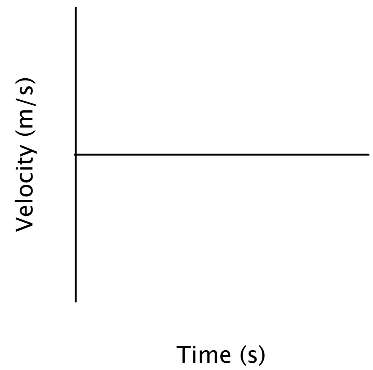
Worksheet 3-6 Free Fall

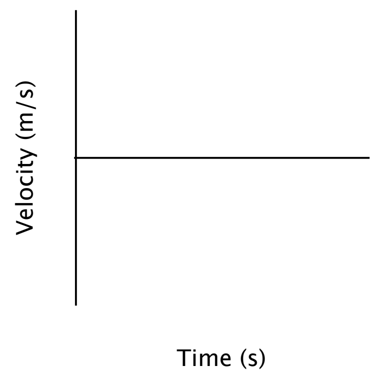
1. You drop a ball from a bridge and time how long it takes to fall to the ground.
   a. If it takes 4.2 s, how fast was the ball falling when it struck the ground?

   b. How high was the bridge?



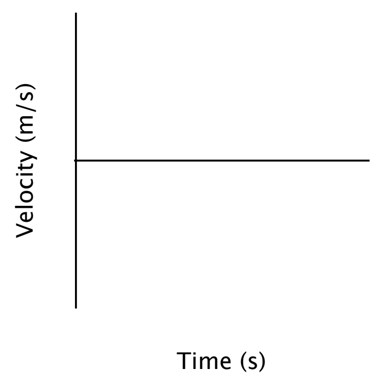
2. On the ride Free–Fall at Magic Mountain, the riders descended for 1.3 s under the influence of gravity.
   a. What was the speed of the riders after this time?

   b. How fad did the riders fall?

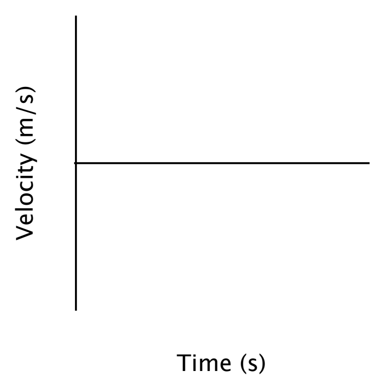


3. The acceleration due to gravity on the surface of Mars is 3.69 m/s^2.
   a. If an astronaut were to throw a rock straight up at a speed of 16 m/s, how long will the rock remain in the air?

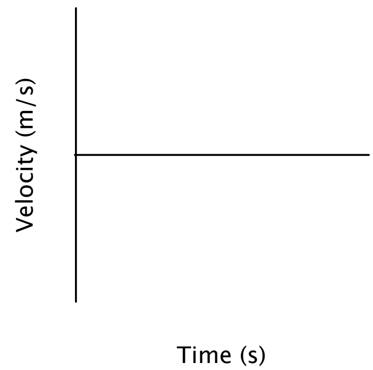
   b. How high will the rock go?



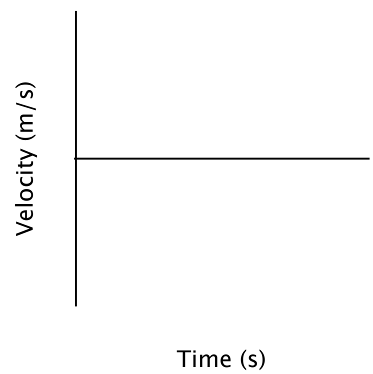
4. A rescue package is dropped from a hovering helicopter and it hits the ground 2.5 s later. How high was the helicopter?



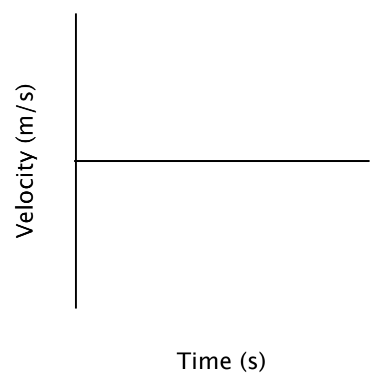
5. If you were to drop a marble from the top of the Empire State Building (381 m), how fast will it be moving when it hits the street below?



