Name Key Seat Number ______________

PHYSICS 2110
Exam II – Fall 2010

INSTRUCTORS (Circle ONE):	CLASS MEETING TIME
Shriner	MWF 8:00 AM
Ayik	MWF 10:10 AM
Murdock	MWF 12:20 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. For problems involving free-fall, you may ignore air resistance.

PROBLEM	POINT VALUE	YOUR SCORE
1	4	
2	8	
3	14	
4	4	
5	4	
6	23	
7	10	
8	15	
9	8	
10	10	
TOTAL	100	

1. For each of the following quantities, identify whether it is a vector or a scalar. (4 pts)

(a) Momentum Vector

(b) The dot product of two vectors Scalar

(c) Kinetic energy Scalar

(d) Potential energy Scalar

2. Find the angle between these two vectors: (8 pts)

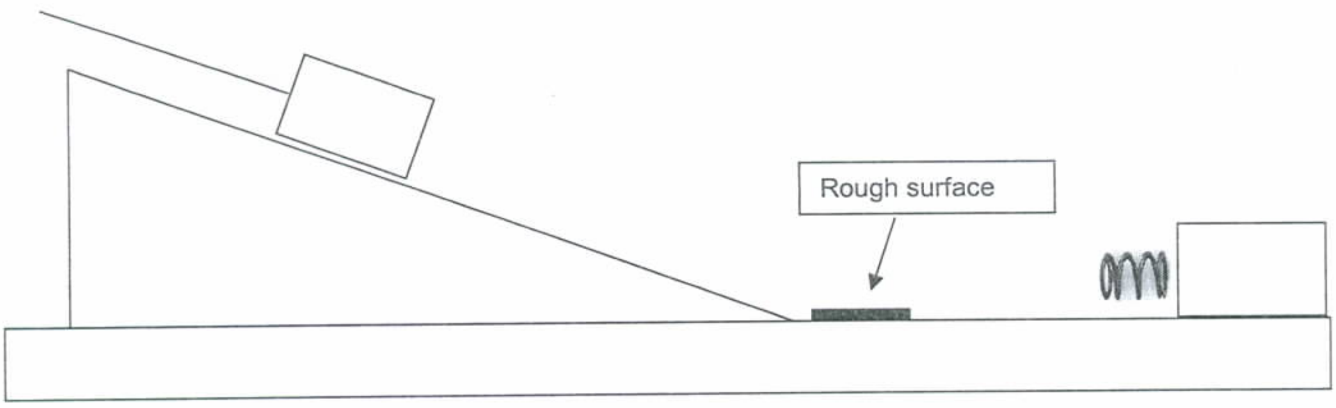
$$\vec{A} = 1.0\hat{\imath} - 2.0\hat{\jmath} - 3.6\hat{k}$$
$$\vec{B} = -4.5\hat{\imath} - 1.6\hat{\jmath} - 2.2\hat{k}$$

$$\vec{A}\cdot\vec{B} = AB\cos\theta$$

$$\cos\theta = \frac{\vec{A}\cdot\vec{B}}{AB} = \frac{[-4.5+3.2+(3.6)(2.2)]}{(1.0^2+2.0^2+3.6^2)^{1/2}(4.5^2+1.6^2+2.2^2)^{1/2}} = 0.30$$

$$\Rightarrow \theta = 73^\circ$$

3. You wish to lower a large crate down a ramp and have attached a rope to the crate to allow you to prevent it crashing to the bottom. Frictional forces along the ramp are sufficiently small in this case that they may be ignored. Just in case you and the rope don't do the job sufficiently well, a section of rough surface 3.0 meters long ($\mu_k = 0.20$) and a spring are located along the horizontal surface, as shown below, to stop runaway objects.



In the particular situation at hand, the crate has mass 122 kg, the ramp makes an angle of 20.5° with horizontal, the spring constant is 440. N/m, and the total distance traveled along the ramp is 5.2 m. Unfortunately, as the crate is part of the way down the ramp, the rope breaks, allowing the crate to slide the rest of the way and run into the spring. The maximum compression of the spring is 0.52 m. Another mechanism (not shown in the figure) then grabs and holds the crate in place to prevent further mayhem.

