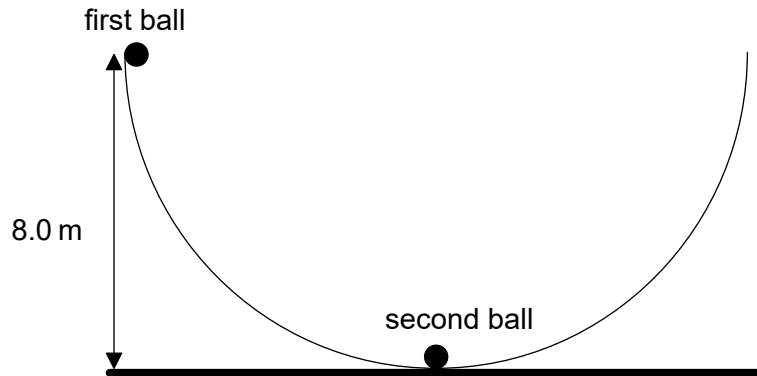


16EP03

**Turn over**

(Question 1 continued)

- (d) A second identical ball is placed at the bottom of the bowl and the first ball is displaced so that its height from the horizontal is equal to 8.0 m.



The first ball is released and eventually strikes the second ball. The two balls remain in contact. Determine, in m, the maximum height reached by the two balls.

[3]

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16EP04

2. (a) An ideal monatomic gas is kept in a container of volume  $2.1 \times 10^{-4} \text{ m}^3$ , temperature 310 K and pressure  $5.3 \times 10^5 \text{ Pa}$ .

(i) State what is meant by an ideal gas. [1]

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(ii) Calculate the number of atoms in the gas. [1]

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(iii) Calculate, in J, the internal energy of the gas. [2]

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(b) The volume of the gas in (a) is increased to  $6.8 \times 10^{-4} \text{ m}^3$  at constant temperature.

(i) Calculate, in Pa, the new pressure of the gas. [1]

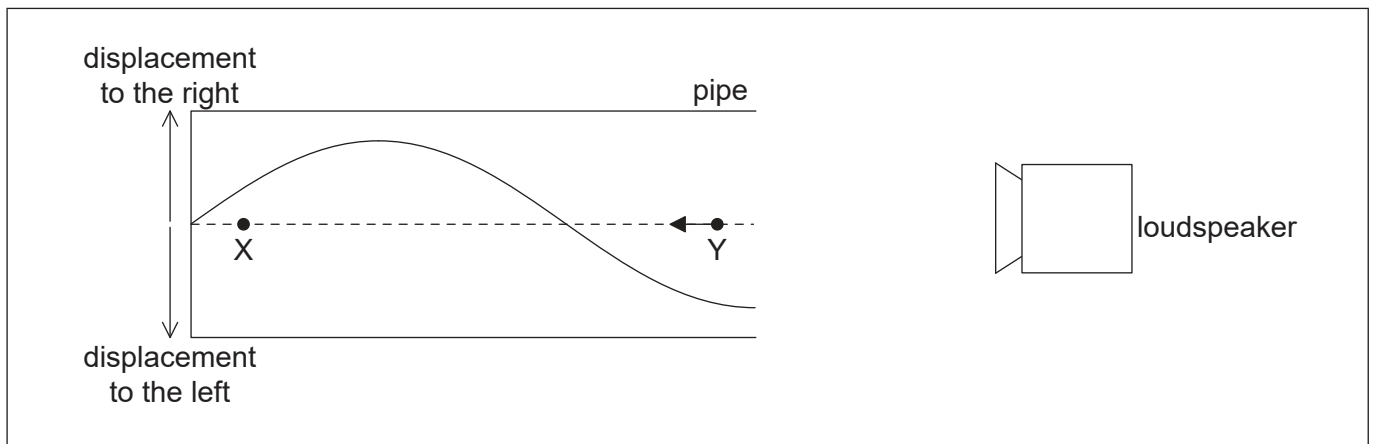
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(ii) Explain, in terms of molecular motion, this change in pressure. [2]

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3. (a) A loudspeaker emits sound towards the open end of a pipe. The other end is closed. A standing wave is formed in the pipe. The diagram represents the displacement of molecules of air in the pipe at an instant of time.



- (i) Outline how the standing wave is formed. [1]

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X and Y represent the equilibrium positions of two air molecules in the pipe. The arrow represents the velocity of the molecule at Y.

