

Answer on Question #47694-Physics-Computational Physics

A 2.7 kg ball is thrown upward with an initial speed of 20.0m/s from the edge of a 45.0m high cliff. At the instant the ball is thrown, a woman starts running away from the base of the cliff with a constant speed of 6.0m/s. The woman runs in a straight line on level ground, and air resistance acting on the ball can be ignored. (a) At what angle above the horizontal should the ball be thrown so that the runner will catch it just before it hits the ground? (b) How far does the woman run before she catches the ball?

Solution

(a) The woman runs with constant speed of v_1 . If the ball is thrown at angle α above the horizontal, its horizontal component of speed is $v_2 \cos \alpha$. This is also constant, because gravity only acts vertically.

The woman and the ball start from the same x coordinate at the same time, and each travels with constant horizontal speed. If one of them is faster than the other, it will always be ahead, and will only get further ahead as time goes on. So she can only catch the ball if its horizontal speed is the same as her speed.

So we must have

$$v_1 = v_2 \cos \alpha \rightarrow \cos \alpha = \frac{v_1}{v_2} = \frac{6}{20} \rightarrow \alpha = \cos^{-1} \frac{6}{20} = 72.5^\circ.$$

(b) We can use the formula for the range of projectile:

$$\begin{aligned} d &= \frac{v_2 \cos \alpha}{g} \left(v_2 \sin \alpha + \sqrt{(v_2 \sin \alpha)^2 + 2gh} \right) \\ &= \frac{20 \cos 72.5^\circ}{9.8} \left(20 \sin 72.5^\circ + \sqrt{(20 \sin 72.5^\circ)^2 + 2 \cdot 9.8 \cdot 45} \right) = 33.4 \text{ m.} \end{aligned}$$