Physics
Standard level
Paper 2

Thursday 28 April 2022 (morning)

1 hour 15 minutes

Candidate session number

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]**.
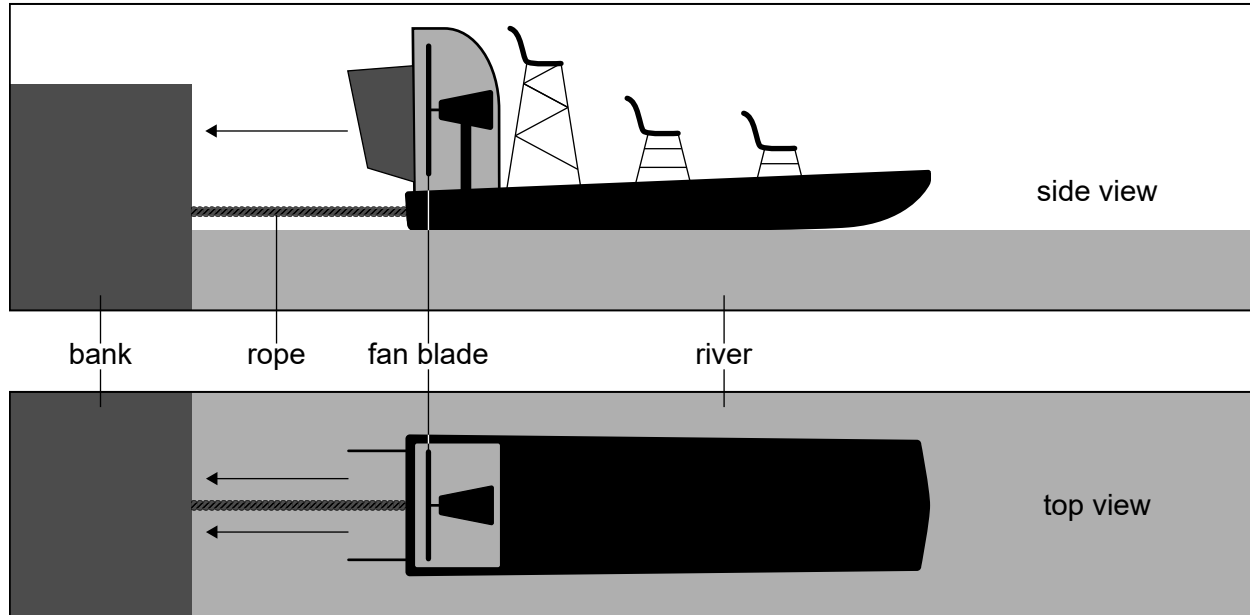
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will not be marked.

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

1. Airboats are used for transport across a river. To move the boat forward, air is propelled from the back of the boat by a fan blade.

side view

bank   rope   fan blade   river

top view

An airboat has a fan blade of radius 1.8 m. This fan can propel air with a maximum speed relative to the boat of 20 m s^{-1}. The density of air is 1.2 kg m^{-3}.

(a) Outline why a force acts on the airboat due to the fan blade.   [3]

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(Question 1 continued)

(b)   In a test the airboat is tied to the river bank with a rope normal to the bank. The fan
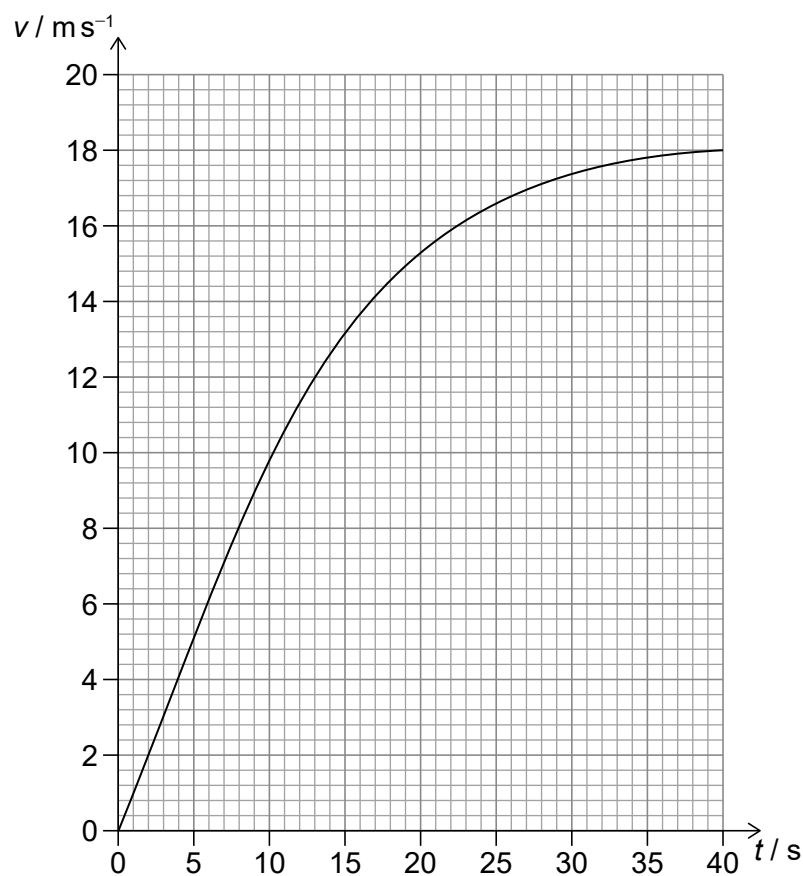   propels the air at its maximum speed. There is no wind.

