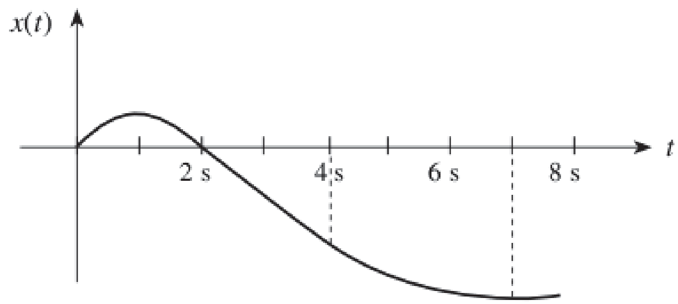
Unit: N
Chapter: N3
Problem Number: N3B.2
Return to User Page

N3B.2 The graph looks like this:



At first, the x-velocity is positive but decreasing, and so the the slope of the $x(t)$ graph is initially positive but decreasing, reaching zero at $t = 1$ s. The slope (following the value of v_x) then becomes increasingly negative, until it reaches a constant negative value at $t = 2$ s. The slope then remains at this constant negative value until $t = 4$ s, when it starts to become less negative, reaching a slope of zero at $t = 7$ s.

Unit: N

Chapter: N3

Problem Number: N3B.3

Return to User Page

N3B.3 Let us define $z_0 = z(0) = 0$, and set $t = 0$ to be the instant when the stone is dropped. Since it dropped "from rest," $v_{0z} = v_z(0) = 0$ also. Let $t = t_h$ be the time that the stone hits the water. According to equation N3.13*b*,

$$z(t_h) = -\tfrac{1}{2}|\vec{g}|t_h^2 + v_{0z}t_h + z_0 = -\tfrac{1}{2}|\vec{g}|t_h^2 + 0 + 0 = -\tfrac{1}{2}(9.8\text{ m}/\cancel{\text{s}}^{\cancel{2}})(2.5\,\cancel{\text{s}})^2 = -30.6\text{ m}$$

This says that the stone is 30.6 m below the bridge after 2.5 s have passed (assuming that the stone is really freely falling).

Unit: N

Chapter: N3

Problem Number: N3B.4

Return to User Page

N3B.4 Let's set up a reference frame in standard orientation and let $t = 0$ to be the instant when the object is dropped. Since it is dropped from rest, $v_{0z} = 0$, and the object will always move only along the z axis. At $t = 5.0$ s, according to equation N3.13a, the object will have a z-velocity of

$$v_z(t) = v_{0z} - |\vec{g}|t = 0 - |\vec{g}|t = -(9.8\ \text{m/s}^2)(5.0\ \text{s}) = -49\ \text{m/s}$$

The negative sign indicates that the object's velocity is downward. The object's speed at that time is thus

$$|\vec{v}(t)| = |v_z(t)| = +49\ \cancel{\text{m/s}}\left(\frac{2.24\ \text{mi/h}}{1\ \cancel{\text{m/s}}}\right) = 110\ \frac{\text{mi}}{\text{h}}.$$

Unit: N
Chapter: N3
Problem Number: N3B.5

Return to User Page

N3B.5 **(a)** Since $\Delta t = 0.05$ s is the same for all displacement arrows $\Delta\vec{r}_{01} = \vec{v}_{01}\Delta t$, $\Delta\vec{r}_{12} = \vec{v}_{12}\Delta t$, etc., in a motion diagram, these arrows depict both the direction and the relative magnitude of the average velocities $\vec{v}_{01}$, $\vec{v}_{12}$, etc., between the dots. The length of the initial velocity vector in an actual-size diagram in this case is

$$\vec{v}_0\Delta t = (2.0\text{ m/s})(0.05\text{ s}) = 0.1\text{ m} = 10\text{ cm} \quad (1)$$