(a) How much work is done by gravity on the crate? (3 pts)

$$W_{grav} = -mg\Delta y = -(122\,kg)(9.80\,m/s^2)(-5.2\,m \sin 20.5^\circ) = 2200\,J$$

(b) How much work is done by the spring on the crate? (3 pts)

$$W_{spring} = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2 = 0 - \frac{1}{2}(440\,N/m)(.52\,m)^2 = -60.\,J$$

(c) How much work is done by friction on the crate? (3 pts)

$$W_{fric} = -\mu_k n \Delta x = -\mu_k mg\Delta x = -(0.20)(122\,kg)(9.8\,m/s^2)(3.0\,m) = -720\,J$$

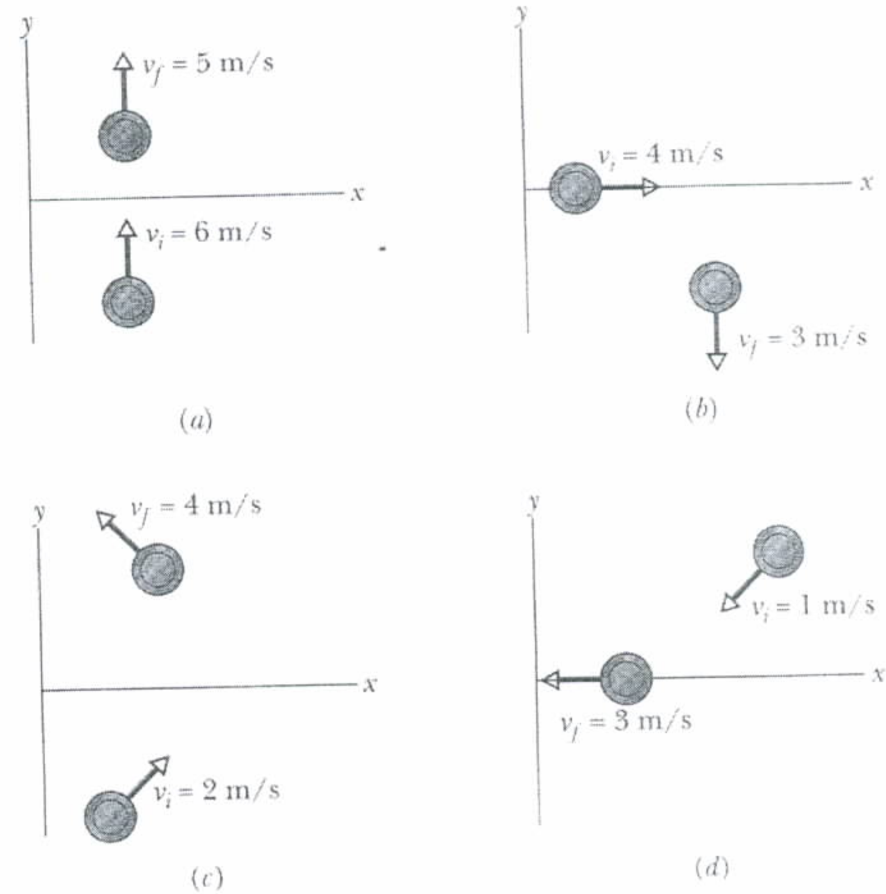
(d) How much work is done by the rope on the crate? (5 pts)

$$W_{net} = \Delta K \qquad \Delta K = K_{bottom} - K_{top} = 0\,J - 0\,J = 0\,J$$

$$W_{net} = W_{grav} + W_{spring} + W_{fric} + W_{rope} = 0$$

$$\Rightarrow W_{rope} = -~~1300~~\ 1400\,J$$

4. In four situations, a horizontal force is applied for a short time to change the velocity of a hockey puck sliding over frictionless ice. The overhead views shown in the figure indicate for each situation the puck's initial velocity $\vec{v}_i$ and its final velocity $\vec{v}_f$. Rank the situations according to the work done on the puck by the applied force in order from most positive to most negative. You must include an explanation of how you determined your ranking in order to receive any credit on this question. (4 pts)



