freefall #1 scenario #1

Var	Given value	Units	Description
v_f		$\frac{m}{s}$	final Velocity
v_i	0	$\frac{m}{s}$	Initial velocity
a	–9.8	$\frac{m}{s^2}$	Acceleration due to gravity
Δx	–20.	m	displacement
t		s	time dration

$$v_f^{\,2} = v_i^{\,2} + 2\,a\,\Delta x$$

$$v_f = \sqrt{v_i^{\,2} + 2\,a\,\Delta x}$$

$$= \sqrt{\left(0\,\frac{m}{s}\right)^2 + 2\left(-9.8\,\frac{m}{s^2}\right)(-20.\,m)}$$

$$= 20.\,\frac{m}{s}$$ ✓

$$\Delta x = v_i\,t + \frac{1}{2}\,a\,t^2$$

$$\Delta x = \frac{1}{2}\,a\,t^2$$

$$2\,\Delta x = a\,t^2$$

freefall #1 scenario #1 (continued)

$$\frac{2\,\Delta x}{a} = t^2$$

$$t = \sqrt{\frac{2\,\Delta x}{a}}$$

$$= \sqrt{\frac{2(-20.\mathrm{m})}{-9.8\,\frac{\mathrm{m}}{\mathrm{s}^2}}}$$

$$= 2.0\,\mathrm{s}$$ ✓

freefall #1 scenario #2

Var	Given value	Units	Description
v_f		$\frac{m}{s}$	final Velocity
v_i	6	$\frac{m}{s}$	Initial velocity
a	–9.8	$\frac{m}{s^2}$	Acceleration due to gravity
Δx	–20.	m	displacement
t		s	time duration

$$v_f^{\,2} = v_i^{\,2} + 2\,a\,\Delta x$$

$$v_f = \sqrt{v_i^{\,2} + 2\,a\,\Delta x}$$

$$= \sqrt{\left(6\,\frac{m}{s}\right)^2 + 2\left(-9.8\,\frac{m}{s^2}\right)(-20.\,m)}$$

$$= -21.\,\frac{m}{s}\ \text{(neg. because final vel. is down)}$$

This time to use the givens, you'd have to use the quadratic formula! Only one of the possible answers gives a positive time.

$$\Delta x = v_i\,t + \frac{1}{2}\,a\,t^2$$

$$0 = \frac{1}{2}\,a\,t^2 + v_i\,t - \Delta x$$

freefall #1 scenario #2 (continued)

$$t = \frac{-v_i \pm \sqrt{v_i^2 - 4\frac{1}{2}a(-\Delta x)}}{2\frac{1}{2}a}$$

$$t = \frac{-v_i - \sqrt{v_i^2 - 4\frac{1}{2}a(-\Delta x)}}{2\frac{1}{2}a}$$

$$= \frac{-\left(6\,\frac{\text{m}}{\text{s}}\right) - \sqrt{\left(6\,\frac{\text{m}}{\text{s}}\right)^2 - 4\frac{1}{2}\left(-9.8\,\frac{\text{m}}{\text{s}^2}\right)(-(-20.\text{m}))}}{2\frac{1}{2}\left(-9.8\,\frac{\text{m}}{\text{s}^2}\right)}$$

$$= 2.7\,\text{s}$$

It may be easier to use the final velocity to get time.

$$a = \frac{v_f - v_i}{t}$$

$$t\,a = v_f - v_i$$

$$t = \frac{v_f - v_i}{a}$$

$$= \frac{\left(-21.\,\frac{\text{m}}{\text{s}}\right) - \left(6\,\frac{\text{m}}{\text{s}}\right)}{-9.8\,\frac{\text{m}}{\text{s}^2}}$$

$$= 2.8\,\text{s}$$

freefall #1 scenario #3

Var	Given value	Units	Description
v_f		$\frac{m}{s}$	final Velocity
v_i	–6	$\frac{m}{s}$	Initial velocity
a	–9.8	$\frac{m}{s^2}$	Acceleration due to gravity
Δx	–20.	m	displacement
t		s	time duration

$$v_f^2 = v_i^2 + 2\,a\,\Delta x$$

$$v_f = \sqrt{v_i^2 + 2\,a\,\Delta x}$$

$$= \sqrt{\left(-6\,\frac{m}{s}\right)^2 + 2\left(-9.8\,\frac{m}{s^2}\right)(-20.\,m)}$$

$$= -21.\,\frac{m}{s}\ \text{(neg. because final velocity is down)}$$

This time to use the givens, you'd have to use the quadratic formula! Only one of the possible answers gives a positive time.

$$\Delta x = v_i\,t + \frac{1}{2}\,a\,t^2$$

$$0 = \frac{1}{2}\,a\,t^2 + v_i\,t - \Delta x$$

freefall #1 scenario #3 (continued)

$$t = \frac{-v_i \pm \sqrt{v_i^{\,2} - 4\,\frac{1}{2}\,a\,(-\Delta x)}}{2\,\frac{1}{2}\,a}$$

$$t = \frac{-v_i - \sqrt{v_i^{\,2} - 4\,\frac{1}{2}\,a\,(-\Delta x)}}{2\,\frac{1}{2}\,a}$$

$$= \frac{-\left(-6\,\frac{m}{s}\right) - \sqrt{\left(-6\,\frac{m}{s}\right)^2 - 4\,\frac{1}{2}\left(-9.8\,\frac{m}{s^2}\right)\left(-(-20.\,m)\right)}}{2\,\frac{1}{2}\left(-9.8\,\frac{m}{s^2}\right)}$$

$$= 1.5\,s$$

It may be easier to use the final velocity to get time.

$$a = \frac{v_f - v_i}{t}$$

$$t\,a = v_f - v_i$$

$$t = \frac{v_f - v_i}{a}$$

$$= \frac{\left(-21.\,\frac{m}{s}\right) - \left(-6\,\frac{m}{s}\right)}{-9.8\,\frac{m}{s^2}}$$

$$= 1.5\,s$$

freefall #1 scenario #4

Var	Given value	Units	Description
a	–9.8	$\frac{m}{s^2}$	acceleartion due to gravity
v_f		$\frac{m}{s}$	final velocity
v_i		$\frac{m}{s}$	initial velocity
t	3	s	time duration

$$a = \frac{(v_f - v_i)}{t}$$

if displacement is zero, the magnitudes of final and initial velocity are equal.

$$v_i = -v_f$$

$$a = \frac{-2\,v_i}{t}$$

$$t\,a = -2\,v_i$$

$$v_i = \frac{-t\,a}{2}$$

$$= \frac{-(3\,\mathrm{s})\left(-9.8\,\frac{\mathrm{m}}{\mathrm{s}^2}\right)}{2}$$

$$= 15.\,\frac{\mathrm{m}}{\mathrm{s}}$$ ✓

freefall #1 scenario #4 (continued)

Using the original givens to find the maximum height:

Var	Given value	Units	Description
Δx_{half}		m	displacement from top of path to bottom
t_{half}	1.5	s	time from top to bottom

At the top of the path, the velocity is zero. Considering the last half of the trip from the top to the bottom:

$$\Delta x_{half} = \frac{1}{2} a\, t_{half}^{2}$$

$$= \frac{1}{2}\left(-9.8\,\frac{m}{s^2}\right)(1.5\,s)^2$$

$$= -11.\,m$$ ✓

$$\textit{The height} = 11\ \textit{m.}$$