**All homework is due at the first day of the next unit**

**UNIT 1 HOMEWORK AFTER SESSION ONE**

• Read the section in the front of the Activity Guide entitled *Workshop Physics Philosophy, Policies, and Procedures* (pp. i-1 through i-12) and come to class prepared to ask any questions you might have.

• *Learn a few letters in the Greek Alphabet. Beware! There may be a quiz!*
Physicists and mathematicians tend to run out of symbols to use in mathematical equations. You should memorize some of the most common letters borrowed from the Greek alphabet that are used in physics equations. These are shown below

| Letter | Capital | Lower Case |
|---|---|---|
| Alpha | Α | α |
| Beta | Β | β |
| Gamma | Γ | γ |
| Delta | Δ | δ |
| Epsilon | Ε | ϵ or ε |
| Theta | Θ | θ |
| Lambda | Λ | λ |
| Pi | Π | π |
| Rho | Ρ | ρ |
| Sigma | Σ | σ |
| Phi | Φ | φ |
| Omega | Ω | ω |

•*Do Problem SP1-1 given below for more spreadsheet practice.*

**SP1-1)** Create a spreadsheet with the combined class data in Activity 1-4 in it by following the procedures outlined in pages A-4 through A-10 in Appendix A.
(a) Use the computer spreadsheet average, max, and min functions to find the average, minimum, and maximum pitching speeds for the class. (**Hint**: You will need to learn to use spreadsheet functions to do this. *****) Be sure to format the spreadsheet cells to give you the appropriate number of significant figures in each of your calculations.
(b) Sort the data columns so that they lie in order from the lowest to highest pitching speed.
(c) Name the file and save it on your disk.
(d) *Upload the file to WebCT.*
* You may want to check your work with hand calculations, but the idea is to let the spreadsheet do the work for you!

## UNIT 1 HOMEWORK AFTER SESSION TWO

- *Complete Unit 1 entries in the Activity Guide.*
- *Read problems SP1-2 and SP1-3 below and then read Appendix E of the Activity Guide*
- *Work Problems SP1-2 and SP1-3 by referring to Appendix E.*

**SP1-2)** Create a mathematical model of the bowling ball motion data you collected in Activity 1-4. The project requires you to find what you think is the best value for the slope, *m*, and the *y*-intercept, *b*, for the computer graph you printed out in Activity 1-6 (b). You should:

(1) Follow the instructions in Appendix E on page E-4 on *Mathematical Modelling with an Excel Spreadsheet* . By practising with a worksheet entitled *Modelling Tutorial* you can learn about the process of modelling for a linear relationship.

(2) Next, open the worksheet entitled *Modelling Worksheet* and enter a title for your graph.
(a) Set the *y*-label to Distance (m) and the *x*-label to Time (s).

(b) Refer to your data table in Activity 1-5(b)). Enter the times you measured for the bowling ball in the Time(s) column (formerly x-label).

(c) Set the y-exp column to D-exp (m) and enter the distances you measured for the bowling ball .

(d) Place the symbol m (for slope) in the cell B2 (in place of "constant 1)". Place the symbol b (for *y*-intercept) in cell B3 (in place of "constant 2").

(e) Put the appropriate theoretical equation for a straight line of the form Distance = m*Time + b in cells C8 through C11. Be sure to refer to cells C2 for slope and C3 for *y*-intercept as absolutes, i.e., use $C$2 and $C$3 when referring to them. (Reread Appendix E page 4 for details if you are confused).

(f) Change the values in cells C2 and C3 until your green theoretical line matches as closely as possible with your red experimental data points in the graph window.

(g) Upload a copy of your modelling spreadsheet to WebCT with the following annotations on it:

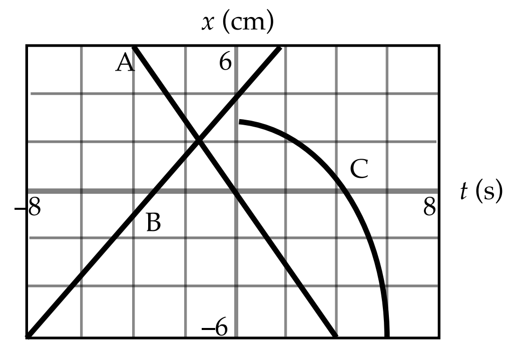
a) Your name, the date, and Problem SP1-2 on it.

b) Report the average speed of the bowling ball that you calculated in Activity 1-5c compared to the slope of the "best" fitting graph for your mathematical model.

c) The equation that provides the "best" mathematical model for the motion you studied in the form Distance (m) = ( ? m/s) Time(s) + ( ? m)

d) A brief discussion of the meaning of the slope of a graph of Distance vs. Time. What does it tell you?

**S1-3)** The diagram below shows the graphs of three possible relationships between the time, *t*, in seconds and the distance, *x*, in centimetres that the object has travelled.




(a) Which graphs represent distance as a linear function of time? A, B, and/or C?
(b) Which graphs, if any, show distance as proportional to time?

## UNIT 2 HOMEWORK AFTER SESSION ONE

• Read Chapter 1 of the textbook with special attention to sections 1-9 and 1-10.
• Read Appendix C of the Activity Guide

• *Work Chapter 1 Problems 8, 12, 20, and 26. Be sure to report the correct number of significant figures.*

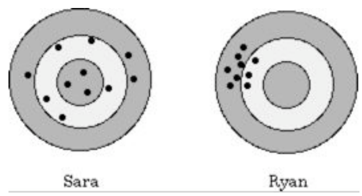
• *Do Problem SP2-1 below,* in which you must calculate a standard deviation by hand using the theoretical formula. This is the last time you'll have to do it the hard way in this course. Just in case you get stuck on a desert island with no computer, you'll know how to do it!

**SP2-1)** Suppose you made the following five length measurements ($N$=5) of the width of a piece of letter size paper which has been cut carefully by a manufacturer using an unfamiliar centimetre rule: 21.3 cm, 21.5 cm, 21.4. cm, 21.2 cm, 21.4 cm. (a) Use the procedures on pages C-5 through the top of page C-9 of Appendix C find the average and standard deviation of the measurements to four significant figures. **Beware:** $N$ is neither 12 nor 8. (b) Is there any evidence of uncertainty in the measurements or are they precise? Explain. (c) Is there any evidence of *systematic* error in the measurements? If so, what might cause this? Explain

## UNIT 2 HOMEWORK AFTER SESSION TWO

• *Do Problems SP2-3, SP2-4 and SP2-5 below*

**SP2-3)** Suppose Sara and Ryan each throw darts at targets as shown here. Each of them is trying very hard to hit the bulls-eye each time. Discuss in essay form which of the two students has the least *uncertainty* associated with his or her throws and is thus *more precise*. Is one of the students *less accurate* is the sense of having a *systematic error* associated with his or her throws? What factors like eyesight and co-ordination might cause one to be more precise and another more accurate?