$W_{net} = \Delta K = K_f - K_i$

(a) $\Delta K = \frac{1}{2}m(5)^2 - \frac{1}{2}m(6)^2 = -\frac{11}{2}m$

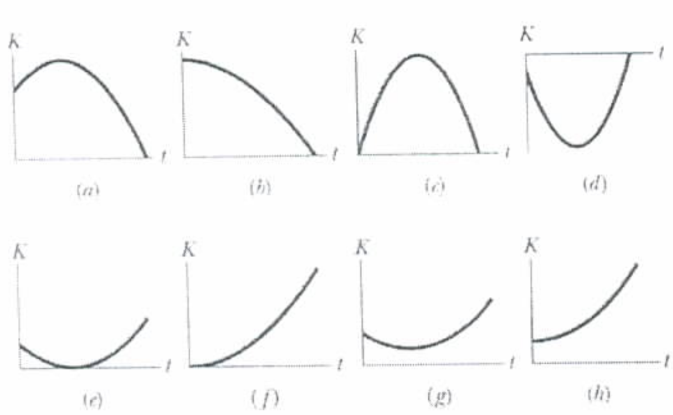
(b) $\Delta K = \frac{1}{2}m(3)^2 - \frac{1}{2}m(4)^2 = -\frac{7}{2}m$

(c) $\Delta K = \frac{1}{2}m(4)^2 - \frac{1}{2}m(2)^2 = 6m$

(d) $\Delta K = \frac{1}{2}m(3)^2 - \frac{1}{2}m(1)^2 = 4m$

So $W_c > W_d > W_b > W_a$

5. A large blob of slime is dropped or thrown from the edge of a cliff. Which of the graphs in the figure below could be a correct representation of the blob's kinetic energy as a function of time? (4 pts)



K always ≥ 0

If thrown upward, K will decrease until it reaches a minimum (could be zero), then will increase.

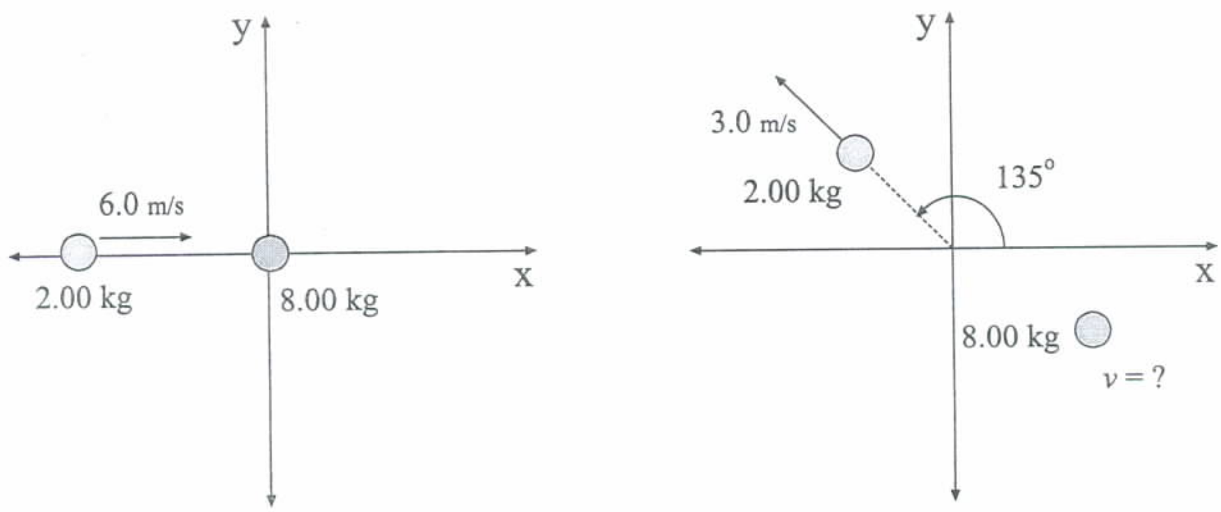
If dropped, K starts at zero and increases.

If thrown downward, K starts positive and always increases.

So e, f, g, h all are possible

6. A 2.00 kg and a 8.00 kg hockey puck move on a frictionless horizontal surface. The 8.00 kg mass is initially at rest at the origin and the 2.0 kg mass moves on the x axis in the +x direction at a speed of $6.00\frac{m}{s}$.

After the collision, the 2.00 kg mass recoils at $3.00\frac{m}{s}$ in a direction 135.0° from the +x axis.



