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

Thursday 28 April 2022 (morning)

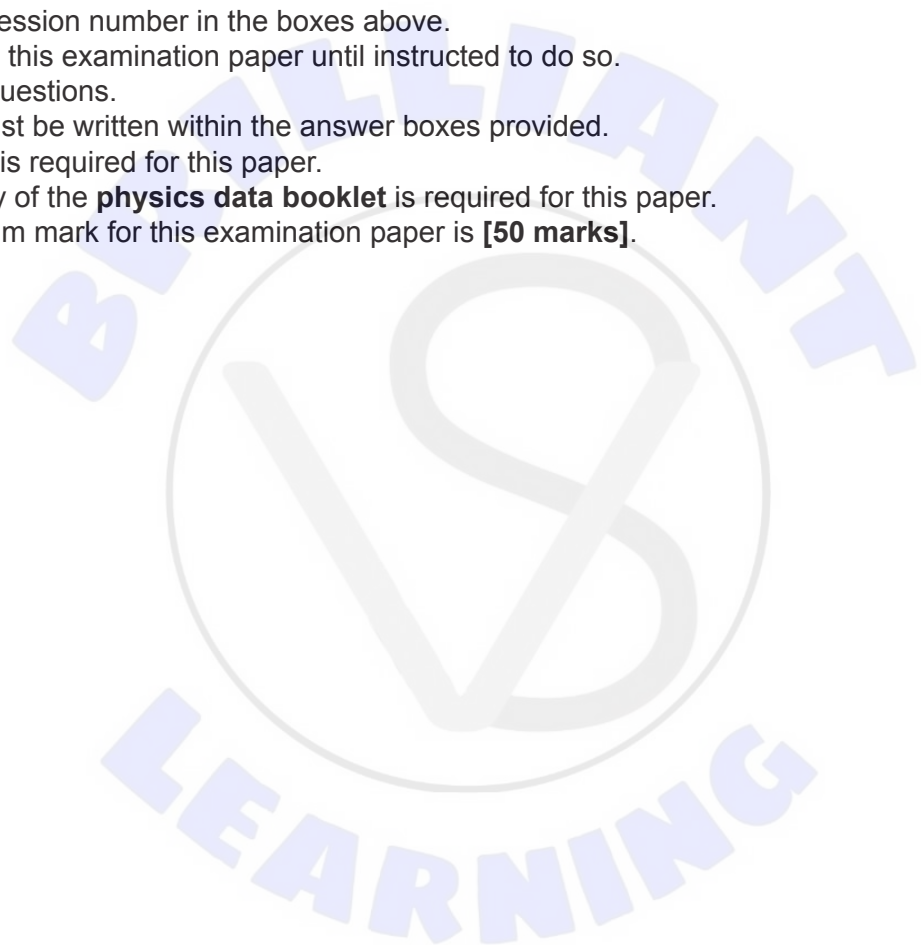
Candidate session number

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1 hour 15 minutes

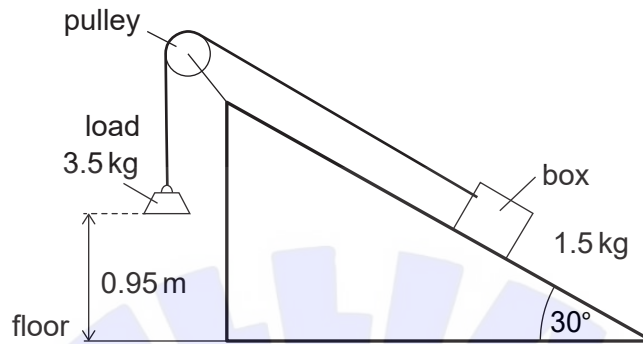
**Instructions to candidates**

- 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]**.



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

1. A student uses a load to pull a box up a ramp inclined at  $30^\circ$ . A string of constant length and negligible mass connects the box to the load that falls vertically. The string passes over a pulley that runs on a frictionless axle. Friction acts between the base of the box and the ramp. Air resistance is negligible.



The load has a mass of 3.5 kg and is initially 0.95 m above the floor. The mass of the box is 1.5 kg.

The load is released and accelerates downwards.

- (a) Outline **two** differences between the momentum of the box and the momentum of the load at the same instant. [2]

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- (b) The vertical acceleration of the load downwards is  $2.4 \text{ ms}^{-2}$ .