**SP2-4) Make a table showing the probabilities that the sum of the roll of 3 dice are 3, 4, 5, 6, 7, ...18. You have already done 11 in the activity guide. Explain your method of calculation. Hint: You can use a symmetry argument to shorten the calculations. The probability for getting 3 is the same as for 18, the probability of getting 4 is the same as for 17, etc. Be sure to show your method.**

**SP2-5)** Instead of measuring the background level in one run of 80 1-minute intervals you do 2 experiments, measuring 30 1-minute intervals and then 50 1-minute intervals. The results are as follows:

30 intervals: average = 11.8 counts/minute, SD = 4.2 counts/minute

50 intervals: average = 12.2 counts/minute, SD = 3.8 counts/minute

Use the formulas for the average and Standard Deviations to determine what the average and SDs would have been if you had done this experiment as a single experiment of 80 1-minute intervals.

**UNIT 3 HOMEWORK AFTER SESSION ONE**

• *Complete the sheets entitled HOMEWORK FOR LAB 1: INTRODUCTION TO MOTION .* it is a stapled collection of white papers attached to this assignment page. You may have to return to the classroom after hours to complete the activities, but the homework can be done anywhere.

• Review the comment about velocity vectors on pages 3-12 and 3-13 and read the section below on how to construct simple motion diagrams.

• *Construct motion diagrams described in supplemental problem SP3-1 below.*

## Position-Velocity Motion Diagrams

A position-velocity motion diagram can be used to sketch a quick picture of the changes in motion that an object might undergo that almost anyone can understand. A motion diagram represents to position and velocity of an object at several equally spaced times. At each position the object's velocity is represented by an arrow. Two sample motion diagrams are shown in the figures below.

Figure 1: A motion diagram of a bike moving to the left with a constant velocity. The acceleration is zero because the velocity is not changing.

Figure 2: A motion diagram for a bike moving to the right with a decreasing speed.

**S3-1:** (a) Construct a motion diagram for a dog running to the right with a decreasing speed, (b) Construct a motion diagram for a truck moving to the left with increasing speed, and (c) Construct a motion diagram for a rocket moving vertically downward at an increasing speed.

**UNIT 3 HOMEWORK AFTER SESSION TWO**

• *Complete the HOMEWORK FOR LAB 2: CHANGING MOTION.*

• *Complete Unit 3 entries for Sessions 2 and 3 in this Activity Guide*

## UNIT 4 HOMEWORK AFTER SESSION ONE

• Read Chapter 2 of the textbook *Understanding Physics*, by Cummins, Laws, Redish and Cooney.

*Formal Problem Solving*
For the next several assignments while you are working with Units 4 and 5 you will be doing a series of homework assignments involving the same set of kinematics problems. These with be done at increasing levels of sophistication to help you learn about the elements of formal problem solving. These elements are–

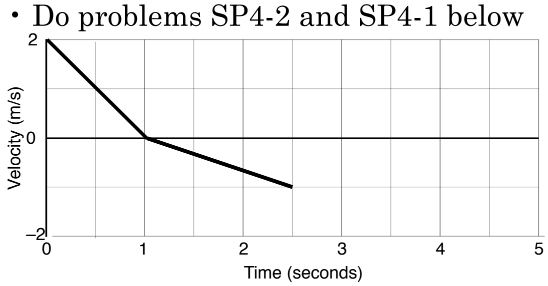
Part 1: Diagrams and Graphs
Part 2: Tables and Equations
Part 3: Algebra and Substitution
Part 4: Computation and Unit Checks

This approach was developed by Bob Morse a teacher at St. Albans School in Washington DC. An example of how to work a typical kinematics problem is included on the next page. Then there is a packet of 10 pages of problems. Each problem is printed at the top of a sheet entitled CONSTANT ACCELERATION PROBLEM WORKSHEET. You are to do parts of each of the 10 problems during the next few assignments until all the parts are completed.

• *Do Part 1 of each of the problems and hand them in for grading.*

## UNIT 4 HOMEWORK AFTER SESSION TWO

• Do problems SP4-2 and SP4-1 below




SP4-1) The above graph shows the velocity of a cart moving along a track for 2.5 seconds. (a) How far is the cart from its starting point at 2.5 s? (b) If it continues with the same acceleration after 2.5 s, when will it return to its starting point? (c) Draw a position vs time graph of the motion of part (b) assuming that the starting point is at zero.

SP4-2) A ball is thrown up with a velocity of 10 m/s and allowed to fall back down. (a) If the acceleration is always –9.8 m/s$^2$ (downward) how long will the ball take to return to its initial position? (b) Air resistance adds some acceleration opposite to the direction of motion, negative on the way up and positive on the way down. If the ball's acceleration on the way up is –9.9 m/s$^2$ and –9.7 m/s$^2$ on the way down, how long does it take to return?

## UNIT 4 HOMEWORK AFTER SESSION THREE

• Do supplemental problem SP4-3 below.

SP4-3) Examine Table 4-1 at the beginning of this unit. Enter the data in columns 2 and 3 into a modelling worksheet. Find the values of acceleration, initial velocity, and initial position that fit that data. Submit your worksheet and graph with a discussion of how the results compare with the calculated results you reported in Table 4-2. **Hint**: How do your results for the average acceleration of the object based on modelling compare with the average of the acceleration values you calculated in column 5 of Table 4-2?

*Complete all Unit 4 entries in the Activity Guide.* This Activity Guide Unit is to be handed in at the end of the class period on Friday.

*Work Part 2 of each of the 10 kinematics problems in your packet. Add tables and equations to the solutions you started in the assignment for the last class.*

**Name________________________________Sec________Date________________**

**UNIT 5 HOMEWORK AFTER SESSION ONE**

• Complete the Unit 5, Session 1 activities. Fill in all the entries for *both* investigations one and two.

• *Complete the homework entitled "HOMEWORK FOR UNIT 5-1: FORCE AND MOTION"* (Credit is equivalent to that obtained by working three text problems).

• Review Chapter 3 sections 3.1 — 3.5 in the Textbook.

• Review the 10 kinematics problems you have been working with Unit 4.

• *Finish working the constant acceleration problems that you started in Unit 4 by adding to the solutions you started in the assignment for the last class. The Sample Problem shows how to do the algebra and substitution for each of the problems.*

**UNIT 5 HOMEWORK AFTER SESSION TWO**

• Complete the Unit 5, Session 2 Activities. Fill in all the entries for investigations one, two, and three.

• *Complete the homework entitled "HOMEWORK FOR UNIT 5-2: COMBINING FORCES" It is a stapled collection of white papers attached to the back of this unit behind this assignment page.* (Credit is equivalent to that obtained by working three text problems).

• *Work Motion Problems 4 in the problems packet at the end of this unit by adding to the solutions you started in the assignment for the last class. which shows how to do the computation and checks for each of the problems . • Describe for each of these problems: (a) the source of the force that causes the acceleration (for example, in the first problem the Boeing 747 engines causes the acceleration force, (b) the magnitude of the force needed to cause the acceleration, and (c) indicate the direction of the acceleration on the diagram.*

• Fill in all the entries for investigations one, two, and three of Unit 5-3.

• *Double check to see that the all unit 5 activities are completed and ready to hand in at the beginning of class.*

• *Complete the homework entitled "HOMEWORK FOR UNIT 5-3: FORCE, MASS, AND ACCELERATION" It is a stapled collection of white papers attached to the back of this unit behind this assignment page.* (Credit is equivalent to that obtained by working three text problems).

