Name ______________________________ Seat Number ______________

PHYSICS 2110
Exam II – Spring 2007

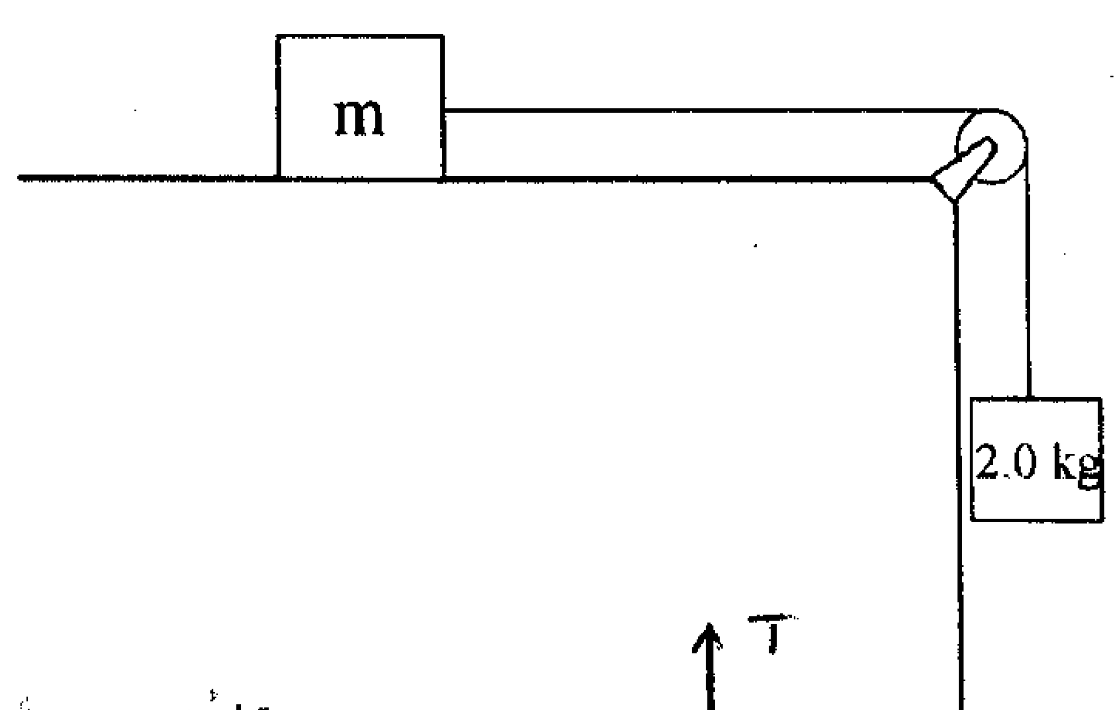
INSTRUCTORS (Circle ONE): CLASS MEETING TIME
Shriner 9:05 AM
Murdock 10:10 AM

YOU MUST SHOW YOUR WORK **AND** EXPLAIN YOUR REASONING TO RECEIVE CREDIT. ALL CELL PHONES AND OTHER COMMUNICATION DEVICES MUST BE TURNED OFF AND STORED OUT OF SIGHT. NO EXTRA PAPERS ARE ALLOWED OTHER THAN THE PROVIDED FORMULA SHEET.

Free-body diagrams are required for problems involving forces.

PROBLEM	POINT VALUE	YOUR SCORE
1	11	
2	21	
3	18	
4	4	
5	4	
6	4	
7	10	
8	6	
9	10	
10	12	
TOTAL	100	

1. A 2.0 kg mass and a mass m are connected by a light string. The 2.0 kg mass hangs vertically from the string which runs over an ideal pulley and pulls the mass m horizontally across a frictionless horizontal surface. The masses are released and they are found to have a common acceleration of $4.0\frac{m}{s^2}$



