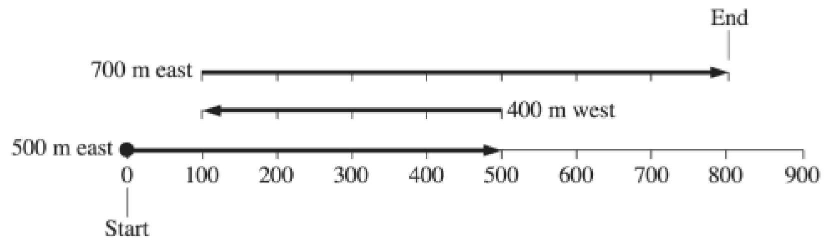
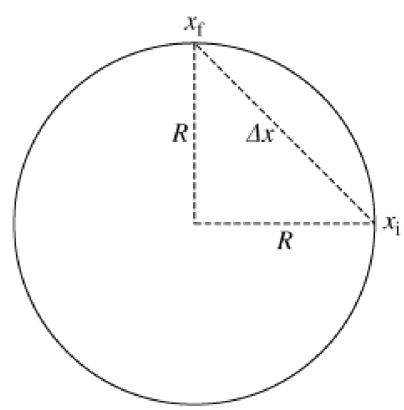
P1.9. Strategize: We must combine three different displacements to determine the total displacement.
Prepare: We have been given three different displacements. The problem is straightforward since all the displacements are along a straight east-west line. All we have to do is add the displacements and see where we end up.
Solve: The first displacement is $\Delta\vec{x}_1 = 500\text{ m}$ east, the second is $\Delta\vec{x}_2 = 400\text{ m}$ west and the third displacement is $\Delta\vec{x}_3 = 700\text{ m}$ east. These three displacements are added in the figure below.



From the figure, note that the result of the sum of the three displacements puts the bee 800 m east of its starting point.
Assess: Knowing what a displacement is and how to add displacements, we are able to obtain the final position of the bee. Since the bee moved 1200 m to the east and 400 m to the west, it is reasonable that it would end up 800 m to the east of the starting point.

P1.32. Strategize: This problem requires us to use the concept of displacement (the difference between two positions) and relate it to the geometry of a lake.
Prepare: If we look at the figure below, it is clear that the straight-line displacement is related to the radius of the circle in a simple way: $(\Delta x)^2 = R^2 + R^2 = 2R^2$.

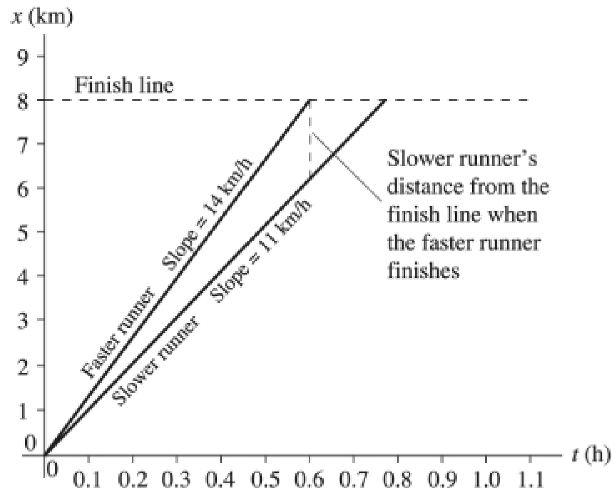


Solve: Using the geometric information from the figure above, we have $\Delta x = \sqrt{2}R$, and we also know that $\Delta x = x_f - x_i = 180\text{ m}$. Combining these two, we have $R = (180\text{ m})/\sqrt{2} \Rightarrow D = 2R = \sqrt{2}(180\text{ m}) = 255\text{ m}$.
Assess: Clearly this diameter is the right order of magnitude. We also expect that the straight line distance must be shorter than $2R$ (as seen from the figure), and it is.

P2.14. Strategize: This problem involves constant-velocity motion.
Prepare: We'll do this problem in multiple steps. Rearrange Equation 1.1 to produce

$$\text{time} = \frac{\text{distance}}{\text{speed}}$$

Use this to compute the time the faster runner takes to finish the race; then use $\text{distance} = \text{speed} \times \text{time}$ to see how far the slower runner has gone in that amount of time. Finally, subtract that distance from the 8.00 km length of the race to find out how far the slower runner is from the finish line.