- (ii) Draw an arrow on the diagram to represent the direction of motion of the molecule at X. [1]
- (iii) Label a position N that is a node of the standing wave. [1]
- (iv) The speed of sound is  $340 \text{ m s}^{-1}$  and the length of the pipe is  $0.30 \text{ m}$ . Calculate, in Hz, the frequency of the sound. [2]

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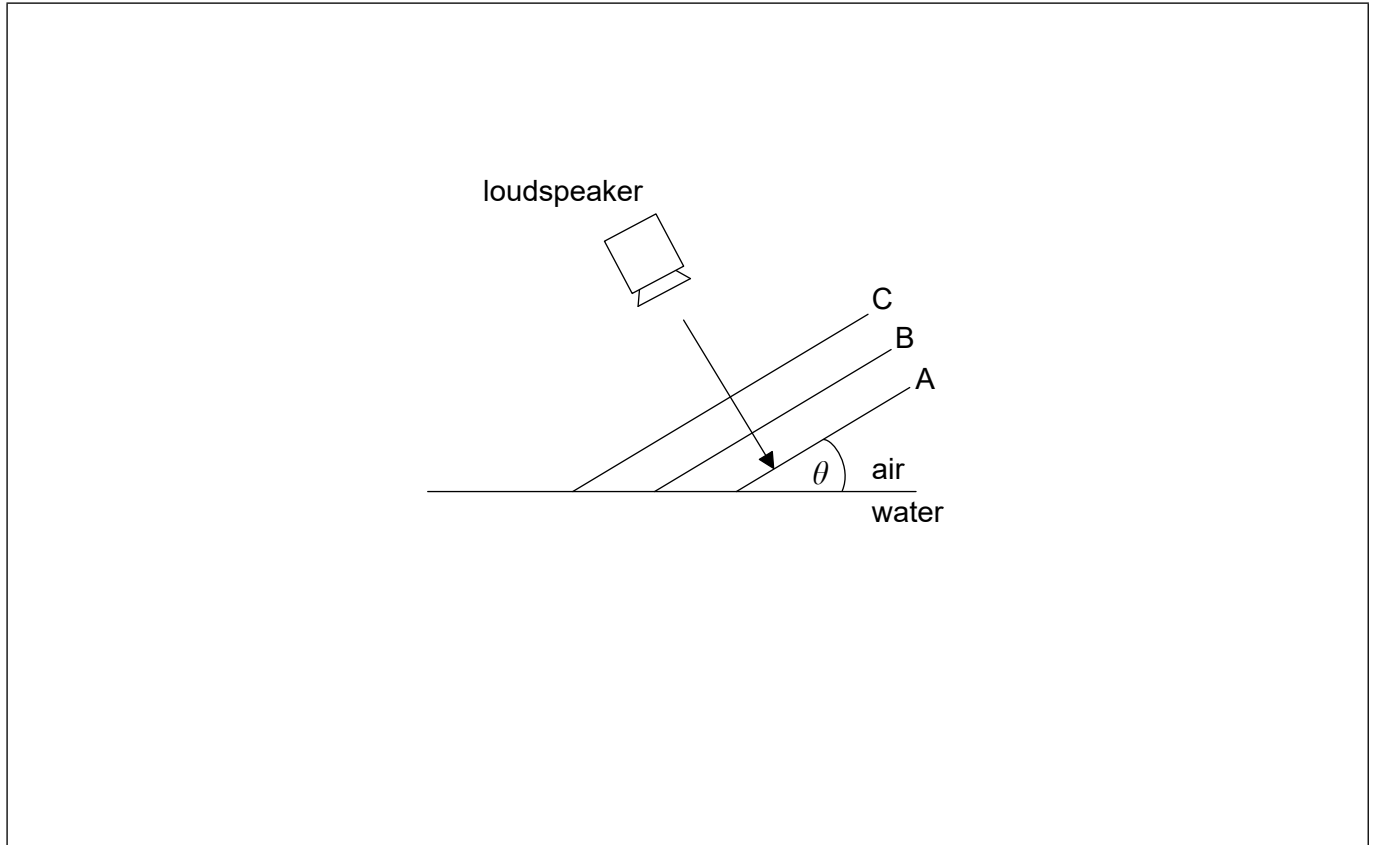
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16EP06

(Question 3 continued)

- (b) The loudspeaker in (a) now emits sound towards an air–water boundary. A, B and C are parallel wavefronts emitted by the loudspeaker. The parts of wavefronts A and B in water are not shown. Wavefront C has not yet entered the water.



