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7. A particle P is projected from a fixed point O on horizontal ground. The particle is projected with speed u at an angle α above the horizontal. At the instant when the horizontal distance of P from O is x, the vertical distance of P above the ground is y.
The motion of P is modelled as that of a particle moving freely under gravity.

(a) Show that $y = x\tan\alpha - \dfrac{gx^2}{2u^2}\left(1 + \tan^2\alpha\right)$

(6)

A small ball is projected from the fixed point O on horizontal ground. The ball is projected with speed $20\,\text{m s}^{-1}$ at angle $\theta°$ above the horizontal. A vertical pole AB, of height 2 m, stands on the ground with $OA = 10\,\text{m}$, as shown in Figure 3.

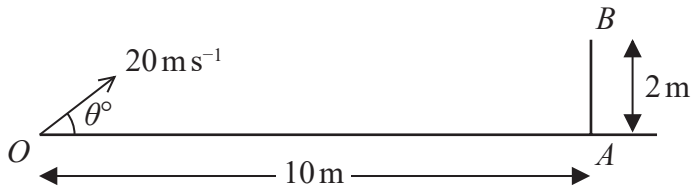


Figure 3

The ball is modelled as a particle moving freely under gravity and the pole is modelled as a rod.
The path of the ball lies in the vertical plane containing O, A and B.

Using the model,

(b) find the range of values of θ for which the ball will pass over the pole.

(3)

Given that $\theta = 40$ and that the ball first hits the ground at the point C

(c) find the speed of the ball at the instant it passes over the pole,

(5)

(d) find the distance OC.

(2)

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