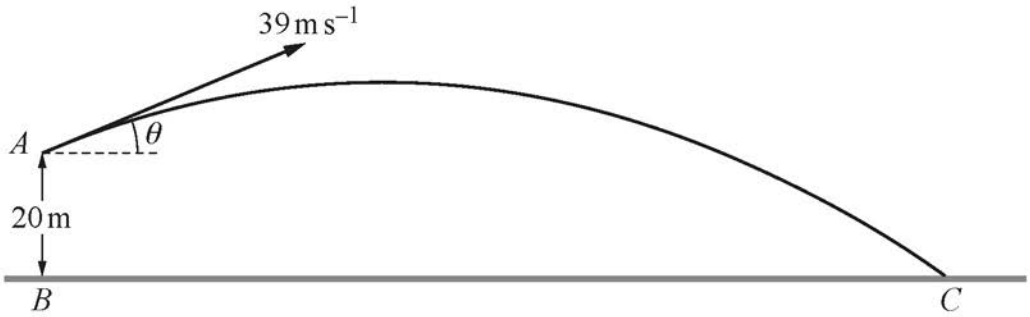
12 In this question you should take the acceleration due to gravity to be $10\,\text{m s}^{-2}$.



A small ball P is projected from a point A with speed $39\,\text{m s}^{-1}$ at an angle of elevation θ, where $\sin\theta = \frac{5}{13}$ and $\cos\theta = \frac{12}{13}$. Point A is 20 m vertically above a point B on horizontal ground. The ball first lands at a point C on the horizontal ground (see diagram).

The ball P is modelled as a particle moving freely under gravity.

(a) Find the maximum height of P above the ground during its motion. **[3]**

The time taken for P to travel from A to C is T seconds.

(b) Determine the value of T. **[3]**

(c) State **one** limitation of the model, other than air resistance or the wind, that could affect the answer to part **(b)**. **[1]**

At the instant that P is projected, a second small ball Q is released from rest at B and moves towards C along the horizontal ground.

At time t seconds, where $t \geqslant 0$, the velocity $v\,\text{m s}^{-1}$ of Q is given by

$$v = kt^3 + 6t^2 + \tfrac{3}{2}t,$$

where k is a positive constant.

(d) Given that P and Q collide at C, determine the acceleration of Q immediately before this collision. **[6]**