

Assignment 5

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Download all python codes from

<https://github.com/Gayathri1729/SRFP/tree/main/Assignment5>

and latex-tikz codes from

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1 QUADRATIC FORMS-2.64

A cricket ball is thrown at a speed of 28ms^{-1} in a direction 30° above the horizontal. Calculate

- the maximum height
- the time taken by the ball to return to the same level, and
- the distance from the thrower to the point where the ball returns to the same level.

2 SOLUTION

Initial velocity of the ball is given by

$$\mathbf{v}_b = 28 \begin{pmatrix} \cos \theta \\ \sin \theta \end{pmatrix} = \begin{pmatrix} 28 \cos 30 \\ 28 \sin 30 \end{pmatrix} = \begin{pmatrix} 14\sqrt{3} \\ 14 \end{pmatrix} \quad (2.0.1)$$

where θ is the angle made by \mathbf{v}_b with the horizontal and given $\theta = 30^\circ$ and let the initial displacement,

$$\mathbf{s}_0 = \begin{pmatrix} 0 \\ 0 \end{pmatrix}.$$

Also, acceleration of the ball due to gravity is

$$\mathbf{a}(t) = \mathbf{g} = \begin{pmatrix} 0 \\ -9.8 \end{pmatrix} \quad (2.0.2)$$

$$\mathbf{v}(t) = \int \mathbf{a}(t) + \mathbf{v}_b \quad (2.0.3)$$

$$= \begin{pmatrix} 14\sqrt{3} \\ -9.8t + 14 \end{pmatrix} \quad (2.0.4)$$

$$\mathbf{s}(t) = \int \mathbf{v}(t) + \mathbf{s}_0 \quad (2.0.5)$$

$$= \begin{pmatrix} 14\sqrt{3}t \\ -4.9t^2 + 14t \end{pmatrix} \quad (2.0.6)$$

Velocity of the ball at the maximum height is

$$\mathbf{v}_m = \begin{pmatrix} 0 \\ 0 \end{pmatrix} \quad (2.0.7)$$

- a) To find the maximum height, we need to find the time at which the vertical velocity is zero.
 \Rightarrow

$$-9.8t + 14 = 0 \quad (2.0.8)$$

$$t = 1.4286\text{s} \quad (2.0.9)$$

\Rightarrow

$$\mathbf{s}(1.4286) = \begin{pmatrix} 14\sqrt{3} \times 1.4286 \\ -4.9 \times (1.4286^2) + 14 \times 1.4286 \end{pmatrix} \quad (2.0.10)$$

$$= \begin{pmatrix} 34.64 \\ 10 \end{pmatrix} \quad (2.0.11)$$

\therefore the maximum height $h_{\max} = 10\text{ m}$

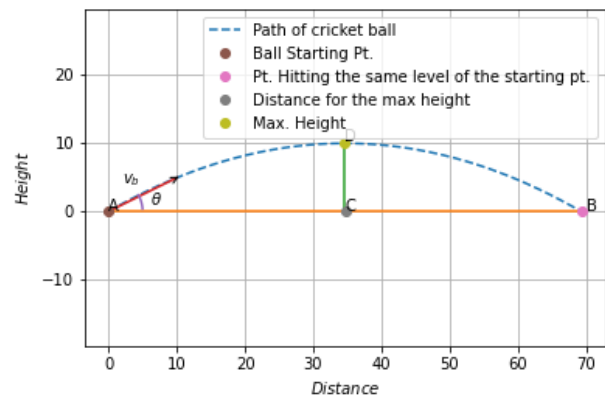


Fig. 2.1

- b) The ball will return to the same level when vertical component of the distance function is equal to zero.

$$-4.9t^2 + 14t = 0 \quad (2.0.12)$$

$$t = 2.8572\text{s} \quad (2.0.13)$$

Thus the time taken by the ball to return to the same level = 2.8572 s

c) Consider,

$$\mathbf{s}(2.8572) = \begin{pmatrix} 14\sqrt{3} \times 2.8572 \\ -4.9 \times 2.8572^2 + 14 \times 2.8572 \end{pmatrix} \quad (2.0.14)$$

$$= \begin{pmatrix} 69.283 \\ 0 \end{pmatrix} \quad (2.0.15)$$

Thus the distance from the thrower to the point where the ball returns to the same level = 69.283 m