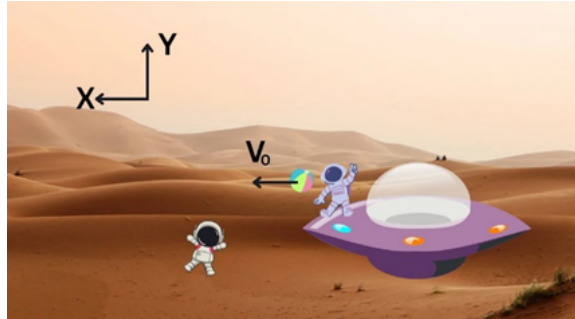


Mars Astronauts



Finally, the ball was in the air for 6 seconds and landed 5 meters away from the spaceship. Find the initial speed v_0 of the ball.

Take $g_{\text{mars}} = 4 \text{ m/s}^2$.

Using known expressions (for constant acceleration):

$$a = \frac{dv}{dt} \Rightarrow dv = a dt \quad (1)$$

$$\int_{v_0}^{v(t)} dv = a \int_0^t dt \quad (2)$$

$$v(t) = at + v_0 \quad (3)$$

$$v = \frac{ds}{dt} \Rightarrow ds = v dt = (v_0 + at) dt \quad (4)$$

$$\int_{s_0}^{s(t)} ds = \int_0^t (v_0 + at) dt \quad (5)$$

$$s(t) = \frac{1}{2}at^2 + v_0t + s_0 \quad (6)$$

Given quantities:

Gravitational acceleration on Mars: $g_{\text{mars}} = 4 \text{ m/s}^2$

Airtime: $t_{\text{end}} = 6 \text{ s}$

End position ball: $x(t_{\text{end}}) = 5 \text{ m}$

Solution:

As can be seen in the image, the positive x -axis is taken to the left. The initial position of the ball is taken to be zero, hence $s_0 = 0$ m. The acceleration in the horizontal direction is also zero, thus Equation (6) becomes:

$$s(t) = \frac{1}{2}at^2 + v_0t + s_0 \quad \Rightarrow \quad x(t) = v_0t \quad (7)$$

Inserting $t = t_{\text{end}} = 6$ s and $x(t_{\text{end}}) = 5$ m gives:

$$x(t_{\text{end}}) = v_0t_{\text{end}} \quad \Rightarrow \quad x(6) = v_0 \cdot 6 = 5 \quad \Rightarrow \quad v_0 = \frac{5}{6} \text{ m/s} \quad (8)$$

Thus the initial velocity of the ball was $v_0 = \frac{5}{6}$ m/s.