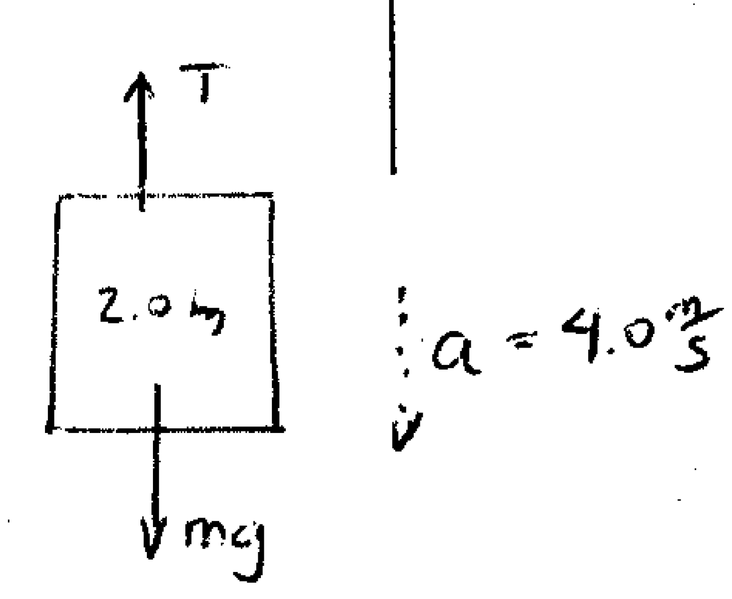
(a) What is the tension in the string? (8 pts)

Consider forces on 2.0 kg mass. N's 2nd law gives

$mg - T = ma$ w/ $a = +4.0\frac{m}{s^2}$. Solve:

$T = mg - ma = m(g-a) = (2.0\,kg)(9.8\frac{m}{s^2} - 4.0\frac{m}{s^2})$

$= 11.6\ N$



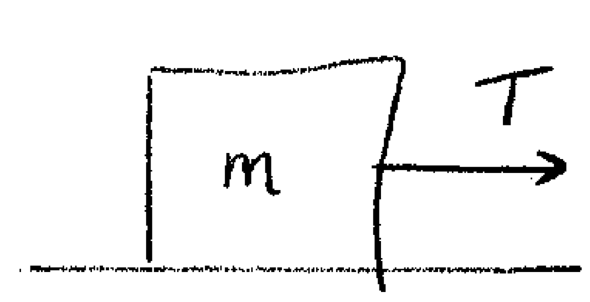
(b) What is the value of the mass m ? (3 pts)

Consider forces on m. N's 2nd law gives

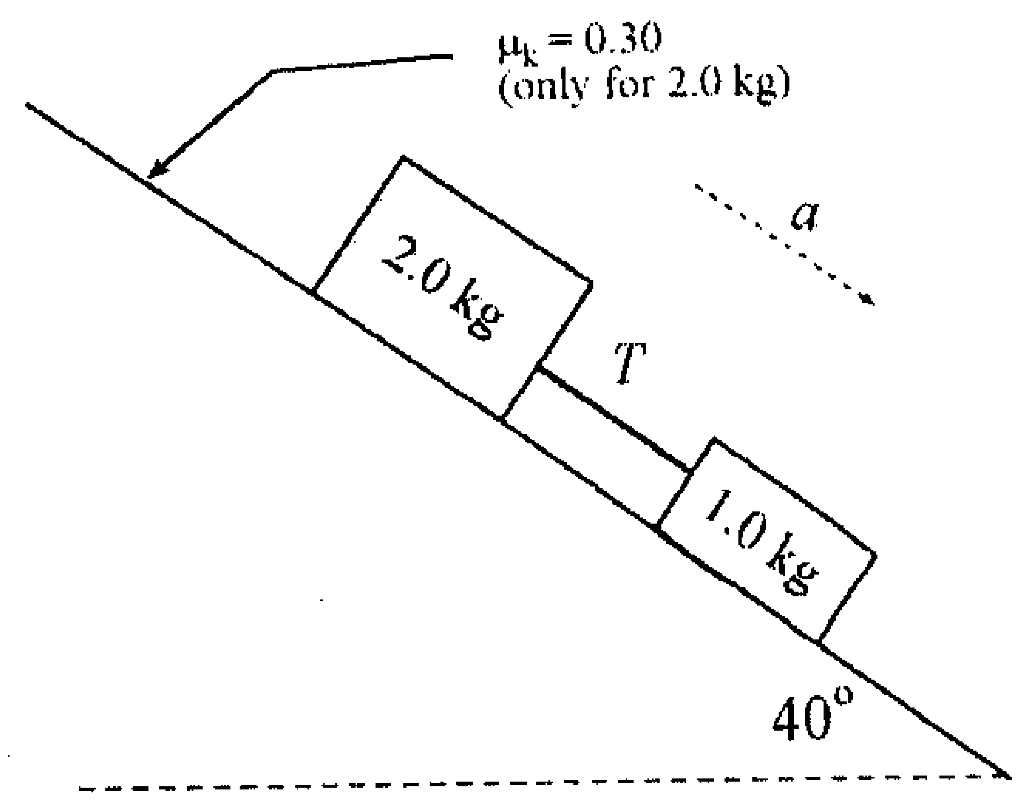
$T = ma$ (T & a same as in (a))

