



ADVANCED GCE
MATHEMATICS
Mechanics 3

4730

Candidates answer on the Answer Booklet

OCR Supplied Materials:

- 8 page Answer Booklet
- List of Formulae (MF1)

Other Materials Required:

None

Monday 25 January 2010
Morning

Duration: 1 hour 30 minutes



INSTRUCTIONS TO CANDIDATES

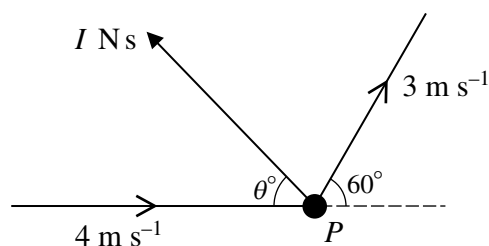
- Write your name clearly in capital letters, your Centre Number and Candidate Number in the spaces provided on the Answer Booklet.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question or is clearly appropriate.
- The acceleration due to gravity is denoted by $g \text{ m s}^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a graphical calculator in this paper.

INFORMATION FOR CANDIDATES

- The number of marks is given in brackets [] at the end of each question or part question.
- **You are reminded of the need for clear presentation in your answers.**
- The total number of marks for this paper is **72**.
- This document consists of **4** pages. Any blank pages are indicated.

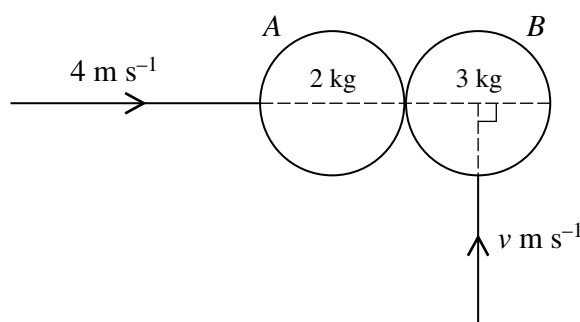
2

1



A particle P of mass 0.4 kg is moving horizontally with speed 4 m s^{-1} when it receives an impulse of magnitude $I \text{ N s}$, in a direction which makes an angle $(180 - \theta)^\circ$ with the direction of motion of P . Immediately after the impulse acts P moves horizontally with speed 3 m s^{-1} . The direction of motion of P is turned through an angle of 60° by the impulse (see diagram). Find I and θ . [7]

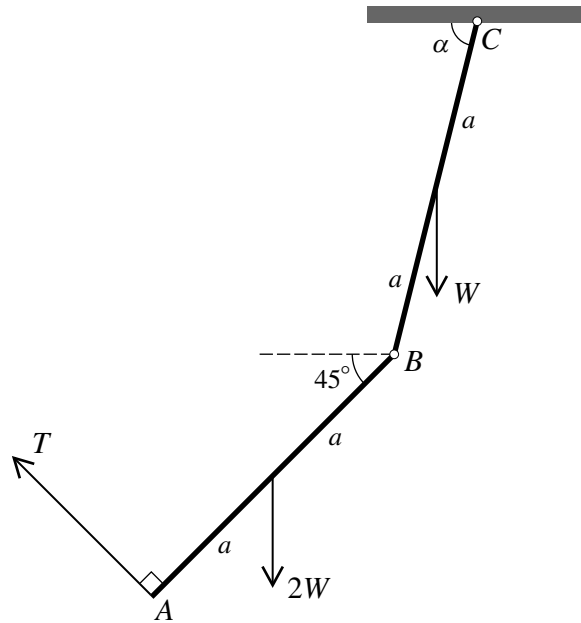
2



Two uniform smooth spheres A and B , of equal radius, have masses 2 kg and 3 kg respectively. They are moving on a horizontal surface when they collide. Immediately before the collision, A has speed 4 m s^{-1} and is moving along the line of centres, and B has speed $v \text{ m s}^{-1}$ and is moving perpendicular to the line of centres (see diagram). The coefficient of restitution is 0.6 . The direction of motion of B after the collision makes an angle of 45° with the line of centres. Find the value of v . [7]

3

3



Two uniform rods AB and BC , each of length $2a$, have weights $2W$ and W respectively. The rods are freely jointed to each other at B , and BC is freely jointed to a fixed point at C . The rods are held in equilibrium in a vertical plane by a light string attached to A and perpendicular to AB . The rods AB and BC make angles 45° and α , respectively, with the horizontal. The tension in the string is T (see diagram).