Calculate the tension in the string. [2]

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**(Question 1 continued)**

- (c) (i) Show that the speed of the load when it hits the floor is about  $2.1 \text{ m s}^{-1}$ . [2]

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- (ii) The radius of the pulley is 2.5 cm. Calculate the angular speed of rotation of the pulley as the load hits the floor. State your answer to an appropriate number of significant figures. [2]

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- (d) After the load has hit the floor, the box travels a further 0.35 m along the ramp before coming to rest. Determine the average frictional force between the box and the surface of the ramp. [4]

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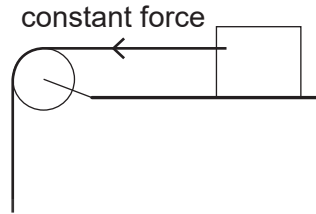
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Answers written on this page  
will not be marked.



**(Question 1 continued)**

- (e) The student then makes the ramp horizontal and applies a constant horizontal force to the box. The force is just large enough to start the box moving. The force continues to be applied after the box begins to move.



Explain, with reference to the frictional force acting, why the box accelerates once it has started to move.

[3]

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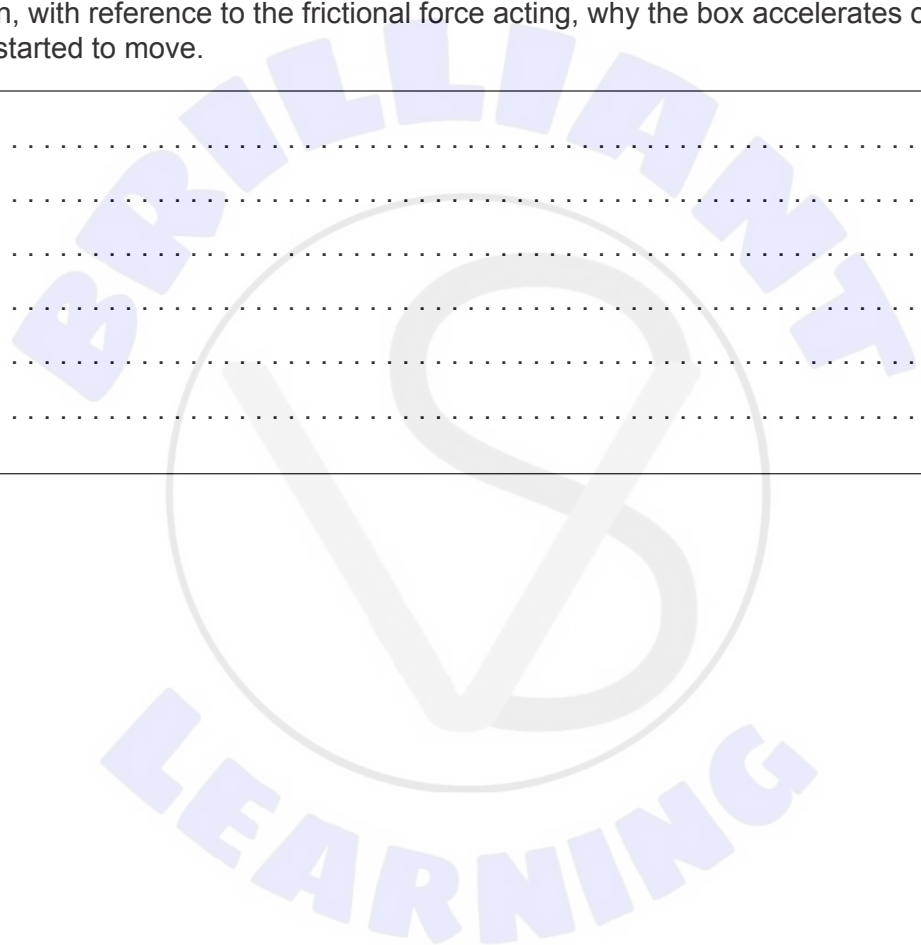
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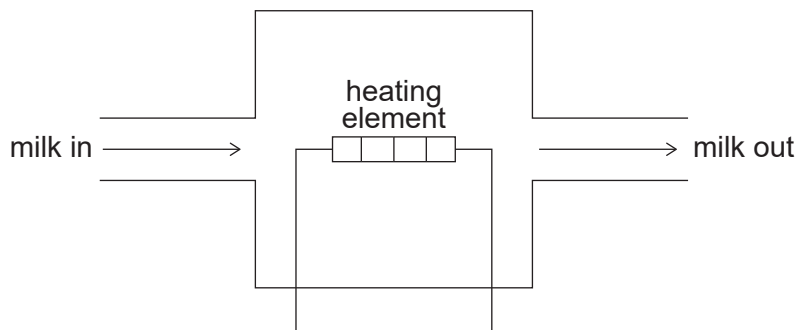
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2. Cold milk enters a small sterilizing unit and flows over an electrical heating element.



