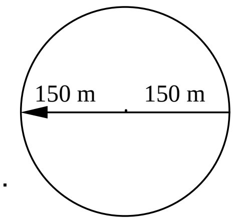
2.2 One-Dimensional Displacement and Velocity: Vector Quantities

1. (a).
2. (c). When it is a straight path, distance is equal to the magnitude of displacement. It is not a straight path; distance is greater than the magnitude of displacement.
3. (c).
4. (c).

[10]. Displacement is the change in position.

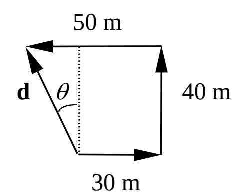


Therefore the magnitude of the displacement for half a lap is [300 m].

For a full lap (the car returns to its starting position), the displacement is [zero].

11. Displacement is the change in position. So it is [1.65 m down].

19. (a) The magnitude of the displacement is [(3) between 40 m and 60 m],



because any side of a triangle cannot be greater than the sum of the other two sides. In this case, looking at the triangle shown, the two sides perpendicular to each other are 20 m and 40 m, respectively. The magnitude of the displacement is the hypotenuse of the right triangle, so it cannot be smaller than the longer of the sides perpendicular to each other.

28. The minimum speed is $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{675\ \text{km}}{7.00\ \text{h}} = 96.4\ \text{km/h} = \boxed{59.9\ \text{mi/h}}$.

[No], she does not have to exceed the 65 mi/h speed limit.

[30]. To the runner on the right, the runner on the left is running at a velocity of

+4.50 m/s – (–3.50 m/s) = +8.00 m/s. So it takes $\Delta t = \dfrac{\Delta x}{\bar{v}} = \dfrac{100\ \text{m}}{8.00\ \text{m/s}} = \boxed{12.5\ \text{s}}$.

They meet at (4.50 m/s)(12.5 s) = [56.3 m (relative to runner on left)].

2.3 Acceleration

31. (d).
32. (d).
33. (c). A negative acceleration only means it is pointing in a particular direction, for example, the –*x*-axis. If an object is moving in the positive *x*-axis, the velocity of the object decreases. However, if an object is moving in the – *x*-axis, then its velocity can actually increase (speed up).
34. (d). Any change in either magnitude or direction results in a change in velocity. The brakes and gearshift change the magnitude, and the steering wheel changes the direction.

48. (a) Given: $v_o = 35.0$ km/h $= 9.72$ m/s, $a = 1.50$ m/s^2, $x = 200$ m (take $x_o = 0$). Find: v.

$v^2 = v_o^2 + 2a(x - x_o) = (9.72 \text{ m/s})^2 + 2(1.5 \text{ m/s}^2)(200 \text{ m}) = 694 \text{ m}^2/\text{s}^2$, ☞ $v = \boxed{26.3 \text{ m/s}}$.

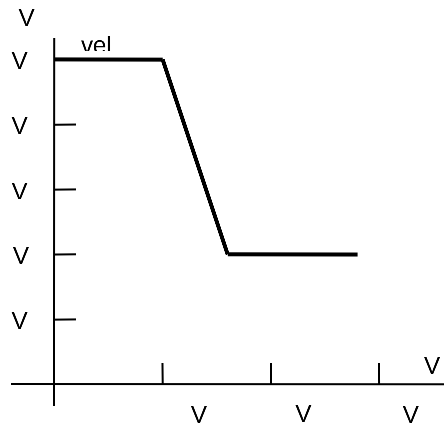
(b) $v = v_o + at$, ☞ $t = \dfrac{v - v_o}{a} = \dfrac{26.3 \text{ m/s} - 9.72 \text{ m/s}}{1.50 \text{ m/s}^2} = \boxed{11.1 \text{ s}}$.

$\boxed{52}$. (a) See the sketch on the right.

(b) The acceleration is negative as the object slows down (assume velocity is positive).

$v = v_o + at = 25 \text{ m/s} + (-5.0 \text{ m/s}^2)(3.0 \text{ s})$

$= \boxed{10 \text{ m/s}}$.



(c) $x = x_1 + x_2 + x_3$

$= (25 \text{ m/s})(5.0 \text{ s})$

$+ (25 \text{ m/s})(3.0 \text{ s}) + \frac{1}{2}(-5.0 \text{ m/s}^2)(3.0 \text{ s})^2$

$+ (10 \text{ m/s})(6.0 \text{ s})$

$= 237.5 \text{ m} = \boxed{2.4 \times 10^2 \text{ m}}$.

(d) $\bar{s} = \dfrac{d}{\Delta t} = \dfrac{237.5 \text{ m}}{14.0 \text{ s}} = \boxed{17 \text{ m/s}}$.

54. (c).

55. (d), because it is a parabola (depending on time squared).

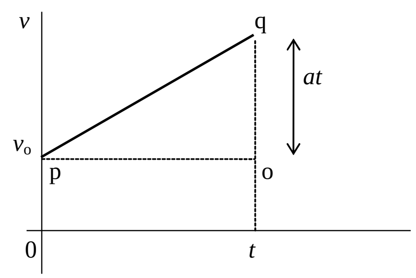
56. (a). Since $v = v_o + at = 0 + at$, $\bar{v} = \dfrac{v_o + v}{2} = \frac{1}{2}at.$

57. $\boxed{\text{It is zero}}$ because the velocity is a constant.

