

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 19 January 2009
Afternoon

Duration: 1 hour 30 minutes



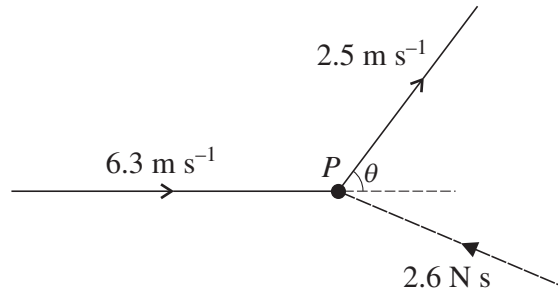
INSTRUCTIONS TO CANDIDATES

- 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.

1



A particle P of mass 0.5 kg is moving in a straight line with speed 6.3 m s^{-1} . An impulse of magnitude 2.6 N s applied to P deflects its direction of motion through an angle θ , and reduces its speed to 2.5 m s^{-1} (see diagram). By considering an impulse-momentum triangle, or otherwise,

(i) show that $\cos \theta = 0.6$, [4]

(ii) find the angle that the impulse makes with the original direction of motion of P . [4]

2

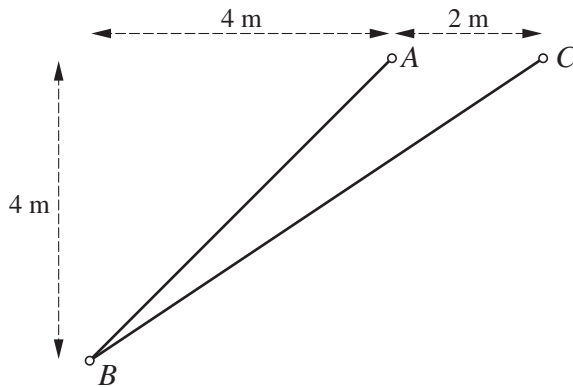


Fig. 1

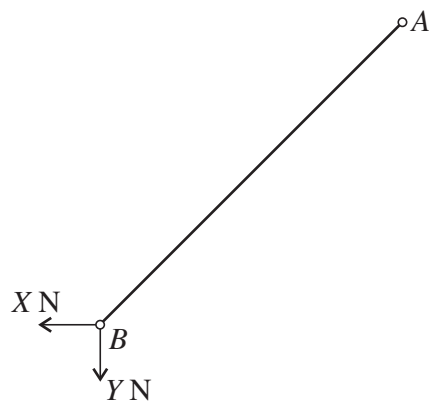


Fig. 2

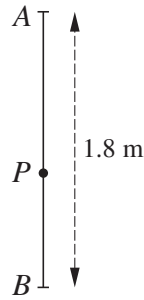
Two uniform rods AB and BC , of weights 70 N and 110 N respectively, are freely jointed at B . The rods are in equilibrium in a vertical plane with A and C at the same horizontal level and $AC = 2 \text{ m}$. The rod AB is freely jointed to a fixed point at A and the rod BC is freely jointed to a fixed point at C . The horizontal distance between B and A is 4 m and B is 4 m below AC ; angle BAC is obtuse (see Fig. 1). The force exerted on the rod AB at B , by the rod BC , has horizontal and vertical components as shown in Fig. 2.

(i) By taking moments about A for the rod AB find the value of $X - Y$. [2]

(ii) By taking moments about C for the rod BC show that $2X - 3Y + 165 = 0$. [2]

(iii) Find the magnitude of the force acting between AB and BC at B . [4]

3



A and B are fixed points with B at a distance of 1.8 m vertically below A . One end of a light elastic string of natural length 0.6 m and modulus of elasticity 24 N is attached to A , and one end of an identical elastic string is attached to B . A particle P of weight 12 N is attached to the other ends of the strings (see diagram).

