Conceptual Questions

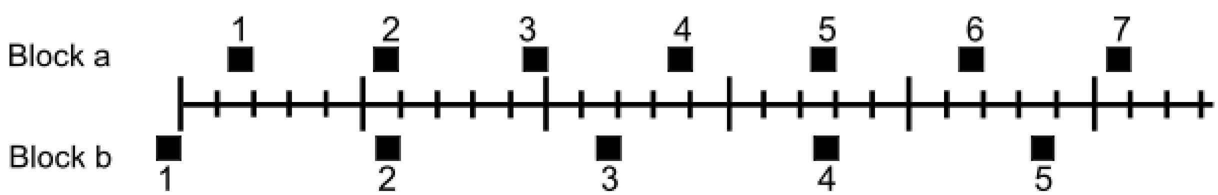
1. In drag racing, is it possible for the car with the greatest speed crossing the finish line to lose the race? Explain.
   YES. To win a race, the time taken must be minimized, and this can be achieved with a lower final velocity compared to other racers. If a racer takes a long time to reach their maximum speed, they will not likely win the race.

2. If the speedometer of a car reads a steady 60 km/h, can you say for sure that the acceleration is zero? Explain.
   NO. The car could be turning, thus changing its direction, which means its velocity is changing, which means it has a non-zero acceleration.

3. Can the velocity of an object be negative when its acceleration is positive? What about vice versa?
   YES. If the object has a negative velocity it means that it is travelling in the negative direction. If the object slows down, its acceleration will be positive. If the object has a positive velocity it means that it is travelling in the positive direction. If the object slows down, its acceleration will be negative.

4. A man was walking westwards down the aisle of a train moving west at 120 km/h when he felt "thrown" to his left. The train:
   a) turned southwards
   b) turned northwards
   c) slowed down
   d) sped up
   e) accelerated eastwards

5. The positions of two blocks at successive 0.20-second intervals are represented by the numbered squares in the figure below. The blocks are moving to the right.
   The accelerations of the blocks are related as follows:



   a) The acceleration of "a" is greater than the acceleration of "b".
   b) The acceleration of "a" equals the acceleration of "b". Both accelerations are greater than zero.
   c) The acceleration of "b" is greater than the acceleration of "a".
   d) The acceleration of "a" equals the acceleration of "b". Both accelerations are zero.
   e) Not enough information is given to answer the question.

Problems

6. In coming to a stop, a car leaves skid marks 92 m long on the highway. Assuming a deceleration of 7.00 m/s^2, estimate the speed of the car just before braking.

$$\Delta\vec{d} = 92\ m\ [fwd]$$
$$\vec{a} = -7.0\ m/s^2\ [fwd]$$
$$\vec{v}_2 = 0\ m/s\ [fwd]$$
$$\vec{v}_1 = ?$$

$$v_2^2 = v_1^2 + 2a\Delta d$$
$$v_1 = (v_2^2 - 2a\Delta d)^{1/2}$$
$$v_1 = \left((0\ m/s)^2 - 2(-7.0\ m/s^2)\ (92\ m)\right)^{1/2}$$
$$v_1 = 36\ m/s$$

7. A car has an initial velocity of 15 m/s. For how many seconds must it accelerate at a constant rate of 3.0 m/s^2 before its average velocity is equal to twice its initial velocity?

$$\vec{v}_1 = 15\ m/s\ [fwd]$$
$$\vec{a} = 3.0\ m/s^2\ [fwd]$$
$$\Delta t = ?$$
$$\Delta\vec{d} = ?$$

$$2\vec{v}_1 = \vec{v} = \frac{\Delta\vec{d}}{\Delta t}$$
$$\Delta\vec{d} = 2\vec{v}_1\Delta t$$

$$\Delta\vec{d} = \vec{v}_1\Delta t + \tfrac{1}{2}\vec{a}\Delta t^2$$
$$2\vec{v}_1\Delta t = \vec{v}_1\Delta t + \tfrac{1}{2}\vec{a}\Delta t^2$$
$$\vec{v}_1 = \tfrac{1}{2}\vec{a}\Delta t$$
$$\Delta t = \frac{2\vec{v}_1}{\vec{a}}$$
$$\Delta t = \frac{2(15\ m/s)}{3.0\ m/s^2}$$
$$\Delta t = 1.0\times10^1\ s$$

8. A car travelling on a straight track accelerates uniformly from rest for 5.0 s and then travels at a constant speed for the next 5.0 s, covering a total distance of 75 m in that time. Determine the constant speed that the car achieved.