• Read Chapter 3 sections 3.6 through 3.8 in the Textbook

## UNIT 6 HOMEWORK AFTER SESSION ONE

- Read Chapter 3 Section 3.9 and Chapter 4 in the Textbook

- *Work Supplemental Problems SP6-2 through SP6-4 shown below.*

Do not do the following problem: (30 pts) **SP6-1)** The Demon Drop is a popular ride at the Cedar Run Amazement Park in Sandusky, Ohio. It allows 8 people to get into a little cage and fall freely for awhile. Physics teacher Bob Speers of Firelands College in Huron Ohio took a video tape of the drop which you can analyse using the 2D Video QT Software. We would like you to use a sequence of these video frames and *mathematical modelling* techniques with an Excel spreadsheet to find an equation that describes the fall.

You can analyse this movie using a program called 2-D Video QT! This analysis software and a folder entitled Movies is on the Workshop Physics hard drive in a folder called 2D Video. **WARNING:** Look on the side white board in Tome 104 for any modifications on the instructions before you start.

If there are no modifications to the instructions you should do the following:
a. Open the 2-D Video QT! file in the 2D Video folder on the Workshop Physics hard drive
b. Open the movie entitled *Demon Drop Vertical*
c. Do a vertical calibration using the fact that Bob Speers measured the horizontal struts on the Demon Drop tower were made in Europe and are exactly 4.0 metres apart. Bob made the digital movie you are using at 10 frames a second, so you should select that when you calibrate.
d. Click on the little man icon at the lower right of the screen and move from frame-to-frame clicking on the bottom of the demon drop cage as it falls (from about frame 3 on)
e. Transfer the computer data to an XL spreadsheet (Use the *Open XL Data Table* command in the **File** Menu)
f. Use the same modelling technique you used in completing supplemental problem S4-1 after session two in Unit 4 to find the equation describing y as a function of t. You are not interested in the x-values in this analysis. Why not? Although you may use the custom fitting tool to check your results you must do this problem using mathematical modelling technique because mastering it will allow you to do fit more complicated motions in the future that the fitting can't handle.

*Hand in a printout of your model. Place your name on it and write the answers to the following questions at the bottom: (a) According to your model, what is the equation that describes the vertical position of the bottom of the cage as a function of time. (b) What is the acceleration of the cage? What is its initial velocity?*

(20 pts) **SP6-2)** Suppose a group of 8 people with an average mass of 55 Kg each are put in a cage of mass 200 Kg. If the cage is dropped from a height of 28 metres above the surface of the earth. According to textbook theory (a) Where will they be after one second? (b) How fast will they be moving at that time? (c) What is the force on the whole falling system consisting of the cage and the people. Be sure to indicate the direction of the force. FOR FULL CREDIT USE THE TECHNIQUES YOU HAVE BEEN PRACTISING FOR CONSTANT ACCELERATION PROBLEMS: Diagram, $v$ vs. $t$ graph sketch, listing values and unknowns in a table, equation, algebra and solutions, etc. (d) How does the text book equation you are using compare with the one you found using the actual data. If they are slightly different discuss why this might be the case.

(10 pts) **SP6-3)** A ball with a mass of 0.50 kg is thrown vertically upward from the ground with an initial speed of 17 m/s from a release point which is 1.5 m above the ground. Assume that any forces exerted on the ball by the air can be neglected **(a)** How long does it take the ball to reach its maximum altitude? **(b)** What is its maximum altitude? **(c)** Determine times at which the velocity the ball is +4.0 m/s and -4.0 m/s. (c) At what heights above the ground do these velocities occur **(e)** What is the force on the ball on its way up, at the top of its path, and on the way down? Be sure to specify both the magnitude and the direction of each force.

(10 pts) **SP6-4)** An astronaut stands on the steps of her spaceship that is resting on the surface of planet X and drops a rock from a height of 4.5 metres. The rock hits the surface in 0.83 s. **(a)** Determine the magnitude of the acceleration due to gravity on the surface. **(b)** If the rock experiences a gravitational force of 20.0 N close to the surface of the earth, what force does it experience when falling close to the surface of planet x.

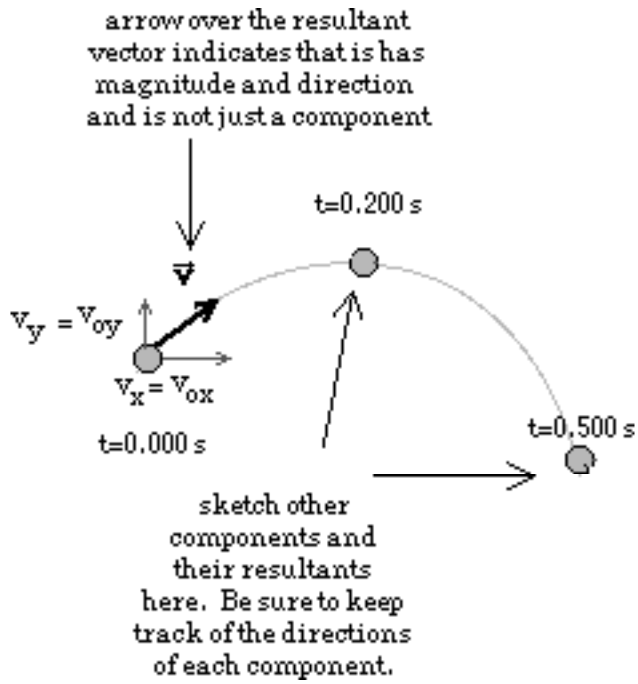
## UNIT 6 HOMEWORK AFTER SESSION TWO

• *Work Supplemental Problem SP6-5 and SP6-6 shown below.*

(30 pts) **SP6-5)** Two small balls are launched at an angle of about 60 degrees with respect to the horizontal. See fig. 5-6 in the textbook. Measure the picture to find the co-ordinates of the ball every 1/15th second, that's every other one. (Use a mm scale and convert to actual real-life measurements.) You are to use mathematical modelling to find the equation that describes: (a) the horizontal motion $x$ vs. $t$ and (b) the equations that describe the vertical motion $y$ vs. $t$. For simplicity you should set the origin at the location of the ball at time $t$=0 seconds. Do (a) and (b) for both the dense ball and the Styrofoam ball. That means you'll have four graphs in all.

Submit your two models on WebCT. Write the answers to the following questions at the bottom: (a) According to your horizontal model, what is the equation that describes the horizontal position of the ball, $x$, as a function of time. What is its horizontal acceleration, $g$? What is its initial horizontal velocity, $v_{0x}$ ? (b) According to your vertical model, what is the equation that describes the vertical position, y of the ball as a function of time. What is its vertical acceleration, $a_y = -g$ ? What is its initial velocity vertical, $v_{0y}$?
(c) Use the components $v_{0x}$ and $v_{0y}$ to compute the initial speed of the ball and to find its launch angle with respect to the horizontal.