$m = T/a = (11.6\ N)/(4.0\frac{m}{s^2})$

$= 2.9\ kg$

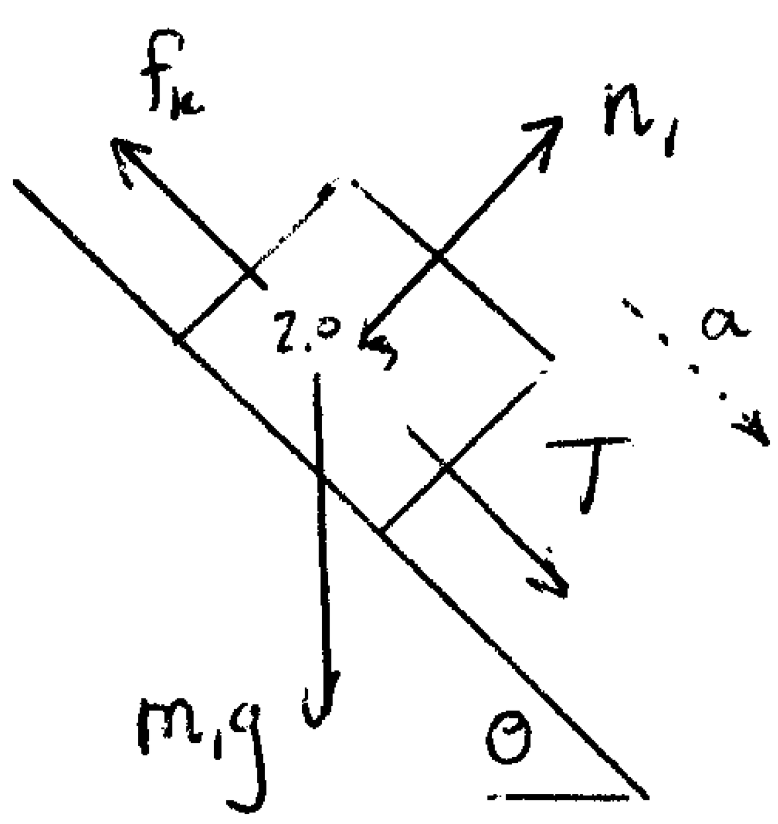


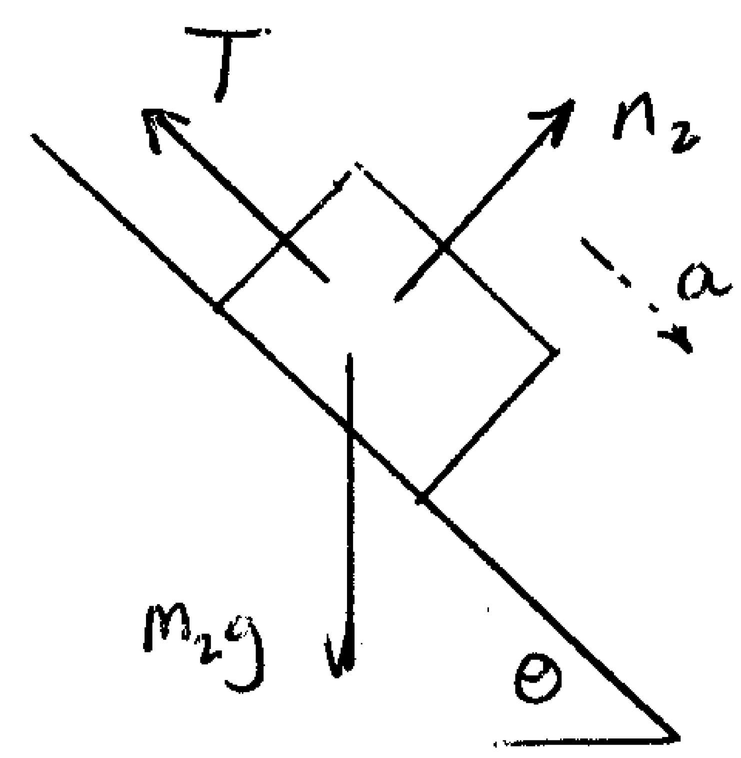
2. A 2.0 mass and a 1.0 kg mass are connected by a light string; they slide down a 40° slope with the 1.0 kg mass leading. There is a friction force with $\mu_k = 0.30$ impeding the motion of the 2.0 kg mass, but NO friction force on the lighter mass.



