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1 A particle P is projected with speed $40\,\text{m s}^{-1}$ at an angle of $35°$ above the horizontal from a point O. For the instant 3 s after projection, calculate the magnitude and direction of the velocity of P. **[5]**

7 A particle P is projected horizontally with speed $15\,\text{m s}^{-1}$ from the top of a vertical cliff. At the same instant a particle Q is projected from the bottom of the cliff, with speed $25\,\text{m s}^{-1}$ at an angle of $\theta°$ above the horizontal. P and Q move in the same vertical plane. The height of the cliff is 60 m and the ground at the bottom of the cliff is horizontal.

(i) Given that the particles hit the ground simultaneously, find the value of θ and find also the distance between the points of impact with the ground. **[6]**

(ii) Given instead that the particles collide, find the value of θ, and determine whether Q is rising or falling immediately before this collision. **[9]**

5 A particle is projected with speed $7\,\text{m s}^{-1}$ at an angle of elevation of $30°$ from a point O and moves freely under gravity. The horizontal and vertically upwards displacements of the particle from O at any subsequent time t s are x m and y m respectively.

(i) Express x and y in terms of t and hence find the equation of the trajectory of the particle. **[4]**

(ii) Calculate the values of x when $y = 0.6$. **[4]**

(iii) Find the direction of motion of the particle when $y = 0.6$ and the particle is rising. **[4]**

6 A small ball B is projected with speed $14\,\text{m s}^{-1}$ at an angle of elevation $30°$ from a point O on a horizontal plane, and moves freely under gravity.

(i) Calculate the height of B above the plane when moving horizontally. **[2]**

B has mass 0.4 kg. At the instant when B is moving horizontally it receives an impulse of magnitude I N s in its direction of motion which immediately increases the speed of B to $15\,\text{m s}^{-1}$.

(ii) Calculate I. **[3]**

For the instant when B returns to the plane, calculate

(iii) the speed and direction of motion of B, **[4]**

(iv) the time of flight, and the distance of B from O. **[5]**

1 A particle is projected horizontally with a speed of $7\,\text{m s}^{-1}$ from a point 10 m above horizontal ground. The particle moves freely under gravity. Calculate the speed and direction of motion of the particle at the instant it hits the ground. **[6]**

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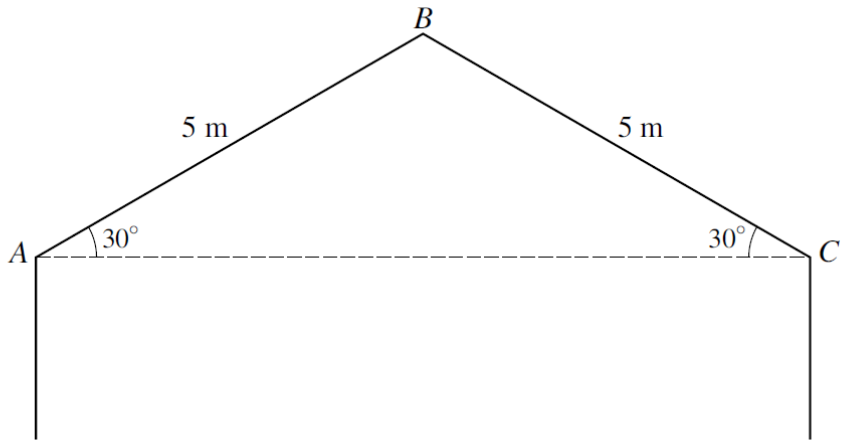

A small ball of mass 0.2 kg is projected with speed 11 m s^{-1} up a line of greatest slope of a roof from a point A at the bottom of the roof. The ball remains in contact with the roof and moves up the line of greatest slope to the top of the roof at B. The roof is rough and the coefficient of friction is $\frac{1}{2}$. The distance AB is 5 m and AB is inclined at 30° to the horizontal (see diagram).

(i) Show that the speed of the ball when it reaches B is 5.44 m s^{-1}, correct to 2 decimal places. **[6]**

The ball leaves the roof at B and moves freely under gravity. The point C is at the lower edge of the roof. The distance BC is 5 m and BC is inclined at 30° to the horizontal.

(ii) Determine whether or not the ball hits the roof between B and C. **[7]**

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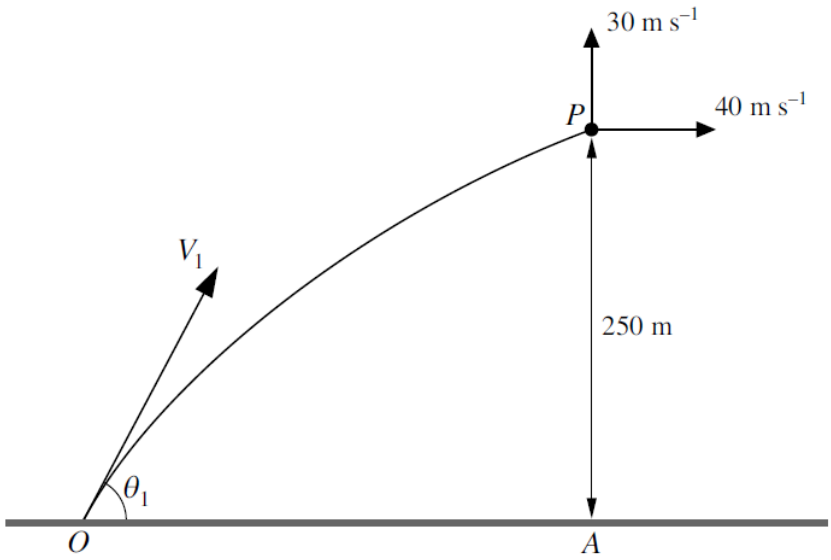

A particle P is projected with speed V_1 m s^{-1} at an angle of elevation θ_1 from a point O on horizontal ground. When P is vertically above a point A on the ground its height is 250 m and its velocity components are 40 m s^{-1} horizontally and 30 m s^{-1} vertically upwards (see diagram).

(i) Show that $V_1 = 86.0$ and $\theta_1 = 62.3°$, correct to 3 significant figures. **[5]**

At the instant when P is vertically above A, a second particle Q is projected from O with speed V_2 m s^{-1} at an angle of elevation θ_2. P and Q hit the ground at the same time and at the same place.

(ii) Calculate the total time of flight of P and the total time of flight of Q. **[4]**

(iii) Calculate the range of the particles and hence calculate V_2 and θ_2. **[8]**