

Week 1 Activities problems

Your Name (**Print**): _____ Date: _____

Group Members (initials of names) : _____

Unit Conversion

Useful unit conversions:

1 mi = 1609 m

1 gal = 3.785 L

1. NASA's unpiloted, experimental X-43A "air-breathing" test plane broke its own world aircraft speed record on its third and final flight on Nov. 16, 2004. The test plane, known as a "scramjet", burns its own fuel - in this case hydrogen - without the need to carry heavy tanks of oxidizer, as rockets must. Instead, it draws its oxygen from the air, which is naturally compressed by the forward speed of the vehicle and the shape of the air inlet. Conventional jet engines have rotating blades to compress the air; scramjets have no such moving parts. The test plane achieved a record speed of 11×10^3 km/hr.
 - a) Convert the scramjet's record breaking speed to miles per hour (mph). **SHOW ALL WORK**

 - b) Convert this speed to nanometers per microsecond (nm/ μ s). **SHOW ALL WORK**

2. Determine the area of a music/data compact disc (CD) in cm^2 . Convert the area to km^2 . Assume the CD is a uniform disk of diameter 12.0 cm with a central hole of diameter 1.5 cm. **SHOW ALL WORK**

3. Density (ρ) is defined as the ratio of mass to volume. The density of aluminum is 2702 kg/m^3 . What is the density in g/cm^3 ? **SHOW ALL WORK**

4. The fuel efficiency of a car is described in the US by citing the number of *miles per gallon* that it gets (MPG). In Europe, they cite *liters per 100 kilometers* (LPK).

a) Does a more fuel efficient car have a larger or smaller MPG number? Why?

b) Does a more fuel efficient car have a larger or smaller LPK number? Why?

c) You are considering buying a gas-electric hybrid from an upstart European manufacturer that claims its hybrid gets 4.6 LPK on the highway. Is this reasonable or are you being “taken for a ride”? **Support your conclusion with calculations.**

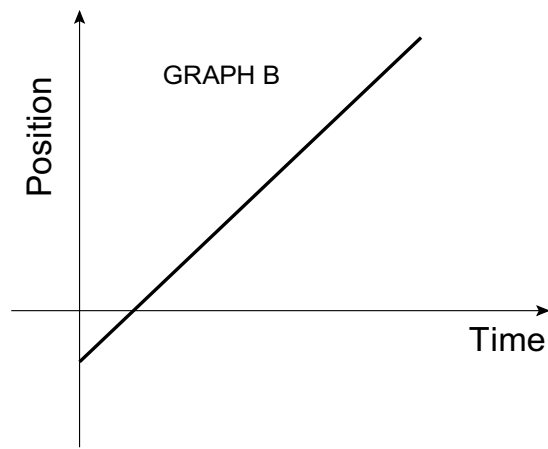
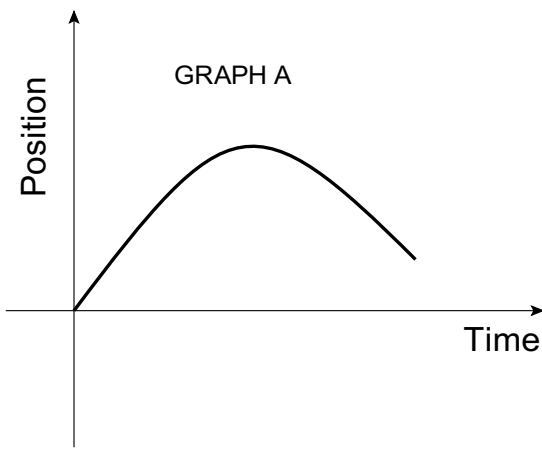
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Position-Time and Velocity-Time Graphs

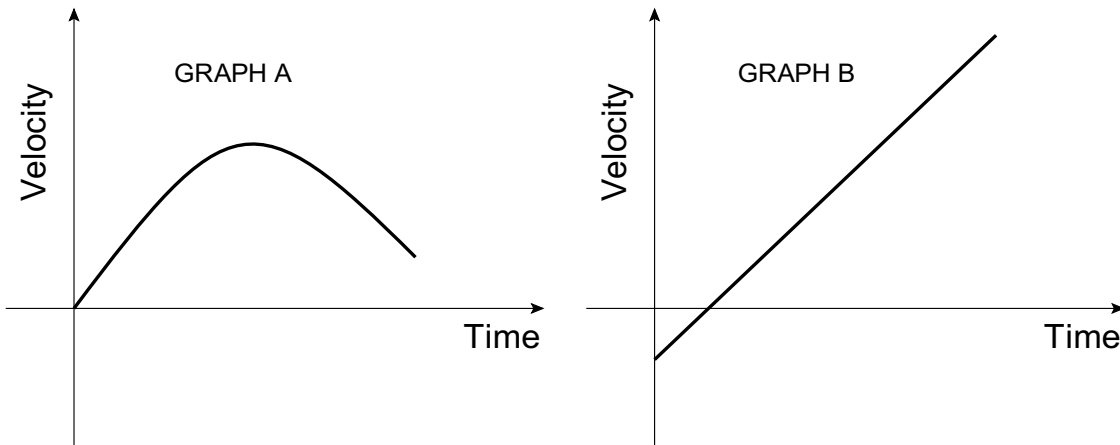
1. A dog walks along a straight line, first in one direction and then in the opposite direction. Shown below are two possible *Position-Time* graphs for the dog's motion.



- a) Which graph (Graph A or Graph B) more closely reflects the dog's movement? **Why?**
- b) Explain why someone might choose the other graph. Also, describe the dog's motion if it were following this "other" graph.