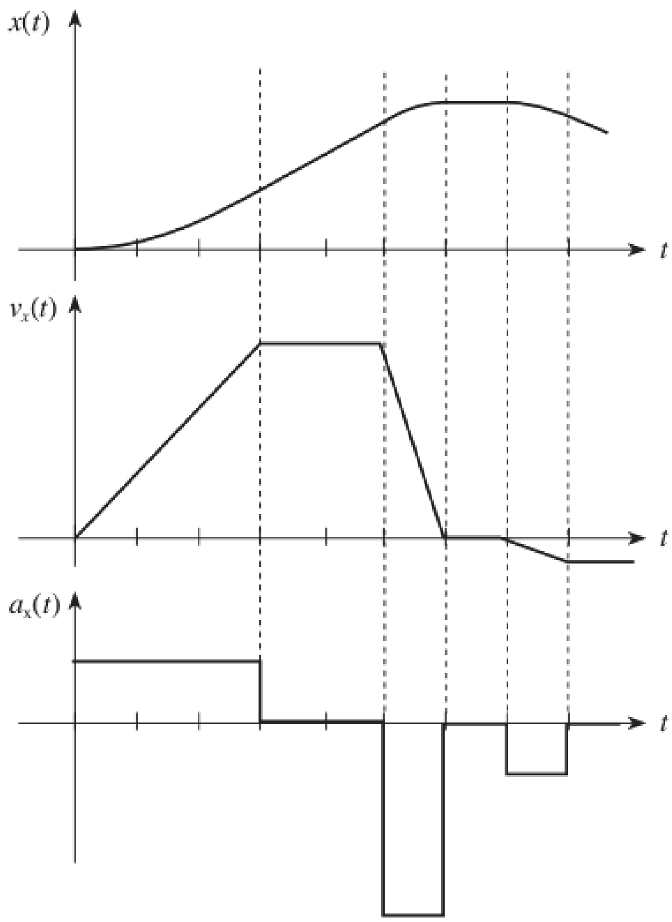
(b) The acceleration in this situation is constant, so all the acceleration arrows we draw will have the same length $|\Delta\vec{v}\ \Delta t| = |\vec{a}|\Delta t^2$, as described in section N3.6, or

$$|\vec{a}|\Delta t^2 = (9.8\text{ m/s}^2)(0.05\text{ s})^2 = 0.0245\text{ m} = 2.45\text{ cm} \quad (2)$$

Of course, we should specially draw the acceleration arrow at the initial point 0 to be *centered* at that point (all the others will have their tails at their respective points).

Unit: N | Chapter: N3 | Problem Number: N3M.2 | Return to User Page

N3M.2 Assuming there is no significant drag or friction opposing the thrust on the car, and that the car travels on a level road (so that the vertical normal and gravitational forces cancel out), then the bottom graph below is a picture of the car's acceleration along the x axis. The x acceleration is constant for some time Δt until the car reaches 15 m/s, after which the acceleration drops to zero as the car reaches cruising speed. When the driver suddenly brakes, the car undergoes a large negative acceleration for a short time, but this acceleration drops to zero quickly as well as the car stops again. As the car backs up, it must accelerate once more before reaching its final velocity of 3 m/s backwards. The braking acceleration and the acceleration as the car backs up are both negative.



Working upwards, we see that the car's velocity initially increases to 15 m/s and then becomes constant (as the acceleration drops to zero). When the driver brakes, the acceleration is large and negative, so the velocity's slope is large and negative until it reaches zero. When the driver accelerates backward, the car's velocity becomes increasingly negative and then (when the acceleration drops to zero) remains at a constant magnitude of 3 m/s.

To create the x position graph, we start with $x = 0$ at $t = 0$. When the car's velocity is initially increasing, the slope and therefore the x position increases. When the velocity becomes constant, the slope of the $x(t)$ graph remains the same positive value, and as the velocity decreases when the driver begins to brake, the *slope* of $x(t)$ decreases as well, but the *value* of x continues to increase. Only when the velocity is zero is the slope of $x(t)$ zero. When the car accelerates backward, the slope of $x(t)$ becomes increasingly negative, but maintains a constant negative slope after the driver reaches 3 m/s backward. The driver ends up far away from the car's initial position, primarily because of the car's large cruising speed.

Unit: N
Chapter: N3
Problem Number: N3M.4
Return to User Page

N3M.4 The acceleration of the car in this case is not constant (since it depends on time), so we cannot use the handy equation N3.6. We will have to use equation N3.7a and integrate the acceleration. We are given that the car's initial x-velocity at time $t = 0$ s is $v_x(0) = 32$ m/s, and we know that $v_x(t_f) = 0$ m/s since the car comes to a rest. We want to find the time t_f when the car comes to a rest. Equation N3.7a tells us that

$$v_x(t) - v_x(0) = \int_0^t a_x(t)\,dt = \int_0^t (-bt)\,dt = -\tfrac{1}{2}bt^2 \tag{1}$$

Since we know $v_x(0)$, b, and that $v_x(t_f) = 0$, we can solve equation 1 for t_f. Equation 1 evaluated at $t = t_f$ becomes

$$0 - v_x(0) = -\tfrac{1}{2}bt_f^2 \quad \Rightarrow \quad t_f = \sqrt{\frac{2v_x(0)}{b}} = \sqrt{\frac{2(32\ \text{m/s})}{1.0\ \text{m/s}^3}} = 8\ \text{s} \tag{2}$$

So the car takes 8 s to come to a rest. (Note that the units work out, and the answer seems reasonable.)