- (i) The speed of sound in air is  $340 \text{ m s}^{-1}$  and in water it is  $1500 \text{ m s}^{-1}$ . The wavefronts make an angle  $\theta$  with the surface of the water. Determine the maximum angle,  $\theta_{\text{max}}$ , at which the sound can enter water. Give your answer to the correct number of significant figures. [2]

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- (ii) Draw lines on the diagram to complete wavefronts A and B in water for  $\theta < \theta_{\text{max}}$ . [2]



16EP07

Turn over

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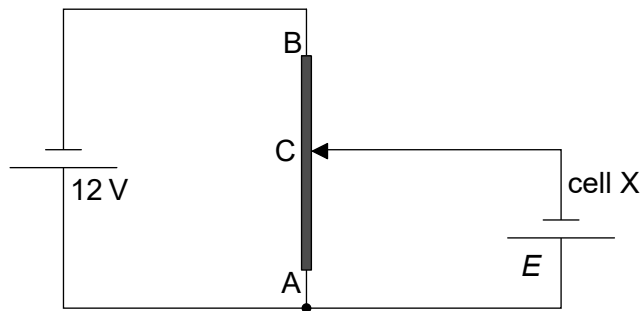
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16EP08



4. The diagram shows a potential divider circuit used to measure the emf  $E$  of a cell X. Both cells have negligible internal resistance.



- (a) State what is meant by the emf of a cell. [2]

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- (b) AB is a wire of uniform cross-section and length 1.0 m. The resistance of wire AB is  $80 \Omega$ . When the length of AC is 0.35 m the current in cell X is zero.

- (i) Show that the resistance of the wire AC is  $28 \Omega$ . [2]

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- (ii) Determine  $E$ . [2]

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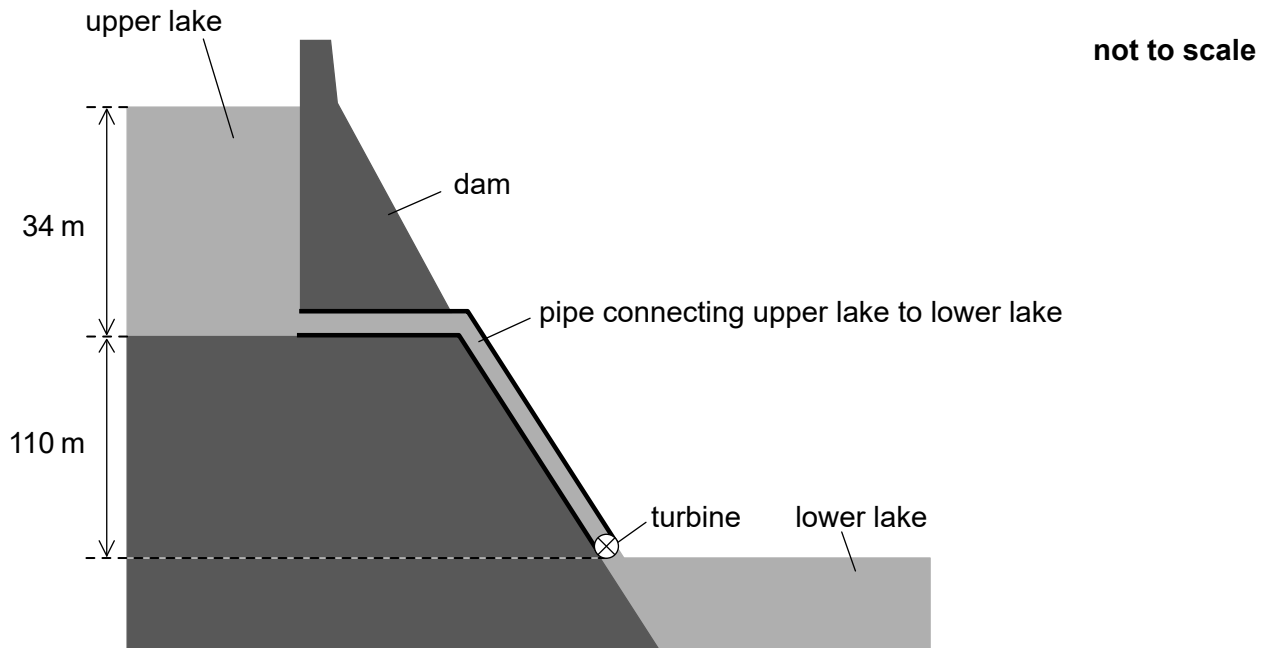
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5. In a pumped storage hydroelectric system, water is stored in a dam of depth 34 m.



The water leaving the upper lake descends a vertical distance of 110 m and turns the turbine of a generator before exiting into the lower lake.