2. A turtle moves along a line; first in one direction and then in the opposite direction. Shown below are two possible *Velocity-Time* graphs for the turtle's motion.

NOTE: The graphs below appear similar to those in Question #1 but the axes are different.



- a) Which graph (Graph A or Graph B) more closely reflects the turtle's motion? **Why?**
- b) Explain why someone might choose the other graph. Also, describe the turtle's motion if it were following this "other" graph.

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Basic Measurements and Uncertainties

There are several methods of determining the uncertainty in a measured quantity; **see Appendix A, posted in Week 1** for a complete description of these uncertainties. In a result, the reported uncertainty is always the largest of the possible measures of uncertainty in the experiment.

In any measurement, the measuring device itself provides results that have an uncertainty that depends on the device's least count (smallest graduation in its scale).

One method of determining an uncertainty due to random error, which is appropriate when you have repeated measurements of the same quantity is a statistical measurement called the Average Deviation. This is similar to a standard deviation, but is a more appropriate choice for small sample sizes. The Average Deviation is a measure of the size of a random error inherent in an experimental determination of the best estimate value of a quantity.

Suppose you measure the diameter of a sphere five times. Each of the values obtained is represented by the symbol D_i , where D_1 is the first measurement, D_2 is the second measurement, ..., and D_5 is the fifth measurement. The average (mean) diameter is defined as

$$D_{AV} = \frac{\sum_{i=1}^N D_i}{N} = \frac{D_1 + D_2 + D_3 + D_4 + D_5}{5}$$

where N is the number of data points in the data set. The average deviation is defined as the average of the absolute deviations from the mean:

$$\delta D = \frac{\sum_{i=1}^N |D_i - D_{AV}|}{N} = \frac{|D_1 - D_{AV}| + |D_2 - D_{AV}| + |D_3 - D_{AV}| + |D_4 - D_{AV}| + |D_5 - D_{AV}|}{5}$$

The diameter of a sphere is measured five times using a digital caliper with a least count of 0.1 mm. The results are: 25.8 mm, 26.2 mm, 24.8 mm, 24.9 mm, 25.8 mm.

a) Calculate the average and the average deviation in the set of measurements.

- b) What is the correct uncertainty to report for the diameter of the sphere?
- c) Write the diameter of the sphere in “proper form”.
- d) The formula for the volume of a sphere is $V = \frac{1}{6}\pi D^3$, where D is the average (best) diameter of the sphere. δD is the uncertainty in D , in this case, the average deviation in D . Using the results obtained above for D_{best} and δD calculate the best estimate for the volume of the sphere and the uncertainty in the volume.
Recall that the uncertainty in a calculated quantity is $\delta V = V_{\text{max}} - V_{\text{best}}$.
Write the final result in “proper form”.

Some common errors to avoid:

1. Average deviation is not calculated correctly (must average the **absolute value** of the deviations)
2. Answer is not written in “proper form” – that is, the uncertainty must be one significant figure and the precision of the quantity (average diameter, volume) must be the same as its uncertainty
3. Units are not included

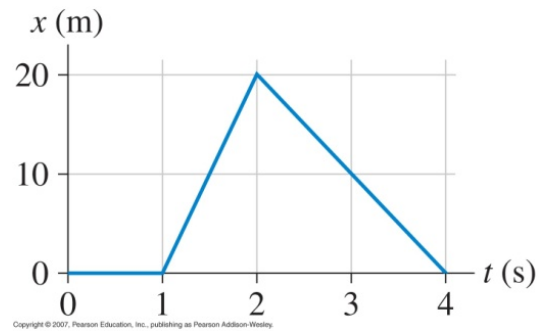
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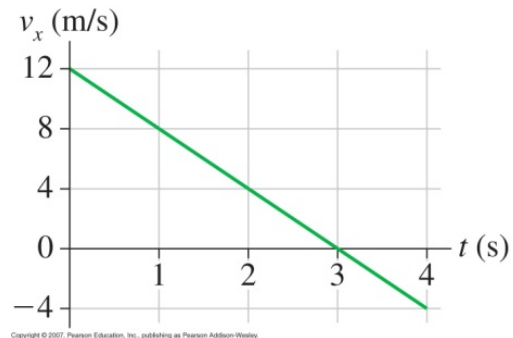
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One Dimensional Kinematics - Problems

1. **KJF2 2-17:** The diagram below shows the position-time graph of a particle.
- Draw the particle's velocity-time graph for the interval $0 \leq t \leq 4$ s.
 - Does this particle have a turning point or points? If so, at what time or times?
(A turning point is a point at which the particle reverses its direction of motion)



2. **~KJF2 2-19:** A car starts from $x_i = 10$ m at $t_i = 0$ and moves with the velocity-time graph shown.
- What is the object's **position** at $t = 4.0$ s? Show calculation **{Ans: 26 m}**
 - Does this car ever change direction? If so, at what time?



3. ~**KJF2 2-50:** When you sneeze, it is claimed that the air droplets in your lungs accelerate from rest to 150 km/hr in 0.500 s. Assume the droplets accelerate uniformly.

- a) What is the average acceleration of a droplet in m/s^2 ?
- b) Assuming the acceleration is constant, how far does a droplet travel in 0.500 s? {Ans: 10.4 m}

4. **KJF 2-54:** Divers compete by diving into a 3.00 m deep pool from a platform 10.0 m above the water. What is the magnitude of the minimum acceleration in the water needed to keep a diver from hitting the bottom of the pool? Assume the diver drops from rest from the platform and the acceleration in the water is constant.

Hint: How many time intervals do you need in this problem? {Ans: 32.7 m/s^2 }