1 A girl throws a small stone with initial speed 14 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.

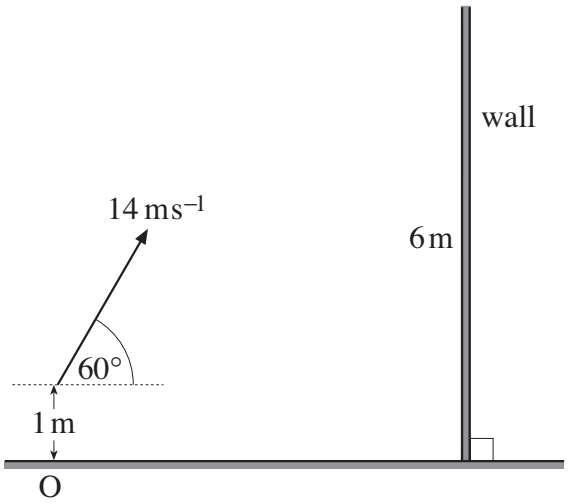

Fig. 8

(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]

2 A particle is projected vertically upwards from a point O at $21\,ms^{-1}$.

(i) Calculate the greatest height reached by the particle. [2]

When this particle is at its highest point, a second particle is projected vertically upwards from O at $15\,ms^{-1}$.

(ii) Show that the particles collide 1.5 seconds later and determine the height above O at which the collision takes place. [6]

3 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 $40\,\text{m s}^{-1}$ at 50° to the horizontal.

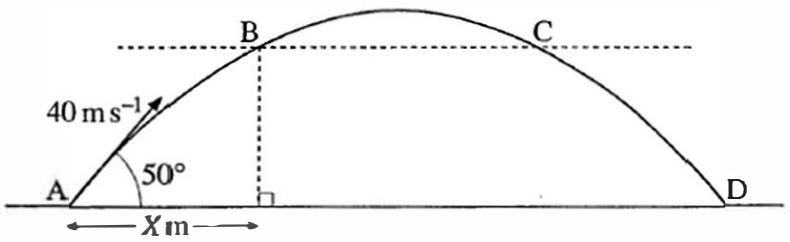

Fig. 7

(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]