

AS Level Further Mathematics A

Y533 Mechanics

Sample Question Paper

Version 2

Date – Morning/Afternoon

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.
- Complete the boxes provided on the Printed Answer Booklet with your name, centre number and candidate number.
- Answer **all** the questions.
- **Write your answer to each question in the space provided in the Printed Answer Booklet.** Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).
- Do **not** write in the bar codes.
- 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 number of marks 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.

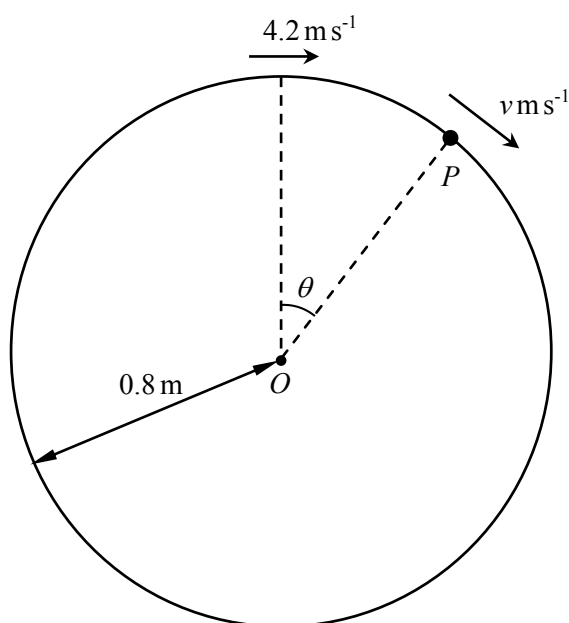
Answer **all** the questions.

- 1** A roundabout in a playground can be modeled as a horizontal circular platform with centre O . The roundabout is free to rotate about a vertical axis through O . A child sits without slipping on the roundabout at a horizontal distance of 1.5 m from O and completes one revolution in 2.4 seconds.

(i) Calculate the speed of the child. [3]

(ii) Find the magnitude and direction of the acceleration of the child. [3]

2



A smooth wire is shaped into a circle of centre O and radius 0.8 m . The wire is fixed in a vertical plane. A small bead P of mass 0.03 kg is threaded on the wire and is projected along the wire from the highest point with a speed of 4.2 m s^{-1} . When OP makes an angle θ with the upward vertical the speed of P is $v\text{ m s}^{-1}$ (see diagram).

(i) Show that $v^2 = 33.32 - 15.68\cos\theta$. [4]

(ii) Prove that the bead is never at rest. [1]

(iii) Find the maximum value of v . [2]

- 3 (i) Write down the dimension of density. [1]

The workings of an oil pump consist of a right, solid cylinder which is partially submerged in oil. The cylinder is free to oscillate along its central axis which is vertical. If the base area of the pump is 0.4 m^2 and the density of the oil is 920 kg m^{-3} then the period of oscillation of the pump is 0.7 s .

A student assumes that the period of oscillation of the pump is dependent only on the density of the oil, ρ , the acceleration due to gravity, g , and the surface area, A , of the circular base of the pump. The student attempts to test this assumption by stating that the period of oscillation, T , is given by $T = C\rho^\alpha g^\beta A^\gamma$ where C is a dimensionless constant.

- (ii) Use dimensional analysis to find the values of α , β and γ . [4]

- (iii) Hence give the value of C to 3 significant figures. [2]

- (iv) Comment, with justification, on the assumption made by the student that the formula for the period of oscillation of the pump was dependent on only ρ , g and A . [2]

- 4 A car of mass 1250 kg experiences a resistance to its motion of magnitude $kv^2 \text{ N}$, where k is a constant and $v \text{ m s}^{-1}$ is the car's speed. The car travels in a straight line along a horizontal road with its engine working at a constant rate of $P \text{ W}$. At a point A on the road the car's speed is 15 m s^{-1} and it has an acceleration of magnitude 0.54 m s^{-2} . At a point B on the road the car's speed is 20 m s^{-1} and it has an acceleration of magnitude 0.3 m s^{-2} .

