Unit 4 *Homework Problems*

- *Complete HOMEWORK FOR UNIT* 4: *CHANGING MOTION II*, a .pdf file included on the homework web page with this assignment.

To get credit for the homework problems, you must include all of the following:

1. All equations must be solved in symbol form before substituting in any numbers.
2. All numbers substituted into the equations must have the correct units and number of significant figures, and the correct vector notation (where appropriate).
3. All final numerical answers must have the correct units, correct number of significant figures, and correct vector notation (where appropriate),
4. All problems should include a reference to the Activity Guide activity or activities that are related to the problem, a discussion of ***how*** the activity is related, and a discussion of the ***concepts*** that were learned in the activity.

4-1) *What's the best way to compare velocities?* In each of the following situations you will be asked to refer to either your own definitions or mathematical definitions and concepts associated with the number line. Assume any moving objects are only moving in the positive or negative x-direction, parallel to the x-axis of the coordinate system.

(a) Consider the abstract numbers you learned about in mathematics. They don't necessarily represent anything like chickens, dollars, position, or velocity. According to the mathematical definition of greater than or less than, is –2 *greater* than or *less* than +1? What do mathematicians mean by greater than and less than?

(b) As an abstract number is –2 *larger* than or *smaller* than +1? What do you mean by larger than? Smaller than?

(c) Consider a moving object with a changing velocity, which you have been learning how to describe in physics. Does an object moving at –2 m/s have a *larger* or *smaller* velocity than when it is moving at +1 m/s? What do you mean by larger than? Smaller than?

(d) Is an object moving at –2 m/s *faster* than or *slower* than an object moving +1 m/s? What do you mean by faster? slower? If the object's motion is being tracked by a motion detector, what does the minus sign in front of the 2 tell you? What does the plus sign in front of the 1 tell you?

(e) What is the most unambiguous way to compare the two velocities in part (d)? To say that:

1. the one moving at +1 m/s has a greater velocity than the one moving at –2 m/s.
2. the one moving in the neg. direction is moving twice as fast as the one moving in the pos. direction.
3. the one moving in the neg. direction has a smaller velocity than the one moving in the pos. direction.
4. the one moving in the neg. direction has a larger velocity than the one moving in the pos. direction.

4-2) *Describing velocity changes:* In each of the following situations you will be asked to refer to the mathematical definitions and the concepts associated with the number line. Note that being more positive is the same as being less negative, and being less positive is the same as being more negative. Assume any moving objects are moving only in the positive or negative x-direction.

(a) Suppose an object undergoes a change in velocity from +2 m/s to +3 m/s. Is its velocity becoming *more positive* or *less positive*? What is meant by more positive? less positive?

(b) Suppose an object undergoes a change in velocity from +3 m/s to +2 m/s. Is its velocity becoming *more positive* or *less positive*? What is meant by more positive? less positive?

(c) Suppose an object undergoes a change in velocity from –3 m/s to –2 m/s. Is its velocity becoming *more positive* or *less positive*? What is meant by more positive? less positive?

(d) Suppose an object undergoes a change in velocity from –2 m/s to –3 m/s. Is its velocity becoming *more positive* or *less positive*? What is meant by more positive? Less positive?

(e) Suppose an object is turning around so that it undergoes a change in velocity from –2 m/s to +2 m/s. Is its velocity becoming *more positive* or *less positive* than it was before? What is meant by more positive? Less positive? Is it undergoing an acceleration while it is turning around?

(f) Suppose an object is turning around so that it undergoes a change in velocity from +2 m/s to –2 m/s. Is its velocity becoming *more positive* or *less positive* than it was before? What is meant by more positive? Less positive? Is it undergoing an acceleration while it is turning around?

(g) What does it mean to say that an object undergoes a deceleration? Can this term be used without ambiguity?

4-3) Three digital movies depicting the motions of ***four*** single objects have been selected for you to examine using the Logger Pro Software. They are as follows:

PASCO 004: A cart moves on the top track while another moves on the bottom track below. (Ignore the cart on the middle track.)
PASCO 153: A metal ball attached to a string swings gently.
DSON002: The Cedar Point Amusement Park Demon Drop Cage with 4 people in it slows down on a horizontal track and almost comes to rest.