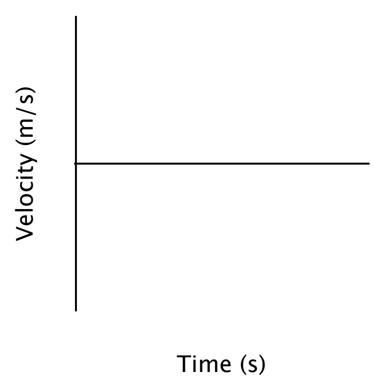
6. If a coin is dropped from a height of 1 m, how long will it take to fall to the floor?



7. A beanbag is thrown into the air and caught 2.2 s later. How high did it go?



8. A ball is thrown straight down at an initial speed of 20 m/s. How long does it take to then fall 120 m?

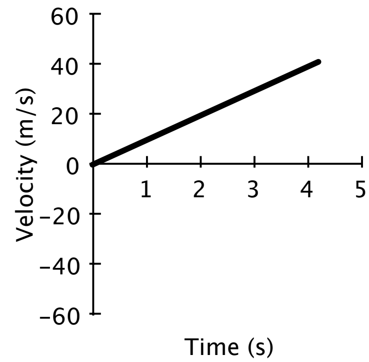


1a.

$$a \equiv \frac{\Delta v}{\Delta t}$$
$$\Delta v = a\Delta t$$
$$\Delta v = (9.8\ \text{m/s}^2)(4.2\ \text{s})$$
$$\Delta v = 41\ \text{m/s}$$
$$v_f = \boxed{41\ \text{m/s}}$$

1b.

$$\Delta x = \tfrac{1}{2}\Delta t\Delta v$$
$$\Delta x = \tfrac{1}{2}(4.2\ \text{s})(41\ \text{m/s})$$
$$\Delta x = \boxed{86\ \text{m}}$$

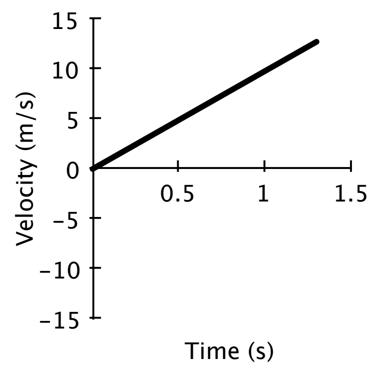


2a.

$$a \equiv \frac{\Delta v}{\Delta t}$$
$$\Delta v = a\Delta t$$
$$\Delta v = (9.8\ \text{m/s}^2)(1.3\ \text{s})$$
$$\Delta v = 13\ \text{m/s}$$
$$v_f = \boxed{13\ \text{m/s}}$$

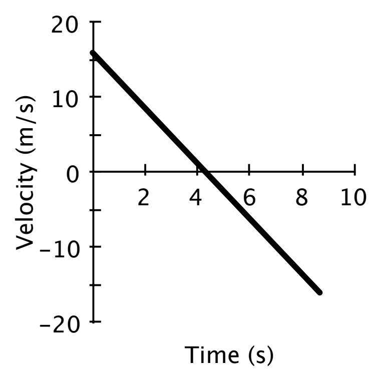
2b.

$$\Delta x = \tfrac{1}{2}\Delta t\Delta v$$
$$\Delta x = \tfrac{1}{2}(1.3\ \text{s})(13\ \text{m/s})$$
$$\Delta x = \boxed{8.3\ \text{m}}$$



3a. Take up as the positive direction, therefore v_i = 16 m/s and a = -3.69 m/s^2. When the rock returns it is at the same height at which it started therefore Δx = 0. The area of the left triangle on the *v–t* graph must be equal to the area of the right triangle therefore v_f = -16 m/s and the rock reaches the top (v = 0) at the mid time.

$$a \equiv \frac{\Delta v}{\Delta t}$$
$$\Delta t = \frac{\Delta v}{a}$$
$$\Delta t = \frac{-16\ \text{m/s} - 16\ \text{m/s}}{-3.69\ \text{m/s}^2}$$
$$\Delta t = \boxed{8.7\ \text{s}}$$



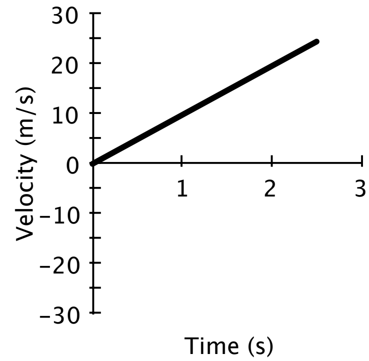
3b. The time to reach the top is 4.3 s.

$$\Delta x = \tfrac{1}{2}\Delta t\Delta v$$
$$\Delta x = \tfrac{1}{2}(4.3\ \text{s})(16\ \text{m/s})$$
$$\Delta x = \boxed{35\ \text{m}}$$

4.

