OCR
Oxford Cambridge and RSA

AS Level Mathematics A

H230/02 Pure Mathematics and Mechanics

Question Set 4

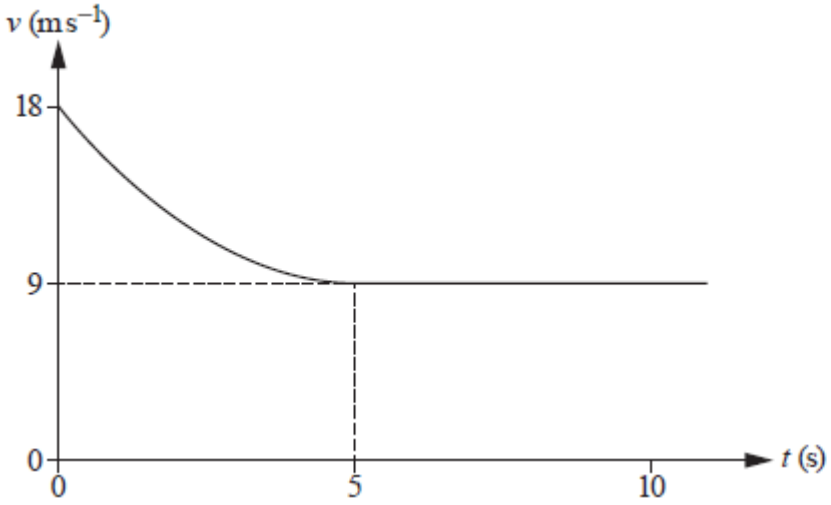
1 Three forces $\begin{pmatrix} 7 \\ -6 \end{pmatrix}$N, $\begin{pmatrix} 2 \\ 5 \end{pmatrix}$N and **F** N act on a particle.

Given that the particle is in equilibrium under the action of these three forces, calculate **F**. **[2]**

$\begin{pmatrix} -7 \\ 6 \end{pmatrix} + \begin{pmatrix} 2 \\ 5 \end{pmatrix} + \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} 0 \\ 0 \end{pmatrix}$

$x = -9$, $y = 1$ $\quad \mathbf{F} = \begin{pmatrix} -9 \\ 1 \end{pmatrix}$

2



The diagram shows the velocity-time graph modelling the velocity of a car as it approaches, and drives through, a residential area.

The velocity of the car, v m s^{-1}, at time t seconds for the time interval $0 \leqslant t \leqslant 5$ is modelled by the equation $v = pt^2 + qt + r$, where p, q and r are constants.

It is given that the acceleration of the car is zero at $t = 5$ and the speed of the car then remains constant.

(a) Determine the values of p, q and r. **[5]**

when $t = 0$ $v = 18$ $\therefore r = 18$

$q = 25p + 5q + r$

$-q = 25p + 5q$

$a = 2pt + q$

$0 = 10p + q$

$10p + q = 0$

$25p + 5q = -9$

$p = 0.36$

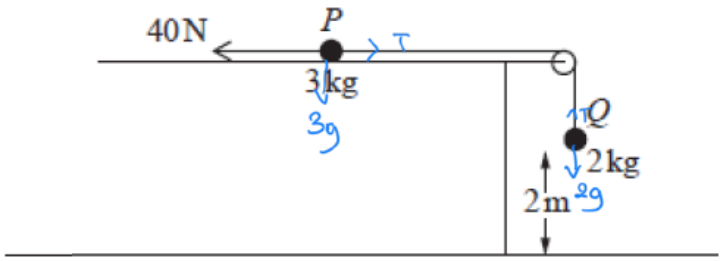
$q = -3.6$

(b) Calculate the distance travelled by the car from $t = 2$ to $t = 10$. **[3]**

$$\int_2^5 0.36t^2 - 3.6t + 18 \, dt + 5 \times 9$$

$$= 30.24 + 45 = 75.24 \text{ m}$$

3 Two small balls P and Q have masses 3 kg and 2 kg respectively. The balls are attached to the ends of a string. P is held at rest on a rough horizontal surface. The string passes over a pulley which is fixed at the edge of the surface. Q hangs vertically below the pulley at a height of 2 m above a horizontal floor.



The system is initially at rest with the string taut. A horizontal force of magnitude 40 N acts on P as shown in the diagram.

P is released and moves directly away from the pulley. A constant frictional force of magnitude 8 N opposes the motion of P. It is given that P does not leave the horizontal surface and that Q does not reach the pulley in the subsequent motion.

The balls are modelled as particles, the pulley is modelled as being small and smooth, and the string is modelled as being light and inextensible.

(a) Show that the magnitude of the acceleration of each particle is $2.48\,\text{m s}^{-2}$. [5]

$40-T-8=3a \quad 32-2q=5a$
$T-2q=2a$
$a=2.48\,\text{ms}^{-2}$

(b) Find the tension in the string. [2]

$T-2g=2\times2.48$
$T=24.58\text{N}$

When the balls have been in motion for 0.5 seconds, the string breaks.

(c) Find the additional time that elapses until Q hits the floor. [5]

$v=(0)+(2.48)(0.5)$
$=1.24\,\text{ms}^{-1}$
$s=(0)(0.5)+\frac{1}{2}(2.48)(0.5)^2$
$=0.31\text{m}$
$t=?\quad a=g\quad s=0.31+2=2.31\text{m}\quad u=1.24\,\text{ms}^{-1}$
$2.31=(1.24)t+\frac{1}{2}(9.81)t^2\quad t=0.571\text{s},\ -0.824\text{s}$
0.571s

(d) Find the speed of Q as it hits the floor. [2]

$v = (1.24) + (9.81)(0.571) = 6.84\ ms^{-1}$

(e) Write down the magnitude of the normal reaction force acting on Q when Q has come to rest on the floor. [1]

2g N

(f) State one improvement that could be made to the model. [1]

If the effect of air resistance was included