The masses have a common acceleration a down the slope, and there is a tension T in the string.

(a) Draw free-body diagrams (force diagrams) for each of two masses, showing all the forces acting on each mass. (6 pts)





$\theta = 40°$.
$m_1 = 2.0\,kg$
$m_2 = 1.0\,kg$

(b) Using your diagrams, write down expressions of Newton's second law ($F=ma$) for the motions of each of the masses down the slope. (You can leave a and T as unknown.) (8 pts)

m_1: $T + m_1 g \sin\theta - f_k = m_1 a$

m_2: $m_2 g \sin\theta - T = m_2 a$

w/ $f_k = \mu_k n_1 = \mu_k m_1 g \cos\theta$

so

$f_k = (0.30)(2.0\,kg)(9.8\,\frac{m}{s^2})\cos 40°$

$= 4.50\,N$

& $\theta = 40°$

(c) Solve the preceding equations for the acceleration a. (4 pts)

Adding the two equations cancels the T and gives:

$(m_1 + m_2) g \sin\theta - f_k = (m_1 + m_2) a$ w/ $f_k = 4.50\,N$

So:

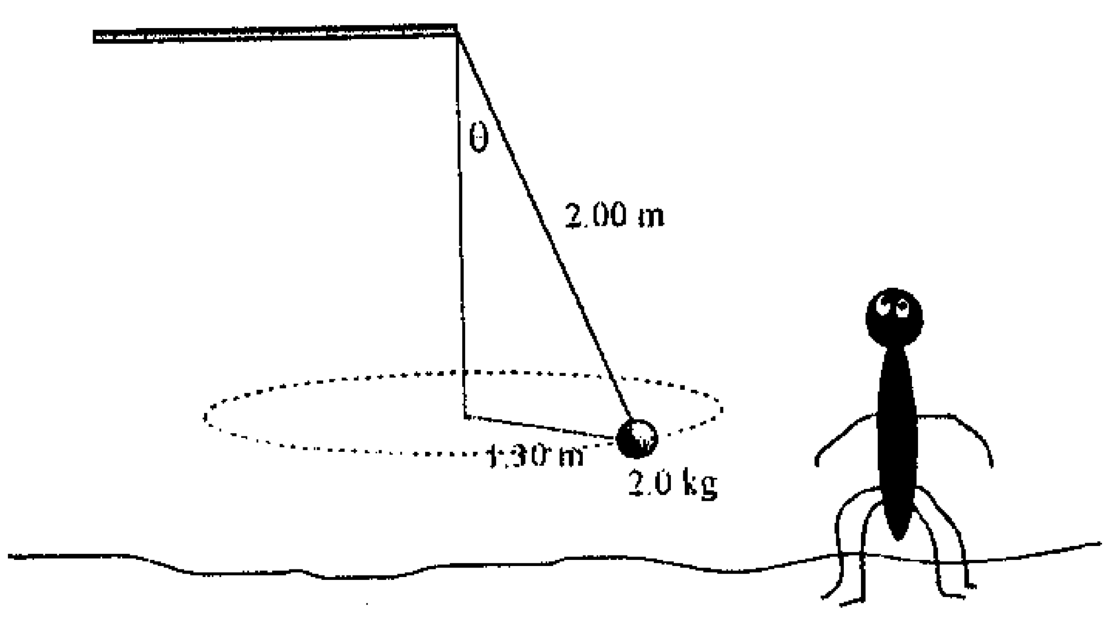
$$a = g\sin\theta - \frac{f_k}{(m_1+m_2)} = 4.80\,\frac{m}{s^2}$$

(d) Solve the equations to get the string tension T. (3 pts)

The second of the two equations gives

$$T = m_2 g \sin\theta - m_2 a$$
$$= m_2 (g\sin\theta - a) = 1.50\,N$$

3. Alien physicists on a strange planet suspend a 2.0 kg mass from a 2.0 m cable and set it in motion so that it moves in horizontal circle of radius 1.30 m. The physicists observe that the mass makes one revolution every 2.90 s.