(20 pts) **SP6-6)** Consider the motion you just analysed. (a) What is the acceleration that the text book predicts. How does your experimentally determined acceleration compare with it? If they are slightly different discuss why this might be the case. (b) Consider the equations you found and use the definition of instantaneous velocity and the process of differentiation (taking derivatives) to find an equation for the x-component of velocity, $v_x$, as a function of time and another equation for the y-component of velocity, $v_y$, vs. time. (c) Use these equations to compute the values of the $x$-and $y$-components of velocity at times $t$=0.000 seconds, at $t$=0.500 seconds and at $t$=0.200 seconds. (d) Draw a scale diagram showing the location of the ball at each of these times and draw the lengths of the component vectors for $v_x$ and for $v_y$ in each case at the location of the ball. Use diagrammatic techniques to draw the resultant velocity vector, **v**. Your diagram will look something like the sketch below, only more careful.




Be sure that the arrows representing the components have lengths proportional to the magnitudes of the velocities (i.e., the speeds) and have directions that are up or to the right if the velocities are positive and down or to the left when the velocities are negative).

## UNIT 6 HOMEWORK AFTER SESSION THREE

Complete all Unit 6 entries in the Activity Guide.

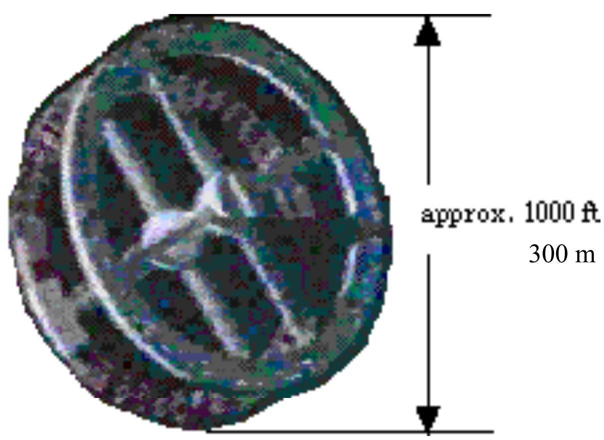
## UNIT 7 HOMEWORK AFTER SESSION ONE

- Read Chapter 5 of your textbook, *Understanding Physics.*
- *Work Ch. 5 Problems 57 & 58*
- *Work Supplemental Problems SP7-1, SP7-2 & SP7-3 shown below.*

**SP7-1)** Refer to Problem 57, Ch 5, which you just completed. If the mass of a stone is 25 g what is the centripetal force exerted on the stone? What might be the source of this force? Hint: How much tension does it take to break the string?

**SP7-2)** (20 pts) The 1960's classic movie 2001: A Space Odyssey was, in its time, one of the most elaborate and technically accurate science fiction films ever produced. One of the more exotic items in the film was a giant space wheel which was intended to serve as a space station orbiting the Earth to be used as base for trips to the moon. According to the 2001 science advisor, the station was "designed" to have a diameter of 1000 ft (300 m) and to rotate at a rate sufficient to cause occupants in the outer rings to experience a centripetal force roughly equal to the gravitational force of the moon. An object on the moon only experiences one-sixth the force that it would experience on the surface of the Earth.

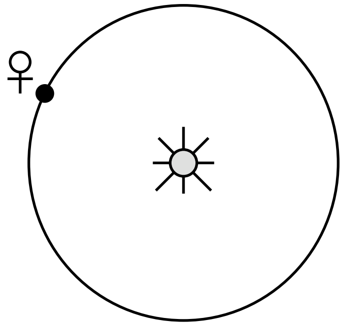
2001
Space
Wheel




To do this problem you should open the movie entitled *RotatingStation1.mp4* or *RotatingStation2.mp4.* If you use Quicktime player to view the movies, exact timings can be found by opening Movie Properties under the Movie menu. Then select Movie and Time in the dialogue box.

**(a)** Explain how the spinning of the wheel can be used to create an artificial gravity for those in the outer ring. **(b)** Use basic geometry and some reasoning to figure out the approximate speed in m/s of the outer rim of the ring. i.e. what is the distance covered after 6 seconds of a point on the outer ring? i.e., what is the length of the circular arc in metres? (You may want to find the time for one-quarter revolution as an alternative method.) **(c)** Calculate the centripetal acceleration that a person in the rim of the wheel would experience and compare this to the gravitational acceleration on the surface of the moon. **(d)** Does the artificial gravity depicted for the space wheel approximately simulate that on the surface of the moon?

**SP7-3)** The planet Venus orbits the sun in nearly a perfect circle. If you have faith in Newton's laws then you must conclude that there is an invisible centripetal force holding Venus in orbit. The data on the orbit of Venus around the sun is shown in the figure below.



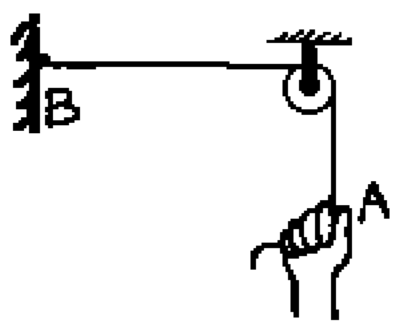

**(a)** Calculate the magnitude of the centripetal force needed to hold Venus in its circular orbit? Please use the proper number of significant figures. **(b)** What is the direction of the force as Venus orbits around the sun? **(c)** What is the most likely source of this force? **(d)** Could this force have anything in common with the force that attracts objects to the earth?

## UNIT 7 HOMEWORK AFTER SESSION TWO

• Read Chapter 6 in the Textbook.

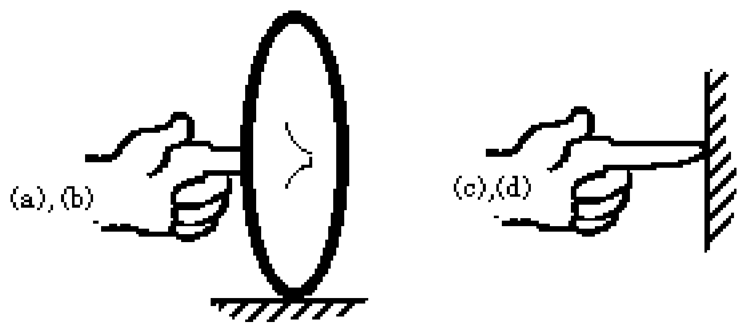
• *Work Supplemental Problems SP7-4 through SP7-7 shown below.*

**SP7-4) (a)** When a force is exerted on one end of a string what is the magnitude of the force on the other end of the string? **(b)** How does the force get transmitted from one end of the string to the other? What does the stretching of the string have to do with this? **(c)** If a string has a force one it at one end and the *direction* of the string is changed by a frictionless post or pulley, what is the magnitude of the force on the other end of the string? **(d)** Refer to the diagram below in which a string exerts a force on a person's hand (at point A) and a force at a fixed point B at the other end of the string. Draw a diagram with arrows indicating the *relative magnitudes* and the *directions* of the two string forces at points A and B.




