3 ACCELERATION

As a car gains speed, we say that it accelerates. The change in speed divided by the time it takes to make the change is called the acceleration. In equation form:

$$a = \frac{v_f - v_0}{t}$$

Here v_0 represents the speed at the start and v_f is the speed after time t has passed. Notice that although in everyday language the word "acceleration" is used only to refer to a gain in speed, if v_0 is larger than v, the acceleration is negative and is actually a deceleration. In physics, we use the word "acceleration" to include this negative case.

(a) What part of the equation represents the change in speed? _____

(b) If a car takes 5 seconds to increase its speed from 30 mi/hr to 50 mi/hr, what is its acceleration? _____

Answers: (a) $v_f - v_0$; (b) 4 miles/hour per second (4 mi/hr/s)

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The unit of acceleration in the problem you just solved is "miles per hour per second," or "mi/hr/s." If the speed is measured in meters per second and its change is measured over a few seconds, a natural unit for acceleration is "m/s/s," which is sometimes called meters per second squared and written "m/s^2."

Suppose a car starts from rest and accelerates at $2\ m/s^2$ for 3 seconds. This means that the car gains _____ of speed for every _____ of time

Answer: 2 m/s . . . 1 second

5

Suppose that, starting from rest, your new truck accelerates at a rate of 5 mi/hr/s and it continues this acceleration for 8 seconds. What will be its speed at the end of the 8 seconds? (If you don't know how to find the answer, read the rest of this frame; otherwise, just calculate the answer.)

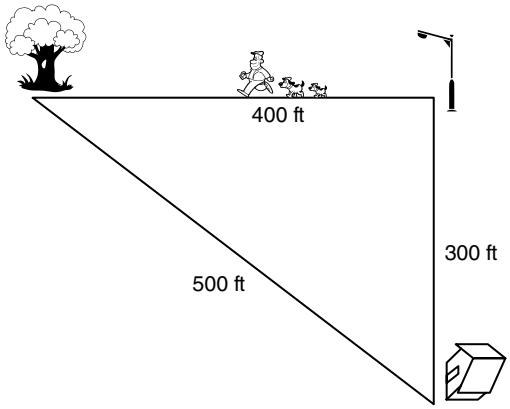
To solve this problem, first rewrite the acceleration equation from frame 3 as:

$$v_f = v_0 + a \cdot t$$

This is a useful form of the acceleration equation because it says that the speed of the object after some time (v_f) depends on its starting speed (v_0), how quickly its speed is changing (a), and how much time has elapsed (t).

Let's apply this equation to your truck. In this case, v_0 is zero since the truck started from rest. Substitute in the acceleration and time, and solve for v_f.

Answer: 40 mi/hr (0 + 5 mi/hr/s · 8 s = 40 mi/hr)



(b) What is the jogger's average velocity?

_____

(c) What is the total distance (not displacement) traveled by the jogger? _____

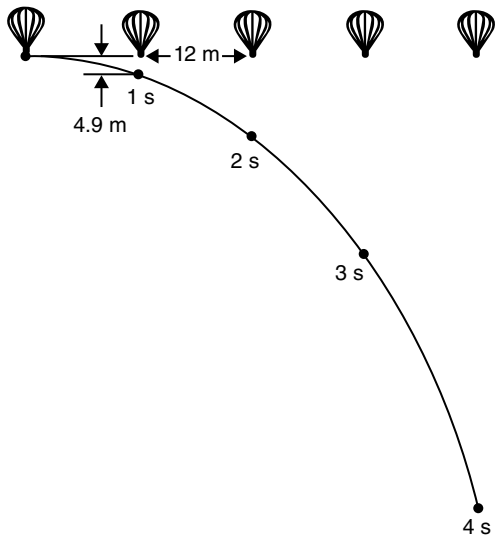
(d) What is the average speed (not velocity) during the 2 minutes? _____

Answers: (a) 500 ft; (b) 250 ft/min in a direction between north and west; (c) 700 ft; (d) 350 ft/min

This example shows that velocity and speed are definitely different things. It may seem to you that speed is the more useful of the two, but the following examples should show the advantage of the concept of velocity.

15 A VECTOR APPLICATION: PROJECTILE MOTION

Imagine a moving hot-air balloon that drops a sandbag. Since the balloon is moving along with the air, the effect of air resistance can be neglected as the sandbag falls. An interesting thing occurs: as the sandbag falls, it continues moving forward at the speed that the balloon had when the sandbag was dropped. The sandbag does fall, of course, but its downward speed is independent of its forward speed. The sandbag continues forward as if it had not been dropped, and it falls downward with an ever-increasing speed just as if it were not moving forward. The figure assumes that the balloon is traveling at 12 m/s, and it shows the sandbag at intervals of 1 second beginning when it is dropped. In each second the sandbag moves forward 12 m. Now note its downward motion. At the end of the first second after being released, its *downward* speed is 9.8 m/s.



(a) At the end of 2 seconds, what is the sandbag's forward speed? _____

(b) At the end of 2 seconds, what is its downward speed? _____