Unit 10 *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 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 10 HOMEWORK AFTER SESSION ONE

10-1) Suppose you throw a stone of mass 0.50 kg straight up and that your hand exerts an average upward force of 95 N for a vertical distance of 0.75 m.

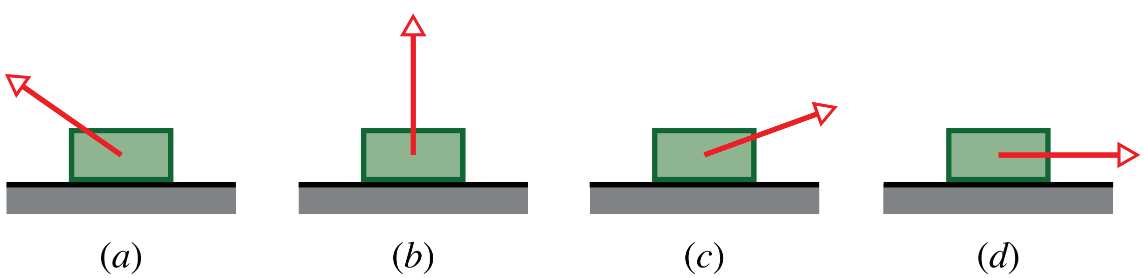
(a) Draw and label a free body diagram showing all the forces on the stone during the time you are throwing it. Describe each force in words and describe all the Newton's third law force pairs that are involved.

(b) Draw and label a free body diagram showing all the forces on the stone as it is rising but after you have released it. Describe each force in words and describe all the Newton's third law force pairs that are involved.

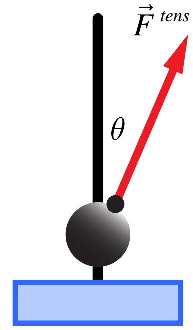
(c) Draw and label a free body diagram showing all the forces on the stone as it is falling back down but before you catch it again. Describe each force in words and describe all the Newton's third law force pairs that are involved.

(d) Calculate the work done on the stone by your hand while you are in the act of throwing it. This question is adapted from problem 4.14 of A. Arons, *Homework and Test Questions for Introductory Physics Teaching* (Wiley, New York, 1994).

10-2) The figure that follows shows four situations in which an external applied force acts on a box while the box slides rightward a distance $|\Delta \vec{x}|$ across a frictionless floor. The magnitudes of the forces are identical; their orientations are as shown. Rank the situations according to the work done on the box by the force during the displacement, from most positive to most negative. Explain the reasons for your answer.



10-3) A smooth vertical post is inserted into a bowling ball with a hole drilled through its center. A rope is attached to a ring that has been affixed to the ball. Linda pulls on the rope at an angle of $\theta = 36.8^{o}$ with respect to the vertical with a constant force of magnitude $F = 148$ N.



(a) How much work, W, does the rope do on the 8.52 kg bowling ball if Linda raises the ball through a vertical distance of 1.52 m?

(b) How much work does the Earth do on the ball while it is being raised through a distance of 1.52 m?

(c) What is the net work done on the ball by the two forces acting on it?

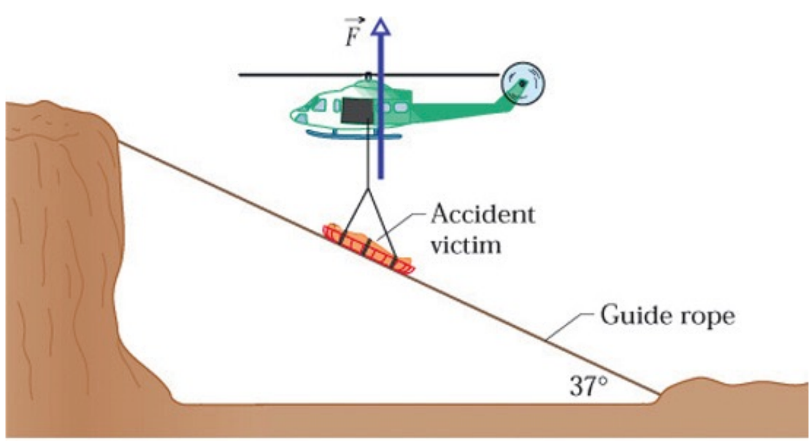
(d) If Linda raises the ball with the rope in a time of 0.850 s, what is her horsepower?

(e) Linda likes to be efficient and would like to be able to raise the ball through the same vertical distance with a minimum effort (smallest force, and the least amount of work). What two changes in her actions would you recommend to her?

10-4) A helicopter lifts a stretcher with a 74 kg accident victim in it out of a canyon by applying a vertical force on the stretcher. The stretcher is attached to a guide rope that is 50 meters long and makes an angle of 37^{o} with respect to the horizontal, as shown in the diagram on the next page.

(a) What is the minimum amount of work that the helicopter needs to do to lift the injured person and stretcher from the bottom end of the guide rope to the top end? **Hint**: What is the angle between the force and the displacement? It is not 37^{o}

(b) If the operation takes 10 seconds, what is the power delivered by the helicopter in Watts? In horsepower?



10-5) In the video movie *pasco004.mov*, a fan cart unit accelerates from rest along a level track as a result of the action of the fan.

(a) Since the fan cart unit accelerates, then according to Newton's Second Law there must be a net horizontal force acting on it. What is the physical source of that force? **Hints**: (1) The fan cart unit cannot exert a force on itself, (2) What does Newton's Third Law tell you? (3) Would the fan cart unit accelerate if it were in outer space?

(b) If friction is negligible identify the three forces acting on the cart, and describe the direction of these forces relative to the coordinate system shown when the movie is opened in Logger Pro.

