PHYSICS 2110 – EXAM #2
March 22, 2012

SEAT NO.______________ **NAME (PRINT)**______________________

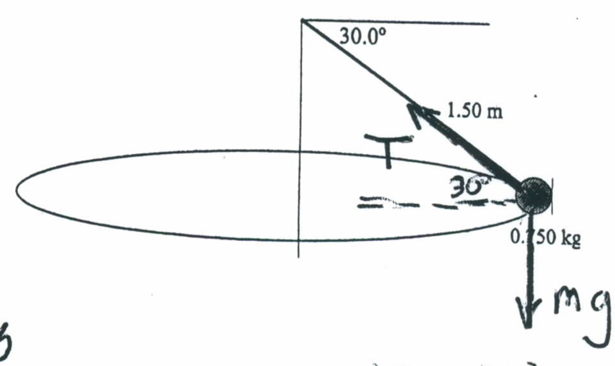
YOU MUST SHOW YOUR WORK **AND** EXPLAIN YOUR REASONING TO RECEIVE CREDIT. ALL CELL PHONES AND OTHER COMMUNICATION DEVICES MUST BE TURNED OFF AND STORED OUT OF SIGHT. NO EXTRA PAPERS ARE ALLOWED OTHER THAN THE PROVIDED FORMULA SHEET. STANDARD SCIENTIFIC CALCULATORS MAY BE USED.

Free-body diagrams are ***required*** for problems involving forces.

INSTRUCTORS (Circle ONE):	CLASS MEETING TIME
Shriner	8:00 AM
Ayik	10:10 AM, 11:15 AM
Murdock	12:20 PM

PROBLEM	POINT VALUE	YOUR SCORE
1	10	
2	15	
3	12	
4	15	
5	15	
6	8	
7	5	
8	10	
9	10	
TOTAL	100	

1. A 0.750-kg mass is attached to the end of a string of length 1.50 m, with the other end attached to some fixed point. The mass is set into motion such that it moves in a horizontal circle (at constant speed) with the string making an angle of 30.0° with the horizontal.



a) What is the tension in the string? (4)

Forces on the mass are as shown.
Vertical forces sum to zero, giving

$T\sin 30° - mg = 0 \longrightarrow T = \frac{mg}{\sin 30} = \frac{(0.750\text{ kg})(9.80\frac{m}{s^2})}{\sin 30°}$

$= 14.7\text{ N}$

b) What is the speed of the mass? (6)

Radius of the circle is $r = L\cos 30° = (1.50\text{m})\cos 30°$
$= 1.30\text{ m}$

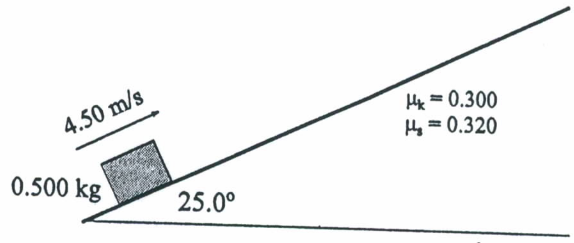
Inward force equals $\frac{mv^2}{r}$ hence

$T\cos 30° = \frac{mv^2}{r} \qquad v^2 = \frac{rT\cos 30°}{m} = \frac{(1.30\text{m})(14.7\text{N})\cos 30°}{(0.750\text{ kg})}$

$= 22.0\ \frac{m^2}{s^2}$

$v = 4.70\ \frac{m}{s}$

2. A 0.500-kg mass is projected up a long 25.0° inclined plane with an initial speed of 4.50 m/s. The block/surface have coefficient of kinetic friction 0.300 and coefficient of static friction 0.320.

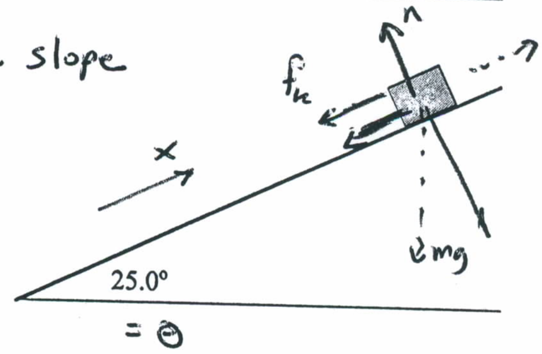


a) What is the magnitude of the acceleration of the block as it moves upward? (5)

On the way up, friction acts down the slope

As $f_k = \mu_k n = \mu_k mg\cos\theta$ then

with x up the slope),



$$F_{x\,net} = -mg\sin\theta - \mu_k mg\cos\theta$$
$$= ma$$

$$\rightarrow \quad a = -g\sin\theta - \mu_k g\cos\theta$$
$$= -(9.8\tfrac{m}{s^2})\sin 25° - (0.300)(9.8\tfrac{m}{s^2})\cos 25° = \boxed{-6.81\ \tfrac{m}{s^2}}$$

b) How far up the slope does the block go before it comes to rest? (3)

