OCR
RECOGNISING ACHIEVEMENT

**ADVANCED GCE**

# MATHEMATICS 4730

Mechanics 3

Candidates answer on the answer booklet.

**OCR supplied materials:**
- 8 page answer booklet (sent with general stationery)
- List of Formulae (MF1)

**Other materials required:**
- Scientific or graphical calculator

**Monday 24 January 2011**
**Morning**

**Duration:** 1 hour 30 minutes

* 4 7 3 0 *

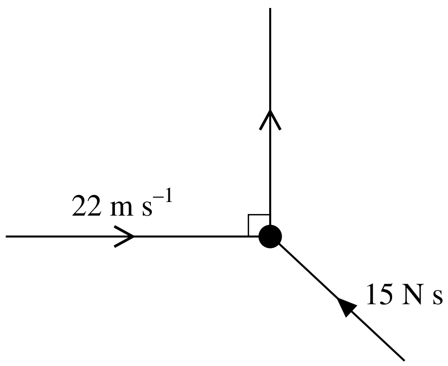
## INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the spaces provided on the answer booklet. Please write clearly and in capital letters.
- Use black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully. Make sure 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 $g$ m s$^{-2}$. Unless otherwise instructed, when a numerical value is needed, use $g = 9.8$.
- You are permitted to use a scientific or 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 ball of mass 0.5 kg is moving with speed $22\ \text{m s}^{-1}$ in a straight line when it is struck by a bat. The impulse exerted by the bat has magnitude 15 N s and the ball is deflected through an angle of $90^\circ$ (see diagram). Find

**(i)** the direction of the impulse, **[3]**

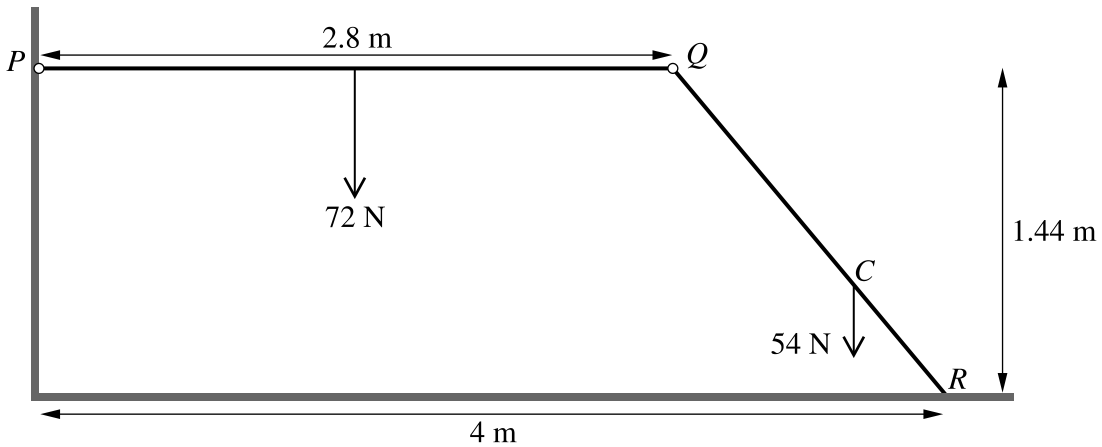
**(ii)** the speed of the ball immediately after it is struck. **[3]**

**2** A particle of mass 0.4 kg is attached to a fixed point $O$ by a light inextensible string of length 0.5 m. The particle is projected horizontally with speed $6\ \text{m s}^{-1}$ from the point 0.5 m vertically below $O$. The particle moves in a complete circle. Find the tension in the string when

**(i)** the string is horizontal,

**(ii)** the particle is vertically above $O$. **[6]**

**3**



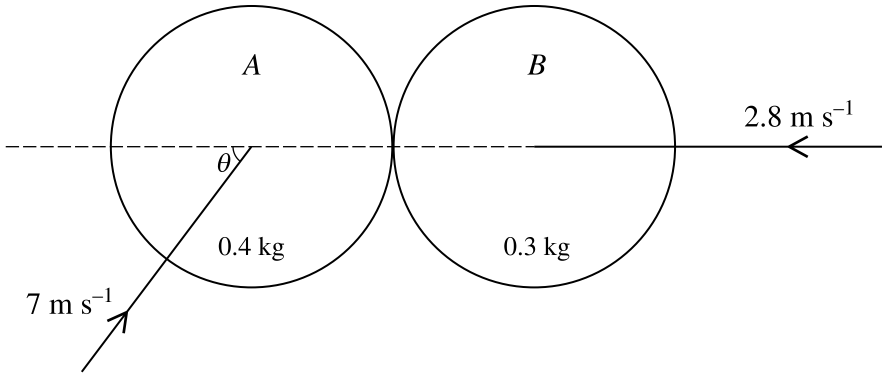

A uniform rod $PQ$ has weight 72 N. A non-uniform rod $QR$ has weight 54 N and its centre of mass is at $C$, where $QC = 2CR$. The rods are freely jointed to each other at $Q$. The rod $PQ$ is freely jointed to a fixed point of a vertical wall at $P$ and the rod $QR$ rests on horizontal ground at $R$. The rod $PQ$ is 2.8 m long and is horizontal. The point $R$ is 1.44 m below the level of $PQ$ and 4 m from the wall (see diagram).