2.4 Kinematic Equations (Constant Acceleration)

75. (a) For constant acceleration, the v vs. t plot is a straight line. Point p has coordinates of $(0, v_o)$ and point q has coordinates of $(t, v_o + at)$. The distance from point q to point o is therefore at. The area under the curve is the area of the triangle $\frac{1}{2}(at)t$ plus the area of the rectangle $v_o t$.

So $A = v_o t + \frac{1}{2}at^2 = x - x_o$. (Here $x - x_o$ is displacement.)



(b) The total area consists of two triangles from 0 to 4.0 s and from 10.0 s to 18.0 s and a rectangle from 4.0 s to 10.0 s.

$x - x_o = A = \frac{1}{2}(4.0 \text{ s} - 0)(8.0 \text{ m/s}) + (10.0 \text{ s} - 4.0 \text{ s})(8.0 \text{ m/s}) + \frac{1}{2}(18.0 \text{ s} - 10.0 \text{ s})(8.0 \text{ m/s}) = \boxed{96 \text{ m}}$

81. (a) Given: $a = 3.00$ m/s^2, $t = 1.40$ s, $x = 20.0$ m (take $x_o = 0$). Find: v_o.

$x = x_o + v_o t + \frac{1}{2}at^2$, ☞ $20.0 \text{ m} = 0 + v_o(1.40 \text{ s}) + \frac{1}{2}(3.00 \text{ m/s}^2)(1.40 \text{ s})^2$.

Solving, $v_o = \boxed{12.2 \text{ m/s}}$.

$v = v_o + at = 12.2 \text{ m/s} + (3.00 \text{ m/s}^2)(1.40 \text{ s}) = \boxed{16.4 \text{ m/s}}$.

(b) Given: $v_o = 0$, $a = 3.00\text{ m/s}^2$, $v = 12.2\text{ m/s}$. Find: x (take $x_o = 0$).

$v^2 = v_o^2 + 2a(x - x_o)$, ☞ $x - x_o = \dfrac{v^2 - v_o^2}{2a} = \dfrac{(12.2\text{ m/s})^2 - 0^2}{2(3.00\text{ m/s}^2)} = \boxed{24.8\text{ m}}$.

(c) $v = v_o + at$, ☞ $t = \dfrac{v - v_o}{a} = \dfrac{12.2\text{ m/s} - 0}{3.00\text{ m/s}^2} = \boxed{4.07\text{ s}}$.

2.5 Free Fall

Neglect air resistance in the following Exercises.

83. (d).

84. (d). Free fall is a motion under the gravitational acceleration. The initial velocity does not matter.

85. (c). It accelerates at 9.80 m/s^2, so it increases its speed by 9.80 m/s in each second.

86. (a). The acceleration is not zero. It is 9.80 m/s^2 downward.

87. (c). It is always accelerates at 9.80 m/s^2 downward.

98. The maximum initial velocity corresponds to the apple reaching maximum height just below the ceiling.

Given: $v = 0$ (max height), $(y - y_o) = 3.75\text{ m} - 0.50\text{ m} = 3.25\text{ m}$. Find: v_o.

$v^2 = v_o^2 - 2g(y - y_o)$, ☞ $v_o = \sqrt{v^2 + 2g(y - y_o)} = \sqrt{0 + 2(9.80\text{ m/s}^2)(3.25\text{ m})} = 7.98\text{ m/s}$.

Therefore it is $\boxed{\text{slightly less than 8.0 m/s}}$.

99. Taking $y_o = 0$, $y = y_o + v_o t - \frac{1}{2}gt^2 = 0 + 0 - \frac{1}{2}gt^2 = -\frac{1}{2}gt^2$, so $t = \sqrt{\dfrac{-2y}{g}}$.

For $y = -452$ m, $t = 9.604$ s; for $y = -443$ m, $t = 9.508$ s.

So $\Delta t = 9.604\text{ s} - 9.508\text{ s} = \boxed{0.096\text{ s}}$.

113. (a) Given: $a = -2.50\text{ m/s}^2$, $x = 300$ m (taking $x_o = 0$), $v = 0$ (come to rest). Find: v_o.

$v^2 = v_o^2 + 2a(x - x_o)$, ☞ $v_o = \sqrt{-2a(x - x_o)} = \sqrt{-2(-2.50\text{ m/s}^2)(300\text{ m})} = \boxed{38.7\text{ m/s}}$.

(b) $v = v_o + at$, ☞ $t = \dfrac{v - v_o}{a} = \dfrac{0 - 38.7\text{ m/s}}{-2.50\text{ m/s}^2} = \boxed{15.5\text{ s}}$.

(c) $v_o = 38.7\text{ m/s} + 4.47\text{ m/s} = 43.2\text{ m/s}$.

$v^2 = v_o^2 + 2a(x - x_o) = (43.2\text{ m/s})^2 + 2(-2.50\text{ m/s}^2)(300\text{ m}) = 366.2\text{ m}^2/\text{s}^2$. So $v = \boxed{19.2\text{ m/s}}$.