

# **A Level Mathematics A**

**H240/03** Pure Mathematics and Mechanics

## **Question Set 2**

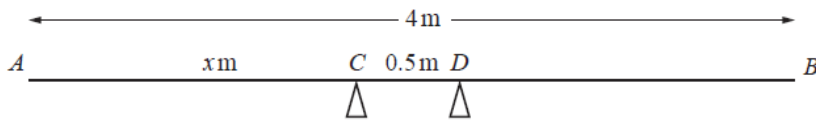
**1** In this question  $\begin{pmatrix} 1 \\ 0 \end{pmatrix}$  and  $\begin{pmatrix} 0 \\ 1 \end{pmatrix}$  denote unit vectors which are horizontal and vertically upwards respectively.

A particle of mass 5 kg, initially at rest at the point with position vector  $\begin{pmatrix} 2 \\ 45 \end{pmatrix}$  m, is acted on by gravity and also by two forces  $\begin{pmatrix} 15 \\ -8 \end{pmatrix}$  N and  $\begin{pmatrix} -7 \\ -2 \end{pmatrix}$  N.

(a) Find the acceleration vector of the particle. [3]

(b) Find the position vector of the particle after 10 seconds. [3]

**2** A uniform plank  $AB$  has weight 100 N and length 4 m. The plank rests horizontally in equilibrium on two smooth supports  $C$  and  $D$ , where  $AC = x$  m and  $CD = 0.5$  m (see diagram).



The magnitude of the reaction of the support on the plank at  $C$  is 75 N. Modelling the plank as a rigid rod, find

(a) the magnitude of the reaction of the support on the plank at  $D$ , [1]

(b) the value of  $x$ . [3]

A stone block, which is modelled as a particle, is now placed at the end of the plank at  $B$  and the plank is on the point of tilting about  $D$ .

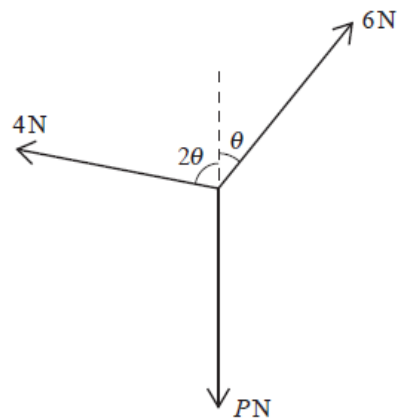
(c) Find the weight of the stone block. [3]

(d) Explain the limitation of modelling

(i) the stone block as a particle, [1]

(ii) the plank as a rigid rod. [1]

- 3 Three forces, of magnitudes 4N, 6N and  $PN$ , act at a point in the directions shown in the diagram.



The forces are in equilibrium.

- (a) Show that  $\theta = 41.4^\circ$ , correct to 3 significant figures. [4]

- (b) Hence find the value of  $P$ . [2]

The force of magnitude 4N is now removed and the force of magnitude 6N is replaced by a force of magnitude 3N acting in the same direction.

- (c) Find

- (i) the magnitude of the resultant of the two remaining forces, [3]

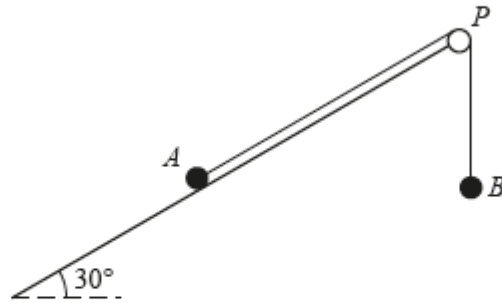
- (ii) the direction of the resultant of the two remaining forces. [2]

- 4 The velocity  $v \text{ m s}^{-1}$  of a car at time  $t \text{ s}$ , during the first 20 s of its journey, is given by  $v = kt + 0.03t^2$ , where  $k$  is a constant. When  $t = 20$  the acceleration of the car is  $1.3 \text{ m s}^{-2}$ . For  $t > 20$  the car continues its journey with constant acceleration  $1.3 \text{ m s}^{-2}$  until its speed reaches  $25 \text{ m s}^{-1}$ .

- (a) Find the value of  $k$ . [3]

- (b) Find the total distance the car has travelled when its speed reaches  $25 \text{ m s}^{-1}$ . [7]

- 5 One end of a light inextensible string is attached to a particle  $A$  of mass  $m$  kg. The other end of the string is attached to a second particle  $B$  of mass  $\lambda m$  kg, where  $\lambda$  is a constant. Particle  $A$  is in contact with a rough plane inclined at  $30^\circ$  to the horizontal. The string is taut and passes over a small smooth pulley  $P$  at the top of the plane. The part of the string from  $A$  to  $P$  is parallel to a line of greatest slope of the plane. The particle  $B$  hangs freely below  $P$  (see diagram).



The coefficient of friction between  $A$  and the plane is  $\mu$ .

- (a) It is given that  $A$  is on the point of moving down the plane.
- (i) Find the exact value of  $\mu$  when  $\lambda = \frac{1}{4}$ . [7]
- (ii) Show that the value of  $\lambda$  must be less than  $\frac{1}{2}$ . [2]
- (b) Given instead that  $\lambda = 2$  and that the acceleration of  $A$  is  $\frac{1}{4}g \text{ m s}^{-2}$ , find the exact value of  $\mu$ . [5]

**Total Marks for Question Set 2: 50 Marks**

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