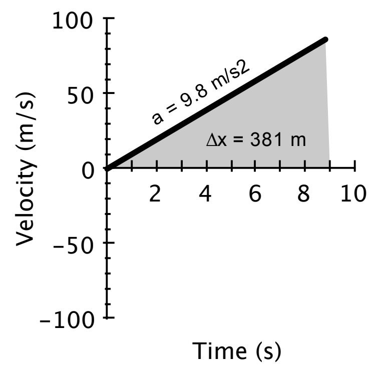
$$a \equiv \frac{\Delta v}{\Delta t}$$
$$\Delta v = a\Delta t$$
$$\Delta v = (9.8\ \text{m/s}^2)(2.5\ \text{s})$$
$$\Delta v = 25\ \text{m/s}$$
$$v_f = \boxed{25\ \text{m/s}}$$

$$\Delta x = \tfrac{1}{2}\Delta t\Delta v$$
$$\Delta x = \tfrac{1}{2}(2.5\ \text{s})(25\ \text{m/s})$$
$$\Delta x = \boxed{31\ \text{m}}$$



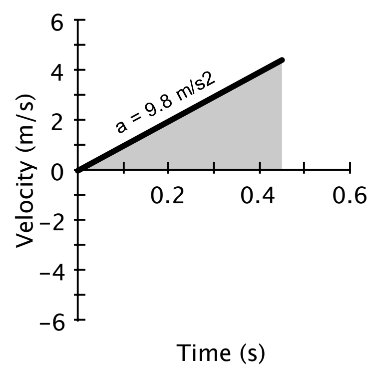
5.

$$\Delta x = \tfrac{1}{2}\Delta t\Delta v \qquad a \equiv \frac{\Delta v}{\Delta t}$$
$$\Delta t = \frac{2\Delta x}{\Delta v} \qquad \Delta t = \frac{\Delta v}{a}$$
$$\frac{2\Delta x}{\Delta v} = \frac{\Delta v}{a}$$
$$\Delta v = \sqrt{2a\Delta x}$$
$$\Delta v = \sqrt{2g(381\ \text{m})}$$
$$\Delta v = \boxed{86\ \text{m/s}}$$



6.

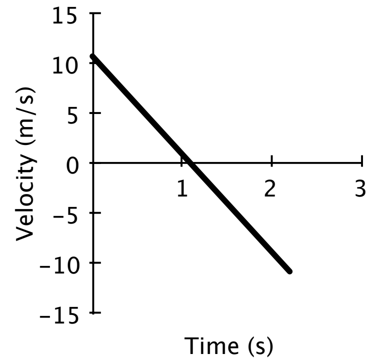
$$\Delta x = \tfrac{1}{2}\Delta t\Delta v \qquad a \equiv \frac{\Delta v}{\Delta t}$$
$$\Delta v = \frac{2\Delta x}{\Delta t} \qquad \Delta v = a\Delta t$$
$$\frac{2\Delta x}{\Delta t} = a\Delta t$$
$$\Delta t = \sqrt{\frac{2\Delta x}{a}}$$
$$\Delta t = \sqrt{\frac{2(1\ \text{m})}{g}}$$
$$\Delta t = \boxed{0.45\ \text{m}}$$



7.

$$a \equiv \frac{\Delta v}{\Delta t}$$
$$\Delta v = a\Delta t$$
$$\Delta v = (9.8\ \text{m/s}^2)(1.1\ \text{s})$$
$$\Delta v = 11\ \text{m/s}$$

$$\Delta x = \tfrac{1}{2}\Delta t \Delta v$$
$$\Delta x = \tfrac{1}{2}(1.1\ \text{s})(11\ \text{m/s})$$
$$\Delta x = \boxed{12\ \text{m}}$$



8.

$$\Delta x = v_i \Delta t + \tfrac{1}{2}\Delta v \Delta t$$
$$\Delta x = v_i \Delta t + \tfrac{1}{2}a \Delta t^2$$
$$\tfrac{1}{2}a\Delta t^2 + v_i \Delta t - \Delta x = 0$$
$$\Delta t = \frac{-v_i \pm \sqrt{{v_i}^2 - 2\left(\frac{1}{2}a\right)(-\Delta x)}}{2\left(\frac{1}{2}a\right)}$$
$$\Delta t = \frac{-20\ \text{m/s} \pm \sqrt{(20\ \text{m/s})^2 + g(120\ \text{m})}}{g}$$
$$\Delta t = \boxed{2.0\ \text{s}}$$