(a) Find the x and y components of the final velocity of the 8.00 kg mass. (10 pts)

x-momentum is conserved:

$(2.00\,kg)(6.0\frac{m}{s}) = (2.00\,kg)(3.0\frac{m}{s})(-\cos 45°) + (8.00\,kg)V_x$

Solve for V_x, get $V_x = 2.03\frac{m}{s}$

y-momentum is conserved:

$0 = (2.00\,kg)(3.0\frac{m}{s})(\sin 45°) + (8.00\,kg)V_y$

Solve for V_y, $V_y = -0.53\frac{m}{s}$

(b) Find the final speed and direction of motion of the 8.00 kg mass. (4 pts)

$V = \sqrt{V_x^2 + V_y^2} = 2.10\frac{m}{s}$

Direction:

$\theta = \tan^{-1}\left(\frac{-0.53}{2.03}\right) = -14.6°$

(c) How much kinetic energy was lost in the collision? (4 pts)

$K_i = \frac{1}{2}(2.00\,kg)(6.0\frac{m}{s})^2 = 36.0\,J$

$K_f = \frac{1}{2}(2.00\,kg)(3.0\frac{m}{s})^2 + \frac{1}{2}(8.00\,kg)(2.10\frac{m}{s})^2 = 26.6\,J$

Loss is $K_i - K_f = 9.36\,J$

(d) What is the velocity of the center of mass of the system before and after the collision? (5 pts)

$\vec{V}_{cm} = \frac{\vec{P}}{M} = \frac{(2.00\,kg)(6.00\frac{m}{s})\hat{i}}{(10.0\,kg)} = 1.20\frac{m}{s}\hat{i}$

This is the V_{cm} both before and after the collision (by cons. of mom.)

7. (a) Circle the correct number or numbers: In order for mechanical energy to be conserved in a process, it is *necessary* that (3 pts)

(i) the process is a collision.

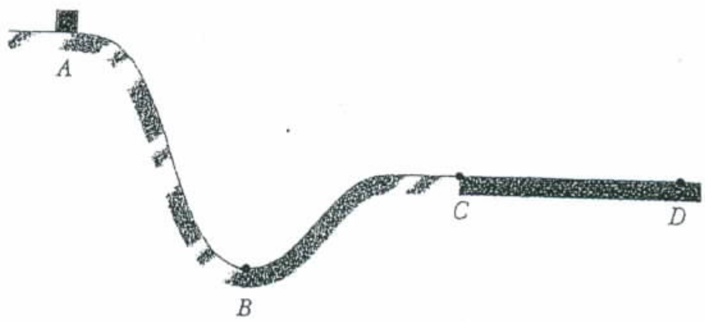
(ii) there are only conservative forces acting.

(iii) there are non-conservative forces acting.

(iv) only conservative forces are doing work during the process.

(v) only non-conservative forces are doing work during the process.

(b) A block slides from A to C along a frictionless ramp, and then passes through a horizontal region CD where a frictional force acts on it. (4 pts)



(i) Is the kinetic energy of the block increasing, decreasing, or constant in region AB?

increasing

(ii) Is the kinetic energy of the block increasing, decreasing, or constant in region CD?

decreasing

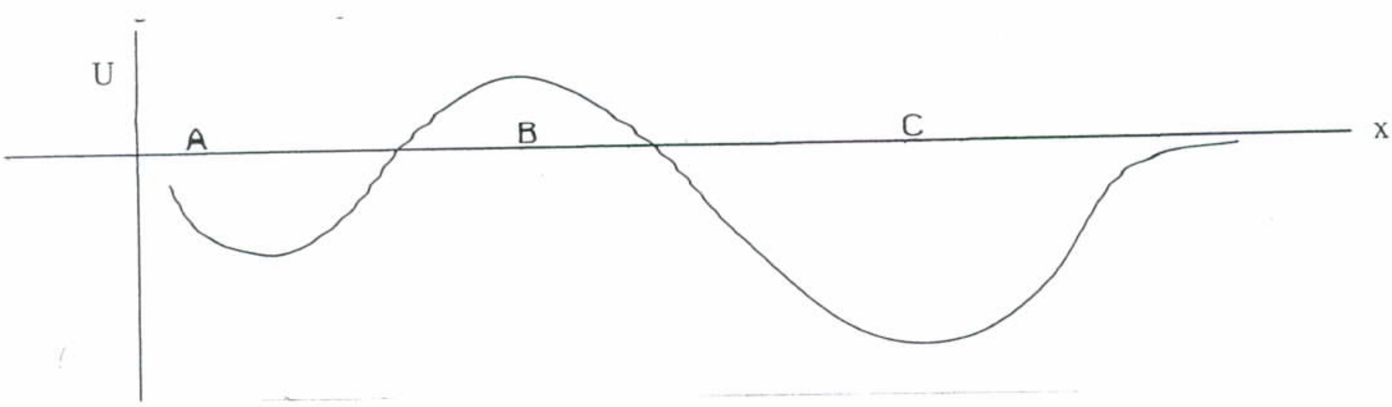
(iii) Is the mechanical energy of the block increasing, decreasing, or constant in region AB?

constant

(iv) Is the mechanical energy of the block increasing, decreasing, or constant in region CD?

decreasing

(c) The figure shows a graph of potential energy vs. position for a particle moving along a straight line. Three points (A, B, C) are marked along the x-axis.



