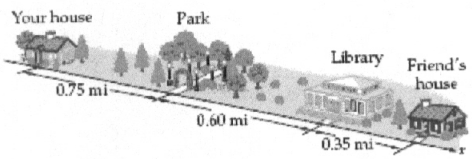
Physics 100A Homework 1 – Ch 2

1. **Picture the Problem**: You walk in both the positive and negative directions along a straight line.



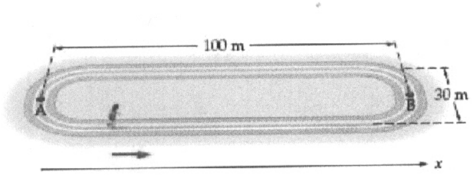
Strategy: The distance is the total length of travel, and the displacement is the net change in position.

Solution: (a) Add the lengths: $(0.75+0.60\text{ mi})+(0.60\text{ mi})=\boxed{1.95\text{ mi}}$

(b) Subtract x_i from x_f to find the displacement. $\Delta x = x_f - x_i = 0.75 - 0.00\text{ mi} = \boxed{0.75\text{ mi}}$

Insight: The distance traveled is always positive, but the displacement can be negative.

5. **Picture the Problem**: The runner moves along the oval track.



Strategy: The distance is the total length of travel, and the displacement is the net change in position.

Solution: 1. (a) Add the lengths: $(15\text{ m})+(100\text{ m})+(15\text{ m})=\boxed{130\text{ m}}$

2. Subtract x_i from x_f to find the displacement. $\Delta x = x_f - x_i = 100-0\text{ m} = \boxed{100\text{ m}}$

3. (b) Add the lengths: $15+100+30+100+15\text{ m} = \boxed{260\text{ m}}$

4. Subtract x_i from x_f to find the displacement. $\Delta x = x_f - x_i = 0-0\text{ m} = \boxed{0\text{ m}}$

Insight: The distance traveled is always positive, but the displacement can be negative. The displacement is always zero for a complete circuit, as in this case.

②

18. **Picture the Problem**: You travel 8.0 km on foot and then an additional 16 km by car, with both displacements along the same direction.

Strategy: First find the total time elapsed by dividing the distance traveled by the average and divide by the total time elapsed to find the average speed. Set that average speed to the given value and solve for the car's speed.

Solution: 1. Use the definition of average speed to determine the total time elapsed.
$$\Delta t = \frac{d}{s_{\text{av}}} = \frac{8.0+16\text{ km}}{22\text{ km/h}} = 1.1\text{ h}$$

2. Find the time elapsed while in the car:
$$\Delta t_2 = \Delta t - \Delta t_1 = 1.1\text{ h} - 0.84\text{ h} = 0.3\text{ h}$$

3. Find the speed of the car:
$$s_2 = \frac{d_2}{\Delta t_2} = \frac{16\text{ km}}{0.3\text{ h}} = \boxed{50\text{ km/h}}$$

Insight: This problem illustrates the limitations that significant figures occasionally impose. If you keep an extra figure in the total elapsed time (1.09 h) you'll end up with the time elapsed for the car trip as 0.25 h, not 0.3, and the speed of the car is 64 km/h. But the rules of subtraction indicate we only know the total time to within a tenth of an hour, so we can only know the time spent in the car to within a tenth of an hour, or to within one significant digit.

33. **Picture the Problem**: The runner accelerates uniformly along a straight track.

Strategy: The change in velocity is the average acceleration multiplied by the elapsed time.

Solution: 1. (a) Multiply the acceleration by the time: $v = v_0 + at = 0\text{ m/s} + (1.9\text{ m/s}^2)(2.0\text{ s}) = \boxed{3.8\text{ m/s}}$

2. (b) Multiply the acceleration by the time: $v = v_0 + at = 0\text{ m/s} + (1.9\text{ m/s}^2)(5.2\text{ s}) = \boxed{9.9\text{ m/s}}$

Insight: World class sprinters have top speeds over 10 m/s, so this athlete isn't bad, but it took him a whole 5.2 seconds to get up to speed. He should work on his acceleration!

38. **Picture the Problem**: The horse travels in a straight line in the positive direction while accelerating in the negative direction (slowing down).

Strategy: Use the definition of acceleration to determine the time elapsed for the specified change in velocity.

Solution: Solve equation 2-7 for time: $t = \dfrac{v - v_0}{a} = \dfrac{6.5 - 11 \text{ m/s}}{-1.81 \text{ m/s}^2} = \boxed{2.5 \text{ s}}$

Insight: We bent the rules a little bit on significant figures. Because the +11 m/s is only known to the ones column, the difference between 6.5 and 11 is 4 m/s, only one significant digit. The answer is then properly 2 s. The answer is probably closer to 2.5 s, so that's why we kept the extra digit.

74. **Picture the Problem**: The shell falls straight down under the influence of gravity.

Strategy: Because the distance of the fall is known, use the time-free equation of motion (equation 2-12) to find the landing speed.