(a) What is the angle θ which the string makes with the vertical? (1 pt)

$$\sin\theta = \frac{1.30\,m}{2.00\,m} = 0.650$$

$$\rightarrow \theta = 40.5^\circ$$

(b) What is the speed of the mass? (4 pts)

$T = 2.90\,s \quad r = 1.30\,m$

$$V = \frac{2\pi r}{T} = 2.82\,\tfrac{m}{s}$$

(c) What is the direction and magnitude of the acceleration of the mass? (4 pts)

$$a = a_c = \frac{v^2}{r} = \frac{(2.82\,\frac{m}{s})^2}{(1.30\,m)} = 6.10\,\tfrac{m}{s^2}$$

The acceleration always points towa d the center of the circle in which the mass moves.

(d) What is the tension in the cable? (5 pts)

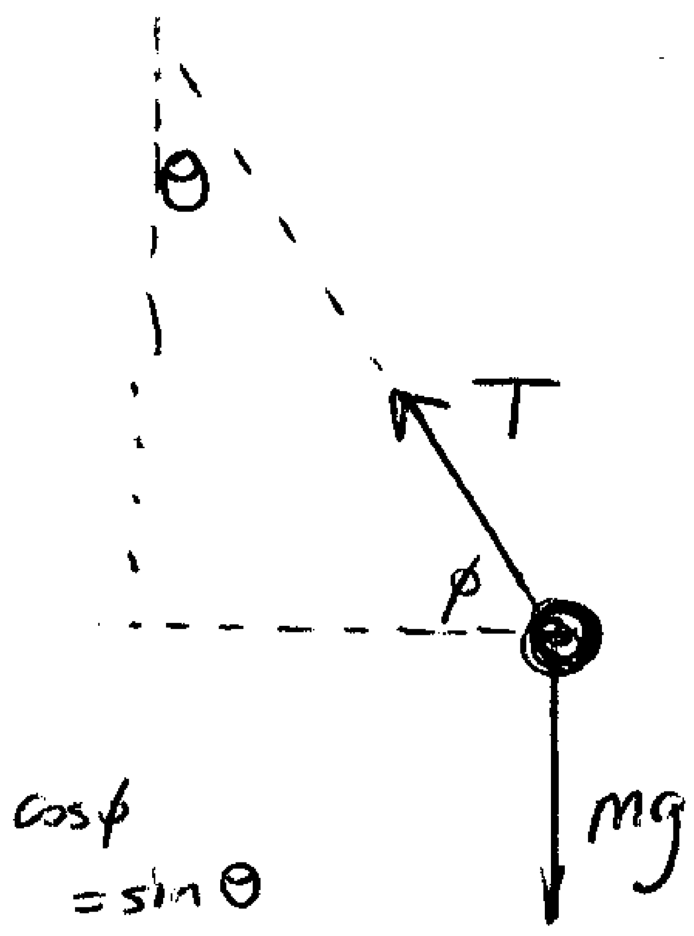
The net inward force on the mass is

$$F_c = ma_c = T\sin\theta .$$

This gives

$$T = \frac{ma_c}{\sin\theta} = \frac{(2.0\,kg)(6.10\,\frac{m}{s^2})}{\sin 40.5^\circ}$$

$$= 18.8\,N$$



(e) What is the value of g on this planet? (It is *not* $9.8\,\frac{m}{s^2}$!) (4 pts)

The vertical forces cancel, so

$$T\cos\theta = mg, \quad \text{or} \quad \frac{ma_c}{\sin\theta}\cos\theta = mg$$

$$\rightarrow g = a_c\frac{\cos\theta}{\sin\theta} = \frac{a_c}{\tan\theta} = 7.1\,\tfrac{m}{s^2}$$