With $v_0 = +4.50\ \tfrac{m}{s}$ and $a_x = -6.81\ \tfrac{m}{s^2}$ use

$v^2 = v_0^2 + 2a_x x$ w/ $v = 0$

$$\rightarrow \quad x = \frac{-v_0^2}{2a_x} = \frac{-(4.5\tfrac{m}{s})^2}{2(-6.81\tfrac{m}{s^2})} = \boxed{1.49\ m}$$

c) How long does it take the block to slide back down the slope and return to the starting point? (7)

On the way back down, force of friction points up the slope hence net force is (x still up slope)

$$F_x = -mg\sin\theta + \mu_k mg\cos\theta = ma_x$$

$$a_x = g(-\sin\theta + \mu_k\cos\theta) = -1.48\ \tfrac{m}{s^2}$$

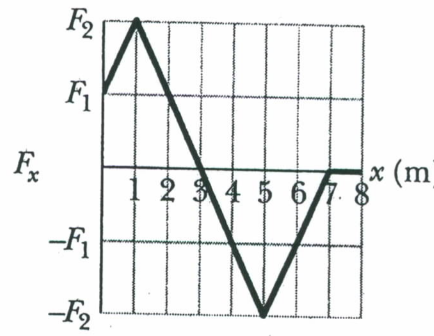
Starting from rest at (now) $x = 1.49\,m$, the time to get to $x = 0$ is

$$x = 0 = x_0 + \tfrac{1}{2}a_x t^2 = 1.49\,m + \tfrac{1}{2}(-1.48\ \tfrac{m}{s^2})t^2$$

Solve for t, get

$$t = \sqrt{\frac{2(1.49\,m)}{(1.48\tfrac{m}{s^2})}} = \boxed{1.42\,s}$$

3a. Figure shows x component of the net force F_x that acts on a particle, which can travel along x-axis starting from rest at $x = 0$.



i) What is the coordinate of the particle when it has largest kinetic energy? (2 pts)

$x = 3.0$ m

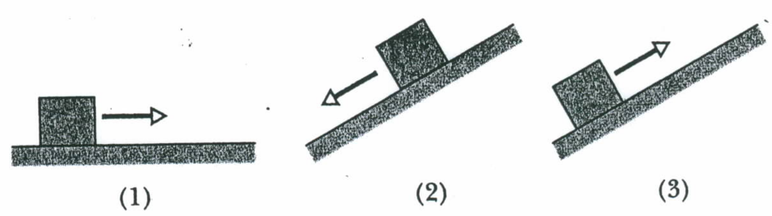
(ii) What is the coordinate of the particle when it has zero speed? (2 pts)

$x = 6.0$ m

3b. Rank the following velocities according to the kinetic energy a particle will have with each velocity, greatest first. (i) $\vec{v} = +4\vec{i} + 3\vec{j}$, (ii) $\vec{v} = -4\vec{i} + 4\vec{j}$, (iii) $\vec{v} = -3\vec{i} + 2\vec{j}$, (iv) $\vec{v} = 3\vec{i} - 5\vec{j}$ (2 pts)

(iv), (ii), (i), (iii)

3c. Figure shows three situations involving a rough plane and a block sliding along the plane. The block begins with the same speed in all three situations and slides until kinetic frictional force is stopped it.



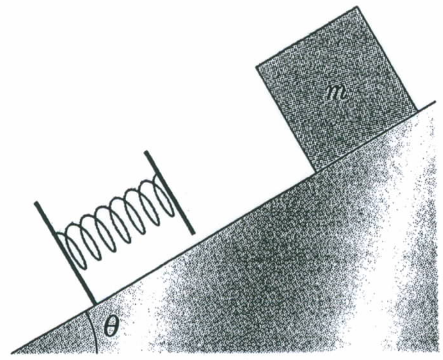
(i) Rank situations according to the magnitude of the work done by friction, greatest first. (4 pts)

2, 1, 3

(ii) Rank the situation according to the net work done on the block during the sliding, the greatest first. (2 pts)

all the same

4. A block of mass $m = 5.00$ kg is released from rest on a frictionless incline of angle $\theta = 30^0$. The block collides with a massless platform that is attached to the free end of a spring on the incline, as shown. The maximum compression of the spring after the collision is $d = 0.20$ m. The spring constant is $k = 800$ N/m.