The temperature of the milk is raised from 11 °C to 84 °C. A mass of 55 g of milk enters the sterilizing unit every second.

Specific heat capacity of milk = 3.9 kJ kg<sup>-1</sup> K<sup>-1</sup>

- (a) Estimate the power input to the heating element. State an appropriate unit for your answer.

[2]

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- (b) Outline whether your answer to (a) is likely to overestimate or underestimate the power input.

[2]

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- (c) Discuss, with reference to the molecules in the liquid, the difference between milk at 11 °C and milk at 84 °C.

[2]

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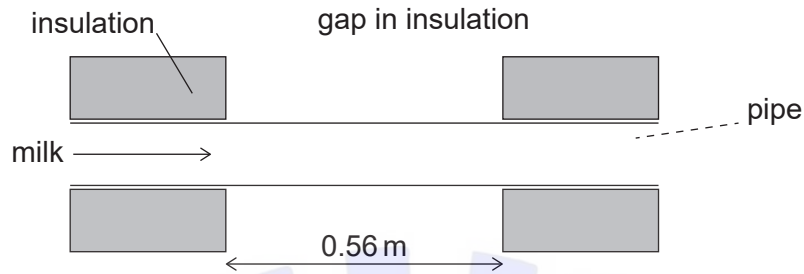
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(Question 2 continued)

- (d) The milk flows out through an insulated metal pipe. The pipe is at a temperature of  $84^{\circ}\text{C}$ . A small section of the insulation has been removed from around the pipe.

diagram not to scale



- (i) State how energy is transferred from the inside of the metal pipe to the outside of the metal pipe. [1]

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- (ii) The missing section of insulation is 0.56 m long and the external radius of the pipe is 0.067 m. The emissivity of the pipe surface is 0.40. Determine the energy lost every second from the pipe surface. Ignore any absorption of radiation by the pipe surface. [3]

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- (iii) Describe **one** other method by which significant amounts of energy can be transferred from the pipe to the surroundings. [2]

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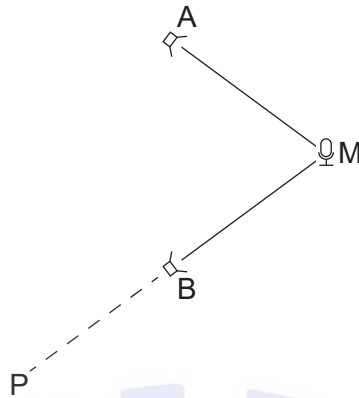
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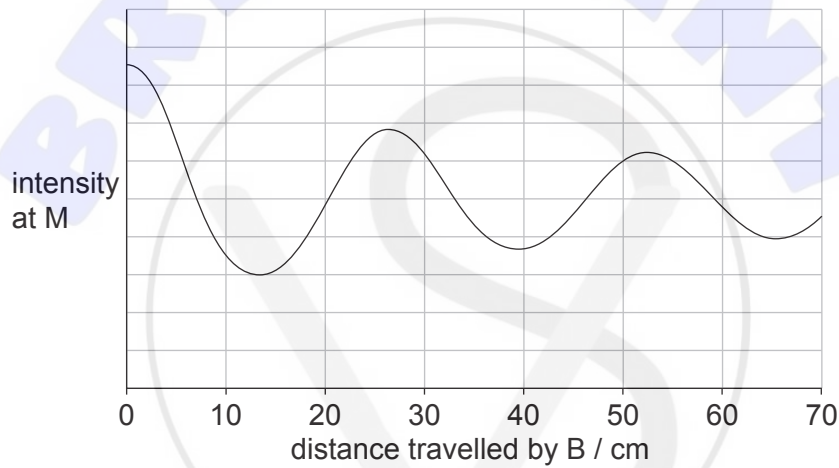
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3. Two loudspeakers A and B are initially equidistant from a microphone M. The frequency and intensity emitted by A and B are the same. A and B emit sound in phase. A is fixed in position.