Part1

$$\vec{v}_1 = 0\ m/s\ [fwd]$$
$$\Delta t = 5.0\ s$$
$$\vec{a} = ?$$
$$\Delta\vec{d} = ?$$
$$\vec{v}_2 = ?$$

Part2

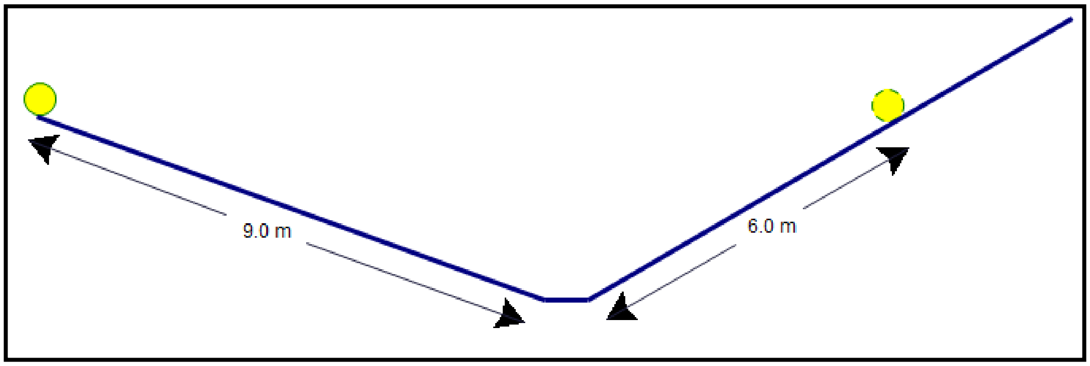
$$\vec{a} = 0\ m/s^2\ [fwd]$$
$$\Delta t = 5.0\ s$$
$$\Delta\vec{d} = ?$$
$$\vec{v}_1 = \vec{v}_2 = \vec{v}_{pt2} = ?$$

$$\Delta\vec{d}_{pt1} + \Delta\vec{d}_{pt2} = 75\ m\ [fwd]$$
$$\vec{v}_{2pt1} = \vec{v}_{pt2}$$

$$\Delta\vec{d}_{pt1} = \tfrac{1}{2}(\vec{v}_{1pt1} + \vec{v}_{2pt1})\Delta t$$
$$\Delta\vec{d}_{pt2} = \vec{v}_{pt2}\Delta t$$

$$\tfrac{1}{2}(\vec{v}_{1pt1} + \vec{v}_{2pt1})\Delta t + \vec{v}_{pt2}\Delta t = 75\ m\ [fwd]$$
$$\tfrac{3}{2}\vec{v}_{pt2}\Delta t = 75\ m\ [fwd]$$
$$v_{pt2} = \frac{2(75\ m)}{3\Delta t}$$
$$v_{pt2} = \frac{2(75\ m)}{3(5.0\ s)}$$
$$v_{pt2} = 1.0\times10^1\ m/s$$

9. A marble started from rest and accelerated at 2.0 m/s^2 down an inclined plane 9.0 m long. After it reached the bottom, the marble rolled up another inclined plane. After moving 6.0 m, it came to rest. How long did the marble take to come to rest, after starting up the second inclined plane?



Moving Down

$\vec{v}_1 = 0\ m/s\ [down\ ramp]$
$\Delta\vec{d} = 9.0\ m\ [down\ ramp]$
$\vec{a} = 2.0\ m/s^2\ [down\ ramp]$
$\vec{v}_2 = ?$

Moving Up

$\Delta\vec{d} = 6.0\ m\ [up\ ramp]$
$\vec{v}_2 = 0\ m/s\ [up\ ramp]$
$\vec{v}_1 = ?$
$\Delta t = ?$

$v_2^2 = v_1^2 + 2a\Delta d$
$v_2 = (2a\Delta d)^{1/2}$
$v_2 = \left(2(2.0\ m/s^2)(9.0\ m)\right)^{1/2}$
$\vec{v}_2 = 6.0\ m/s\ [down\ ramp]$

$v_{2\ down\ ramp} = v_{1\ up\ ramp}$

$\Delta\vec{d} = \frac{1}{2}(\vec{v}_1 + \vec{v}_2)\Delta t$
$\Delta t = \frac{2\Delta\vec{d}}{(\vec{v}_1 + \vec{v}_2)}$
$\Delta t = \frac{2(6.0\ m)}{(6.0\ m/s + 0\ m/s)}$
$\Delta t = 2.0\ s$