4. Two cyclists of the same mass ride identical bicycles up a mountain. They start at the same time, and Sally rides straight up the mountain while Joe rides up a longer road that is less steep. Sally arrives at the top first. Assume that friction and wind resistance are both negligible. Which of the following statements is true? (4 pts)

A. The amount of work done by Sally is equal to the amount of work done by Joe, but the average power exerted by Sally is greater than that of Joe.
B. The amount of work done by Sally is greater than the amount of work done by Joe, and the average power exerted by Sally is also greater than that of Joe.
C. The amount of work done by Sally is equal to the amount of work done by Joe, and the average power exerted by Sally is also equal to that of Joe.
D. The average power exerted was the same for the two cyclists, but Sally did more work.

5. A person stands on the edge of a cliff and throws three different rocks off with the same speed. Rock A is thrown horizontally, Rock B is thrown outward and upward, and Rock C is thrown outward and downward. The ground on which the rocks land is very flat. Which rock hits the ground with higher speed? (4 pts)

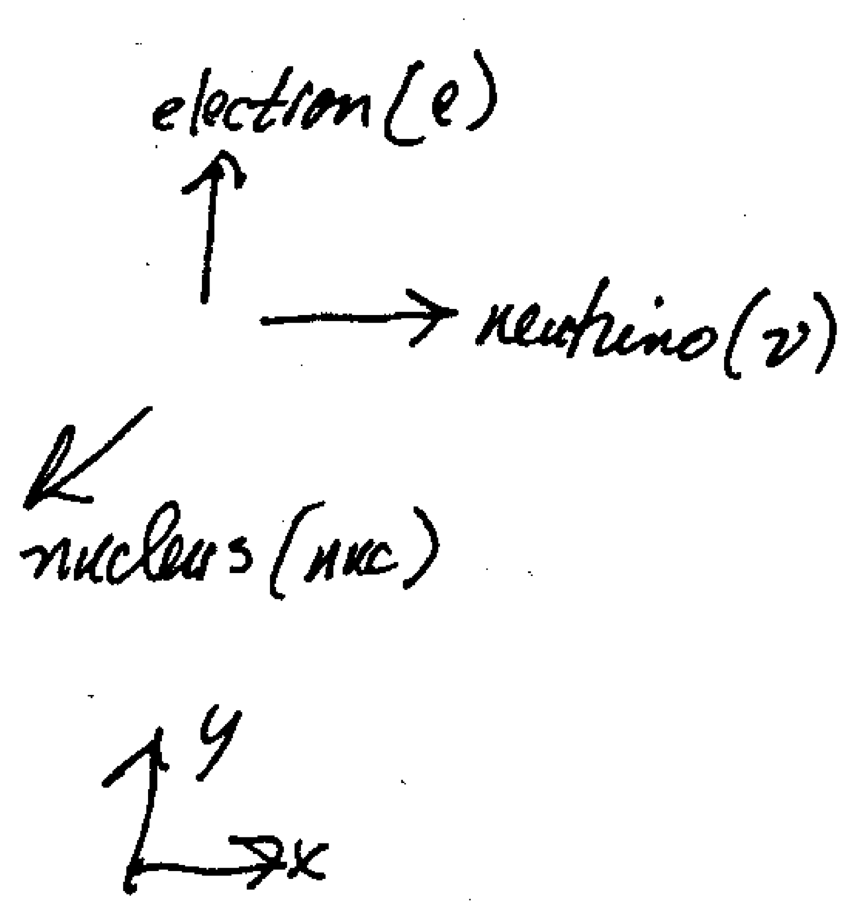
A. Rock A.
B. Rock B.
C. Rock C.
D. They all have the same speed.
E. None of the above.

6. Two objects sit on a horizontal frictionless surface; one of the objects has an ideal spring attached to its side. The first object is pushed so that it slides into the spring. At the instant that the spring reaches maximum compression, both objects are moving with the same speed. For the system consisting of the two objects and the spring, which quantities are conserved during this interaction? (4 pts)

A. Mechanical energy.
B. Momentum.
C. Mechanical energy and momentum.
D. Kinetic energy.
E. Kinetic energy and momentum.
F Mechanical energy, kinetic energy, and momentum.