**SP7-5)** Refer to the words of the Bricklayer's Song reprinted in the Session 2 Activity Guide notes. **(a)** Assuming that there is no friction in the bricklayer's pulley and rope system, *estimate* the total amount of time that elapses during the injurious events described by the poor bricklayer in the song. **Hint**: To make this estimate you need to figure out approximate values for the height of the building, the mass of the bricklayer, and the mass of the bricks and the barrel. Then, you will need to use the Atwood's equation. **(b)** If friction were considered what effect would this have on your estimated time? Would the actual time be smaller, larger or the same as the one you estimated? **Note**: There is no single "right" or best answer. Different assumptions could be made that would lead to reasonable time estimates. *You cannot simply assume that all of the bricklayer's travels occur at free-fall.*

**SP7-6)** Refer to the diagrams below. **(a)** A hand pushes on a flexible piece of stretched fabric with a force of 5.0 N. The fabric assembly is fixed and does not move. What is the direction and magnitude of the normal force exerted back on the hand by the sheet? Is the normal force larger, smaller, the same, or zero? **(b)** What does the stretching of the fabric have to do with this? **(c)** Suppose the hand pushes in the same way on a wall. What is the direction and magnitude of the normal force exerted back on the hand by the wall? **(d)** Does the wall stretch noticeably? What causes the wall to be able to exert a force on the hand? How does the wall "know" what force to exert back on the hand?




**SP7-7)** Refer to the diagram below. A book has a mass of 0.51 kg. **(a)** What is the magnitude and direction of the force exerted on the table by the book? **(b)** What is the magnitude and direction of the normal force of the table on the book? **(c)** Sketch the relative magnitudes and directions of the forces on a diagram.

- *Work Ch. 6 Problems 1, 6 , 14 & 16*

**UNIT 7 HOMEWORK AFTER SESSION THREE**

- *Work Ch 5, Problems 12 and 22, and Ch. 6 Problems 36, 58 & 63*
- *Complete Unit 7 entries in the Activity Guide*

## UNIT 8 HOMEWORK

The homework following the Unit 8 sessions will include some review problems involving free body diagrams like those assigned in Unit 7. In addition, some simple problems will be assigned which involve the key concepts in our study of collisions: impulse, momentum change, and conservation of momentum.

## UNIT 8 HOMEWORK AFTER SESSION ONE

- Read Chapter 7 in the Textbook *Understanding Physics*
- *Work Ch. 7 Problems 16, 17 & 18*
- *Work Supplemental Problem SP8-1*

**SP8-1)** [20 pts] Hands-on inclined plane problem: Your table group is to take some very simple data and come up with a theoretical estimate of the angle with respect to the horizontal so that a 4-battery fan cart with its fan thrusting it up the track does not move. In order to do the calculations you will need to make some very simple measurements. Between session 1 and session 2 the following equipment will be available on the lecture demo table.

- a fan cart with 4 batteries
- a spring scale
- a balance or scale

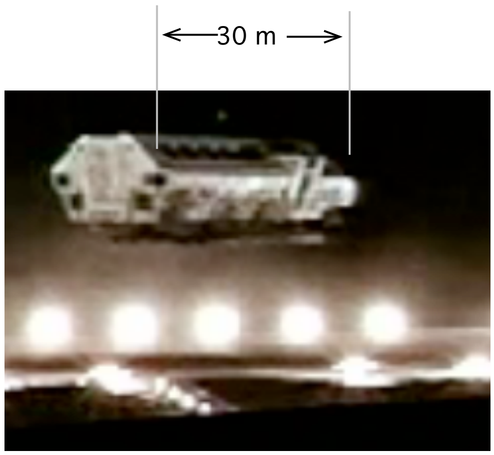
Take whatever measurements you need in order to *calculate* the angle with respect to the horizontal through which a track should be tilted so the cart will not move when placed on the cart. *The rule in making these measurements is that you must not place the cart on a track that is tilted up.* **Hint:** You may want to review pages 7-39 and 7-40 in your Activity Guide and/or Examples in the text.

**Note:** If your group seems to have a correct analysis of this hands-on problem, the instructor may raise a track to the specified angle to demonstrate the viability of your solution.

## UNIT 8 HOMEWORK AFTER SESSION TWO

• *Work Supplemental Problems SP8-2 and SP8-3*

**SP8-2)** [30 pts] In the classic film 2001: A Space Odyssey there is a scene in which the Aries 1B Lunar Vehicle is landing on the Moon. We would like you to examine a sequence of frames taken from the film and determine the thrust force exerted by Aries during its moon landing that allows it to land gently.




• Some data are provided by the film's scientific advisor*. Aries 1B was designed to use standard cryogenic propellent to provide thrust forces. It carries between 20 and 30 passengers and a crew. Aires has a total mass with fuel, passengers, and crew of about $4.5x10^5$ kg.

• Given the mass and passenger capacity Aries probably has a length of about 30m. We know that the Moon has a gravitational acceleration constant which is 1/5.8 times that of the Earth.

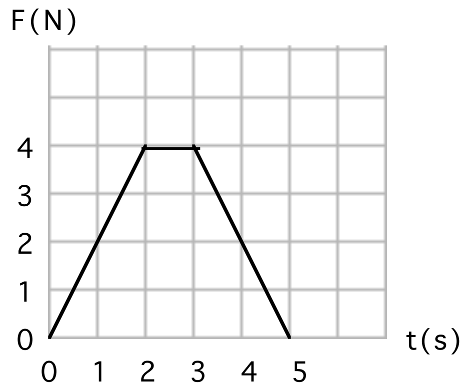
**(a)** On the basis of a video analysis of the movie of Airies landing, what is the magnitude and direction of the acceleration of Aires as it lands on the moon. Is it constant? What is the initial height of the centre of Aires above its location when it has landed on the surface of the Moon. What is the initial velocity? Explain how you determined the $a$,$v$, and $y$ values at $t$=0s. (To do the video analysis use the video analysis ability of Logger Pro. Insert the movie entitled *Moon_Landing.mp4*). **Note**: The movie clip is 17 seconds recorded at the rate of two frames per second. You will need to calibrate using the length of Aires as a scale factor. When you select an origin, the location of Aries is calculated relative to that origin in each frame.
**(b)** What is magnitude and direction of the gravitational force on Aires?
**(c)** Draw a free body diagram showing the directions of the forces on Aires just above the surface of the Moon. Assume that the engine thrust force is vertical in the upward (positive direction). What is the *other* vertical force on Aires and in what direction is it? Are there any horizontal forces on Aires?
**(d)** If Newton's Second Law still holds on the Moon, then what is the magnitude and direction of the net force on Aires? What is the magnitude and direction of the vertical thrust force provided by the Airies engines?

*Frederick I. Ordway, III, "Return Visit to 2001: A Space Odyssey," 1-78:supplementary text for 2110:A Space Odyssey, 3 laserdiscs, 149 min., 1988; The Criterion Collection, Santa Monica, CA.

## UNIT 8 HOMEWORK AFTER SESSION TWO (CONTINUED)

• If necessary, refer to Chapter 10 Sections 10-3 and 10-4 in the Textbook before working problem SP8-3.

**SP8-3)** The force $F_x$ acting on a 2.00 kg particle varies in time as shown in the figure below. Find (a) The impulse of the force, (b) the final velocity of the particle if it is initially at rest, and (c) the final velocity of the particle if it is initially moving along the x-axis with a velocity of –1.00 m/s.




## UNIT 8 HOMEWORK AFTER SESSION THREE

• *Complete Unit 8 entries in the Activity Guide*
You probably didn't have time to finish Session 3 in class.