- (i) By taking moments about B for AB , show that $W = \sqrt{2}T$. [3]
- (ii) Find the value of $\tan \alpha$. [6]

4 A particle P of mass 0.2 kg travels in a straight line on a horizontal surface. It passes through a point O on the surface with speed 2 m s^{-1} . A resistive force of magnitude $0.2(v + v^2)$ N acts on P in the direction opposite to its motion, where $v \text{ m s}^{-1}$ is the speed of P when it is at a distance x m from O .

- (i) Show that $\frac{1}{1+v} \frac{dv}{dx} = -1$. [3]
- (ii) By solving the differential equation in part (i) show that $\frac{-e^x}{3-e^x} \frac{dx}{dt} = -1$, where t s is the time taken for P to travel x m from O . [5]
- (iii) Hence find the value of t when $x = 1$. [3]

5 A light elastic string of natural length 1.6 m has modulus of elasticity 120 N. One end of the string is attached to a fixed point O and the other end is attached to a particle P of weight 1.5 N. The particle is released from rest at the point A , which is 2.1 m vertically below O . It comes instantaneously to rest at B , which is vertically above O .

- (i) Verify that the distance AB is 4 m. [4]
- (ii) Find the maximum speed of P during its upward motion from A to B . [7]

6

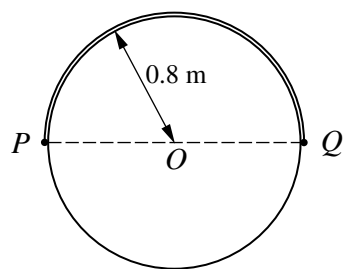


Fig. 1

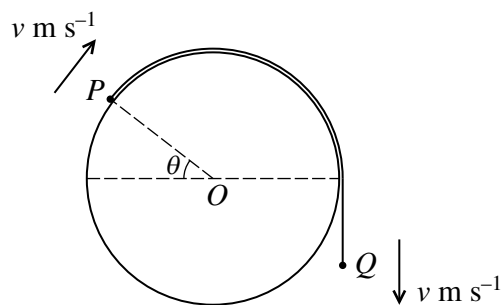


Fig. 2

A light inextensible string of length $0.8\pi\text{ m}$ has particles P and Q , of masses 0.4 kg and 0.58 kg respectively, attached to its ends. The string passes over a smooth horizontal cylinder of radius 0.8 m , which is fixed with its axis horizontal and passing through a fixed point O . The string is held at rest in a vertical plane perpendicular to the axis of the cylinder, with P and Q at opposite ends of the horizontal diameter of the cylinder through O (see Fig. 1). The string is released and Q begins to descend. When OP has rotated through θ radians, with P remaining in contact with the cylinder, the speed of each particle is $v\text{ m s}^{-1}$ (see Fig. 2).

- (i) By considering the total energy of the system, obtain an expression for v^2 in terms of θ . [5]
- (ii) Show that the magnitude of the force exerted on P by the cylinder is $(7.12 \sin \theta - 4.64\theta)\text{ N}$. [4]
- (iii) Given that P leaves the surface of the cylinder when $\theta = \alpha$, show that $1.53 < \alpha < 1.54$. [4]

7 A particle P of mass 0.5 kg is attached to one end of each of two identical light elastic strings of natural length 1.6 m and modulus of elasticity 19.6 N . The other ends of the strings are attached to fixed points A and B on a line of greatest slope of a smooth plane inclined at 30° to the horizontal. The distance AB is 4.8 m and A is higher than B .

- (i) Find the distance AP for which P is in equilibrium on the line AB . [5]

P is released from rest at a point on AB where both strings are taut. The strings remain taut during the subsequent motion of P and t seconds after release the distance AP is $(2.5 + x)\text{ m}$.

- (ii) Use Newton's second law to obtain an equation of the form $\frac{d^2x}{dt^2} = kx$. State the property of the constant k for which the equation indicates that P 's motion is simple harmonic, and find the period of this motion. [5]
- (iii) Given that $x = 0.5$ when $t = 0$, find the values of x for which the speed of P is 2.8 m s^{-1} . [4]



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