Study Guide for Midterm 1

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1 Estimation and Unit Conversion

- Below are some examples of estimation and unit conversion.

1. Which of the following is most likely the speed of a runner on a track?
   - A: 0.5 m/s
   - B: 5 m/s
   - C: 50 m/s
   - D: 500 m/s
2. Convert the speed you chose in to kilometers per hour.

3. Water flows through a pipe at a rate of 1000 cm^3/s. What is this rate in m^3/hour?

4. One *knot* is about 0.51 m/s. A submarine travels at 20 knots, and another submarine travels at 25 knots. What is the difference in speed, in meters per second?

2 Displacement, Velocity, and Constant Acceleration Vectors

The definition of average velocity and acceleration are

$$\vec{v}_{ave} = \frac{\vec{x}_f - \vec{x}_i}{t_f - t_i} = \frac{\Delta\vec{x}}{\Delta t} \tag{1}$$

$$\vec{a}_{ave} = \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i} = \frac{\Delta\vec{v}}{\Delta t} \tag{2}$$

The numerator of Eq. 1 is in general a vector called *the displacement*: $\Delta\vec{x}$, describing the change in position of an object. If an object experiences constant acceleration, $\vec{a}$, the following equations apply:

$$x(t) = x_0 + v_0 t + \frac{1}{2}at^2 \tag{3}$$

$$v(t) = v_0 + at \tag{4}$$

$$a(t) = a \tag{5}$$

$$v^2 = v_0^2 + 2a\Delta x \tag{6}$$

Let's practice solving problems with these equations, starting with Eq. 1 and 2.

1. An object has an initial position of 3 m, and a final position of -4 m, after 3.5 seconds elapses. What is the average velocity?

2. Suppose the position of an object is described by the following equation: $x(t) = 3.0t + 5.0$ m. Which of the following is true of the velocity and acceleration?
   - A: Velocity is positive, acceleration is negative.
   - B: Velocity is negative, acceleration is positive.
   - C: Velocity is positive, acceleration is zero.
   - D: Velocity is negative, acceleration is zero.

3. If $x(t) = 3.0t + 5.0$ m, what is the displacement between $t = 1.0$ sec and $t = 5.0$ sec? What is the acceleration?
   - A: 8 m, 0 m/s^2
   - B: 12 m, 2 m/s^2
   - C: 12 m, 0 m/s^2
   - D: 8 m, 2 m/s^2

Now let's practice using Eqs. 3-6.

1. A basketball is shot horizontally from the top of a 100 m-tall building. The initial vertical velocity is 0 m/s, and the initial horizontal velocity is 3 m/s. How far away from the edge of the building does the ball land? (You can assume that $g = -10$ m/s^2 for this problem).

2. What is the final velocity of the ball?

3 Vectors

You must be able to do the following with vectors:

- Add and subtract them.
  1. Let $\vec{x}_f = (3.0, -3.0)$ m, and $\vec{x}_i = (3.0, 3.0)$ m. What is $\Delta\vec{x} = \vec{x}_f - \vec{x}_i$?

  2. A jet fighter (Maverick) has an initial speed of 100 m/s, at a 60 degree angle with respect to horizontal. Another fighter (Jester) has an initial speed of 100 m/s, but at a 45 degree angle with respect to horizontal. What is the velocity of Maverick, minus the velocity of Jester? *Hint: it's not 0 m/s. Build the velocity vector for each fighter first.*

- Compute their magnitude. If Maverick accelerates to a velocity of $v = (100, 100)$ m/s, what is his speed?

- Multiply them via the dot-product. Evaluate the dot product $\vec{x}_1 \cdot \vec{x}_2$, if $\vec{x}_1 = (0, 1)$ m, and $\vec{x}_2 = (2, 5)$ m.