Unit 10 *Homework Problems*

Learning Goals:

F.10 Apply the definition of work to a physical situation, particularly identifying if the work done by a force should be positive, negative or zero.

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.

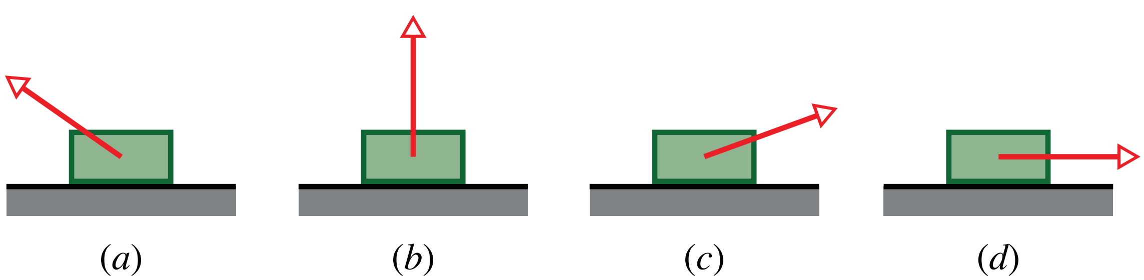
(a) Draw and label a free body diagram showing all the forces on the stone during the time you are throwing it. Describe each force in words and describe all the Newton's third law force pairs for each of the forces on your FBD.

(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 for each of the forces on your FBD.

(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 for each of the forces on your FBD.

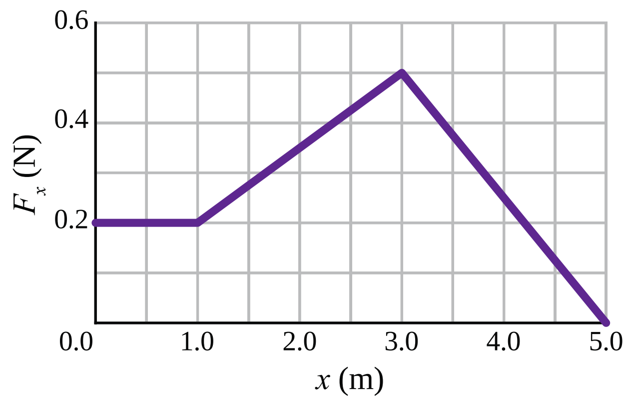
(d) Calculate the work done on the stone by your hand while you are in the act of throwing it. This question is adapted from problem 4.14 of A. Arons, *Homework and Test Questions for Introductory Physics Teaching* (Wiley, New York, 1994).

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) 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.

10-4) The center of mass of a fan cart having a mass of 0.62 kg starts with a velocity of $\vec{v} = (-2.5\ \mathrm{m/s})\hat{x}$ 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 5.0 m to 0.0 m?

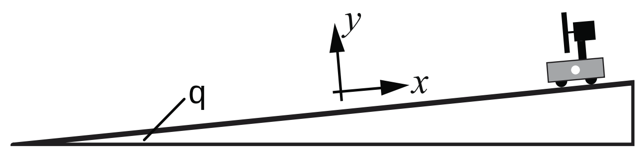
(b) What is the change in kinetic energy of the cart between 5.0 m and 0.0 m?

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

10-5) 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?

Now let's look at a different movie. 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.

(b) 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.

(c) 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 model the position data using *modelingWorksheet.xlsx* (*not* using Logger Pro) 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?

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

(e) 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 $F_x^{grav} = -0.55$ N. (Hint: what is the angle the gravitational force makes with the +*x*-axis?)

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

(g) 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 $W^{net} = 0.60\ \mathrm{N \cdot m}$. Explain how you determined the net work.

10-6) Problem 10.8.1 from the Activity Guide.