7. The carbon isotope ^{14}C is used for carbon dating of archeological artifacts. ^{14}C (mass of 2.34×10^{-26} kg) decays by the process known as beta decay in which the nucleus emits an electron (the beta particle) and another subatomic particle called a neutrino. In one such decay, the ^{14}C nucleus is initially at rest and emits the electron and neutrino at right angles to each other. The electron (mass 9.11×10^{-31} kg) has a speed of 5.00×10^{6} m/s, and the neutrino has a momentum of 4.00×10^{-24} kg-m/s. What is the recoil speed of the nucleus? (10 pts)

$\Sigma \vec{F}_{ext} = 0$, so momentum is conserved



Momentum before decay = 0 = momentum after decay

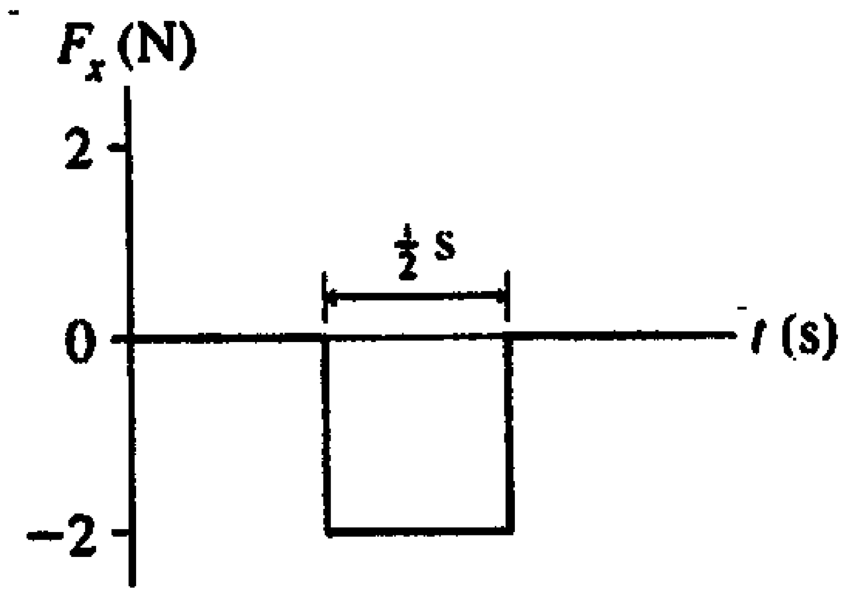
$$\vec{P}_e + \vec{P}_\nu + \vec{P}_{nuc} = 0$$

$$(9.11\times10^{-31}\,kg)(5.00\times10^{6}\,m/s\,\hat{j}) + 4.00\times10^{-24}\,kg\text{-}m/s\,\hat{i} + (2.34\times10^{-26}\,kg)\vec{V}_{nuc} = 0$$

$$\Rightarrow \vec{V}_{nuc} = (-171\hat{i} - 195\hat{j})\,m/s$$

$$V_{nuc} = \sqrt{(-171)^2 + (-195)^2}\,m/s = 259\,m/s$$

8. 10. A 2.0 kg object is moving in the positive-x direction with a speed of 0.2 m/s when it experiences the force shown in the figure. What is the object's velocity after the force ends? (6 pts)



$\vec{J} = \int \vec{F} dt = (-2N\hat{i})(\frac{1}{2}s) = -1.0N\text{-}s\,\hat{i}$