(c) Use the Logger Pro software with the *pasco004.cmbl* file and spreadsheet modeling to find the *magnitude* and *direction* of the acceleration of the cart in the horizontal direction. Explain how you determined the acceleration. Is it constant? How do you know?

(d) What is the net work done on the cart as it travels from its location in frame one to its location in frame 14? What physical agent does this work?

UNIT 10 HOMEWORK AFTER SESSION TWO

10-6) Idealized data for a spring's displacement x from its equilibrium position as a function of an external force, F^{ext}, is shown.

x (cm)	F^{ext} (N)
0	0.0
5	1.0
10	2.0
15	3.0
20	4.0

(a) Draw a properly scaled and carefully labeled graph of F^{ext} vs. x for this data.

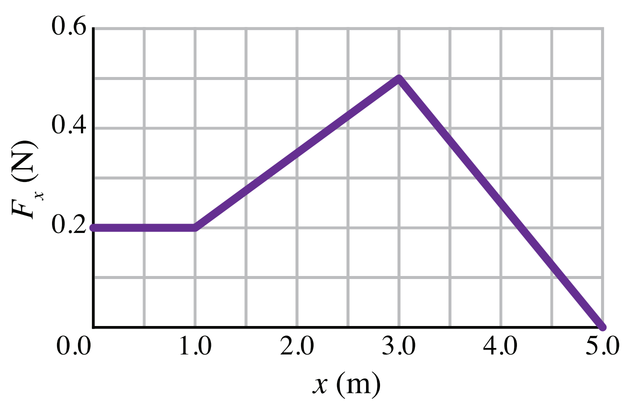
(b) Does this spring obey Hooke's Law? Why or why not?

(c) What is the value of its spring constant k?

(d) Shade the area on the graph that represents the amount of work done in stretching the spring from a displacement or extension of 0 cm to one of 5 cm. Also shade the area on the graph that represents the amount of work done in stretching the spring from a displacement or extension of 15 cm to one of 20 cm.

(e) Explain why the amount of work done in the second case is different than the amount done in the first case even though the change in displacement of the spring is the same in both cases.

10-7) The center of mass of a fan cart having a mass of 0.62 kg starts with a velocity of $\vec{v} = (-2.5\text{m/s})\hat{x}$ along an x-axis. It starts from a position of 5.0 m and moves without any noticeable friction acting on it to a position of 0.0 meters. This is in spite of the fact that a fan assembly is exerting a force on it in a positive x-direction. However, instead of being powered by batteries the fan is driven by a voltage source that is programmed to change with distance from a motion detector. This program leads to a set of changes in the force that is shown in the diagram that follows. (*Warning*: pay careful attention to the angle between the force and the displacement vectors – it's not zero!)



(a) What is the work done on the cart by the air pushing back on the fan as the cart moves from 5.0m to 0.0m?

(b) What is the change in kinetic energy of the cart between 5.0 m and 0.0 m?

(c) What is the final velocity of the cart when it is at 0.0 m?

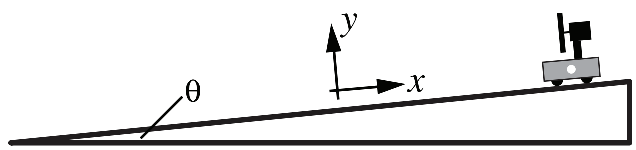
10-8) An ice skater of mass m is given a shove on a frozen pond. After the shove she has a speed of v_1 = 3.0 m/s. Assuming that the only horizontal force that acts on her is a slight frictional force between the blades of the skates and the ice.

(a) Draw a free body diagram showing the horizontal force and the two vertical forces that act on her. Identify these forces.

(b) Use the work-energy theorem to find the distance the skater moves before coming to rest. Assume that the coefficient of kinetic friction between the blades of the skates and ice is $\mu^{kin} = 0.20$.

10-9) Suppose a rock of mass 2.2 kg is attached to a string of length 1.00 m is twirled around horizontally in a perfect circle at a constant speed of 2.5 m/s. Calculate the work done on the rock by the tension force exerted on the rock by the string during one revolution of the rock. Ignore the effect of gravitational forces.

10-10) In the video movie *pasco008.mov*, a fan cart unit starts from rest and then accelerates from right to left down an inclined track as a result of a combination of forces.



Assume that the positive x-axis is not horizontal but instead points up along the incline. The net force along the incline (or x-axis) on the fan unit includes a combination of the "reaction" force to the fan's thrust force and the x-component of the gravitational force. After answering some questions and doing some preliminary calculations, you are going to be asked to use the definition of work to find the net work done on the fan unit.

(a) If friction is negligible there are three forces acting on the cart. Assume that the fan causes there to be a thrust force on the cart that acts up the incline from left to right. Draw a free body diagram showing the direction of each of these forces and identify them.

(b) Use the Logger Pro software with the *pasco008.cmbl* file and spreadsheet modeling to find the acceleration of the cart *down the ramp.* Once you have position data, you can use modeling to find the *magnitude* and *direction* of the acceleration of the cart along the x-direction. Explain how you determined the acceleration. Is it constant? How do you know?

(c) Assuming Newton's Second Law holds and that the acceleration of the cart down the ramp is given by $\vec{a} = \left(-0.76 \text{ m/s}^2\right)\hat{x}$, then what is the net force on the cart?

(d) If the ramp makes an angle of 5.5° with respect to the horizontal, show that the component of the gravitational force on the fan cart unit that acts in the negative x-direction is given by $F_x^{grav} = -0.55 \text{ N}$.

(e) What is the magnitude and direction of the "air" force that opposes the motion down the ramp?

(f) Show that the net work done on the cart as it moves from its location in frame 1 to its location in frame 20 is given by $W^{net} = 0.60$ N•m. Explain how you determined the net work.