5. ***REASONING AND SOLUTION*** The velocity of the car is a vector quantity with both magnitude and direction The speed of the car is a scalar quantity and has nothing to do with direction. It is possible for a car to drive around a track at constant speed. As the car drives around the track, however, the car must change direction. Therefore, the direction of the velocity *changes*, and the velocity cannot be constant. The *incorrect* statement is (a).

7. ***REASONING AND SOLUTION*** The acceleration of an object is the rate at which its velocity is changing. No information can be gained concerning the acceleration of an object if all that is known is the velocity of the object at a single instant. No conclusion can be reached concerning the accelerations of the two vehicles, so the car does not necessarily have a greater acceleration.

10. ***REASONING AND SOLUTION*** An object moving with a constant acceleration will slow down if the acceleration vector points in the opposite direction to the velocity vector; however, if the acceleration remains constant, the object will never come to a permanent halt. As time increases, the magnitude of the velocity will get smaller and smaller. At some time, the velocity will be instantaneously zero. If the acceleration is constant, however, the velocity vector will continue to change at the same rate. An instant after the velocity is zero, the magnitude of the velocity will begin increasing in the same direction as the acceleration. As time increases, the velocity of the object will then increase in the same direction as the acceleration. In other words, if the acceleration truly remains constant, the object will slow down, stop *for an instant*, reverse direction and then speed up.

14. ***REASONING AND SOLUTION*** The magnitude of the muzzle velocity of the bullet can be found (to a very good approximation) by solving Equation 2.9, $v^2 = v_0^2 + 2a\,x$, with $v_0 = 0$ m/s; that is

$$v = \sqrt{2ax}$$

where a is the acceleration of the bullet and x is the distance traveled by the bullet before it leaves the barrel of the gun (i.e., the length of the barrel).

Since the muzzle velocity of the rifle with the shorter barrel is greater than the muzzle velocity of the rifle with the longer barrel, the product ax must be greater for the bullet in the rifle with the shorter barrel. But x is smaller for the rifle with the shorter barrel, thus the *acceleration of the bullet must be larger in the rifle with the shorter barrel.*

58. ***REASONING*** The average velocity for each segment is the slope of the line for that segment.

SOLUTION Taking the direction of motion as positive, we have from the graph for segments A, B, and C,

$$v_A = \frac{10.0\text{ km} - 40.0\text{ km}}{1.5\text{ h} - 0.0\text{ h}} = \boxed{-2.0 \times 10^1\ \text{km/h}}$$

$$v_B = \frac{20.0\text{ km} - 10.0\text{ km}}{2.5\text{ h} - 1.5\text{ h}} = \boxed{1.0 \times 10^1\ \text{km/h}}$$

$$v_C = \frac{40.0\text{ km} - 20.0\text{ km}}{3.0\text{ h} - 2.5\text{ h}} = \boxed{40\ \text{km/h}}$$

59. ***REASONING AND SOLUTION*** The average acceleration for each segment is the slope of that segment.

$$a_A = \frac{40 \text{ m/s} - 0 \text{ m/s}}{21 \text{ s} - 0 \text{ s}} = \boxed{1.9 \text{ m/s}^2}$$

$$a_B = \frac{40 \text{ m/s} - 40 \text{ m/s}}{48 \text{ s} - 21 \text{ s}} = \boxed{0 \text{ m/s}^2}$$

$$a_C = \frac{80 \text{ m/s} - 40 \text{ m/s}}{60 \text{ s} - 48 \text{ s}} = \boxed{3.3 \text{ m/s}^2}$$

60. ***REASONING*** The slope of a straight-line segment in a position-versus-time graph is the average velocity. The algebraic sign of the average velocity, therefore, corresponds to the sign of the slope.