Please examine the horizontal motion of each object carefully by viewing the digital movies. In other words just examine the motion in the x-direction (and ignore any slight motions in the y-direction). You may use the Logger Pro software and a spreadsheet to analyze the motion in more detail if needed. Based on what you have learned so far, there is more than one analysis method that can be used to answer the questions that follow. **Note:** Since we are interested in the nature of the motions you do not need to scale any of these movies for this problem. Working in pixel units is fine.

(a) Which of these four objects (PASCO 004–top cart, PASCO 004–bottom cart, PASCO 153–metal ball, or DSON 002–cage), if any, move at a constant horizontal velocity? Cite the ***evidence*** for your conclusions.

(b) Which of these four objects, if any, move at a constant, non-zero, horizontal acceleration? Cite the ***evidence*** for your conclusions.

(c) Which of these four objects, if any, move at neither a constant horizontal velocity or acceleration? Cite the ***evidence*** for your conclusions.

(d) The kinematic equations are very useful for describing motions. Which one of the four motions cannot be described using the kinematic equations? Explain the reasons for your answer.

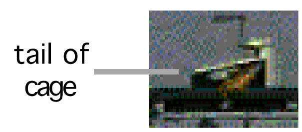
Problems **4-4** and **4-5** should be handed in using a Constant Acceleration Problem Worksheet, included as a .pdf file on the homework web page with this assignment. Be sure to use all the elements of formal problem-solving detailed in Section 4.9 of the Activity Guide and in the sample worksheet.

4-4) A Boeing 747 jumbo jet with 400 passengers requires a takeoff speed of about 350 km/h with a take-off length of 3.32 km. If the plane accelerates constantly starting from rest, what is the necessary acceleration? The mass of the jet = 368,500 kg.

4-5) A car traveling 56.0 km/h is 24.0 m from a barrier when the driver slams on the brakes. The car hits the barrier 2.00 s later. Assuming constant acceleration for the entire braking period, how fast is the car traveling at impact? The mass of the car = 1,430 kg.

4-6) Let's return to one of the movies you looked at in problem 3. At the Cedar Point Amazement Park in Ohio a cage containing people is moving at a fairly high initial velocity as the result of a previous free fall. It has changed direction on a curved track and is coasting in a horizontal direction when brakes are applied to it. This situation is depicted in a digital movie entitled DSON 002.

(a) Use the Logger Pro software to gather data for the horizontal positions of the tail of the cage in meters as a function of time. Place the coordinate system so that the origin is on the tail of the cage on the first frame of the movie. Also, don't forget to use the scale of the title screen of the movie so your results are in meters rather than pixels. Summarize this data in a table or in a printout attached to your homework.



(b) Transfer your data to a spreadsheet and do a model like that you did in Unit 4, Section 4-7 to show that, within 5% or better, the *x* position is given by

$$x = \left(-7.6\frac{\text{m}}{\text{s}^2}\right)t^2 + \left(+23\frac{\text{m}}{\text{s}}\right)t + 0.0\,\text{m}$$

Please attach a printout of your Excel model and graph with your name on it as "proof of completion." **Notes**: Use modeling techniques and *not* the "Add Trendline …" feature of Excel to complete this assignment. Your judgments about the location of the cage tail and the best parameters to be used in the model may lead to slightly different results.

(c) Use this equation you found along with its interpretation as embodied in the first kinematic equation to determine the horizontal acceleration, a_x, of the cage as it slows down. What is its initial horizontal velocity, v_{1x}, at time *t*=0 s? What is the initial position, x_1 of the cage?

(d) The movie ends before the cage comes to a complete stop. Use your knowledge of a_x, v_{1x}, and x_1 along with the kinematic equations to determine the position of the cage when it comes to a complete stop. At this time the final velocity of the cage is given by v_{2x} = 0.00 m/s.