Which of the following statement is true for this potential energy? (3 pts)

(i) This could not represent an actual physical situation because the potential energy is negative at some points.

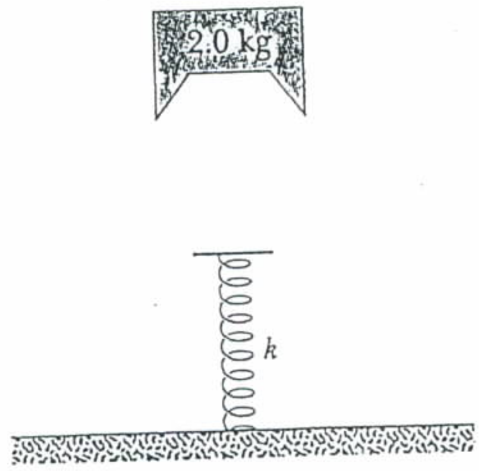
(ii) There are three positions which are points of stable equilibrium.

(iii) The magnitude of the force on the particle is larger at point A than at point C.

(iv) For a given value of x, the particle can have a total energy that lies either above or below the value given by the curve at that point.

(v) The magnitude of the force on the particle is greatest near point B.

8. A $M = 2.0$ kg block is dropped from rest onto a vertical spring. The velocity of the block just before touching the platform attached to the spring is v = 5.0 m/s, and the maximum compression of the spring is D = 0.50 m. Ignore friction, the mass of the spring and the mass of the platform.



(a) Calculate the spring constant k. (9 pts)

$$\frac{1}{2}mv^2 + mg\,D = \frac{1}{2}kD^2$$

$$\frac{1}{2}\times 2\times 25 + 2\times 9.8\times 0.5 = \frac{1}{2}k\,0.25$$

$$(25+9.8)\frac{2}{0.25} = k$$

$$k = 278.4 = \boxed{2.8\times 10^2\ N/m}$$

(b) On the rebound, calculate the maximum height that the block rises above the equilibrium level of the platform. (6 pts)

$$mg\,H = \frac{1}{2}mv^2$$

$$H = \frac{v^2}{2g}$$

$$= \frac{25}{2\times 9.8} = \boxed{1.3\,m}$$

9. A $m = 1.2$ kg ball drops vertically onto the floor, striking with a speed of $v_0 = 25.m/s$. It rebounds with an initial speed of $v = 10.m/s$. The ball is in contact with the floor for $\Delta t = 0.02s$.

(a) What impulse acts on the ball during the contact? (4 pts)

$$J = mv - mv_0 = 1.2\times 10 - 1.2\times(-25)$$

$$J = 12 + 30 = \boxed{42.\ N\cdot s}$$

(b) Calculate the magnitude F of the average force on the floor from the ball. (4 pts)

$$F = \frac{J}{\Delta t} = \frac{42}{0.02} = 2100 = \boxed{2.1\times 10^3\,N}$$

10. A particle moving along the x axis experiences a force given by

$$F_x(x) = -\frac{4.00\ N \cdot m^2}{x^2}$$

a) What is the work done on the particle as it moves from x=1.0 m to x=3.0 m ? (8 pts)

$$W = \int_{x_1}^{x_2} F_x\,dx = -(4.00\ N\cdot m^2)\int_{(1.0m)}^{(3.0m)} \frac{1}{x^2}\,dx$$

$$= (4.00\ N\cdot m^2)\left(\frac{1}{x}\right)\Big|_{(1.0m)}^{(3.0m)} = (4.00\ N\cdot m^2)\left(\frac{1}{3.00m} - \frac{1}{1.00m}\right)$$

$$= \boxed{-2.67\ J}$$

b) What is the change in potential energy of the particle for this same displacement? (2 pts)

$$\Delta U = -W = \boxed{2.67\ J}$$