SOLUTION

a. The slope, and hence the average velocity, is *positive* for segments A and C, *negative* for segment B, and <u>zero</u> for segment D.

b.

$$v_A = \frac{1.25\text{ km} - 0\text{ km}}{0.20\text{ h} - 0\text{ h}} = \boxed{+6.3\text{ km/h}}$$

$$v_B = \frac{0.50\text{ km} - 1.25\text{ km}}{0.40\text{ h} - 0.20\text{ h}} = \boxed{-3.8\text{ km/h}}$$

$$v_C = \frac{0.75\text{ km} - 0.50\text{ km}}{0.80\text{ h} - 0.40\text{ h}} = \boxed{+0.63\text{ km/h}}$$

$$v_D = \frac{0.75\text{ km} - 0.75\text{ km}}{1.00\text{ h} - 0.80\text{ h}} = \boxed{0\text{ km/h}}$$

61. **SSM** ***REASONING*** The average acceleration is given by Equation 2.4: $\bar{a} = (v_C - v_A)/\Delta t$. The velocities v_A and v_C can be found from the slopes of the position-time graph for segments A and C.

SOLUTION The average velocities in the segments A and C are

$$v_A = \frac{24\text{ km} - 0\text{ km}}{1.0\text{ h} - 0\text{ h}} = 24\text{ km/h}$$

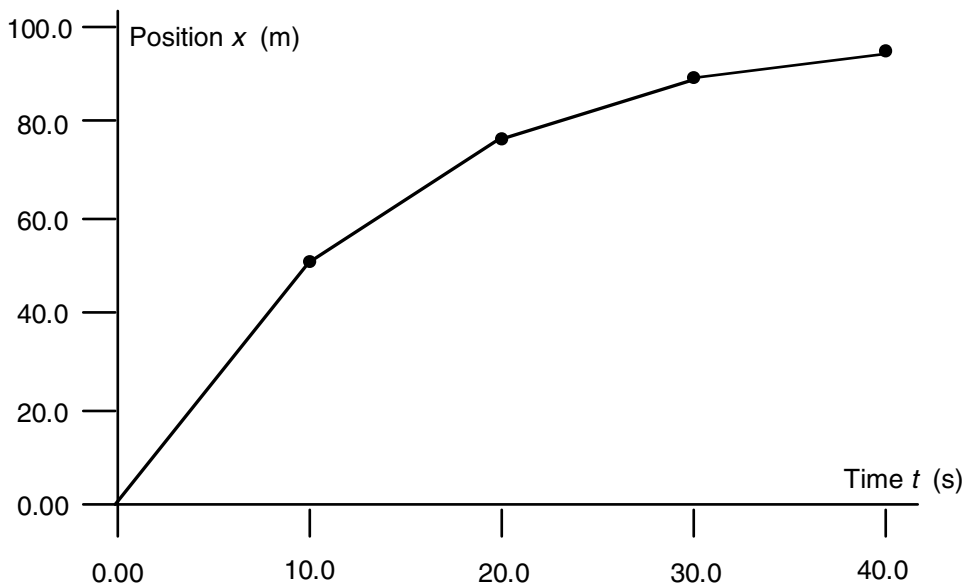
$$v_C = \frac{27\text{ km} - 33\text{ km}}{3.5\text{ h} - 2.2\text{ h}} = -5\text{ km/h}$$

From the definition of average acceleration,

$$\bar{a} = \frac{\Delta v}{\Delta t} = \frac{v_C - v_A}{\Delta t} = \frac{(-5\text{ km/h}) - (24\text{ km/h})}{3.5\text{ h} - 0\text{ h}} = \boxed{-8.3\text{ km/h}^2}$$

62. ***REASONING AND SOLUTION*** The runner is at the position $x = 0$ m when time $t = 0$ s; the finish line is 100 m away. During each ten-second segment, the runner has a constant velocity and runs half the remaining distance to the finish line. Therefore, from $t = 0$ s to $t = 10.0$ s, the position of the runner changes from $x = 0$ m to $x = 50.0$ m. From $t = 10.0$ s to $t = 20.0$ s, the position of the runner changes from $x = 50.0$ m to $x = 50.0 \text{ m} + 25.0 \text{ m} = 75.0$ m. From $t = 20.0$ s to $t = 30.0$ s, the position of the runner changes from $x = 75.0$ m to $x = 75.0 \text{ m} + 12.5 \text{ m} = 87.5$ m. Finally, from $t = 30.0$ s to $t = 40.0$ s, the position of the runner changes from $x = 87.5$ m to $x = 87.5 \text{ m} + 6.25 \text{ m} = 93.8$ m. This data can be used to construct the position-time graph. Since the runner has a constant velocity during each ten-second segment, we can find the velocity during each segment from the slope of the position-time graph for that segment.