(i)   Show that a mass of about 240 kg of air moves through the fan every second.   [2]

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(ii)   Show that the tension in the rope is about 5 kN.   [1]

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(c)   The rope is untied and the airboat moves away from the bank. The variation with time t
      of the speed v of the airboat is shown for the motion.

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(Question 1 continued)

       (i)   Estimate the distance the airboat travels to reach its maximum speed.   [2]

       (ii)   Deduce the mass of the airboat.   [3]

    (d)   The fan is rotating at 120 revolutions every minute. Calculate the centripetal acceleration of the tip of a fan blade.   [2]

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2. A fixed mass of an ideal gas is contained in a cylinder closed with a frictionless piston. The volume of the gas is $2.5 \times 10^{-3}\,m^3$ when the temperature of the gas is 37 °C and the pressure of the gas is $4.0 \times 10^5\,Pa$.

(a) Calculate the number of gas particles in the cylinder. [2]

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(b) Energy is now supplied to the gas and the piston moves to allow the gas to expand. The temperature is held constant.

Discuss, for this process, the changes that occur in the

(i) density of the gas. [2]

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(ii) internal energy of the gas. [2]

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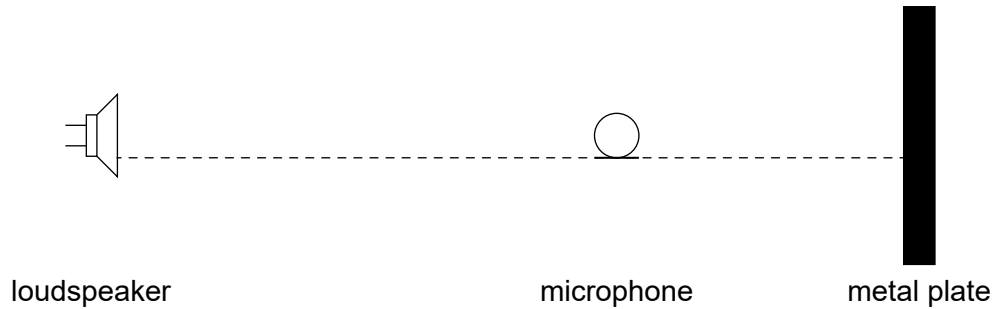..

3. A loudspeaker emits sound waves of frequency f towards a metal plate that reflects the waves. A small microphone is moved along the line from the metal plate to the loudspeaker. The intensity of sound detected at the microphone as it moves varies regularly between maximum and minimum values.

loudspeaker   microphone   metal plate

The speed of sound in air is $340\,\mathrm{m\,s^{-1}}$.

(a) (i) Explain the variation in intensity. [3]

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   (ii) Adjacent minima are separated by a distance of 0.12 m. Calculate f. [2]

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(Question 3 continued)

(b)   The metal plate is replaced by a wooden plate that reflects a lower intensity sound wave than the metal plate.

State and explain the differences between the sound intensities detected by the same microphone with the metal plate and the wooden plate.   [3]

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4. (a) Identify the laws of conservation that are represented by Kirchhoff's circuit laws. [2]

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(b) A cell is connected to an ideal voltmeter, a switch S and a resistor R. The resistance of R is $4.0\,\Omega$.
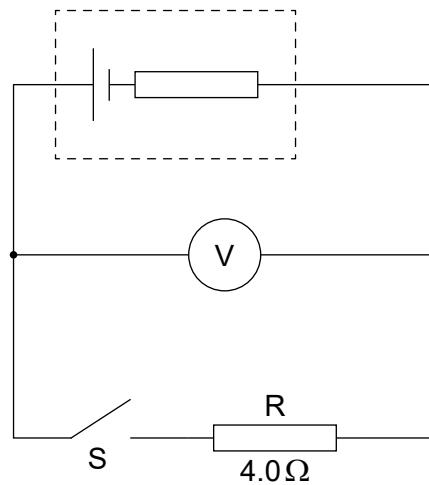
When S is open the reading on the voltmeter is 12 V. When S is closed the voltmeter reads 8.0 V.