(a) Water flows out of the upper lake at a rate of  $1.2 \times 10^5 \text{ m}^3$  per minute. The density of water is  $1.0 \times 10^3 \text{ kg m}^{-3}$ .

(i) Estimate the specific energy of water in this storage system, giving an appropriate unit for your answer.

[2]

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16EP10

**(Question 5 continued)**

- (ii) Show that the average rate at which the gravitational potential energy of the water decreases is 2.5 GW. [3]

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- (iii) The storage system produces 1.8 GW of electrical power. Determine the overall efficiency of the storage system. [1]

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- (b) After the upper lake is emptied it must be refilled with water from the lower lake and this requires energy. Suggest how the operators of this storage system can still make a profit. [1]

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16EP11

Turn over

6. (a) Rutherford constructed a model of the atom based on the results of the alpha particle scattering experiment. Describe this model. [2]

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- (b) Rhodium-106 ( $^{106}_{45}\text{Rh}$ ) decays into palladium-106 ( $^{106}_{46}\text{Pd}$ ) by beta minus ( $\beta^-$ ) decay. The binding energy per nucleon of rhodium is 8.521 MeV and that of palladium is 8.550 MeV.

- (i) State what is meant by the binding energy of a nucleus. [1]

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- (ii) Show that the energy released in the  $\beta^-$  decay of rhodium is about 3 MeV. [1]

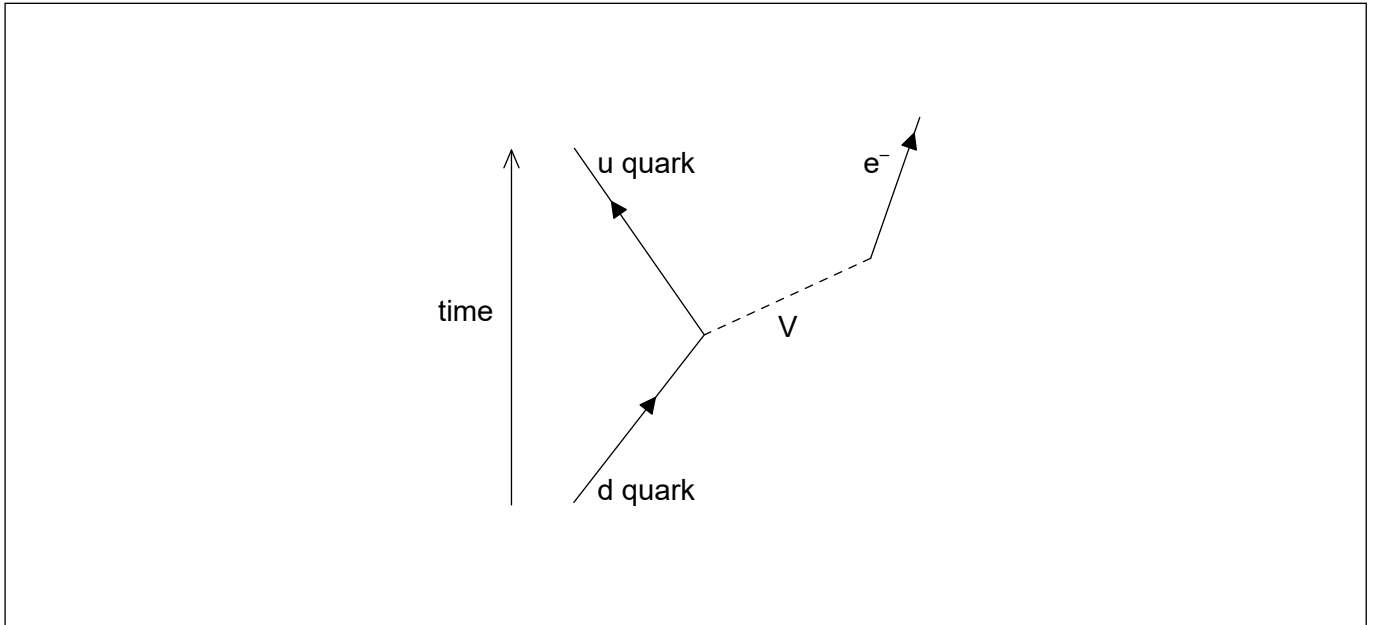
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(Question 6 continued)

(c)  $\beta^-$  decay is described by the following incomplete Feynman diagram.



(i) Draw a labelled arrow to complete the Feynman diagram. [1]

(ii) Identify particle V. [1]

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