$\vec{J}_{net} = \Delta\vec{p} \Rightarrow \vec{p}_f = \vec{p}_i + \vec{J}$

$= (2.0kg)(0.2m/s\,\hat{i}) - 1.0N\text{-}s\,\hat{i}$

$= -0.6N\text{-}s\,\hat{i} = mV_f$

$\Rightarrow V_f = -0.3\,m/s\,\hat{i}$

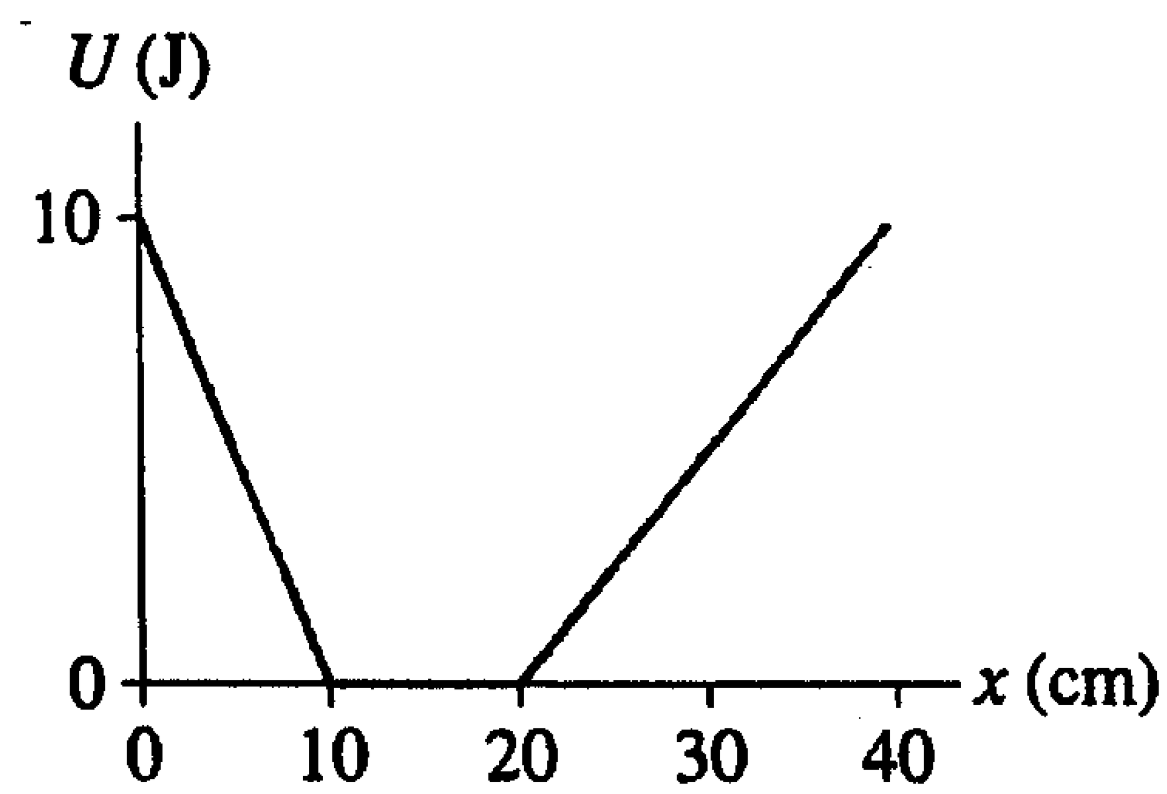
9. You and your bicycle have a combined mass of 80.0 kg. When you reach the base of a bridge, you are traveling along the road at 5.00 m/s. At the top of the bridge, you have climbed a vertical distance of 5.20 m and have slowed to a speed of 1.50 m/s. You can ignore friction and air resistance. How much work have you done with the force you apply to the pedals during your climb? (10 pts)

$W_{net} = \Delta K \Rightarrow W_{nc} = \Delta K + \Delta U$

$W_{nc} = W_{pedals} = [\frac{1}{2}(80.0kg)(1.50m/s)^2 - \frac{1}{2}(80.0kg)(5.00m/s)^2]$
$+ [(80.0kg)(9.80m/s^2)(5.20m) - (80.0kg)(9.80m/s^2)(0m)]$

3170 J

10. A particle of mass 0.10 kg moving along the x-axis has the potential energy shown in the accompanying graph. No other forces are present. The total mechanical energy of the particle is 5.0 J. (12 pts)



(a) Find the force on the particle when it is at x = 8 cm.

$F_x = -\frac{dU}{dx} = -\frac{-10J}{.10m}$ +100 N

Find the speed of the particle when it is at x = 8 cm.

Conservative force ⇒ mechanical energy is conserved

$E = 5.0J = K(x=8cm) + U(x=8cm) = K + 2.0J \Rightarrow K = 3.0J$

$3.0J = \frac{1}{2}(.10kg)v^2 \Rightarrow v = 7.7m/s$

Find the turning points of the particle's motion.

Turning points occur where $K = 0$ (i.e., $E = U$)

$U = 5.0J$ at $x = 5cm$ and $x = 30cm$