

AS Level Mathematics A

H230/02 Pure Mathematics and Mechanics

Question Set 2

- 1 In this question the horizontal unit vectors i and j are in the directions east and north respectively.

A model ship of mass 2 kg is moving so that its acceleration vector $a\text{ ms}^{-2}$ at time t seconds is given by $a = 3(2t-5)i + 4j$. When $t = T$, the magnitude of the horizontal force acting on the ship is 10 N .

Find the possible values of T . [4]

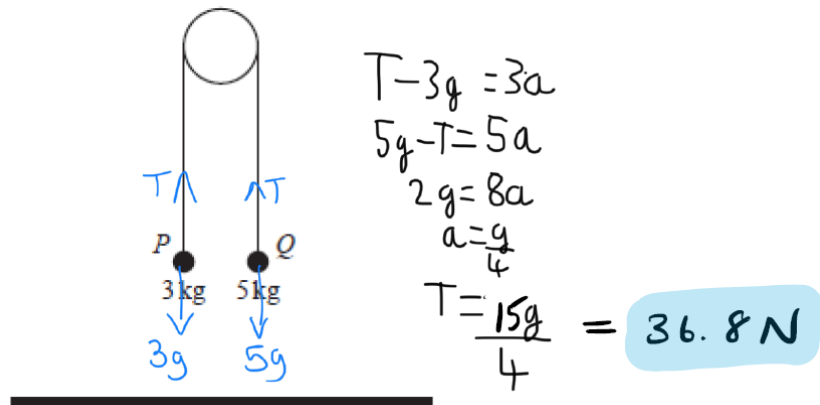
$$10 = 2 \sqrt{\frac{(6t-15)^2}{4}} \quad (12t-30)^2 = 36$$

$$12t-30 = \pm 6$$

$$t = 3, 2$$

$$10 = \sqrt{(12t-30)^2 + 8^2} = 10^2$$

- 2 Particles P and Q , of masses 3 kg and 5 kg respectively, are attached to the ends of a light inextensible string. The string passes over a smooth fixed pulley. The system is held at rest with the string taut. The hanging parts of the string are vertical and P and Q are above a horizontal plane (see diagram).



- (a) Find the tension in the string immediately after the particles are released. [4]

After descending 2.5 m , Q strikes the plane and is immediately brought to rest. It is given that P does not reach the pulley in the subsequent motion.

- (b) Find the distance travelled by P between the instant when Q strikes the plane and the instant when the string becomes taut again. [4]

$$s = 2.5 \quad s = ?$$

$$u = 0 \quad v = \sqrt{5g}$$

$$v = ? \quad v = 0$$

$$a = \frac{g}{4} \quad a = -g$$

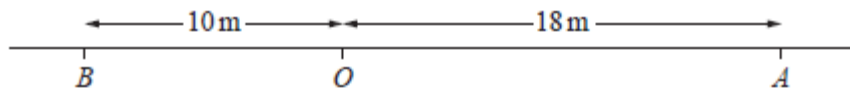
$$T = \quad T =$$

$$v^2 = u^2 + 2as \rightarrow$$

$$v^2 = \frac{5g}{4} \quad 0 = \frac{5g}{4} - 2gs$$

$$v = \frac{\sqrt{5g}}{2}$$

$$s = \frac{5}{8} \text{ m}$$



A particle P is moving along a straight line with constant acceleration. Initially the particle is at O . After 9 s, P is at a point A , where $OA = 18$ m (see diagram) and the velocity of P at A is 8 m s^{-1} in the direction \overrightarrow{OA} .

- (a) (i) Show that the initial speed of P is 4 m s^{-1} . [2]

$$\begin{aligned}
 s &= 18 & s &= \left(\frac{u+v}{2}\right)t \\
 u &= & & \\
 v &= 8 & \frac{36}{9} &= u + 8 \\
 a &= & u &= -4 \text{ speed} = 4 \\
 T &= 9 & &
 \end{aligned}$$

- (ii) Find the acceleration of P . [2]

$$\begin{aligned}
 v &= u + at \\
 8 &= -4 + 9a & a &= \frac{4}{3}
 \end{aligned}$$

B is a point on the line such that $OB = 10$ m, as shown in the diagram.

- (b) Show that P is never at point B . [4]

$$\begin{aligned}
 s &= -10 & -10 &= -4t + \frac{1}{2}\left(\frac{4}{3}\right)t^2 \\
 u &= -4 & 2t^2 - 12t + 30 &= 0 \\
 v &= & t^2 - 6t + 15 &= 0 \therefore \text{no solutions} \\
 A &= 1.33 & & \\
 T &= ? & &
 \end{aligned}$$

A second particle Q moves along the same straight line, but has variable acceleration. Initially Q is at O , and the displacement of Q from O at time t seconds is given by

$$x = at^3 + bt^2 + ct,$$

where a , b and c are constants.

$$\begin{aligned}
 v &= 3at^2 + 2bt + c \\
 a &= 6at + 2b
 \end{aligned}$$

It is given that

- the velocity and acceleration of Q at the point O are the same as those of P at O ,
- Q reaches the point A when $t = 6$.

$$\begin{aligned}
 v &= \frac{1}{4}t^2 + \frac{4}{3}t - 4 \\
 t &= 6 & v &= \frac{1}{4}(6)^2 + \frac{4}{3}(6) - 4 \\
 & & &= 13 \text{ m s}^{-1}
 \end{aligned}$$

$$\begin{aligned}
 t &= 0, v = -4 \\
 -4 &= 3a(0)^2 + 2b(0) + c \\
 c &= -4 \\
 t &= 0, a = \frac{4}{3} \\
 \frac{4}{3} &= 6a(0) + 2b \\
 b &= \frac{2}{3} \\
 t &= 6, x = 18 \\
 18 &= a(6)^3 + \frac{2}{3}(6)^2 + (-4)(6) \\
 a &= \frac{1}{12}
 \end{aligned}$$

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