**(i)** Find the vertical component of the force exerted by the wall on $PQ$. **[2]**

**(ii)** Hence show that the normal component of the force exerted by the ground on $QR$ is 90 N. **[2]**

**(iii)** Given that the friction at $R$ is limiting, find the coefficient of friction between the rod $QR$ and the ground. **[5]**

**4**




Two uniform smooth spheres $A$ and $B$ of equal radius are moving on a horizontal surface when they collide. $A$ has mass 0.4 kg and $B$ has mass 0.3 kg. Immediately before the collision $A$ is moving with speed 7 m s$^{-1}$ at an acute angle $\theta$ to the line of centres, where $\cos\theta = 0.6$, and $B$ is moving with speed 2.8 m s$^{-1}$ along the line of centres (see diagram). The coefficient of restitution between the spheres is 0.7. Find

**(i)** the speed of $B$ immediately after the collision, **[6]**

**(ii)** the angle turned through by the direction of motion of $A$ as a result of the collision. **[5]**

**5** A particle $P$ of mass 0.05 kg is suspended from a fixed point $O$ by a light elastic string of natural length 0.5 m and modulus of elasticity 2.45 N.

**(i)** Show that the equilibrium position of $P$ is 0.6 m below $O$. **[3]**

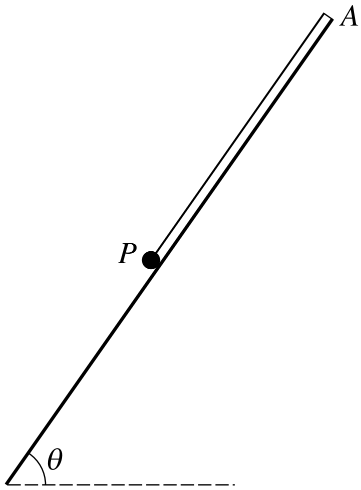
$P$ is held at rest at a point 0.675 m vertically below $O$ and then released. At time $t$ s after $P$ is released, its downward displacement from the equilibrium position is $x$ m.

**(ii)** Show that $\dfrac{d^2x}{dt^2} = -98x$. **[3]**

**(iii)** Find the value of $x$ and the magnitude and direction of the velocity of $P$ when $t = 0.2$. **[7]**

**[Questions 6 and 7 are printed overleaf.]**

**6**




A particle $P$, of mass 3.5 kg, is in equilibrium suspended from the top $A$ of a smooth slope inclined at an angle $\theta$ to the horizontal, where $\sin\theta = \frac{40}{49}$, by an elastic rope of natural length 4 m and modulus of elasticity 112 N (see diagram). Another particle $Q$, of mass 0.5 kg, is released from rest at $A$ and slides freely downwards until it reaches $P$ and becomes attached to it.

**(i)** Find the value of $V^2$, where $V\,\text{m s}^{-1}$ is the speed of $Q$ immediately before it becomes attached to $P$, and show that the speed of the combined particles, immediately after $Q$ becomes attached to $P$, is $\frac{1}{2}\sqrt{5}\,\text{m s}^{-1}$. **[6]**

The combined particles slide downwards for a distance of $X$ m, before coming instantaneously to rest at $B$.

**(ii)** Show that $28X^2 - 8X - 5 = 0$. **[6]**

**7** A particle $P$ of mass 0.2 kg is released from rest at a point $O$ and falls vertically. Air resistance of magnitude $\dfrac{v^2}{2000}$ N acts upwards on $P$, where $v\,\text{m s}^{-1}$ is the velocity of $P$ when it has fallen a distance of $x$ m.

**(i)** Show that $\left(\dfrac{400v}{3920 - v^2}\right)\dfrac{dv}{dx} = 1$. **[2]**

**(ii)** Find $v^2$ in terms of $x$ and hence show that $v^2 < 3920$ for all values of $x$. **[7]**

**(iii)** Find the work done against the air resistance while $P$ is falling, from $O$, to the point where its downward acceleration is $5.8\,\text{m s}^{-2}$. **[6]**