Physics 218: Mechanics Exam 3, 20 November 2007

Print your name **neatly**:

Last name: | | | | | | | | | | | | | | | | | |

First name: | | | | | | | | | | | | | | | | | |

Sign your name: ______________________________

Your instructor: ____________________ Your section: ______________

Please fill in your Student ID number (UIN): _ _ _ – _ _ – _ _ _ _

IMPORTANT

Read these directions carefully:

- There are 4 problems totalling 100 points. Check your exam to make sure you have all the pages. Work each problem on the page the problem is on. You may use the back. If you need extra pages, I have plenty up front.
- Each problem with its associated figure is self explanatory. If you *must* ask a question, then come to the front, being as discrete as possible so as not to disturb others.
- **Indicate what you are doing!** We cannot give full credit for merely writing down the answer. **Neatness counts!** I will give generous partial credit **if** I can tell that you are on the right track. This means you must be *neat* and organized.
- There is potentially useful information on the last page. Do not waste time on complex algebra or arithmetic.

Grading:

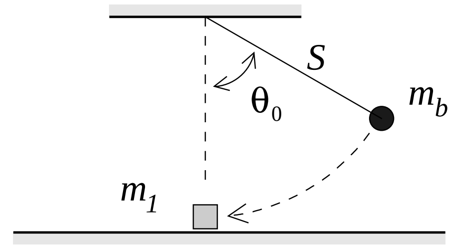
Problem 1	Problem 2	Problem 3	Problem 4	**TOTAL**

1a. (20 points) Derive the expressions for the $\vec{i}_r$ and $\vec{i}_\theta$ components of the velocity and acceleration.

1b. (5 points) An object of mass m is moving in the x, y plane. Its position varies with time so that a vector from the origin to the object has a length given by kt^2 where k is a known constant and t is the time in seconds. The vector points at an angle with the x axis that varies according to bt^2 where b is a known constant.

What is the force, as a function of time, acting on the object?

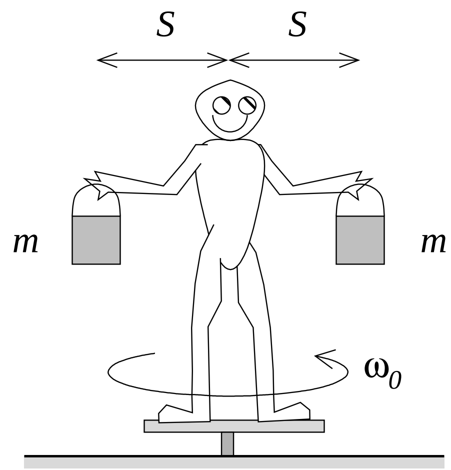
2. (25 points) In an experiment a small ball with mass m_b hangs from a massless rod of length S. It starts at rest in the position shown, swings down and strikes a small object, mass m_1, which is at rest on a frictionless surface.



a. If the object sticks to the ball, how high will the ball go after striking the object?

b. If instead of sticking to the ball the object bounces off it, so that the collision is perfectly elastic, write down the equations that could be solved for how high will the ball go. **DO NOT SOLVE THE EQUATIONS**

3. (25 points) A man stands on a massless platform that is free to rotate in the horizontal plane. He holds a weight in each hand that has mass m. He has his arms extended so that they have length S. The system is set into rotation so that the angular velocity of the platform is ω_0.

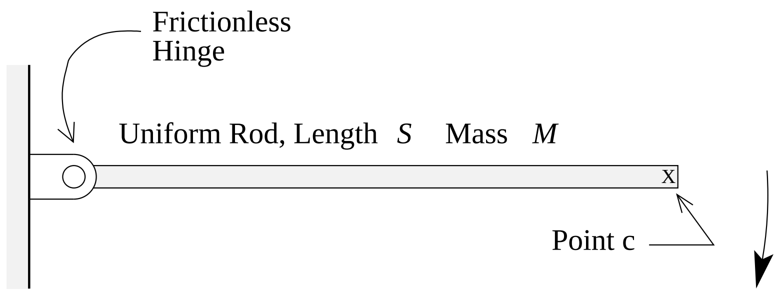


a. Assume the man's mass can be neglected compared to the weights. What force would have to be applied to one of the weights at the distance S so that in t_0 seconds the platform, which is initially at rest, is rotating with angular velocity ω_0?

b. Assuming the man's mass can be neglected compared to the weights, what would be the angular velocity of the system if he starts with angular velocity ω_0 and then brings his arms in so that the distance from his center is reduced from S to $\frac{S}{4}$?

c. If instead of being massless assume the man can be considered to be a cylinder with moment of inertia I_{man} about an axis through his center. He is again set spinning with his arms, considered massless, extended a distance S and still holding the masses, m. His initial angular velocity is again ω_0 and he brings his arms in as before so that the distance is again reduced to $\frac{S}{4}$. What will the new angular velocity be?

4. (25 points) A rod of mass M length S is free to rotate in the vertical plane about a frictionless pin through one end. The moment of inertia about the end is I. The rod is uniform so that the force of gravity acts at its center.



a. What is the torque exerted on the rod by gravity about the pin when the rod is horizontal?

b. If the right end of the rod is released from rest find the acceleration $\vec{a}$ of the point marked c at the right end when the rod is horizontal.

c. What is the torque exerted on the rod by gravity about the pin when the rod is vertical?

d. If the right end of the rod is released from rest find the acceleration $\vec{a}$ of the point marked c at the right end when the rod is vertical, in terms of ω_f, its angular velocity.

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USEFUL INFORMATION

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

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

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

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

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

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

DO NOT WASTE TIME DOING ARITHMETIC

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