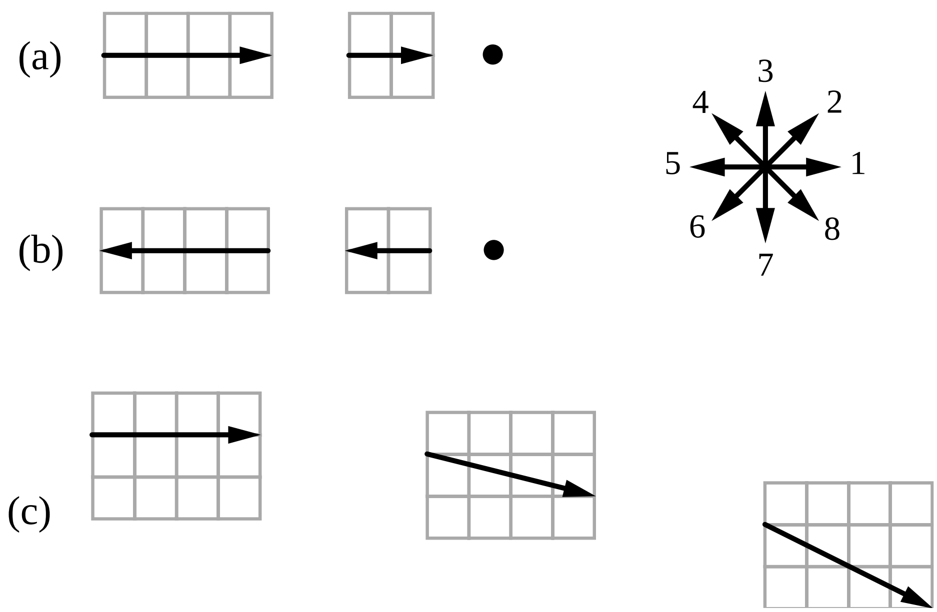
# *Unit 7 Homework Problems*

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

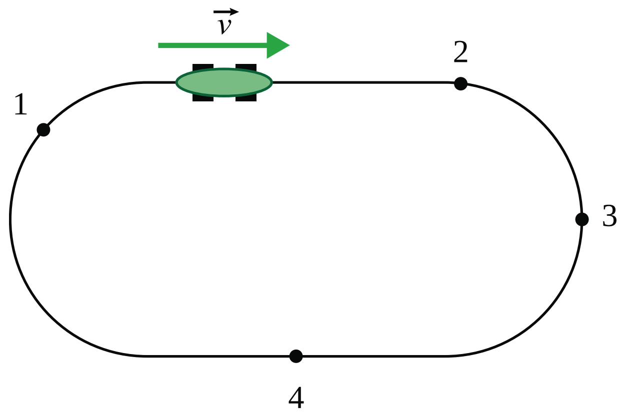
1. All equations must be solved in symbol form before substituting in any numbers.
2. All numbers substituted into the equations must have the correct units and number of significant figures, and the correct vector notation (where appropriate).
3. All final numerical answers must have the correct units, correct number of significant figures, and correct unit 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.

## UNIT 7 HOMEWORK AFTER SESSION ONE

**7-1)** **Velocity Vector Changes:** The motion of three objects is shown in the motion diagrams (a), (b), and (c) below. In each case, the velocity of the object is shown at three equally spaced times (**Note:** The little ▪ on the right in (a) and (b) signify a velocity vector with zero magnitude.) Indicate for each part which number is next to the arrow on the right side of the diagram that best shows the direction of the change in velocity. (In (b), the object is moving from right to left.) ***Hint:*** Use the techniques developed in Section 7-3 of the Activity Guide to draw vectors representing the change in velocity in each case. Note: This exercise is adapted from a conceptual exercise developed by Dennis Albers of Columbia College.



**7-2)** **Constant Speed On A Race Track:** The racetrack shown in the diagram below has two straight sections connected by semicircular ends. A car is traveling in a clockwise direction around the track at a constant speed. Draw three sets of diagrams each having a sketch of the racetrack:



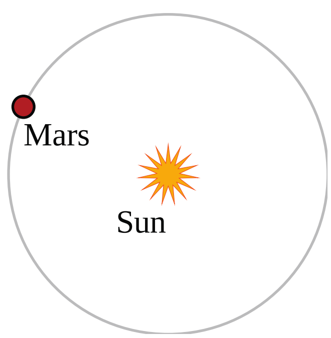

(a) One sketch should show the velocity vector at each of the numbered points 1-4. Use the same length as that of the sample velocity vector shown in the diagram for your velocity vectors.

(b) Another sketch should show the acceleration vectors at each of the numbered points 1-4. **Hint**: Use the techniques developed in Section 7-3 of the Activity Guide to draw vectors representing the acceleration or change in velocity.

