OCR
Oxford Cambridge and RSA

Accredited

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

* 0 0 0 0 0 0 *

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 $g\,\text{m}\,\text{s}^{-2}$. 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.

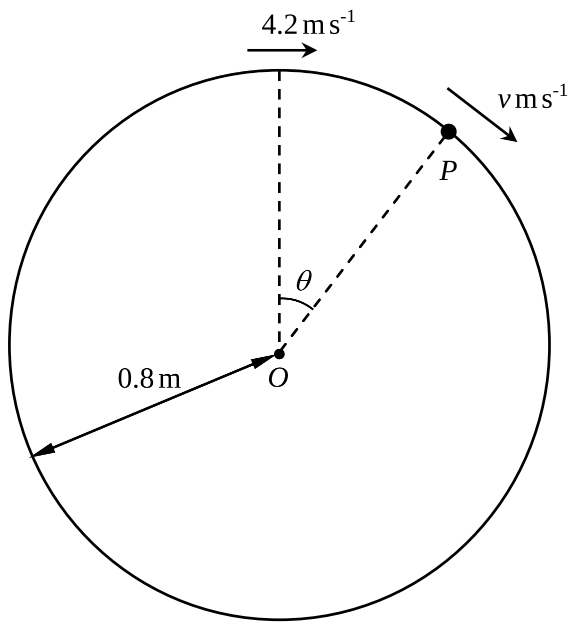
Answer **all** the questions.

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 $4.2\,\mathrm{m\,s^{-1}}$. When OP makes an angle θ with the upward vertical the speed of P is $v\,\mathrm{m\,s^{-1}}$ (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 N, where *k* is a constant and *v* 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* 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 $3m$ kg and m kg respectively. The spheres are moving towards each other with constant speeds $2u\,\mathrm{m\,s^{-1}}$ and $u\,\mathrm{m\,s^{-1}}$ 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 $v\,\mathrm{m\,s^{-1}}$ and $w\,\mathrm{m\,s^{-1}}$, 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

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

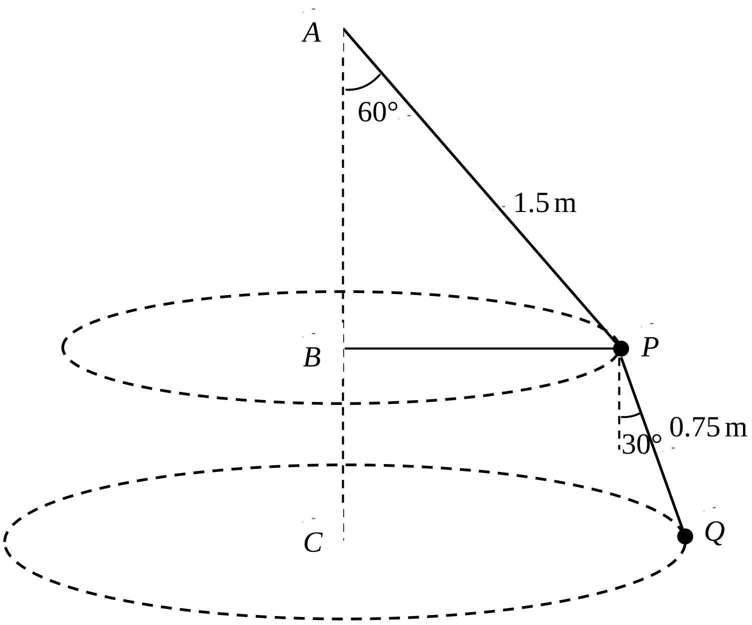
[3]

(iv) Comment on the cases when

(a) $\lambda = 1$,

(b) $\lambda = \frac{25}{52}$. **[3]**

6



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

BLANK PAGE

BLANK PAGE