7 The trajectory ABCD of a small stone moving with negligible air resistance is shown in Fig. 7. AD is horizontal and BC is parallel to AD.

The stone is projected from A with speed $40\,\mathrm{m\,s^{-1}}$ at 50° to the horizontal.

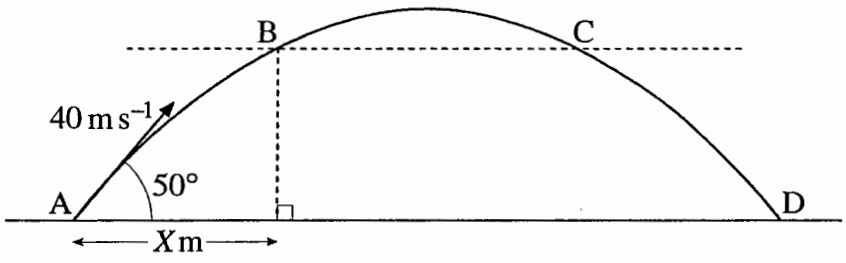

Fig. 7

(i) Write down an expression for the horizontal displacement from A of the stone t seconds after projection. Write down also an expression for the vertical displacement at time t. [3]

(ii) Show that the stone takes 6.253 seconds (to three decimal places) to travel from A to D. Calculate the range of the stone. [5]

You are given that $X = 30$.

(iii) Calculate the time it takes the stone to reach B. Hence determine the time for it to travel from A to C. [4]

(iv) Calculate the direction of the motion of the stone at C. [5]

7 In this question take the value of g to be $10\,\text{m s}^{-2}$.

A particle A is projected over horizontal ground from a point P which is 9 m above a point O on the ground. The initial velocity has horizontal and vertical components of $10\,\text{m s}^{-1}$ and $12\,\text{m s}^{-1}$ respectively, as shown in Fig. 7. The trajectory of the particle meets the ground at X. Air resistance may be neglected.

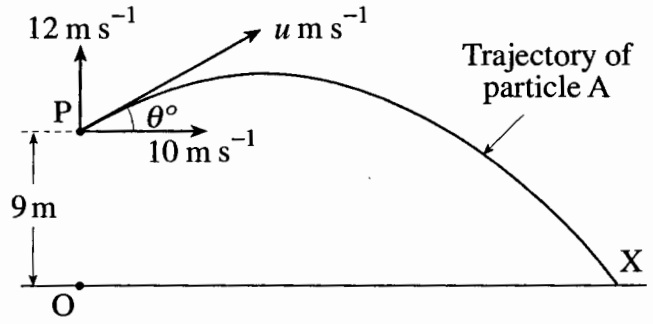

Fig. 7

(i) Calculate the speed of projection $u\,\text{m s}^{-1}$ and the angle of projection $\theta°$. [3]

(ii) Show that, t seconds after projection, the height of particle A above the ground is $9 + 12t - 5t^2$. Write down an expression in terms of t for the horizontal distance of the particle from O at this time. [4]

(iii) Calculate the maximum height of particle A above the point of projection. [2]

(iv) Calculate the distance OX. [4]

A second particle, B, is projected from O with speed $20\,\text{m s}^{-1}$ at 60° to the horizontal. The trajectories of A and B are in the same vertical plane. Particles A and B are projected at the same time.

(v) Show that the horizontal displacements of A and B are always equal. [2]

(vi) Show that, t seconds after projection, the height of particle B above the ground is $10\sqrt{3}t - 5t^2$. [1]

(vii) Show that the particles collide 1.7 seconds after projection (correct to two significant figures). [3]

8 A girl throws a small stone with initial speed $14\,\text{m s}^{-1}$ at an angle of 60° to the horizontal from a point 1 m above the ground. She throws the stone directly towards a vertical wall of height 6 m standing on horizontal ground. The point O is on the ground directly below the point of projection, as shown in Fig. 8. Air resistance is negligible.

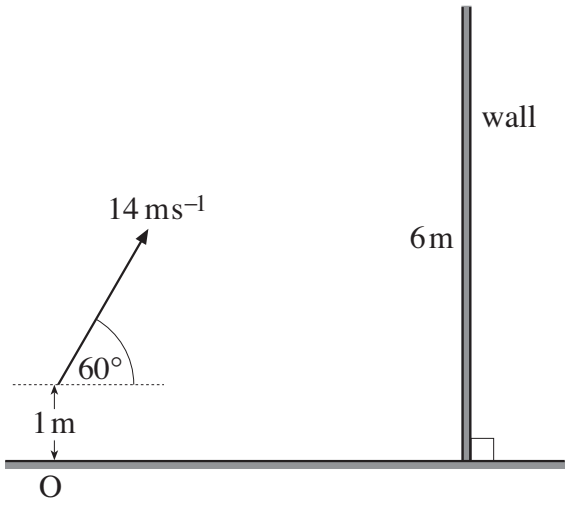

Fig. 8

(i) Write down an expression in terms of t for the horizontal displacement of the stone from O, t seconds after projection. Find also an expression for the height of the stone above O at this time. [5]

The stone is at the top of its trajectory when it passes over the wall.

(ii) (*A*) Find the time it takes for the stone to reach its highest point. [2]

(*B*) Calculate the distance of O from the base of the wall. [2]

(*C*) Show that the stone passes over the wall with 2.5 m clearance. [4]

(iii) Find the cartesian equation of the trajectory of the stone referred to the horizontal and vertical axes, Ox and Oy. There is no need to simplify your answer. [2]

The girl now moves away a further distance d m from the wall. She throws a stone as before and it just passes over the wall.

(iv) Calculate d. [5]

5 You should neglect air resistance in this question.

A small stone is projected from ground level. The maximum height of the stone above horizontal ground is 22.5 m.

(i) Show that the vertical component of the initial velocity of the stone is $21\ \mathrm{m\,s^{-1}}$. [2]

The speed of projection is $28\ \mathrm{m\,s^{-1}}$.

(ii) Find the angle of projection of the stone. [2]

(iii) Find the horizontal range of the stone. [4]