Solution: Solve equation 2-12 for v. Let $v_0 = 0$ and let downward be the positive direction.

$$v = \sqrt{v_0^2 + 2g\Delta x} = \sqrt{0^2 + 2\left(9.81 \text{ m/s}^2\right)\left(14 \text{ m}\right)} = \boxed{17 \text{ m/s}}$$

Insight: That speed (about 38 mi/h) is sufficient to shatter the shell and provide a tasty meal!

83. **Picture the Problem**: The swimmers fall straight down from the bridge into the water.

Strategy: The initial velocities of the swimmers are zero because they step off the bridge rather than jump up or dive downward. Use the equation of motion for position as a function of time and acceleration, realizing that the acceleration in each case is 9.81 m/s^2. Set $x_0 = 0$ and let downward be the positive direction for simplicity. The known acceleration can be used to find velocity as a function of time for part (b). Finally, the same equation of motion for part (a) can be solved for time in order to answer part (c).

Solution: 1. (a) Apply equation 2-11 directly:

$$x = x_0 + v_0 t + \tfrac{1}{2}at^2 = 0.0\text{ m} + 0 + \tfrac{1}{2}\left(9.81\text{ m/s}^2\right)\left(1.5\right)^2$$

$$\boxed{x = 11\text{ m}}$$

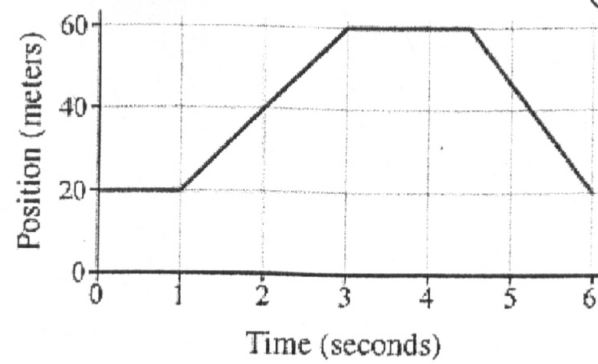
2. (b) Apply equation 2-7 directly:

$$v = v_0 + at = 0 + \left(9.81\text{ m/s}^2\right)\left(1.5\text{ s}\right) = \boxed{15\text{ m/s}}$$

3. (c) Solve equation 2-11 for t:

$$t = \sqrt{\frac{2x}{a}} = \sqrt{\frac{2\left(11\text{ m} \times 2\right)}{9.81\text{ m/s}^2}} = \boxed{2.1\text{ s}}$$

Insight: The time in part (c) doesn't double because it depends upon the square root of the distance the swimmer falls. If you want to double the fall time you must quadruple the height of the bridge.



• Average Velocity

A) $V_{avg} = \frac{x_f - x_i}{t_f - t_i} = \frac{\Delta x}{\Delta t}$

0 to 1 s. $x_f = 20m$ $x_i = 20m$ $\rightarrow \Delta x = 0$ $V_{av} = 0$

B) 1 to 3 s. $x_f = 60m$ $x_i = 20m$ $V_{avg} = \frac{60-20}{3-1} = \frac{40}{2} = 20 \frac{m}{s}$

C) 0 to 3 s $x_f = 60m$ $x_i = 20m$ $V_{avg} = \frac{60-20}{3-0} = \frac{40}{3} = 13.3 \frac{m}{s}$

D) 3 to 6 s $x_f = 20m$ $x_i = 60m$ $V_{avg} = \frac{20-60}{6-3} = -\frac{40}{3} = -13.3 \frac{m}{s}$

E) 0 to 6 s $x_f = 20m$ $x_i = 20m$ $V_{avg} = \frac{20-20}{6-0} = 0$

• Analyzing position vs. time

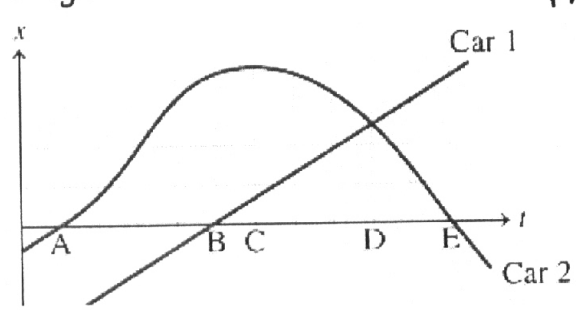
A) Cars pass each other, when the two position lines cross: D

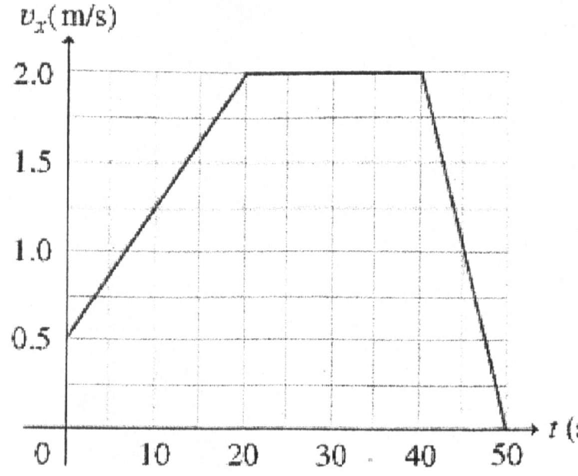
B) When they cross Car 1 has a positive velocity / ← tangent, while Car 2 has a negative velocity \ . This means they are going in opposite directions

C) Car 1 never stops. It has constant velocity

D) Car 2 stops at C when the velocity is zero

E) At A the tangents to both curves appear identical.