(i) State the emf of the cell. [1]

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(ii) Deduce the internal resistance of the cell. [2]

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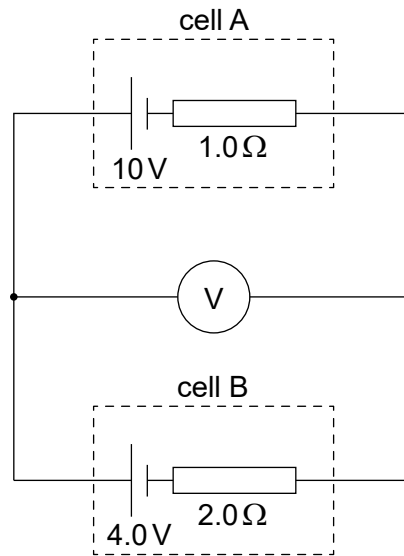
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(Question 4 continued)

(c)   The voltmeter is used in another circuit that contains two secondary cells.

cell A

1.0 Ω

10 V

V

cell B

2.0 Ω

4.0 V

Cell A has an emf of 10 V and an internal resistance of 1.0 Ω. Cell B has an emf of 4.0 V and an internal resistance of 2.0 Ω.

Calculate the reading on the voltmeter.   [3]

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(Question 4 continued)

(d) Electricity can be generated using renewable resources.

(i) Outline why electricity is a secondary energy source. [1]

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(ii) Some fuel sources are renewable. Outline what is meant by renewable. [1]

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(e) (i) A fully charged cell of emf 6.0 V delivers a constant current of 5.0 A for a time of 0.25 hour until it is completely discharged.

The cell is then re-charged by a rectangular solar panel of dimensions $0.40\,m \times 0.15\,m$ at a place where the maximum intensity of sunlight is $380\,W\,m^{-2}$.

The overall efficiency of the re-charging process is 18%.

Calculate the minimum time required to re-charge the cell fully. [3]

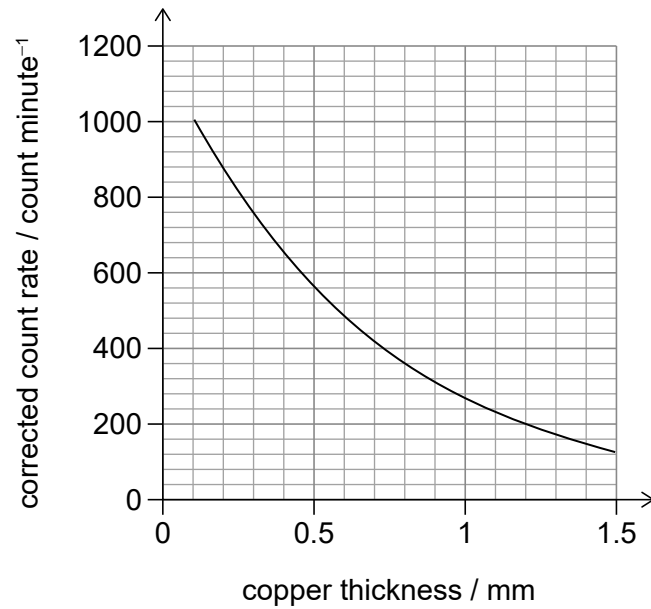...

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(ii) Outline why research into solar cell technology is important to society. [1]

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5. An experiment is carried out to determine the count rate, corrected for background radiation, when different thicknesses of copper are placed between a radioactive source and a detector. The graph shows the variation of corrected count rate with copper thickness.

(a) Outline how the count rate was corrected for background radiation. [1]

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(b) When a single piece of thin copper foil is placed between the source and detector, the count rate is 810 count minute^{-1}. The foil is replaced with one that has three times the thickness. Estimate the new count rate. [2]

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(Question 5 continued)

(c)   Further results were obtained in this experiment with copper and lead absorbers.

Absorber	Thickness / mm	Corrected count rate / count minute^{-1}
copper	3.5	32
lead	3.5	10

Comment on the radiation detected from this radioactive source.   [4]

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(d)   Another radioactive source consists of a nuclide of caesium ($^{137}_{55}$Cs) that decays to barium ($^{137}_{56}$Ba).

Write down the reaction for this decay.   [2]

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