a. The following figure shows the position-time graph for the first forty seconds.



b. The slope of each segment of the position-time graph is calculated as follows:

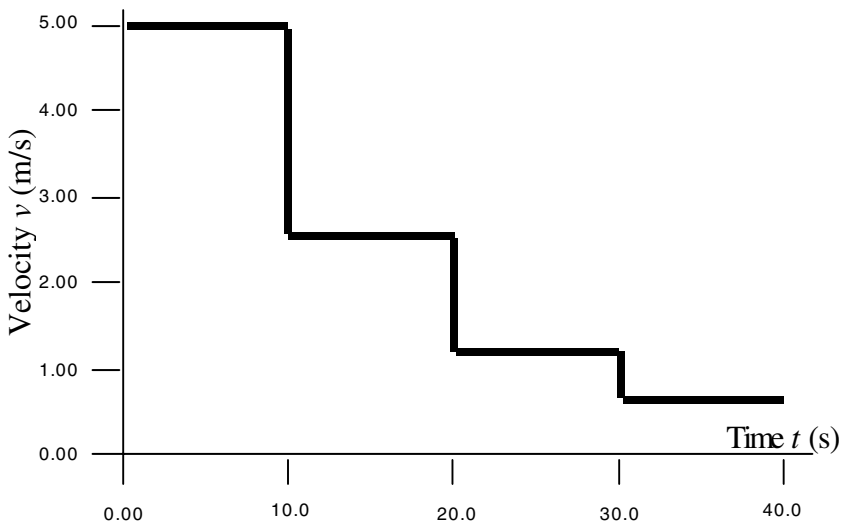
$$[0.00 \text{ s to } 10.0 \text{ s}] \qquad v = \frac{\Delta x}{\Delta t} = \frac{50.0 \text{ m} - 0.00 \text{ m}}{10.0 \text{ s} - 0 \text{ s}} = 5.00 \text{ m/s}$$

$$[10.0 \text{ s to } 20.0 \text{ s}] \qquad v = \frac{\Delta x}{\Delta t} = \frac{75.0 \text{ m} - 50.0 \text{ m}}{20.0 \text{ s} - 10.0 \text{ s}} = 2.50 \text{ m/s}$$

$$[20.0 \text{ s to } 30.0 \text{ s}] \qquad v = \frac{\Delta x}{\Delta t} = \frac{87.5 \text{ m} - 75.0 \text{ m}}{30.0 \text{ s} - 20.0 \text{ s}} = 1.25 \text{ m/s}$$

$$[30.0 \text{ s to } 40.0 \text{ s}] \qquad v = \frac{\Delta x}{\Delta t} = \frac{93.8 \text{ m} - 87.5 \text{ m}}{40.0 \text{ s} - 30.0 \text{ s}} = 0.625 \text{ m/s}$$

Therefore, the velocity-time graph is:



73. **SSM** ***REASONING AND SOLUTION***

a. The total displacement traveled by the bicyclist for the entire trip is equal to the sum of the displacements traveled during each part of the trip. The displacement traveled during each part of the trip is given by Equation 2.2: $\Delta x = \bar{v}\Delta t$. Therefore,

$$\Delta x_1 = (7.2 \text{ m/s})(22 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) = 9500 \text{ m}$$

$$\Delta x_2 = (5.1 \text{ m/s})(36 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) = 11\,000 \text{ m}$$

$$\Delta x_3 = (13 \text{ m/s})(8.0 \text{ min})\left(\frac{60 \text{ s}}{1 \text{ min}}\right) = 6200 \text{ m}$$

The total displacement traveled by the bicyclist during the entire trip is then

$$\Delta x = 9500 \text{ m} + 11\,000 \text{ m} + 6200 \text{ m} = \boxed{2.67\times10^4 \text{ m}}$$

b. The average velocity can be found from Equation 2.2.

$$\bar{v} = \frac{\Delta x}{\Delta t} = \frac{2.67\times10^4 \text{ m}}{(22 \text{ min} + 36 \text{ min} + 8.0 \text{ min})}\left(\frac{1\text{min}}{60 \text{ s}}\right) = \boxed{6.74 \text{ m/s, due north}}$$