(a) Calculate the speed v of the block just before it touches the platform. (8 pts)

$$\frac{1}{2}k d^2 = \frac{1}{2}m V_0^2 + mgh_0$$

$$\frac{1}{2}5 \times V_0^2 = \frac{1}{2}800 \times (0.2)^2 - 5 \times 9.8 \times 0.1$$

$$\frac{1}{2}5 \times V_0^2 = 16.0 - 4.9 = 11.1 \rightarrow \boxed{V_0 = 2.11 \text{ m/s}}$$

(b) During the rebound, starting from the position of maximum compression, how far does the block move up the incline before coming to a momentary stop? (7 pts)

$$\frac{1}{2}k d_0^2 = mgh$$

$$16 = 5 \times 9.8\, h$$

$$h = \frac{16}{5 \times 9.8} = 0.326$$

$$d = \frac{h}{\sin\theta} = \boxed{0.65 \text{ m}}$$

5. An object of mass $m = 4.0$ kg moves from rest at an initial position $\vec{r}_1 = (3.0\vec{i} - 2.0\vec{j} + 5.0\vec{k})$ m to a final position $\vec{r}_2 = (-5.0\vec{i} + 4.0\vec{j} + 7.0\vec{k})$ m under the action of a constant force $\vec{F} = (3.0\vec{i} + 7.0\vec{j} + 7.0\vec{k})$ N over a time interval of $\Delta t = 5.0$ s.

(a) Calculate the work done on the object by the force $\vec{F}$ during time interval $\Delta t = 5.0$ s. (8 pts)

$$\Delta\vec{r} = \vec{r}_2 - \vec{r}_1 = -8\vec{i} + 6\vec{j} + 2\vec{k}$$

$$W = \vec{F}\cdot\Delta\vec{r} = -24 + 42 + 14 = \boxed{32.0 \text{ J}}$$

(b) What is the speed of the particle at the position $\vec{r}_2$? (4 pts)

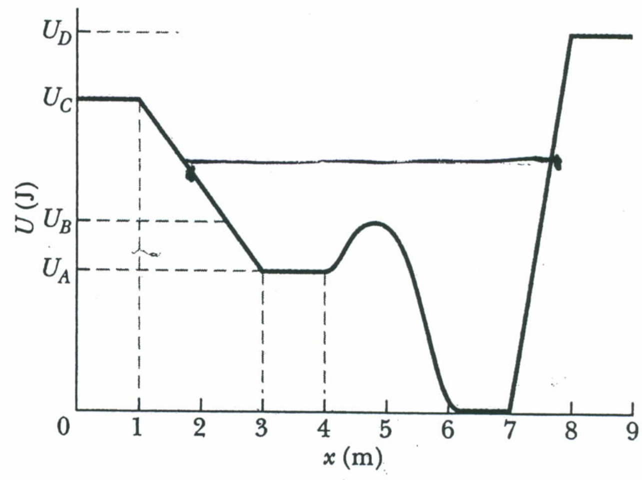
$$\frac{1}{2}m V_2^2 = 32 \qquad V_2^2 = \frac{2}{4} \times 32 = 16$$

$$\boxed{V_2 = 4.0 \text{ m/s}}$$

(c) What is the average power supplied by the force during time interval $\Delta t = 5.0$ s. (3 pts)

$$P_{av} = \frac{32.0}{5} = \boxed{6.4 \text{ W}}$$

6. Figure shows a plot of potential energy U versus position x of a 2.0 kg particle that can move along x-axis. The graph has the these values: $U_A = 9.0\,\text{J}$, $U_C = 20.0\,\text{J}$ and $U_D = 24.0\,\text{J}$. The particle is released at position $x = 5.0\,\text{m}$ with kinetic energy $4.0\,\text{J}$ where the potential energy is $U_B = 12.0\,\text{J}$,



(a) What is the kinetic energy of the particle at $x = 3.5\,\text{m}$? (3 pts)

$12 + 4 = 9 + K$

$K = 16 - 9 = \boxed{7.0\,\text{J}}$

(b) What is the maximum speed of the particle, and in which interval does it occur? (3 pts)

