



Oxford Cambridge and RSA

Monday 20 May 2019 – Afternoon

AS Level Further Mathematics A

Y533/01 Mechanics

Time allowed: 1 hour 15 minutes



You must have:

- Printed Answer Booklet
- Formulae AS Level Further Mathematics A

You may use:

- a scientific or graphical calculator

INSTRUCTIONS

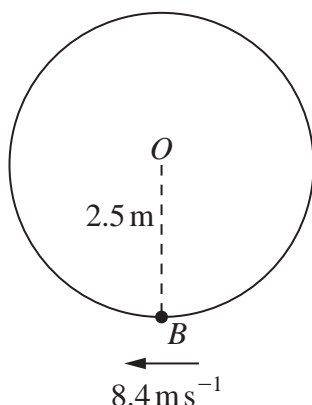
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions.
- **Write your answer to each question in the space provided in the Printed Answer Booklet.** If additional space is required, use the lined page(s) at the end of the Printed Answer Booklet. The question number(s) must be clearly shown.
- You are permitted to use a scientific or graphical calculator in this paper.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question.
- The acceleration due to gravity is denoted by $g\text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.

INFORMATION

- The total mark for this paper is **60**.
- The marks for each question are shown in brackets [].
- **You are reminded of the need for clear presentation in your answers.**
- The Printed Answer Booklet consists of **12** pages. The Question Paper consists of **8** pages.

Answer **all** the questions.

1



A smooth wire is shaped into a circle of radius 2.5 m which is fixed in a vertical plane with its centre at a point O . A small bead B is threaded onto the wire. B is held with OB vertical and is then projected horizontally with an initial speed of 8.4 m s^{-1} (see diagram).

- (a) Find the speed of B at the instant when OB makes an angle of 0.8 radians with the downward vertical through O . [3]
- (b) Determine whether B has sufficient energy to reach the point on the wire vertically above O . [3]

2 A particle A of mass 3.6 kg is attached by a light inextensible string to a particle B of mass 2.4 kg .

A and B are initially at rest, with the string slack, on a smooth horizontal surface. A is projected directly away from B with a speed of 7.2 m s^{-1} .

- (a) Calculate the speed of A after the string becomes taut. [3]
- (b) Find the impulse exerted on A at the instant that the string becomes taut. [2]
- (c) Find the loss in kinetic energy as a result of the string becoming taut. [2]

- 3** A car of mass 1500 kg has an engine with maximum power 60 kW. When the car is travelling at 10 m s^{-1} along a straight horizontal road using maximum power, its acceleration is 3.3 m s^{-2} .

In an initial model of the motion of the car it is assumed that the resistance to motion is constant.

- (a) Using this initial model, find the greatest possible steady speed of the car along the road. [4]

In a refined model the resistance to motion is assumed to be proportional to the speed of the car.

- (b) Using this refined model, find the greatest possible steady speed of the car along the road. [5]

The greatest possible steady speed of the car on the road is measured and found to be 21.6 m s^{-1} .

- (c) Explain what this value means about the models used in parts (a) and (b). [2]

- 4** A student is studying the speed of sound, u , in a gas under different conditions.

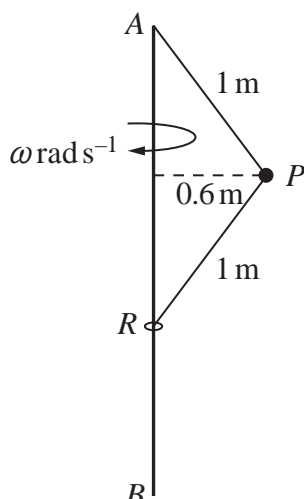
He assumes that u depends on the pressure, p , of the gas, the density, ρ , of the gas and the wavelength, λ , of the sound in the relationship $u = kp^\alpha \rho^\beta \lambda^\gamma$, where k is a dimensionless constant. (The wavelength of a sound is the distance between successive peaks in the sound wave.)

- (a) Use the fact that density is mass per unit volume to find $[\rho]$. [1]
- (b) Given that the units of p are N m^{-2} , determine the values of α , β and γ . [7]
- (c) Comment on what the value of γ means about how fast sounds of different wavelengths travel through the gas. [1]

The student carries out two experiments, A and B , to measure u . Only the density of the gas varies between the experiments, all other conditions being unchanged. He finds that the value of u in experiment B is double the value in experiment A .

- (d) By what factor has the density of the gas in experiment A been multiplied to give the density of the gas in experiment B ? [2]

5



As shown in the diagram, AB is a long thin rod which is fixed vertically with A above B . One end of a light inextensible string of length 1 m is attached to A and the other end is attached to a particle P of mass $m_1\text{ kg}$. One end of another light inextensible string of length 1 m is also attached to P . Its other end is attached to a small smooth ring R , of mass $m_2\text{ kg}$, which is free to move on AB .

Initially, P moves in a horizontal circle of radius 0.6 m with constant angular velocity $\omega\text{ rad s}^{-1}$. The magnitude of the tension in string AP is denoted by $T_1\text{ N}$ while that in string PR is denoted by $T_2\text{ N}$.

(a) By considering forces on R , express T_2 in terms of m_2 . [2]

(b) Show that

(i) $T_1 = \frac{49}{4}(m_1 + m_2)$, [2]

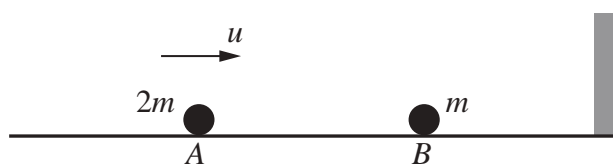
(ii) $\omega^2 = \frac{49(m_1 + 2m_2)}{4m_1}$. [3]

(c) Deduce that, in the case where m_1 is much bigger than m_2 , $\omega \approx 3.5$. [2]

In a different case, where $m_1 = 2.5$ and $m_2 = 2.8$, P slows down. Eventually the system comes to rest with P and R hanging in equilibrium.

(d) Find the total energy lost by P and R as the angular velocity of P changes from the initial value of $\omega\text{ rad s}^{-1}$ to zero. [5]

- 6 Particles A of mass $2m$ and B of mass m are on a smooth horizontal floor. A is moving with speed u directly towards a vertical wall, and B is at rest between A and the wall (see diagram).



A collides directly with B . The coefficient of restitution in this collision is $\frac{1}{2}$.

B then collides with the wall, rebounds, and collides with A for a second time.

- (a) Show that the speed of B after its second collision with A is $\frac{1}{2}u$. [6]

The first collision between A and B occurs at a distance d from the wall. The second collision between A and B occurs at a distance $\frac{1}{5}d$ from the wall.

- (b) Find the coefficient of restitution for the collision between B and the wall. [5]

END OF QUESTION PAPER

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