• *Work Ch. 7 Problems 21 & 30*

## UNIT 9 HOMEWORK AFTER SESSION ONE

• Read Chapter 8 in the Textbook *Understanding Physics*

• *Work Supplemental Problems SP9-1, 9-2 and 9-3 shown below*

**SP9-1)** [20 pts] *How does the centre of mass of a system of two equal masses move?* You are to graph the motion of the position average for moving carts of equal mass and interpret the graph. (In the special case of equal masses the position average and the *centre of mass*, which we will define more carefully in the next session, are the same thing.) Re-analyse the two same-mass cart collision movie you made in this unit in order to obtain a graph of the x-value of the position average, <x>, as a function of time. The position average can be obtained by using previously taken or new data on the positions of the carts in metres (i.e. you must perform a horizontal calibration). Once these data are transferred to a spreadsheet you can set up a column for calculating the average position of the two cart system. By rearranging columns on the spreadsheet you can graph <x> in metres as a function of time in seconds.

**(a)** Do a fit to find an equation that describes your data. Display the equation for <x> vs. t on the graph. Upload a copy of your plot to WebCT assignments.

**(b)** Is the velocity of cart 1 a constant (i.e. the same) before and after the collision occurs or does it change as a result of the collision? How about cart 2? Examine your graph. Is the velocity of the average position (i.e. the centre of mass) a constant before and after the collision? During the collision?

**(c)** Based on the equation you determined, what is the magnitude of velocity of the centre of mass (average position) of the carts? How does the total mass ($M = m+m = 2m$) times the velocity compare with the average total momentum of this two-cart system?

**SP 9-2)** [4 pts] **(a)** Consider the "before" picture in Figure 9-6. According to the Law of Momentum Conservation what quantity is constant before, during, and after the collision if no outside forces are present?

**(b)** Use the definition of instantaneous velocity and the fact that a constant can be pulled out of a derivative to show that if $\vec{p} = \vec{p}_1 + \vec{p}_2$ and if the objects only move along a line in one dimension then,

$$p = m_1 \frac{dx_1}{dt} + m_2 \frac{dx_2}{dt}$$

**(c)** Noting that any constant can be pulled in or out of a derivative, show that

$$p = \frac{d(m_1 x_1 + m_2 x_2)}{dt}$$

**(d)** Now by defining the centre of mass of the two particle system as

$$x_{cm} = \frac{(m_1 x_1 + m_2 x_2)}{M} \qquad \text{where} \quad M = m_1 + m_2$$

show that

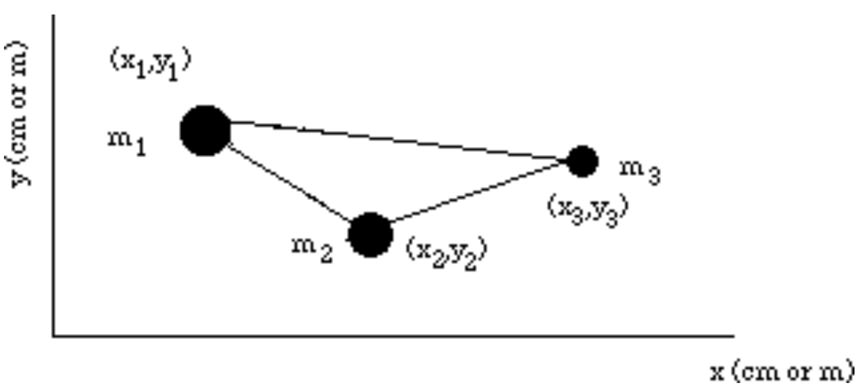
$$p = \frac{d(m_1 x_1 + m_2 x_2)}{dt} = Mv_{cm}$$

**SP 9-3)** [4 pts] Most objects or systems of particles extend in all three dimensions rather than lying along a line. The definition of centre of mass can be readily extended to two and three dimensions. For example, the defining equations for the two-dimensional case can be given as follows:

$$\vec{r}_{cm} = X_{cm}\hat{i} + Y_{cm}\hat{j}$$

where $$X_{cm} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3}{m_1 + m_2 + m_3}$$

and $$Y_{cm} = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3}{m_1 + m_2 + m_3}$$




Suppose the three masses located in the *xy* plane have the following coordinates: a 3.0-kg mass has coordinates given by (3.0, -2.0) m; a 4.0-kg mass has coordinates (-2.0, 4.0) m; a 1.0-kg mass has coordinates (2.0, 2.0) m. Find the coordinates of the centre of mass.

## UNIT 9 HOMEWORK AFTER SESSION TWO

• *Complete Unit 9 entries in the Activity Guide*
You probably didn't have time to finish in class.

• *Work Supplemental Problems 9-4, 9-5, 9-6, and 9-7 listed below.*

**SP9-4)** [2 pts] The mass of the Sun is 329,390 Earth masses and the mean distance from the centre of the Sun to the centre of the Earth is 1.496 x $10^8$ km. Treating the Earth and Sun as particles, with each mass concentrated at the respective geometric centre, how far from the centre of the Sun is the C.M. of the Earth-Sun system? Compare this distance with the mean radius of the Sun (6.960 x $10^5$ km).

**SP9-5)** [20 pts] *Momentum components* Since momentum is a vector, the Law of Conservation of Momentum in two dimensions requires that if the vector conservation equation is broken into components then the conservation law must also hold for each of the vector components. Thus, if we consider the interaction of three or more objects, and if

$$\Sigma \vec{p} = \vec{p}_{1,i} + \vec{p}_{2,i} + \vec{p}_{3,i} + ... = \vec{p}_{1,f} + \vec{p}_{2,f} + \vec{p}_{3,f} + \ldots = \text{a constant}$$

then

$$\Sigma p_x = p_{1x,i} + p_{2x,i} + p_{3x,i} + ... = p_{1x,f} + p_{2x,f} + p_{3x,f} + \ldots = \text{a constant}$$

and

$$\Sigma p_y = p_{1y,i} + p_{2y,i} + p_{3y,i} + ... = p_{1y,f} + p_{2y,f} + p_{3y,f} + \ldots = \text{a constant}$$

If a coordinate system is chosen and a given momentum vector makes an angle θ with respect to the designated x-axis then the momentum vector can be broken into components in the usual way:

$$\vec{p} = p_x \hat{i} + p_y \hat{j} = p\cos\theta \hat{i} + p\sin\theta \hat{j}$$

Let's consider the fairly complex interaction of three air pucks that you examined in Activity 9-8.

**(a)** Determine the *x* and *y*-components of the momentum for each of the three pucks before the collision. Use these to find *x* and *y*-components of the total initial momentum of the system.
**(b)** Determine the *x* and *y*-components of the momentum for each of the three pucks after the collision. Use these to find *x* and *y*-components of the total final momentum of the system.
**(c)** Does momentum appear to be conserved (within reasonable experimental uncertainties) in this collision? Justify your answer.

**SP9-6)** [10 pts] *Momentum as a vector*
**(a)** Use the results from SP9-5 (a) to determine the magnitude and angular direction of the total initial momentum of the system.
**(b)** Use the results from SP9-5 (b) to determine the magnitude and angular direction of the total final momentum of the system.
**(c)** According to these results, does momentum appear to be conserved (within reasonable experimental uncertainties) in this collision? Justify your answer.