$12 + 4 = \frac{1}{2} m v^2 = \frac{1}{2} \times 2 \times v^2$

$v^2 = 16 \rightarrow \boxed{v = 4.0\,\text{m/s}}$

$\boxed{\text{interval } (6-7)\,\text{m}}$

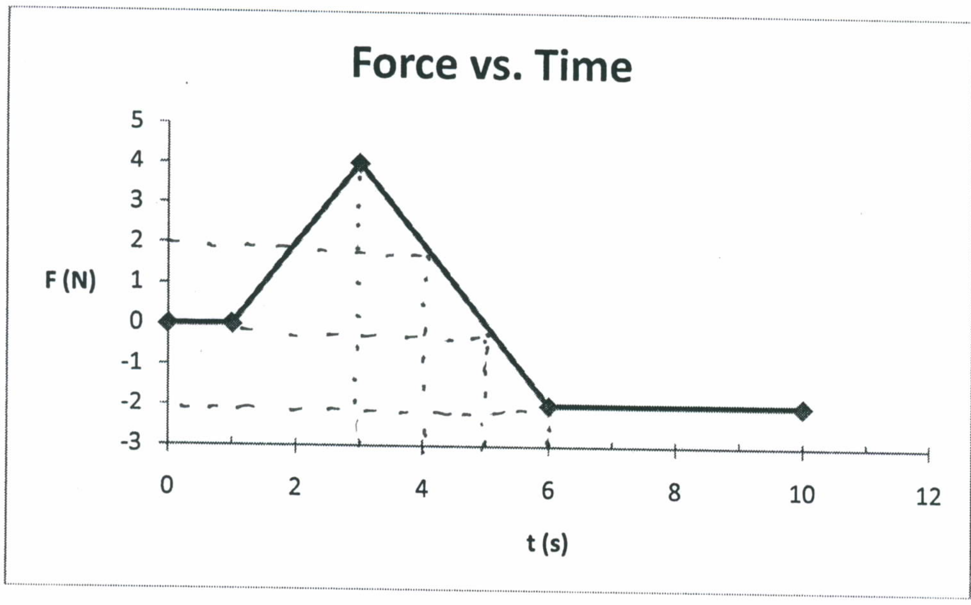
(c) What are the positions of left and right turning points? (2 pts)

(2, 8) m

7. State the physical conditions which must be satisfied for the momentum of a system of particles to be conserved. (5 pts)

The momentum of a system is conserved when the net, external force on the system is zero.

8. A particle with mass m = 0.21 kg starts at rest at the point (x,y,z) = (1.0 m, - 1.3 m, 1.4m). A force which has only an x-component is applied to the particle starting at t = 1.0 s (no other forces are present). The behavior of the force is shown in the graph below



a) Find the impulse of this force between t = 0 s and t = 4 s. (3 pts)

$$\vec{J} = \int_{0s}^{4s} F_x \hat{i}\, dt$$ Integral is area under curve

$$\vec{J} = \left[(0N)(1s) + \tfrac{1}{2}(4N)(2s) + \tfrac{1}{2}(2N)(1s) + (2N)(1s)\right]\hat{i} = 7N\text{-}s\,\hat{i}$$

b) Find the speed of the particle at t = 4 s. (4 pts)

$$\vec{J}_{net} = \Delta\vec{p} = m\vec{v}_f - m\vec{v}_i \qquad \vec{v}_i = 0$$

So $7N\text{-}s\,\hat{i} = (0.21\,kg)\vec{v}_f \Rightarrow \vec{v}_f = 33\,m/s\,\hat{i}$

$$\Rightarrow v_f = 33\,m/s$$

c) At what time will this particle reach a turning point? (3 pts)

Turning point when $K = 0 \Rightarrow v = 0 \Rightarrow \vec{P}_f = 0 \Rightarrow \vec{J}_{net} = 0$

$$\vec{J}_{net} = \left[\tfrac{1}{2}(4N)(2s) + \tfrac{1}{2}(4N)(2s) + \tfrac{1}{2}(-2N)(1s) + (-2N)(t - 6s)\right]\hat{i} = 0$$

$$\Rightarrow t = 9.5s$$

9. A 2.1 kg particle has initial velocity $\vec{v}_{1i} = 3.5\hat{\imath}$ m/s. It strikes a 1.4 kg particle at rest. After the collision, the 2.1 kg particle has a velocity $(\vec{v}_{1f} = 1.5\hat{\imath} - 1.2\hat{\jmath})$ m/s.

a) What is the velocity of the 1.4-kg particle after the collision? (7 pts)

Momentum is conserved in the colliseon : $\vec{P_i} = \vec{P_f}$

$$(2.1\,kg)(3.5\hat{i}\ m/s) + (1.4\,kg)(0\,m/s\ \hat{i}) = (2.1\,kg)(1.5\hat{i} - 1.2\hat{j})\,m/s + (1.4\,kg)\,\vec{v}_{2f}$$

$$\Rightarrow \vec{V}_{2f} = [3.0\hat{i} + 1.8\hat{j}]\ m/s$$

b) Determine if this collision is elastic or inelastic. (3 pts)

For collision to be elastic requires $K_i = K_f$

$$K_i = \frac{1}{2}(2.1\,kg)(3.5\,m/s)^2 = 12.9\ J$$

$$K_f = \frac{1}{2}(2.1\,kg)\left[(1.5\,m/s)^2 + (1.2\,m/s)^2\right] + \frac{1}{2}(1.4\,kg)\left[(3.0\,m/s)^2 + (1.8\,m/s)^2\right]$$

$$= 12.4\ J$$

$K_i \neq K_f \Rightarrow$ inelastic