

EXAM III Physics 218

Name.....Section Number.....

USEFUL INFORMATION

$$\text{If } f(x) = kx^n \quad \frac{df}{dx} = nkx^{n-1}$$

$$\text{If } f(x) = kx^n \quad \int_A^B f(x)dx = \frac{1}{n+1}k(B^{n+1} - A^{n+1})$$

$$\int_{\vec{r}_1}^{\vec{r}_2} \vec{F}_{tot} \cdot d\vec{r} = \frac{1}{2}mv^2(\vec{r}_2) - \frac{1}{2}mv^2(\vec{r}_1)$$

If  $\vec{F}$  is conservative:

$$\int_{\vec{r}_1}^{\vec{r}_2} \vec{F} \cdot d\vec{r} = -[U(\vec{r}_2) - U(\vec{r}_1)]$$

and

$$F_x = -\frac{\partial U}{\partial x} \quad F_y = -\frac{\partial U}{\partial y}$$

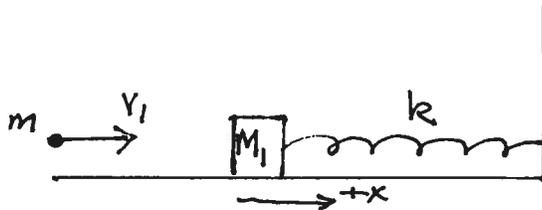
$$\vec{L} = \vec{r} \times \vec{p} \quad \vec{\tau} = \vec{r} \times \vec{F} \quad I = \sum m_i r_i^2$$

DO NOT WASTE TIME DOING ARITHMETIC

- 1. \_\_\_\_\_
- 2. \_\_\_\_\_
- 3. \_\_\_\_\_
- 4a. \_\_\_\_\_
- 4b. \_\_\_\_\_

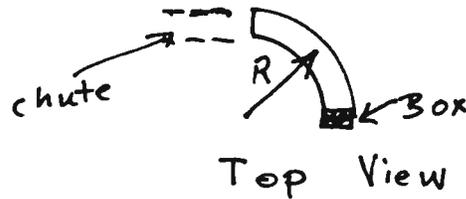
1. (25 points) Derive the expressions for the  $\vec{i}_r$  and  $\vec{i}_\theta$  components of the velocity and acceleration.

2. (25 points) A block of mass  $M_1$  is at rest on a frictionless table. It is attached to a spring with known spring constant  $k$ . It is struck by an object of mass  $m$  traveling horizontally in the  $+x$  direction with velocity  $v_1$ . (Neglect gravity.)



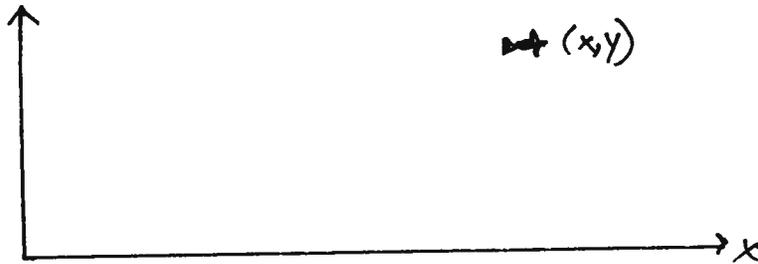
- a. If the incoming object bounces off the block and goes in the  $-x$  direction find the maximum amount the spring will be compressed assuming there is no loss of kinetic energy (perfectly elastic) when the object bounces off the block. Also assume that the collision takes place in a very short time so that during the collision there is not enough time for the spring to be compressed. (NO ALGEBRA PLEASE! Stop when you have as many equations as needed to solve for the maximum amount the spring is compressed.)
- b. If the incoming object sticks (perfectly inelastic) to the block find the maximum amount the spring will be compressed. Here assume again that the collision takes place in a very short time so that during the collision there is not enough time for the spring to be compressed.

3. (25 points) In a manufacturing facility boxes are placed, at rest, on a conveyor belt which carries them around a circular path of radius  $R$ . After traveling a quarter of a circle,  $\frac{\pi}{2}$  radians, they slide down a chute. The conveyor belt starts at rest and when a box is placed on it a motor supplies a torque so that the belt has an angular acceleration  $\alpha = c_1 t$ .



- a. What will be the velocity of the box when it reaches the chute?
- b. What will be the force exerted by the belt on the box as a function of time, starting when the box is placed on the belt, assuming the box does not slip?
- c. If the coefficient of friction between the box and the belt is  $\mu$ , what is the largest value that  $c_1$  can have for this device to work? (No algebra please.)

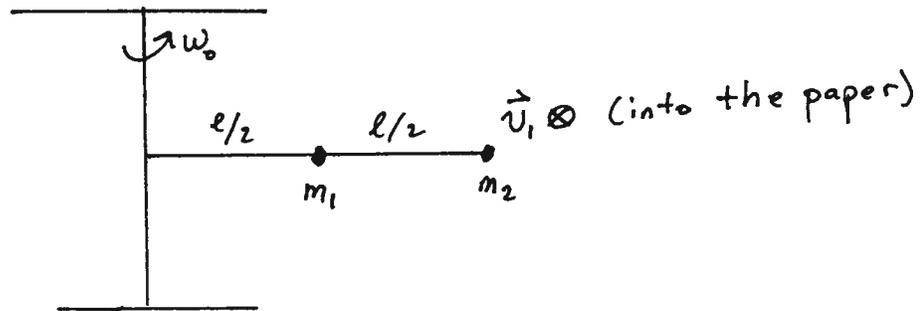
4. (Part 1)(10 points) A very small plane of mass  $m$  is flying horizontally with a constant velocity of magnitude  $v_1$ . Given the origin shown in the picture below



- a. What is the plane's angular momentum about the origin when it is at the point  $(x, y)$  as shown?

- b. What is the torque,  $\vec{\tau}_g$ , exerted on the plane by gravity about the origin when the plane is at the point  $(x, y)$ ?

4. (Part 2) (15 points) A vertical axle is free to rotate. A massless rod is attached to the axle, as shown, and there are two masses,  $m_1$  and  $m_2$  attached to the rod. The axle is given an angular velocity  $\omega_0$ . Some internal spring-like force ejects mass  $m_2$  so that it leaves the rod perpendicular to the rod, horizontally, with velocity of magnitude  $v_1$ . Neglect gravity.



- a. What will be the angular velocity of the rod after the mass is ejected?
- b. What would the angular momentum of the rod be if instead of being massless it had a moment of inertia  $I$ , about the axle?