**SP9-7)** [20 pts] *What does an observer moving with the centre of mass of a system with two equal masses see?* We know that in the laboratory coordinate system (where the observer is at rest in the laboratory) the velocities of the two carts are different from each other most of the time. What velocities does a moving observer see? You can re-analyse one more time the two same-mass cart collision movie in order to obtain a graph of the velocity of cart 1 and the velocity of cart 2 as measured by our observer who is moving with the centre of mass of the system. Imagine you are moving so that you are always just opposite the point that lies in the centre between the two carts as they move. You already *know* you will be moving with a constant velocity of magnitude $V$ which you determined in part (c) in SP9-1. What do you see as the carts interact? This point of view can be simulated by choosing a moving origin which lies halfway between the carts in each frame of the cart movie. (No calculations are needed, but you may want to hold a ruler up to the computer monitor screen to help you determine the halfway points.) The software will then calculate how far each of the carts is from this moving origin on a frame-by-frame basis. You should transfer your data to a spreadsheet and calculate the velocities of the carts as a function of time.

**(a)** Create a correctly labelled overlay graph of the positions of the two carts ($x1$ (m/s) vs. $t$(s) and $x2$ vs. $t$(s) ) relative to the centre-of-mass location. Upload a copy of your plot to WebCT assignments.
**(b)** Calculate best values for the velocities of the carts before and after the collision by determining the slope of the position vs. time graph for cart 1 before collision and the slope of the position vs. time for cart 1 after the collision. Do the same for cart 2.
**(c)** In the centre-of-mass coordinate system, how does the magnitude of the cart 1 velocity compare to the magnitude of the cart 2 velocity before and after the collision?
**(d)** What is the total momentum of the two cart system when it is viewed by the observer in the centre-of-mass coordinate system? Does this view of the collision bear any relationship to the collisions you observed in Activity 9-2?
**(e)** Examine your graph (no need for calculations). Does the moving observer still believe momentum is conserved in the process? Explain.

## UNIT 10 HOMEWORK AFTER SESSION ONE

- Read Chapter 9 in the Textbook.
- *Work Ch. 9 Problems 18 & 44*
- *Work Supplemental Problems 10-1, 10-2 and 10-3 listed below*

**SP10-1)** Wonder Woman, whose mass is 55 kg, is holding onto the free end of a 12.0-m rope, the other end of which is fixed to a tree limb above. She is able to get the rope in motion so that she can reach a ledge when the rope makes a 60 degree angle with the downward vertical axis. How much work does Wonder Woman do against the force of gravity?

**SP10-2)** A vector is given by $\mathbf{A} = -1.8\,\hat{\imath} + 3.2\,\hat{\jmath}$. Find (a) the magnitude of **A** and (b) the angle that **A** makes with the positive $y$ -axis.

**SP10-3)** A 70 kg rock-climber scales an 8.3 m vertical cliff at uniform speed in 10 s. What is his power output?

## UNIT 10 HOMEWORK AFTER SESSION TWO

- *Work Supplemental Problems 10-4 through 10-7 listed below*

**SP10-4)** When a 5.0-kg mass is hung vertically on a light spring that obeys Hooke's law, the spring stretches 3.2 cm. If the 5.0-kg mass is removed, (a) how far will the spring stretch if a 2.5-kg mass is hung on it, and (b) how much work must an external agent do to stretch the same spring 6.0 cm from its unstretched position?

**SP10-5)** A tow truck pulls a $1.50\text{x}10^3$ kg car from rest to a final speed doing $4.00\text{x}10^3$ J of work in the process. During this time, the car moves 25 m. Neglecting friction between the car and the road and assuming the acceleration is constant, (a) what is the final speed, $v$, of the car? (b) What is the horizontal force exerted on the car? **Hint**: Don't forget to use the appropriate number of significant figures.

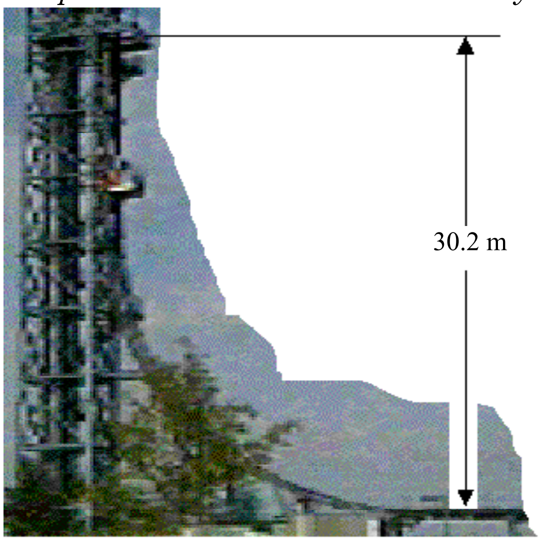
**SP10-6)** An ice skater of mass $m$ is given a kick on a frozen pond, imparting to it an initial speed $v_0 = 2$ m/s. The coefficient of kinetic friction between the blades of the skates and ice is $\mu_k = 0.12$. Use the work-energy theorem to find the distance the skater moves before coming to rest.

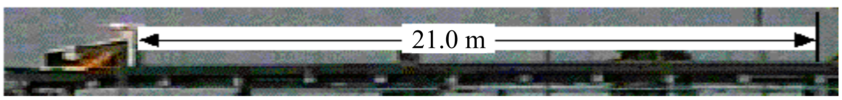
**SP10-7)** (20 pts) Demon Drop is a free fall amusement part ride similar to one shown in *The Mechanical Universe* videos. If we haven't shown it to you, there's a picture at the end.

(a) *Demon Drop Vertical (The drop part):* Suppose the cage full of people of mass $1.25\text{x}10^3$ kg falls under the influence of the gravitational force for a total vertical distance of 30.2 m without experiencing any friction forces (this is an idealization!). How much work does the gravitational force do on the cage? Use the work-energy theorem to calculate the kinetic energy of the cart at the point where it hits the horizontal part of the track.

(b) *Demon Drop Slow Down (The stopping part):* If the brakes are applied just as the cart hits the level part of the track and the cart stops in a distance of 21.0 m, use the work-energy theorem to find the coefficient of friction between the brake pads and the horizontal portion of the track.

• *Complete Unit 10 entries in the Activity Guide*




http://www.cedarpoint.com/public/inside_park/rides/thrill/demondrop.cfm

## UNIT 11 HOMEWORK AFTER SESSION ONE

- Read Chapter 10 in the Textbook *Understanding Physics*
- *Work Textbook Problems 10-4, 10-10 & 10-15*
- *Work Supplemental Problem SP11-1 listed below*

**Ride Info**
Demon Drop celebrated its 20th anniversary at Cedar Point in 2003. Constructed in 1983, Demon Drop simulates a free-fall from the top of a ten story building. Riders seated in four-passenger cars ascend to a height of 131 feet before plunging down ten stories reaching speeds of 55 mph.