B is moved slowly away from M along the line MP. The graph shows the variation with distance travelled by B of the received intensity at M.



- (a) Explain why the received intensity varies between maximum and minimum values. [3]

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**(Question 3 continued)**

(b) State and explain the wavelength of the sound measured at M.

[2]

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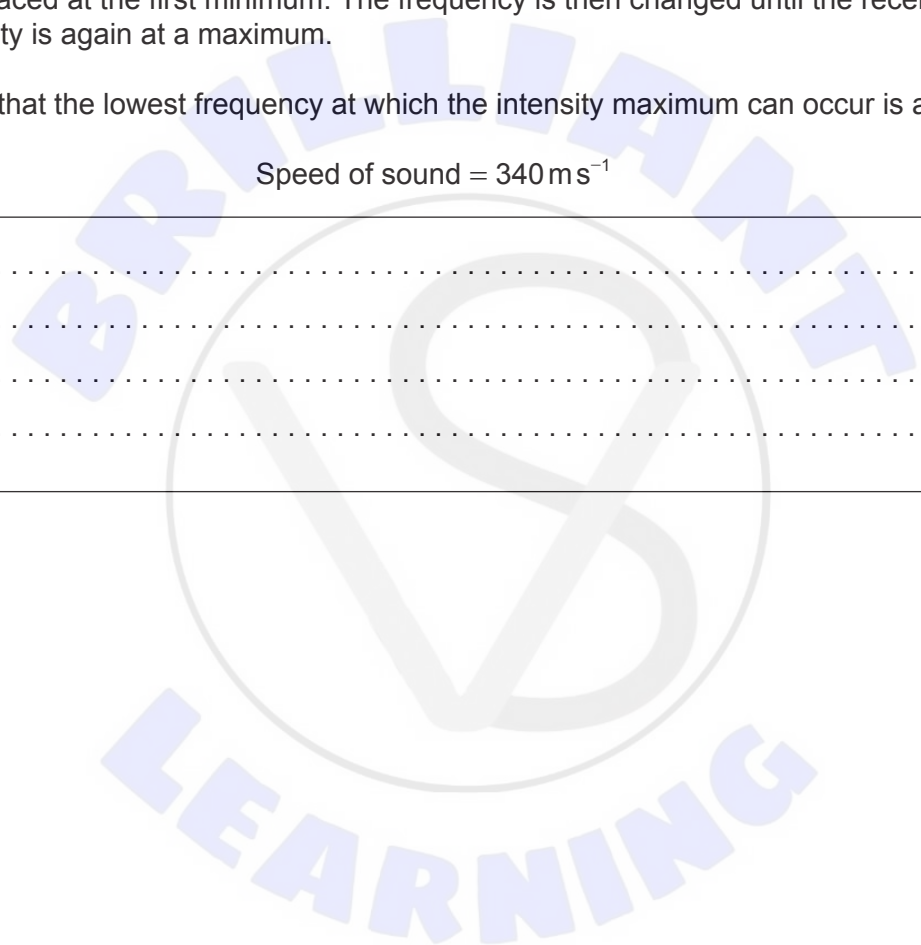
(c) B is placed at the first minimum. The frequency is then changed until the received intensity is again at a maximum.

Show that the lowest frequency at which the intensity maximum can occur is about 3 kHz.

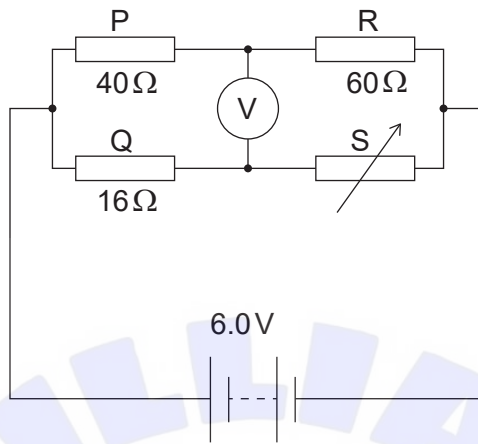
Speed of sound =  $340 \text{ ms}^{-1}$

[2]

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4. A power supply is connected to three resistors P, Q and R of fixed value and to an ideal voltmeter. A variable resistor S, formed from a solid cylinder of conducting putty, is also connected in the circuit. Conducting putty is a material that can be moulded so that the resistance of S can be changed by re-shaping it.



