Introduction to Kinematics

A large variety of physics problems can be solved with a small set of fundamental relations. In your Workshop section, you will practice with your classmates the application of this small set of relations to solve physics problems. In order to make your work most reliable in your workshop (and in your homework), please remember to:

1) Draw pictures and/or diagrams of the situation before beginning a solution

2) Start your solution by writing down a fundamental definition or relation that you think is relevant.

Equations and Relations:

- Average Speed = distance traveled / time elapsed
- Instantaneous Velocity = slope of tangent to x-t graph = dx/dt
- Instantaneous Acceleration = slope of tangent to v-t graph = dv/dt

Average Velocity: $\bar{v} = \Delta x / \Delta t = (x_2 - x_1) / \Delta t$

Average Acceleration: $\bar{a} = \Delta v / \Delta t = (v_2 - v_1) / \Delta t$

<u>Motion with Constant Acceleration:</u>

$v = v_0 + at$

$x = x_0 + v_0 t + \frac{1}{2} a t^2$

$v^2 = v_0{}^2 + 2a(x - x_0)$

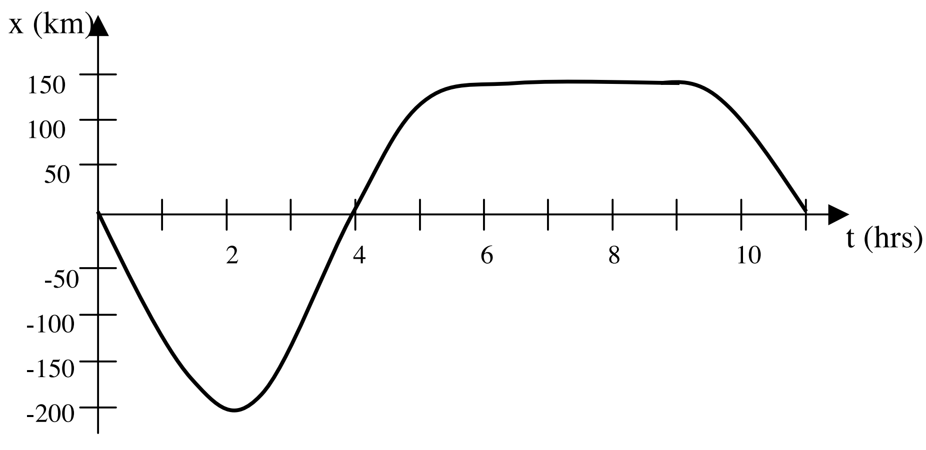
$\bar{v} = (v + v_0) / 2$

$g = 9.80 m/s^2 \approx 10 m/s^2$

1. You are jogging around a ¼-mile track. Timing yourself, you find that you complete a lap in exactly 2 minutes.
   (a) What is your *average speed* for this lap, in miles per hour?
   (b) What is your *displacement* after completing exactly one lap?
   (c) What is your *average velocity* for this lap?

Check Point

2. The position of your car during a recent road trip on the interstate highway (essentially a straight line) is described by the position-time graph to the right, where North is assigned to be positive. You should begin this problem by redrawing the graph on a whiteboard or blank sheet of paper. Draw it large!



   (a) When is the car's *speed* zero?
   (b) Determine the car's approximate *average velocity* for the intervals
      (i) from 0 to 6 hrs
      (ii) from 2 to 4 hrs
      (iii) from 4 to 11 hrs
   (c) Determine the car's *average speed* for its entire 11-hour motion.
   (d) Sketch the velocity versus time graph corresponding to this motion.

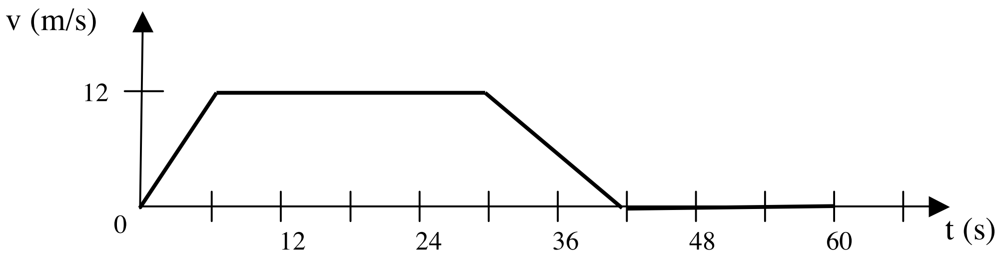
Check Point

3. Lamborghini advertises that its Diablo model can go from 0-62 mph in 4.1 seconds.

   (a) Given that 1m/s ≈ 2.2 mph, what is the average acceleration of the car for these 4.1 seconds in SI units?
   (b) Despite the limitations of the Lamborghini engine, how could you get this car to accelerate faster than the answer to part (a)?

Check Point

4. The following graph represents velocity versus time graph for the motion of an object over a particular one minute time interval:



Please start by redrawing this graph on your whiteboard. Draw it large!

   (a) Make up a story that describes motion that is consistent with this graph. Be creative! Think about the speeds and times involved and make your story realistic.
   (b) Find the average acceleration of this object for the interval from 0-6 seconds.
   (c) What is the average acceleration of this object for the entire one-minute interval?

Check Point

5. Smoky the cat is relaxing on the arm of a couch, one meter above the ground, when he is startled by something and jumps straight up in the air with initial speed 4 m/s. Coming down, he misses the couch and lands on the ground. You can neglect air resistance in your answers below.

   (a) What is Smoky's *acceleration*…
      (i) …just after his paws leave the couch and he is on his way up?
      (ii) …at the exact instant when he is at his maximum height?
      (iii) …just before he hits the ground on his way back down?

   (b) What is Smoky's maximum height above the ground during his motion?
   (c) What is Smoky's velocity just before he hits the ground?
   (d) How long is Smoky in the air?

Check Point

<u>Additional Questions</u>

1) Can something be accelerating even though it has zero velocity? If so, give some examples. If not, state why not.

2) Give an example of an object that is moving upward but which has a downward acceleration, or state why this is impossible.

3) When driving, what are the different ways you know to accelerate your car? Come up with as many as possible.