Solve: The faster runner finishes in

$$t = \frac{8.00 \text{ km}}{14.0 \text{ km/h}} = 0.571 \text{ h}$$

In that time the slower runner runs $d = (11.0 \text{ km/h}) \times (0.571 \text{ h}) = 6.29 \text{ km}$.
This leaves the slower runner $8.00 \text{ km} - 6.29 \text{ km} = 1.71 \text{ km}$ from the finish line as the faster runner crosses the line.
Assess: The slower runner will not even be in sight of the faster runner when the faster runner crosses the line.
We did not need to convert hours to seconds because the hours cancelled out of the last equation. Notice we kept 3 significant figures, as indicated by the original data.

P2.18. Strategize: The distance traveled is the area under the v_y graph.

Prepare: Since the graph of v_y vs. t is linear in each region, calculating the area under the line is simple.

Solve:

(a) The area of a triangle is $\frac{1}{2}BH$.

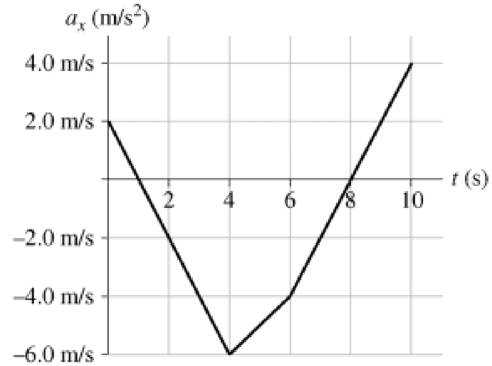
$$\Delta y = \text{area} = \frac{1}{2}BH = \frac{1}{2}(0.20 \text{ s})(0.75 \text{ m/s}) = 7.5 \text{ cm}$$

(b) We estimate the distance from the heart to the brain to be about 30 cm.

$$\Delta t = \frac{\Delta y}{v_y} = \frac{30 \text{ cm}}{7.5 \text{ cm/beat}} = 4.0 \text{ beats}$$

Assess: Four beats seems reasonable. There is some doubt that we are justified using two significant figures here.

P2.23. Strategize: Acceleration is the rate of change of velocity. We must draw a velocity vs. time graph in which the slope at a given point is equal to the value of the acceleration in the plot above.
Prepare: We are told the initial speed of the object is 2.0 m/s. We can simply start drawing a line from that point with the appropriate slope, changing slopes at the appropriate times.
Solve:



Assess: We can check our answer by calculating the velocity after a certain time and seeing if it matches the graph. Let us check the lowest point, which on our graph is –6.0 m/s and occurs at 4 s. Using Equation 2.11, we have $(v_x)_\text{f} = (v_x)_\text{i} + a_x\Delta t = (2.0\text{ m/s}) + (-2.0\text{ m/s}^2)(4\text{ s}) = -6.0\text{ m/s},$ which is consistent.

P2.30. Strategize: We will assume acceleration is constant, such that we can use kinematic equations.
Prepare: Fleas are amazing jumpers; they can jump several times their body height—something we cannot do. We assume constant acceleration so we can use the kinematic equations. The last of the three relates the three variables we are concerned with in part (a): speed, distance (which we know), and acceleration (which we want).

$$(v_y)_\text{f}^2 = (v_y)_\text{i}^2 + 2a_y\Delta y$$

In part (b) we use Equation 2.11 because it relates the initial and final velocities and the acceleration (which we know) with the time interval (which we want).

$$(v_y)_\text{f} = (v_y)_\text{i} + a_y\Delta t$$

Part (c) is about the phase of the jump *after* the flea reaches takeoff speed and leaves the ground. So now it is $(v_y)_\text{i}$, that is 1.0 m/s instead of $(v_y)_\text{f}$. And the acceleration is not the same as in part (a)—it is now $-g$ (with the positive direction up) since we are ignoring air resistance. We do not know the time it takes the flea to reach maximum height, so we employ Equation 2.13 again because we know everything in that equation except Δy.