(c) Horizontal forces are needed to maintain the car's motion around the track. These are provided by road friction and by road forces where the track is banked at the curves. Draw another sketch showing the vectors representing the required horizontal force (*i.e.*, the net force) at each of the numbered points 1-4.

**Note**: This exercise is adapted from Arons, A., Homework and Test Questions for Introductory Physics Teaching, Wiley, New York, 1994. Ch 3.

**7-3)** **Keeping Mars In Orbit:** Although the planet Mars orbits the Sun in a Kepler ellipse with an eccentricity of 0.09, we can approximate its orbit by a circle. If you have faith in Newton's laws then you must conclude that there is an invisible force holding Mars in a circular orbit. The data on the orbit of Mars around the sun are shown below.




$m_{Sun} = 1.99\times10^{30}$ kg

$m_{Mars} = 0.108$ earth masses
$= 6.46\times10^{23}$ kg

$d_{Mars} = 1.523$ AU $= 2.28\times10^{11}$ m
distance from the sun (= radius of circ. orbit)

$\langle v \rangle = 24.13$ km/s (mean orbital speed)

(a) Calculate the magnitude of the net force needed to hold Mars in its circular orbit. Please use the proper number of significant figures.

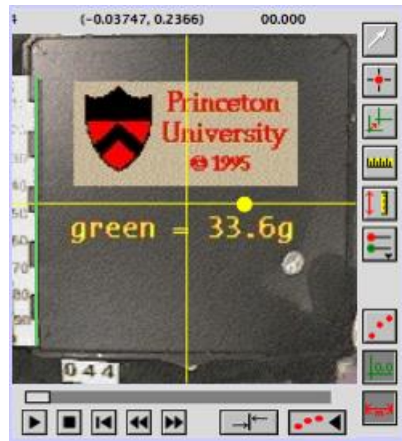
(b) What is the direction of the force as Mars orbits around the Sun?

(c) What object 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?

**7-4)** In this problem you are to examine the motion of a puck of mass 33.6 g that undergoes circular motion without friction on the surface of an air table. A movie of this puck is shown in the digital video film clip entitled ***pru044s.mov***. This movie was made at 10 frames per second so the time interval between one frame and the next is 0.1000 s. There are several ways to get the information you need to answer the following questions. You can use ruler and protractor measurements of the location of the puck at various times (don't forget to find a scale factor), or you can use the Logger Pro software.

I've created a ***pru044s.cmbl*** file that is on the homework page. Save both the ***pru044s.mov*** file and the ***pru044s.cmbl*** file to the same location, and then double click on the ***pru044s.cmbl*** file to open Logger Pro. The ***pru044s.mov*** will automatically open in Logger Pro, and the movie will already be scaled and the coordinate system origin placed in the correct location.




(a) Based on an examination of the movie, how do you know the puck is moving in a circle? What is your supporting evidence?

(b) Is the puck moving at a constant *speed* as is moves around? Why or why not. Explain the reasons for your answer.

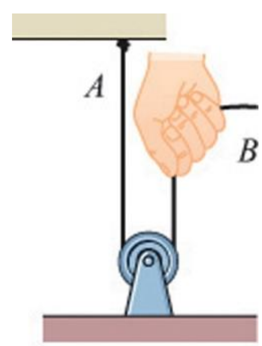
(c) Is the puck moving at a constant *velocity* as is moves around? Why or why not. Explain the reasons for your answer.

(d) Examine the movie and use basic geometry and some reasoning to calculate the speed in m/s of the center of the puck. **Hint**: What is the distance swept out by the puck in passing through a full revolution? What is the time taken for the puck to revolve in a full circle?

(e) Calculate the magnitude of the centripetal acceleration that the puck is experiencing as it moves in a circle. In what direction is this acceleration in each frame?

(f) Calculate the magnitude of the net force that the puck must experience to keep moving in a circle. In what direction is the net force in each frame?

## UNIT 7 HOMEWORK AFTER SESSION TWO




**7-5)** **Tension Forces In A String:** (a) Suppose a person exerts a force of +50 N on one end of a rope as shown in the diagram on the right. What is the magnitude and direction of the force at point A exerted on the rope by the ceiling?

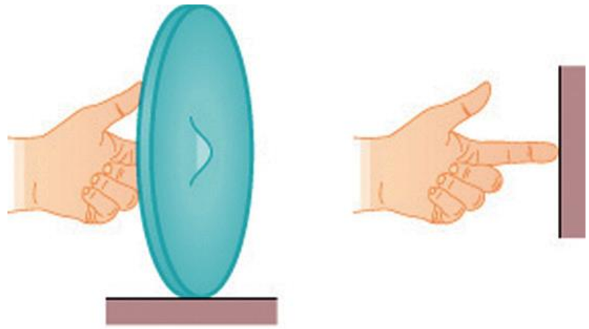
(b) How does the force get transmitted from one end of the string to the other? What does the stretching of the string have to do with this?

(c) If a string has a force on it at one end and a frictionless post or pulley changes the direction of the string, what is the magnitude of the force on the other end of the string?

