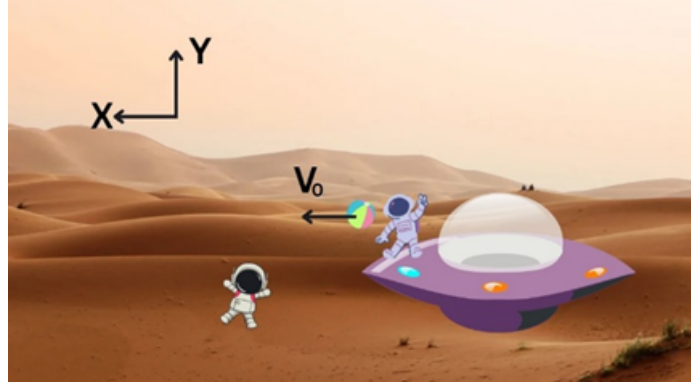


## Mars Astronauts



Determine the height  $H$  of the spaceship if the ball is in the air for 6 seconds. Take  $g_{\text{mars}} = 4 \text{ m/s}^2$  and assume that the ball is released at height  $H$  above the Martian surface.

*Using known expressions (for constant acceleration):*

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

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

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

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

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

$$s(t) = \frac{1}{2} at^2 + v_0 t + s_0 \quad (6)$$

*Given quantities:*

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

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

*Solution:*

The time it takes to reach the surface can be calculated using Equation (6), where the gravity on Mars is pointing downwards. The initial velocity in  $y$ -direction is equal to zero, hence  $v_0 = 0$ . Take the origin of the coordinate system at the spaceship (hence  $y(0) = 0 \text{ m} \Rightarrow s_0 = 0 \text{ m}$ ). Thus Equation (6) becomes:

$$s(t) = \frac{1}{2}at^2 + v_0t + s_0 \quad \Rightarrow \quad y(t) = -\frac{1}{2}g_{\text{mars}}t^2 \quad (7)$$

Inserting  $t = \text{end} = 6 \text{ s}$  and  $g_{\text{mars}} = 4 \text{ m/s}^2$  gives:

$$y(t_{\text{end}}) = -\frac{1}{2}g_{\text{mars}}t_{\text{end}}^2 \Rightarrow y(6) = -\frac{1}{2} \cdot 4 \cdot 6^2 = -72 \text{ m} \quad (8)$$

Thus the ball traveled 72 m downwards, which means that the height of the spaceship is  $H = 72 \text{ m}$ .