**Ride Facts**
Height: 131 feet
Vertical Drop: 60 feet
Freefall: 2.5 seconds
Total Descent: 99 feet
Top Speed: 55 mph

Ride Designer:
Intamin AG of Switzerland

Capital Investment:
$2.5 million in 1983

**SP11-1)** [20 pts] **Frames of Reference:** Different observers can choose to use different co-ordinate systems. Some observers might be moving relative to others. Some simply choose a different origin. Let's simulate the case of the devilish college president dropping a balloon on a hapless student as in Activity 11-3. You can use the movie of the ball toss for this analysis. Simply pretend that (1) the falling ball is a water balloon of mass .321 kg, and (2) the president's floor is at the highest point the tossed ball reaches. You should do the following:

(1) Use Logger Pro to examine the movie.
(2) Calibrate assuming the meter stick is 2 m long.
(3) Set the origin at the president's floor level i.e. at the top of the toss. Take data for position vs. time and save it.
(4) Reset the origin at the student's floor level (i.e. the lab floor level) and recalculate the data with the new origin.
(5) Set up spreadsheets to calculate the total energy of the balloon (potential and kinetic in each case). Be sure to use the leap-frog method for determining the velocities. See Figure 11-1.

(a) What is the total mechanical energy that the president observes? Does the president see a constant total energy? (b) What is the total mechanical energy that the student observes? Does the student see a constant total energy? (d) Do they agree on the value of the total mechanical energy? (e) Do they agree that energy is conserved? Explain.

## UNIT 11 HOMEWORK AFTER SESSION TWO

- *Work Textbook Problems 10-46, 10-54 & 10-73*
- *Work Supplemental Problem SP11-2 listed below*

**SP11-2)** A 5.0-kg block travels on a rough, horizontal surface and collides with a spring. The speed of the block *just before* the collision is 3.0 m/s. As the block rebounds to the left with the spring uncompressed, its speed as it leaves the spring is 2.2 m/s. If the coefficient of kinetic friction between the block and surface is 0.3, determine (a) the work done by friction while the block is in contact with the spring and (b) the maximum distance the spring is compressed.

- *Complete Unit 11 entries in the Activity Guide*

**UNIT 12 HOMEWORK AFTER SESSION TWO** (SESSION ONE IS SKIPPED)

- Read Chapter 11 in the textbook

- *Work Ch 11 Problems 12 , 18, 23, 24 & 41*

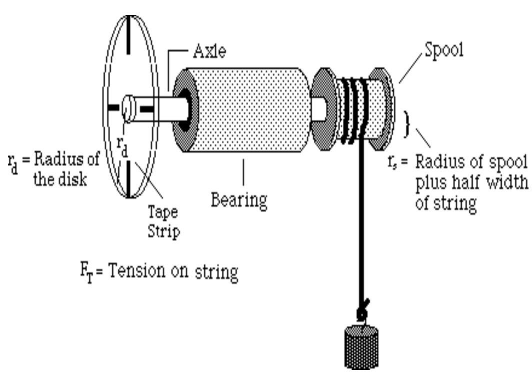
- *Finish Activity Guide Entries for Session 2*
- *Work supplemental problems SP12-1, SP12-3 & SP12-4* (Problem S12-4 will help you prepare for the experiment to be done during the next class session.)

**SP12-1)** A racing car travels on a circular track of radius 250 m. If the car moves with a constant speed of 45 m/s, find (a) the angular speed of the car and (b) the magnitude and direction of the car's acceleration.

**SP12-2)** A tractor is travelling at 20 km/h through a row of corn. The radii of the rear tires are .75 m. Find the angular speed of one of the rear tires with its axle taken as the axis of rotation.

**SP12-3)** Sharon pulls on a rod mounted on a frictionless pivot with a force of 125 N at a distance of 87 cm from the pivot. Roger is trying to stop the rod from turning by exerting a force in the opposite direction at a distance of 53 cm from the pivot. What is the magnitude of the force he must exert?

**SP12-4)** (20 pts) A small spool of radius $r_s$ and a large Lucite disk of radius $r_d$ are connected by an axle that is free to rotate in an almost frictionless manner inside of a bearing as shown in the diagram below.




A string is wrapped around the spool and a mass $m$, which is attached to the string, is allowed to fall. (See next page)

(a) Draw a free body diagram showing the forces on the falling mass, $m$, in terms of $m$, $g$ and $F_T$.

(b) If the magnitude of the linear acceleration of the mass, $m$, is measured to be $a$, what is the equation that should be used the calculate the tension, $F_T$, in the string (i.e., what equations relates $m, g$ , $F_T$ and $a$)? **Note:** In a system where $F_T - mg = ma$, if $a \ll g$ then $F_T \approx mg$.

(c) What is the torque, $\tau$, on the spool-axle-disk system as a result of the tension, $F_T$, in the string acting on the spool?

(d) What is the magnitude of the angular acceleration, $\alpha$, of the rotating system as a function of the linear acceleration, $a$, of the falling mass and the radius, $r_s$, of the spool?

(e) If the rotational inertia of the axle and the spool are neglected, what is the rotational inertia, $I$, of the large disk of radius $r_d$ as a function of the torque on the system, $\tau$, and the magnitude of the angular acceleration, $\alpha$?

(f) What is the theoretical value of the rotational inertia, $I_d$, of a disk of mass $M$ and radius $r_d$ in terms of $M_d$ and $r_d$?

## UNIT 12 HOME WORK AFTER SESSION THREE

- *Finish Unit 12 Entries in the Activity Guide* (Due before class)

## UNIT 13 HOME WORK AFTER SESSION ONE

- Read Chapter 12 in the Textbook *Understanding Physics*
- *Work Supplemental Problem 13-1 listed below*
- *Work Textbook Exercises 12-16, 12-21 & 12-28*

**SP13-1)** A particle is located at the vector position $\vec{r} = (4\hat{\imath} + 6\hat{\jmath})$ m and the force acting on it is given by $\vec{F} = (3\hat{\imath} + 2\hat{\jmath})$ N. What is the torque acting on the particle about the origin?

**Hint:** The vector cross product between two vectors $\vec{A} = A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k}$ and $\vec{B} = B_x\hat{\imath} + B_y\hat{\jmath} + B_z\hat{k}$ can be calculated as follows:

$$\vec{A} \times \vec{B} = (A_yB_z - A_zB_y)\hat{\imath} + (A_zB_x - A_xB_z)\hat{\jmath} + (A_xB_y - A_yB_x)\hat{k}$$

## UNIT 13 HOME WORK AFTER SESSION TWO

- *Work Textbook Exercises 12-33,12-40 & 12-54*
- *Complete Unit 13 entries in the Activity Guide*

## UNIT 14 HOME WORK AFTER SESSION ONE

- Finish the activities in Session 1.
- Read Chapter 16-1 through 16-4 in the textbook
- *Work Chapter 16 Problems 1,3,4, 8 & 30*

## UNIT 14 HOME WORK AFTER SESSION TWO

- Read Chapter 16, sections 16-5 through 16-8 in the textbook.
- *Work Chapter 16 Problems 34 and 52.*

## UNIT 14 HOME WORK AFTER SESSION THREE

**Before the final examination:**

- *Study for the final examination*

**About the Final:** The final examination will cover Units 1-14 with special attention to Unit 14. You should remember and be able to apply fundamental equations from which others can be derived.

**Immediately after the final examination:**

- *Hand in the Unit 14 Activity Guide Entries*