Solve: (a) Use $(v_y)_\text{i} = 0.0\text{ m/s}$ and rearrange Equation 2.13.

$$a_y = \frac{(v_y)_\text{f}^2}{2\Delta y} = \frac{(1.0\text{ m/s})^2}{2(0.50\text{ mm})}\left(\frac{1000\text{ mm}}{1\text{ m}}\right) = 1000\text{ m/s}^2$$

(b) Having learned the acceleration from part **(a)** we can now rearrange Equation 2.12 to find the time it takes to reach takeoff speed. Again use $(v_y)_\text{i} = 0.0\text{ m/s}$.

$$\Delta t = \frac{(v_y)_\text{f}}{a_y} = \frac{1.0\text{ m/s}}{1000\text{ m/s}^2} = .0010\text{ s}$$

Assess: Just over 5 cm is pretty good considering the size of a flea. It is about 10–20 times the size of a typical flea. Check carefully to see that each answer ends up in the appropriate units.

P2.77. Strategize: When speeding up, we will assume that the acceleration of any creature (horse or human) is constant. Of course, once we are told that the creature reaches its top speed, the acceleration must drop to zero. During a period of constant acceleration, we can apply the kinematic equations.

Prepare: Use the kinematic equations with $(v_x)_\text{i} = 0 \text{ m/s}$ in the acceleration phase.

Solve: The man gains speed at a steady rate for the first 1.8 s to reach a top speed of

$$(v_x)_\text{f} = (v_x)_\text{i} + a_x \Delta t = 0 \text{ m/s} + (6.0 \text{ m/s}^2)(1.8 \text{ s}) = 10.8 \text{ m/s}$$

During this time he will go a distance of

$$\Delta x = \frac{1}{2} a_x (\Delta t)^2 = \frac{1}{2}(6.0 \text{ m/s}^2)(1.8 \text{ s})^2 = 9.72 \text{ m}$$

The man then covers the remaining 100 m – 9.72 m = 90.28 m at constant velocity in a time of

$$\Delta t = \frac{\Delta x}{v_x} = \frac{90.28 \text{ m}}{10.8 \text{ m/s}} = 8.4 \text{ s}$$

The total time for the man is then 1.8 s + 8.4 s = 10.2 s for the 100 m.

We now re-do all the calculations for the horse going 200 m. The horse gains speed at a steady rate for the first 4.8 s to reach a top speed of

$$(v_x)_\text{f} = (v_x)_\text{i} + a_x \Delta t = 0 \text{ m/s} + (5.0 \text{ m/s}^2)(4.8 \text{ s}) = 24 \text{ m/s}$$

During this time the horse will go a distance of

$$\Delta x = \frac{1}{2} a_x (\Delta t)^2 = \frac{1}{2}(5.0 \text{ m/s}^2)(4.8 \text{ s})^2 = 57.6 \text{ m}$$

The horse then covers the remaining 200 m – 57.6 m = 142.4 m at constant velocity in a time of

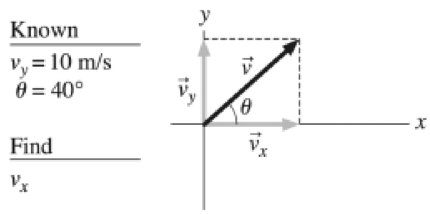
$$\Delta t = \frac{\Delta x}{v_x} = \frac{142.2 \text{ m}}{24 \text{ m/s}} = 5.9 \text{ s}$$

The total time for the horse is then 4.8 s + 5.9 s = 10.7 s for the 200 m.

The man wins the race (10.2 s < 10.7 s), but he only went half the distance the horse did.

Assess: We know that 10.2 s is about right for a human sprinter going 100 m. The numbers for the horse also seem reasonable.

P3.6. Strategize: This problem involves two orthogonal legs of a triangle. In right triangles, we can use trigonometric functions.
Prepare: The figure below shows the components v_x and v_y, and the angle θ. We will use Tactics Box 3.2 to find the sign attached to the components of a vector.



