Workshop Tutorials for Introductory Physics

MI1: **Motion in a Line**

A. Review of Basic Ideas:

Use the following words to fill in the blanks:
starting line, velocity, displacement, constant, acceleration, kinematics, change, time, $\Delta t = t_1 - t_0$, increases, average, ½ $(v_0 + v_1)$.

Describing motion

The study of motion is called ________. We can describe the motion of an object by talking about how far it has moved, how long it took to move that far, how fast it is moving and how much it is speeding up or slowing down.

Imagine watching a drag race. At the start of the race the cars are lined up at the _______ _______, not moving. Let's label this time and position as time $t = t_0$, and position $x = x_0$. The race starts and the cars take off. A short time later one of the cars is halfway along the track, we'll call this position x_1, and the ________ it arrives there is $t = t_1$. The distance the car has traveled is called the ________, and is given by $\Delta x = x_1 - x_0$, the time it took to travel this distance is ________. The car started at rest, so its velocity at (x_0, t_0) was $v_0 = 0$. As the car accelerates away from x_0 its velocity ________. We can find the average velocity of the car between $t = t_0$ and $t = t_1$ by using

$$v_{av} = \frac{\Delta x}{\Delta t} = \frac{x_1 - x_0}{t_1 - t_0}$$

________ is the rate of change of displacement with time. The rate of ________ of velocity with time is called the acceleration. If the car is moving with velocity v_1 when it reaches the point x_1 at time t_1 then its ________ acceleration between $t = t_0$ and $t = t_1$ is

$$a_{av} = \frac{\Delta v}{\Delta t} = \frac{v_1 - v_0}{t_1 - t_0}$$

In car racing it's important not only that the car has a high velocity, but also that it has a large _____ so that it can reach that velocity quickly.

If we decide to set the time $t_0 = 0$, which is usually very convenient, then we can rearrange to find our velocity at some later time, say at t_1:

$$v_1 = v_0 + a_{av}\, t_1$$

If the acceleration is ________ then the average velocity is v_{av} =________.Using this and the expression for v_1 above, we can work out how far the car has gone, how fast it's moving and how quickly it's accelerating.

Discussion questions
What is the difference between instantaneous velocity and average velocity? How can you find an instantaneous velocity?

B. Activity Questions:

1. Velocities
Try to walk from one marker to the other at 1 m.s^{-1}.
Get someone to time you so that you can check how fast you are going.
Now try to go at 0.5 m.s^{-1} and 3 m.s^{-1}.
What do you need to do to move at –1 m.s^{-1}?

2. Train set
The train can only move in one dimension.
Choose a convention to label the positive and negative directions.
Use the controller to vary the velocity and acceleration of the train. Can you move the train from one point to another point such that it has a negative velocity and a positive acceleration?

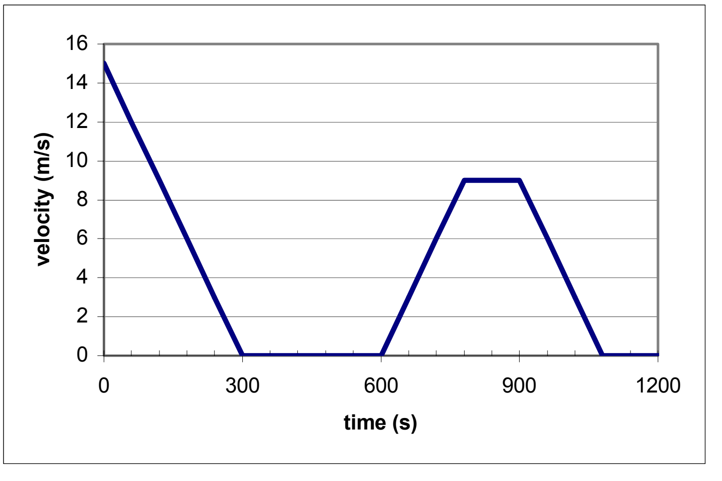
3. Acceleration due to collision
Send the toy car into the sponge, so that it bounces back.
a. Describe what happens in terms of the velocity and acceleration of the car.
b. Sketch the acceleration of the car as a function of time.

4. Acceleration due to gravity
Throw the ball straight up into the air, and catch it when it comes back down again.
a. Describe what happens to the velocity and acceleration of the ball.
b. Sketch the acceleration as a function of time.
c. Sketch the ball's velocity and displacement with time.

C. Qualitative Questions:

1. Brent is jumping on a trampoline. He leaps up into the air, and falls back again.
a. Is Brent's acceleration zero at any point? If so, where?
b. Is the direction of Brent's velocity always in the direction of his acceleration? If not, when is it different?

2.
You are driving west on Parramatta Road at peak hour, so you are starting and stopping a lot. A graph of your velocity as a function of time is shown.
a. Describe what is happening to the speed and position of the car in the first 10 minutes shown.
b. Describe what is happening to the speed and position of the car in the second 10 minutes shown.
c. Sketch a graph of the car's acceleration as a function of time.
d. Sketch a graph of the car's displacement as a function of time.



D. Quantitative Question:

A sneeze can exit the body at more than 150 $km.h^{-1}$, or around 42 $m.s^{-1}$. Imagine a droplet of moisture initially at rest in your mouth, which travels 5 cm to be sneezed out at 150 $km.h^{-1}$ in the horizontal direction.
a. What is the average acceleration of the droplet during the sneeze?
When you sneeze you involuntarily close your eyes.
b. If your eyes are closed for 0.2 seconds after the droplet leaves your mouth, how far has it traveled horizontally when you open your eyes again? (ignore air resistance).
Little droplets of moisture usually only travel a few metres before coming to a stop due to air resistance.
c. If a droplet travels 5m horizontally before coming to a stop, what is its average deceleration?
d. How long does it take to travel this distance?