(d) Refer to the diagram to the above right in which a string exerts a force on a person's hand (at point B) and a force at a fixed point A at the other end of the string. Draw a diagram with the vector arrows indicating the *relative magnitudes* and the *directions* of the forces the rope exerts on the ceiling at point A and the force the rope exerts on the person's hand at point B.

**7-6)** (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?

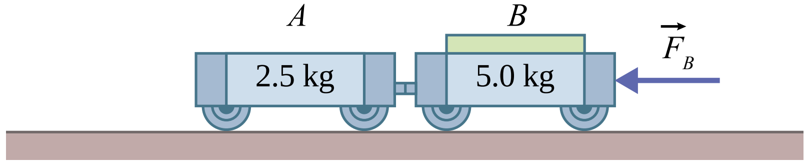
**7-7)** (a) Refer to the words of the *Bricklayer's Song*. Assuming there is no friction in the bricklayer's pulley and rope system, *estimate* the total amount of time that elapses during the injurious events described by the poor bricklayer in the song. **Hint**: there are four separate injurious events that the bricklayer experiences – you will need to find the time interval for each and then add them up.

(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? Why?

**Hints:** (1) 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. (2) You'll need to use the Atwood's equation to determine the Bricklayer's acceleration in each part of his journey. You cannot simply assume that all of the bricklayer's travels occur at $|\vec{a}| = 9.8\text{m/s}^2$. (3) Although your answer should be similar to that obtained by others, there is no single "right" answer as you are being asked to make reasonable estimates.

**UNIT 7 HOMEWORK AFTER SESSION THREE**

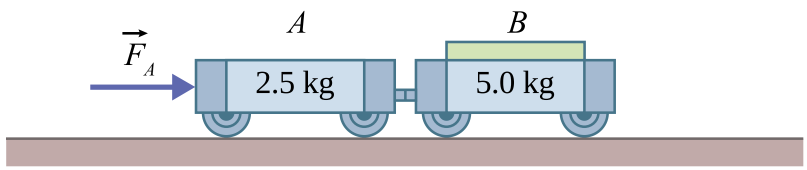
**7-8)** Two low friction carts A and B have masses of 2.5 kg and 5.0 kg respectively. Initially a student is pushing them with an applied force of $\vec{F}_B = -20\text{N}\,\hat{x}$ which is exerted on cart B as shown in the diagram that follows.




(*a*)

(a) Find the magnitude and direction of the interaction forces between the two carts $\vec{F}_{AB}$ and $\vec{F}_{BA}$ where $\vec{F}_{AB}$ represents the force on cart A due to cart B and $\vec{F}_{BA}$ represents the force on cart B due to cart A.

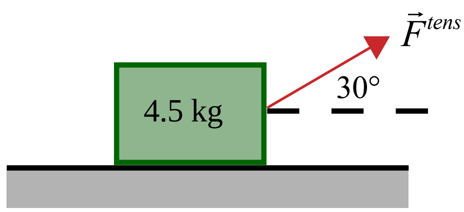
(b) If the student pushes on cart A with an applied force of $\vec{F}_A = +20\text{N}\,\hat{x}$ instead, determine the magnitude and direction of the interaction forces between the two carts $\vec{F}_{AB}$ and $\vec{F}_{BA}$ for this situation.




(*b*)

(c) Explain why the interaction forces in (a) are different than the interaction forces in (b). **Hint**: If you consider the two carts together as a system with mass 7.5 kg, what is the acceleration of each of the carts A and B? What does the *net* force on cart A have to be to result in this acceleration?

**7-9)** A string is attached to a 4.5 kg block and it is pulling on the block at an angle of 30° above the horizontal. Assume the tension in the string is 22 N and the block is not moving.

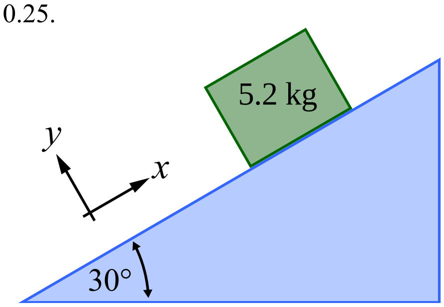



(a) Represent the block as a point and draw a free body diagram showing the forces on the block.

(b) Find the magnitude and direction of the normal force on the box.

(c) Find the static friction force.

**7-10)** A 5.2 kg box is sliding down a ramp to a loading dock, as shown below. The coefficient of kinetic friction $\mu^{kin}$ is given by 0.25.




(a) Represent the block as a point and draw a free body diagram showing all the forces on the block. **Hint**: Use a coordinate system with the *x*-axis along the incline (as shown above), instead of along the horizontal.

(b) Find the normal force on the block. What angle does it make with respect to the horizontal?

(c) Find the friction force on the block. What angle does it make with respect to the horizontal?

(d) Find the acceleration of the block.