10. While being overtaken by a speeding car on the highway a truck slows down from 9.0×10^1 km/h to 75 km/h in 8.0 seconds.
    a) How far does the truck travel in this time?

a) truck:

$\vec{v}_1 = 9.0 \times 10^1\ \text{km/h [fwd]} = 25\ \text{m/s [fwd]}$
$\vec{v}_2 = 75\ \text{km/h [fwd]} = 20.8\ \text{m/s [fwd]}$
$\Delta t = 8.0\ s$
$\Delta\vec{d} = ?$

$\Delta\vec{d} = \frac{1}{2}(\vec{v}_1 + \vec{v}_2)\Delta t$
$\Delta\vec{d} = \frac{1}{2}(25\ \text{m/s [fwd]} + 20.8\ \text{m/s [fwd]})(8.0\ s)$
$\Delta\vec{d} = 180\ m\ [fwd]$

b) If the speeding car, which is travelling at a constant 1.0×10^2 km/h, is 2.0×10^2 m behind the truck when it starts to slow down, how far apart will they be when the 8.0 seconds is up?

b) car:
$\vec{v}_1 = \vec{v}_2 = 1.0 \times 10^2 \text{ km/h [fwd]} = 27.8 \text{ m/s [fwd]}$
$\vec{a} = 0\, m/s^2\, [fwd]$
$\Delta t = 8.0\, s$
$\Delta\vec{d} = ?$

$\Delta\vec{d} = \frac{1}{2}(\vec{v}_1 + \vec{v}_2)\Delta t$
$\Delta\vec{d} = \frac{1}{2}(27.8 \text{ m/s [fwd]} + 27.8 \text{ m/s [fwd]})(8.0\, s)$
$\Delta\vec{d} = 222\, m\, [fwd]$

$d_{behind} = d_{head\ start} + d_{truck} - d_{car}$
$d_{behind} = 2.0 \times 10^2 \text{m} + 180\, m - 222\, m$
$d_{behind} = 158\, m$

11. A person driving her car at 45 km/h approaches an intersection just as the traffic light turns yellow. She knows that the yellow light lasts only 2.0 s before turning red, and she is 28 m away from the near side of the intersection. Should she try to stop, or should she speed up to cross the intersection before the light turns red? The intersection is 15 m wide. Her car's maximum deceleration is -5.8 m/s^2, whereas it can accelerate from 45 km/h to 65 km/h in 6.0 s. Ignore the length of her car and her reaction time.

Case1: stopping
$\vec{v}_1 = 45 \text{ km/h [fwd]} = 12.5 \text{ m/s [fwd]}$
$\vec{a} = -5.8\, m/s^2\, [fwd]$
$\vec{v}_2 = 0\, m/s\, [fwd]$
$\Delta\vec{d} = ?$

$v_2^2 = v_1^2 + 2a\Delta d$
$\Delta d = \frac{v_2^2 - v_1^2}{2a}$
$\Delta d = \frac{(0\, m/s)^2 - (12.5\, m/s)^2}{2(-5.8\, m/s^2)}$
$\Delta d = 13\, m$ she can stop in time.

Case2: speeding though intersection
$\vec{v}_1 = 45 \text{ km/h [fwd]} = 12.5 \text{ m/s [fwd]}$
$\vec{v}_2 = 65 \text{ km/h [fwd]} = 18.1 \text{ m/s [fwd]}$
$\Delta t = 6.0\, s$
$\vec{a} = ?$

Finding acceleration of car:
$\vec{v}_2 = \vec{v}_1 + \vec{a}\Delta t$
$\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{\Delta t}$
$\vec{a} = \frac{18.1\, m/s\, [fwd] - 12.5\, m/s\, [fwd]}{6.0\, s}$
$\vec{a} = 0.926\, m/s^2\, [fwd]$

Finding distance car travels in 2.0 s:
$\vec{v}_1 = 45\ \text{km/h [fwd]} = 12.5\ \text{m/s [fwd]}$
$\vec{a} = 0.926\ m/s^2\ [fwd]$
$\Delta t = 2.0\ s$
$\Delta \vec{d} = ?$

$\Delta \vec{d} = \vec{v}_1 \Delta t + \frac{1}{2}\vec{a}\Delta t^2$
$\Delta \vec{d} = (12.5\ \text{m/s [fwd]})(2.0\ s) + \frac{1}{2}(0.926\ m/s^2\ [fwd])(2.0\ s)^2$
$\Delta \vec{d} = 27\ m$ she would be short of the required 43 m to safely pass the intersection. She should stop.