- (i) Find the values of k and P . [7]

The power is increased to 15 kW .

- (ii) Calculate the maximum steady speed of the car on a straight horizontal road. [3]

5



The masses of two spheres A and B are $3m \text{ kg}$ and $m \text{ kg}$ respectively. The spheres are moving towards each other with constant speeds $2u \text{ m s}^{-1}$ and $u \text{ m s}^{-1}$ respectively along the same straight line towards each other on a smooth horizontal surface (see diagram). The two spheres collide and the coefficient of restitution between the spheres is e . After colliding, A and B both move in the same direction with speeds $v \text{ m s}^{-1}$ and $w \text{ m s}^{-1}$, respectively.

(i) Find an expression for v in terms of e and u . [6]

(ii) Write down unsimplified expressions in terms of e and u for

(a) the total kinetic energy of the spheres before the collision, [1]

(b) the total kinetic energy of the spheres after the collision. [2]

(iii) Given that the total kinetic energy of the spheres after the collision is λ times the total kinetic energy before the collision, show that

$$\lambda = \frac{27e^2 + 25}{52}.$$

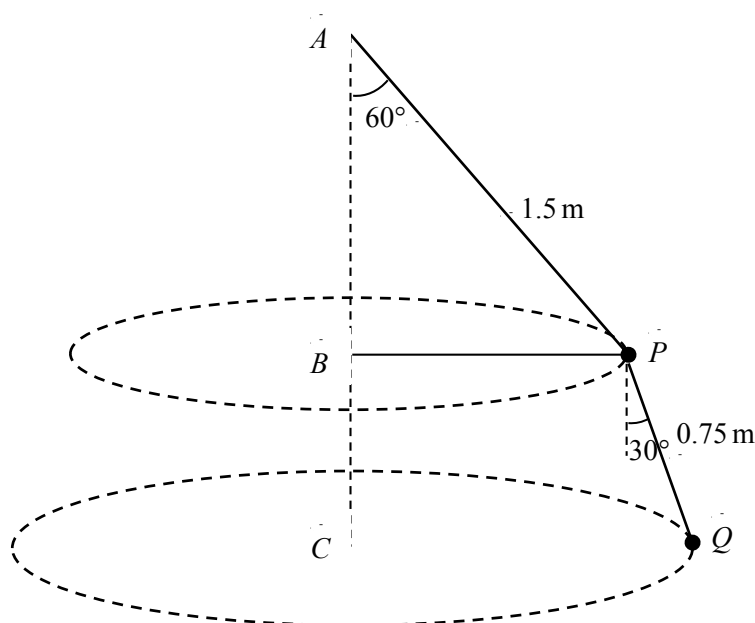
[3]

(iv) Comment on the cases when

(a) $\lambda = 1$,

(b) $\lambda = \frac{25}{52}$.

[3]



The fixed points A , B and C are in a vertical line with A above B and B above C . A particle P of mass 2.5 kg is joined to A , to B and to a particle Q of mass 2 kg , by three light rods where the length of rod AP is 1.5 m and the length of rod PQ is 0.75 m . Particle P moves in a horizontal circle with centre B . Particle Q moves in a horizontal circle with centre C at the same constant angular speed ω as P , in such a way that A , B , P and Q are coplanar. The rod AP makes an angle of 60° with the downward vertical, rod PQ makes an angle of 30° with the downward vertical and rod BP is horizontal (see diagram).

- (i) Find the tension in the rod PQ . [2]
- (ii) Find ω . [3]
- (iii) Find the speed of P . [1]
- (iv) Find the tension in the rod AP . [3]
- (v) Hence find the magnitude of the force in rod BP .
Decide whether this rod is under tension or compression. [4]

END OF QUESTION PAPER

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