

NAME : .....



Massachusetts Institute of Technology

## 16.07 Dynamics

### Problem Set 5

Out date: Oct 3, 2007

Due date: Oct 10, 2007

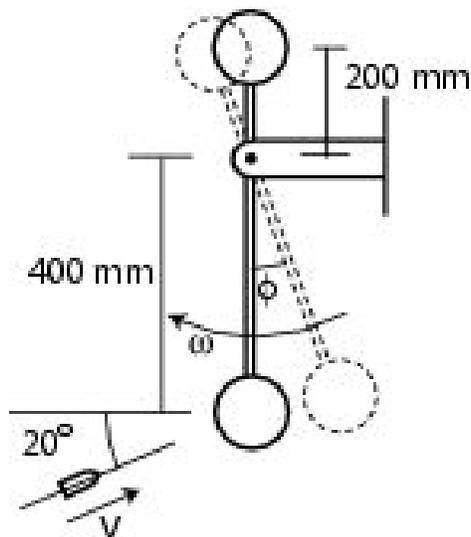
	Time Spent [minutes]
Problem 1	
Problem 2	
Problem 3	
Study Time	

*Turn in each problem on separate sheets so that grading can be done in parallel*

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**Problem 1 (20 points) Part A**

A pendulum consists of two 3.5 kg concentrated masses positioned as shown on a massless but rigid bar. The pendulum is swinging through the vertical position with a clockwise angular velocity  $\omega = 5 \text{ rad/s}$  when a 50g bullet traveling with velocity  $v = 350 \text{ m/s}$  in the direction shown strikes the lower mass and becomes embedded in it. Calculate the angular velocity  $\omega'$  which the pendulum has immediately after impact and find the maximum angular deflection  $\phi$  of the pendulum.



**Part B** For the pendulum in Part A, find the impulse acting on the support pivot at the instant of impact; acting on the rod at the boundary between the rod and the upper mass at the instant of impact; and acting on the rod between the rod and the lower mass at the instant of impact. Ignore the forces due to gravity and centrifugal acceleration. (Hint: since the rod is massless, the forces on it must balance to zero. The forces are transmitted between the pivot and the masses to cause the observed motion.)

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**Problem 2** (10 points)

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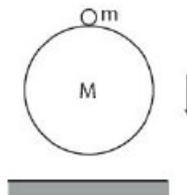
**Part A**

2 children, each of mass  $m$ , stand on a small flatcar of mass  $M$ , which is initially at rest. They run towards the rear of the car, reach a relative velocity of  $u$  with respect to the car and jump off the end of the flatcar. (That is, an instant after jumping the relative velocity between the children and the cart is  $u$ ). As a result, the car rolls in the opposite direction without friction.

- what is the final velocity of the flatcar if the two children run and jump at the same time?
- what is the final velocity of the flatcar if one child remains fixed with respect to the car while the first runs and jumps off with relative velocity  $u$ ; and then the 2nd child runs, reaches a relative velocity  $u$  and then jumps?
- which case above gives a larger velocity?

**Part B**

A small ball of mass  $m$  is placed on top of a large rigid ball of mass  $M$ , and the two balls are dropped to the floor from a height  $h$ . Assume that the two balls are a millimeter apart when the first ball hits the ground. What happens? How high does the small ball rise after the collision? Assume that all collisions are elastic (i.e. energy is conserved) and that  $m \ll M$ .



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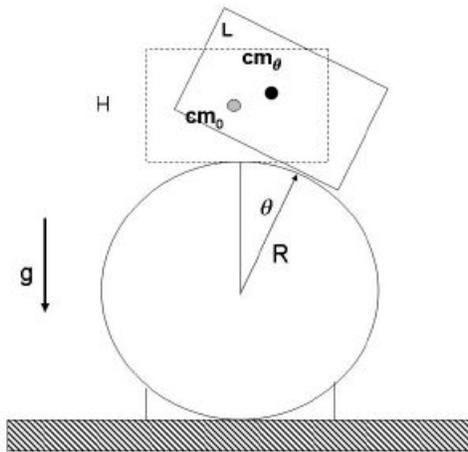
**Problem 3** (10 points)

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Part A. A block of uniform density, of height  $H$  and length  $L$ , is initially sitting symmetrically on a fixed cylinder of radius  $R$  in a gravitational field. Thus its center of mass is directly above the  $\theta = 0$  position on the cylinder. What is the gravitational potential energy of the block?

Now, the mass is free to rotate as shown with its surface keeping contact without slipping on the surface of the cylinder. After it has rotated through an angle  $\theta$ , what is the gravitational potential energy of the block? Express your final result in  $\theta$  using the “small angle” approximation: replace  $\sin\theta$  by  $\theta$  and  $\cos\theta$  by  $1 - \frac{1}{2}\theta^2$ .

How does the result depend upon  $H/R$ ? Does the gravitational potential energy increase or decrease as the block rotate through an angle  $\theta$ . What is the implication of this dependence of the potential energy on  $H/R$ ?



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