OCR
RECOGNISING ACHIEVEMENT

**ADVANCED GCE**

# MATHEMATICS

4730

Mechanics 3

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

*4730*

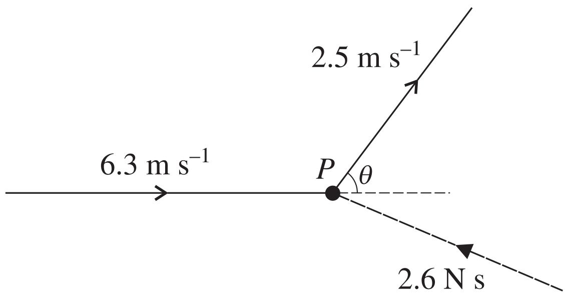
## INSTRUCTIONS TO CANDIDATES

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

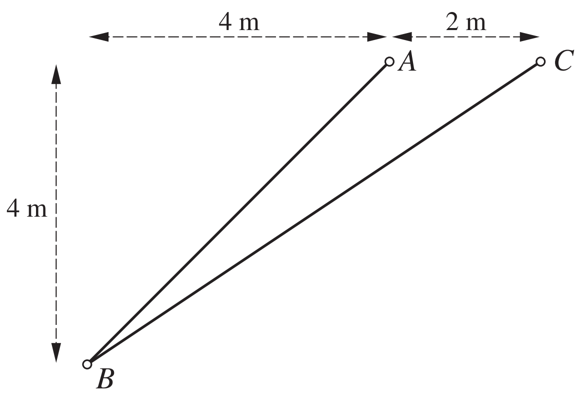



**Fig. 1**

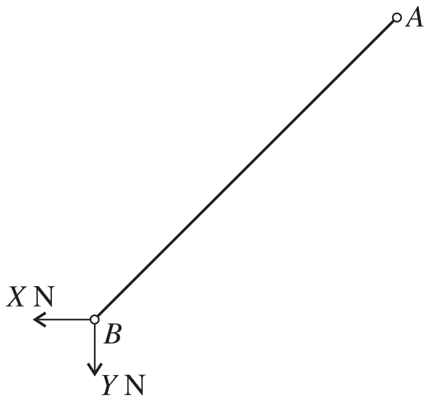



**Fig. 2**

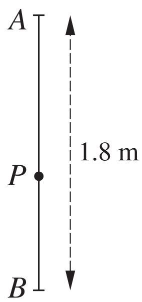
Two uniform rods $AB$ and $BC$, of weights 70 N and 110 N respectively, are freely jointed at $B$. The rods are in equilibrium in a vertical plane with $A$ and $C$ at the same horizontal level and $AC$ = 2 m. The rod $AB$ is freely jointed to a fixed point at $A$ and the rod $BC$ is freely jointed to 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]**

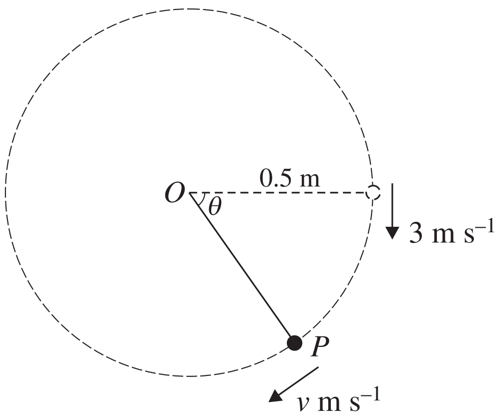
$P$ is released from rest at the point 1.2 m vertically below $A$ and begins to move.

**(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



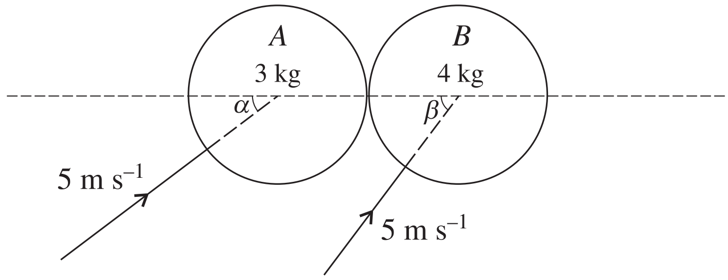

One end of a light inextensible string of length 0.5 m is attached to a fixed point $O$. A particle $P$ of mass 0.2 kg is attached to the other end of the string. With the string taut and horizontal, $P$ is projected with a velocity of $3\,\text{m}\,\text{s}^{-1}$ vertically downward. $P$ begins to move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

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

**(ii)** Find, in terms of $\theta$, 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 $\theta$ 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 $5\,\text{m}\,\text{s}^{-1}$, when they collide. The directions of motion of $A$ and $B$ make angles $\alpha$ and $\beta$ 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 $0.025v$ N, where $v\,\text{m}\,\text{s}^{-1}$ is the speed of the stone $t$ s after the instant that it enters the resisting medium.

**(i)** Show by integration that $v = 49 - 35\text{e}^{-0.2t}$. **[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 $x$ m, the particle is moving with speed $v\,\text{m}\,\text{s}^{-1}$.

**(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]**