The resistance values of P, Q and R are  $40\Omega$ ,  $16\Omega$  and  $60\Omega$  respectively. The emf of the power supply is  $6.0\text{V}$  and its internal resistance is negligible.

- (a) Calculate the potential difference across P. [2]

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- (b) The voltmeter reads zero. Determine the resistance of S. [3]

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**(Question 4 continued)**

- (c) All the putty is reshaped into a solid cylinder that is four times longer than the original length.
- (i) Deduce the resistance of this new cylinder when it has been reshaped. [3]

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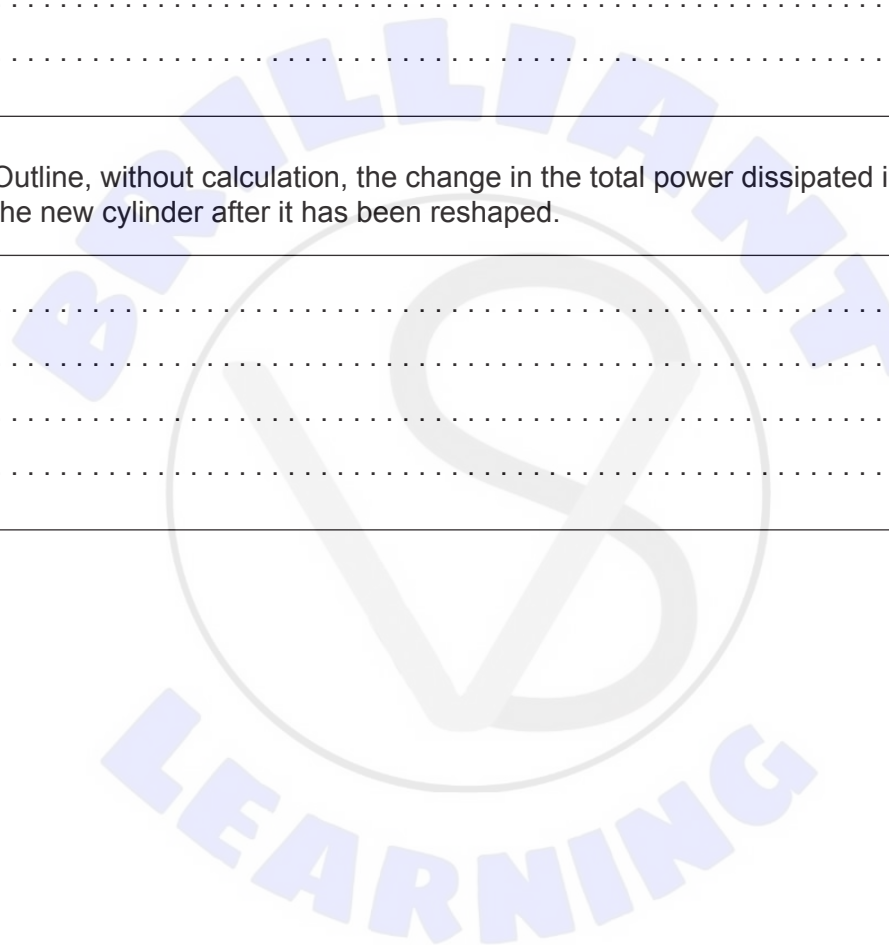
- (ii) Outline, without calculation, the change in the total power dissipated in Q and the new cylinder after it has been reshaped. [2]

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5. (a) Describe the quark structure of a baryon. [2]

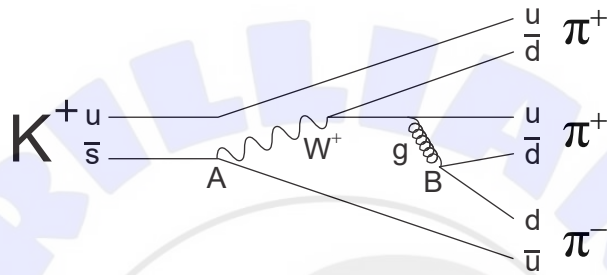
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(b) The Feynman diagram shows a possible decay of the  $K^+$  meson.



Identify the interactions that are involved at points A and B in this decay. [2]

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(c) The  $K^+$  meson can decay as

$$K^+ \rightarrow \mu^+ + \nu_\mu$$

State and explain the interaction that is responsible for this decay. [2]

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References:

