Topic X8 Mechanics (Pre-TT A) [58]

Covering chapters 19, 20 and Ex 21A (resolving forces).

1.

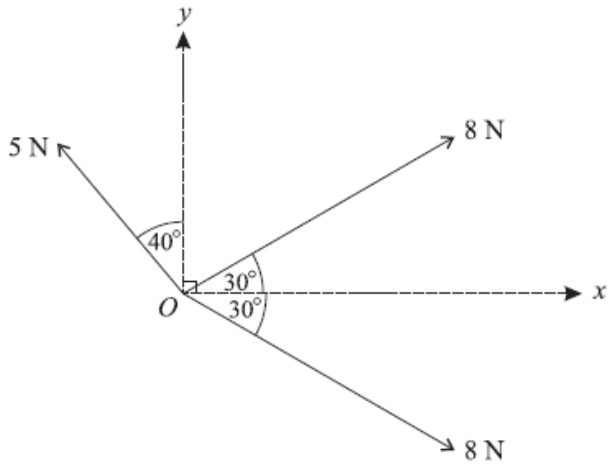
A golfer hits a ball from a point O on horizontal ground with a velocity of $50\,\text{m s}^{-1}$ at an angle of 25° above the horizontal. The ball first hits the ground at a point A. Assuming that there is no air resistance, calculate

(i) the time taken for the ball to travel from O to A, [3]

(ii) the distance OA. [2]

(Total 5 marks)

2.



Three coplanar forces of magnitudes 5 N, 8 N and 8 N act at the origin O of rectangular coordinate axes. The directions of the forces are as shown in the diagram.

(i) Find the component of the resultant of the three forces in

(a) the x-direction,

(b) the y-direction.

[5]

(ii) Find the magnitude and direction of the resultant. [4]

(Total 9 marks)

3.

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

A particle of mass 0.12 kg is moving so that its position vector **r** metres at time t seconds is given by $\mathbf{r} = 2t^3\mathbf{i} + \left(5t^2 - 4t\right)\mathbf{j}$.

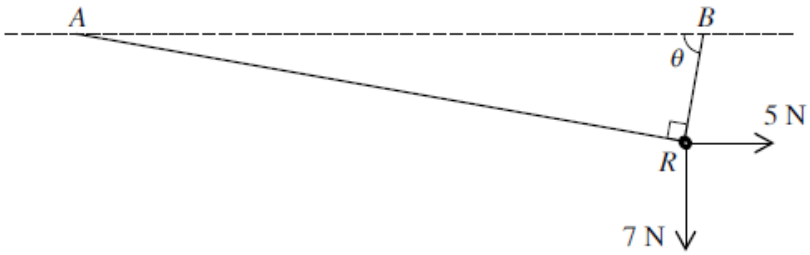
(i) Show that when $t = 0.7$ the bearing on which the particle is moving is approximately 044°. **[3]**

(ii) Find the magnitude of the resultant force acting on the particle at the instant when $t = 0.7$. **[4]**

(iii) Determine the times at which the particle is moving on a bearing of 045°. **[2]**

(Total 9 marks)

4.



A small smooth ring R of weight 7 N is threaded on a light inextensible string. The ends of the string are attached to fixed points A and B at the same horizontal level. A horizontal force of magnitude 5 N is applied to R. The string is taut. In the equilibrium position the angle ARB is a right angle, and the portion of the string attached to B makes an angle θ with the horizontal (see diagram).

(i) Explain why the tension T N is the same in each part of the string. **[1]**

(ii) By resolving horizontally and vertically for the forces acting on R, form two simultaneous equations in $T\cos\theta$ and $T\sin\theta$. **[4]**

(iii) Hence find T and θ. **[6]**

(Total 11 marks)

5.

[*In this question* **i** *and* **j** *are horizontal unit vectors due east and due north respectively*]

A radio controlled model boat is placed on the surface of a large pond.

The boat is modelled as a particle.

At time $t = 0$, the boat is at the fixed point O and is moving due north with speed 0.6 m s^{-1}.

Relative to O, the position vector of the boat at time t seconds is $\mathbf{r}$ metres.

At time $t = 15$, the velocity of the boat is $(10.5\mathbf{i} - 0.9\mathbf{j})$ m s^{-1}.

The acceleration of the boat is constant.

(a) Show that the acceleration of the boat is $(0.7\mathbf{i} - 0.1\mathbf{j})$ m s^{-2}.

(2)

(b) Find $\mathbf{r}$ in terms of t.

(2)

(c) Find the value of t when the boat is north-east of O.

(3)

(d) Find the value of t when the boat is moving in a north-east direction.

(3)

(Total 10 marks)

6.

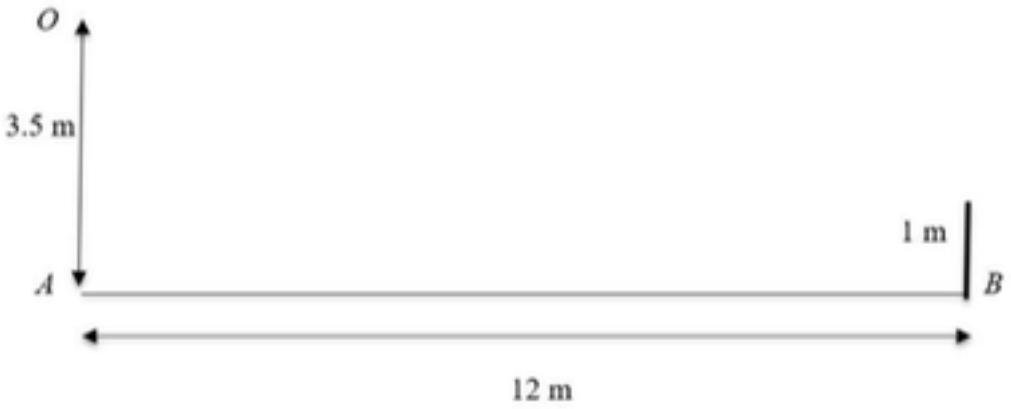


Figure 3

A tennis player serves a ball so as to pass over the net.
The ball is given an initial velocity of 45 m s^{-1} in a direction 10° below the horizontal.

The ball is struck at a point O which is 3.5 m vertically above the point A which is on horizontal ground.
The bottom of the net is the point B which is on the ground and $AB = 12$ m.
The height of the net is 1 m, as shown in Figure 3.

The ball is modelled as a particle moving freely under gravity.
The ball passes over the net at a point which is vertically above B.

Using the model,

(a) find, in centimetres to 2 significant figures, the distance between the ball and the top of the net, as the ball passes over the net,

(8)

(b) find, to 2 significant figures, the speed of the ball as it passes over the net.

(4)

(c) State two limitations of the model that could affect the reliability of your answers.

(2)

(Total 14 marks)