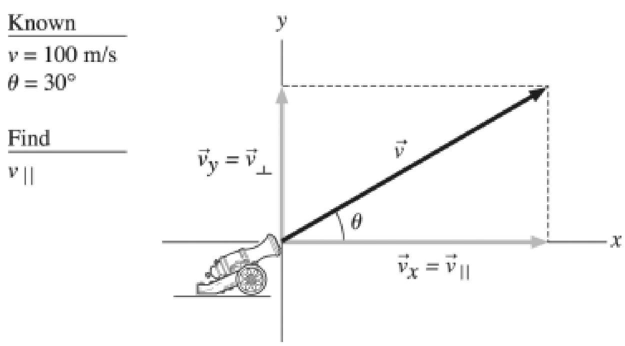
Solve: We have,

$$v_y = v \sin 40°, \quad \text{or} \quad 10 \text{ m/s} = v \sin 40°, \text{ or } v = 15.56 \text{ m/s}.$$

Thus the x-component is $v_x = v \cos 40° = (15.56 \text{ m/s}) \cos 40° = 12 \text{ m/s}$.

Assess: Note that we had to insert the minus sign manually with v_y since the vector is in the fourth quadrant.

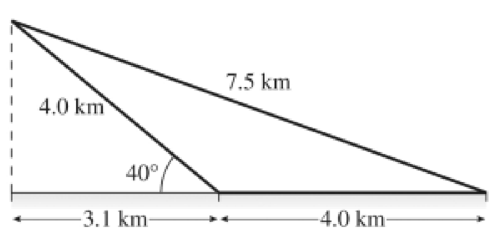
P3.7. Strategize: This problem involves a right triangle. In right triangles, we can use trigonometric functions.
Prepare: The figure below shows the components $v_{\|}$ and $v_{\perp}$, and the angle θ. We will use Tactics Box 3.2 to find the sign attached to the components of a vector.



Solve: We have $\vec{v} = \vec{v}_x + \vec{v}_y = \vec{v}_{\|} + \vec{v}_{\perp}$. Thus, $v_{\|} = v \cos\theta = (100 \text{ m/s}) \cos 30° = 87 \text{ m/s}$.

Assess: For the small angle of 30°, the obtained value of 87 m/s for the horizontal component is reasonable.

P3.13. Strategize: This problem is not given in terms of right triangles. We must find orthogonal components and put the problem in terms of a right triangle in order to use trigonometry and the Pythagorean Theorem.
Prepare: Draw a diagram of the situation.



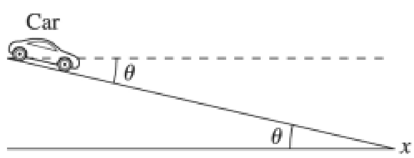
Solve: The x-component of the second leg of the trip is $(4.0\text{ km})(\cos 40°) = -3.064\text{ km}$ which is about 3.1 km more west.
The total distance west of their initial position is $4.0\text{ km} + 3.1\text{ km} = 7.1\text{ km}$.
The magnitude of the total displacement can be computed from the Pythagorean theorem:

$$\sqrt{(4.0\text{ km} + 3.064\text{ km})^2 + ((4.0\text{ km})\sin 40°)^2} = 7.5\text{ km}$$

Assess: The magnitude of the total displacement can also be computed from the law of cosines:

$$d^2 = (4.0\text{ km})^2 + (4.0\text{ km})^2 - 2(4.0\text{ km})(4.0\text{ km})\cos 140° \Rightarrow d = 7.5\text{ km}$$

P3.18. Strategize: This problem involves motion on a ramp. Since the acceleration is constant (a component of gravity), we can use kinematic equations.
Prepare: We can find the acceleration on the ramp and then use the acceleration to find the final velocity of the car.



Known
$\theta = 13°$
$\Delta x = 55\text{ ft}$
$(v_x)_i = 0\text{ m/s}$

Find
a_x
$(v_x)_f$

Solve: **(a)** The maximum possible acceleration is given by the formula $a_x = g\ \sin\theta$. Plugging in the values of g and θ, we get $a_x = 2.2\text{ m/s}^2$.
(b) The final velocity can be obtained from the formula $(v_x)_f^2 - (v_x)_i^2 = 2a_x\Delta x$, using $(v_x)_i = 0\text{ m/s}$ and $\Delta x = 16.8\text{ m}$, the latter being obtained by converting 55 ft: $55\text{ ft} = 55\text{ ft}\left(\dfrac{1\text{ m}}{3.28\text{ ft}}\right) = 16.8\text{ m}$. The solution to the first equation is $(v_x)_f = 8.6\text{ m/s}$.
Assess: As with most ramp problems, this one was best solved by using a rotated coordinate system with the x-axis along the ramp.