(i) Verify that P is in equilibrium when it is at a distance of 1.05 m vertically below A . [2]

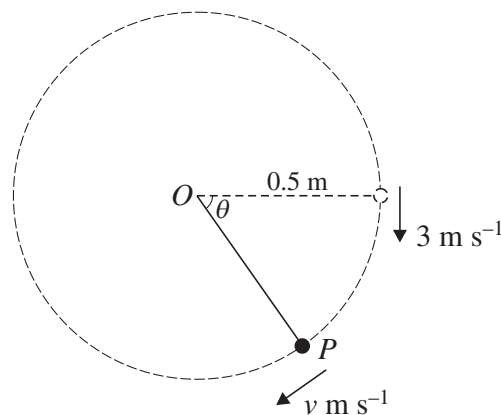
P is released from rest at the point 1.2 m vertically below A and begins to move.

(ii) Show that, when P is x m below its equilibrium position, the tensions in PA and PB are $(18 + 40x)$ N and $(6 - 40x)$ N respectively. [2]

(iii) Show that P moves with simple harmonic motion of period 0.777 s, correct to 3 significant figures. [3]

(iv) Find the speed with which P passes through the equilibrium position. [2]

4



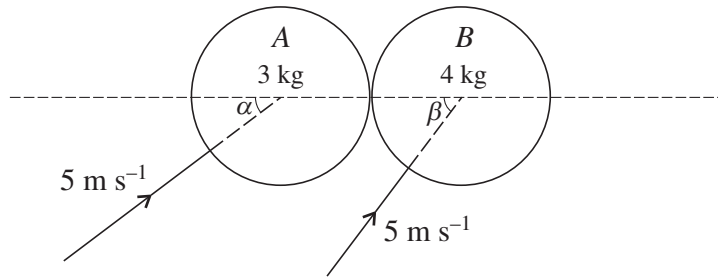
One end of a light inextensible string of length 0.5 m is attached to a fixed point O . A particle P of mass 0.2 kg is attached to the other end of the string. With the string taut and horizontal, P is projected with a velocity of 3 m s^{-1} vertically downward. P begins to move in a vertical circle with centre O . While the string remains taut the angular displacement of OP is θ radians from its initial position, and the speed of P is $v \text{ m s}^{-1}$ (see diagram).

(i) Show that $v^2 = 9 + 9.8 \sin \theta$. [3]

(ii) Find, in terms of θ , the radial and tangential components of the acceleration of P . [3]

(iii) Show that the tension in the string is $(3.6 + 5.88 \sin \theta)$ N and hence find the value of θ at the instant when the string becomes slack, giving your answer correct to 1 decimal place. [4]

5



Two smooth uniform spheres A and B , of equal radius, have masses 3 kg and 4 kg respectively. They are moving on a horizontal surface, each with speed 5 m s^{-1} , when they collide. The directions of motion of A and B make angles α and β respectively with the line of centres of the spheres, where $\sin \alpha = \cos \beta = 0.6$ (see diagram). The coefficient of restitution between the spheres is 0.75 . Find the angle that the velocity of A makes, immediately after impact, with the line of centres of the spheres.

[10]

- 6 A stone of mass 0.125 kg falls freely under gravity, from rest, until it has travelled a distance of 10 m . The stone then continues to fall in a medium which exerts an upward resisting force of $0.025v\text{ N}$, where $v\text{ m s}^{-1}$ is the speed of the stone $t\text{ s}$ after the instant that it enters the resisting medium.

(i) Show by integration that $v = 49 - 35e^{-0.2t}$. [8]

(ii) Find how far the stone travels during the first 3 seconds in the medium. [4]

- 7 A particle of mass 0.8 kg is attached to one end of a light elastic string of natural length 2 m and modulus of elasticity 20 N . The other end of the string is attached to a fixed point O . The particle is held at rest at O and then released. When the extension of the string is $x\text{ m}$, the particle is moving with speed $v\text{ m s}^{-1}$.

(i) By considering energy show that $v^2 = 39.2 + 19.6x - 12.5x^2$. [4]

(ii) Hence find

(a) the maximum extension of the string, [2]

(b) the maximum speed of the particle, [4]

(c) the maximum magnitude of the acceleration of the particle. [5]