• What velocity vs. time graphs can tell us

A) $V_0 = 0.5 \, m/s$

B) Total distance travelled

Divide into 3 intervals 0 - 20 s, 20 - 40 s, 40 - 50 s

0 - 20 s

$$a_x = \frac{V_f - V_i}{\Delta t}$$

In these cases $a_{av} = a$

$$a_1 = \frac{2.0 - 0.5}{20 - 0} = 0.075 \, \frac{m}{s^2}$$

The distance travelled from t = 0 s to t = 20 s

$$X_1 = V_{1o} t + \frac{1}{2} a_1 t^2 = (0.5)(20) + \frac{1}{2}(0.075)(20)^2$$

$$X_1 = 25 \, m$$

20 - 40 s

$$a_2 = 0$$

$$X_2 = V_{2o} t = (2.0)(20) = 40 m$$

40 - 50 s

$$a_3 = \frac{0 - 2.0}{50 - 40} = -0.2 \, \frac{m}{s^2}$$

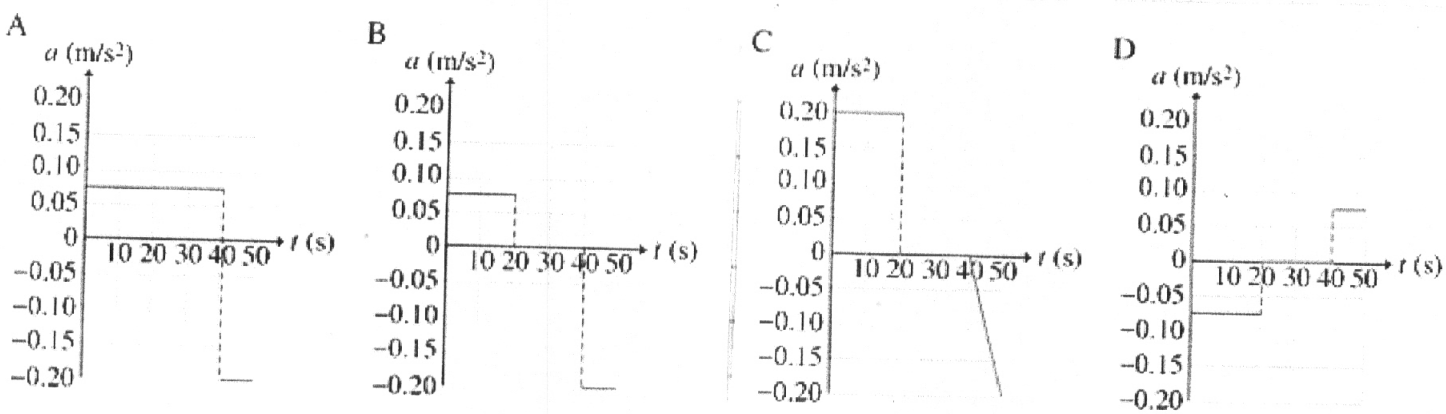
$$X_3 = V_{3o} t + \frac{1}{2} a_3 t^2 = (2.0)(10) + \frac{1}{2}(-0.2)(10)^2 = 10 m$$

$$X = X_1 + X_2 + X_3 = 25 + 40 + 10 = 75 m$$

C) The acceleration is $a_1 = 0.075 \, \frac{m}{s^2}$

D) At $t = 45\ s$, the car is between 40 s and 50 s. This corresponds to $a_3 = -0.2\ \frac{m}{s^2}$

E) Graph B $a_1 = 0.075\ \frac{m}{s^2}$, $a_2 = 0\ \frac{m}{s^2}$, $a_3 = -0.2\ \frac{m}{s^2}$



- One dimensional kinematics

$$x(t) = x_i + v_i t + \frac{1}{2} a t^2$$

$$v(t) = v_i + a t$$

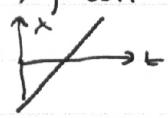
Functions of time: $x(t)$, $v(t)$ Gives the quantities at <u>any</u> time

Constants: x_i, v_i, a

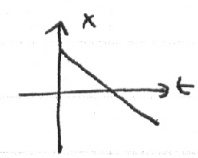
- Displacement vs. Time Graphs

X negative is West from the origin
X positive is East from the origin

A) Graph D. Coming from the negative X, passing through origin continuing to positive X, without changing the velocity (slope)



B) Graph A. Counterpart part of last case



C) Graph F. X is decreasing, going towards the west, and the slope is decreasing, slowing down, finally stopping with slope zero.

D) Graph E. It is at rest, slope zero, slope increases, speeding up, moving to larger X, towards the east.