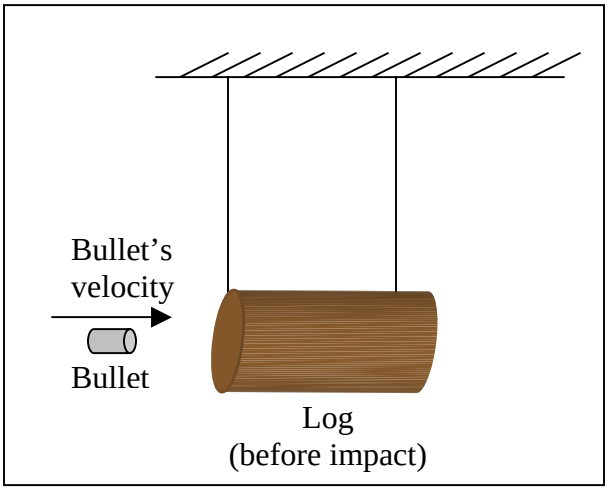
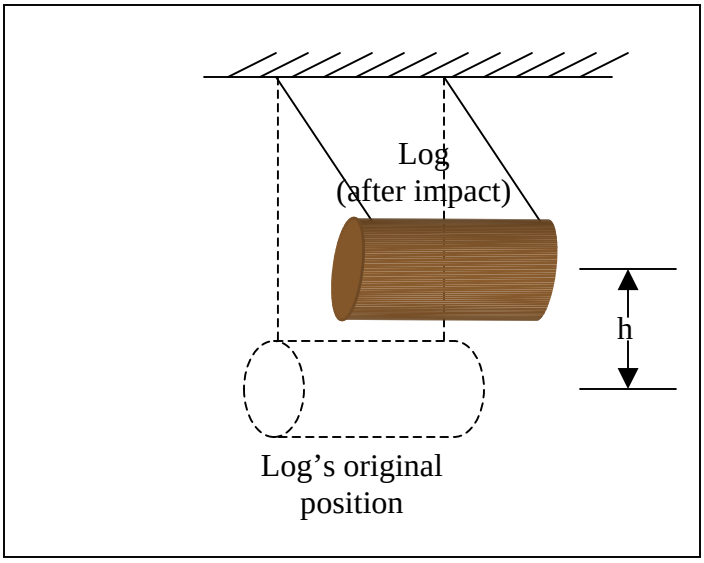
Physics 206a

Homework Assignment IX
due March 16, 2006

1. A billiard ball whose mass is 300 grams and whose velocity is $5\frac{\text{meters}}{\text{second}}\hat{x}$ strikes another ball. The second ball is at rest, initially. The impact is perfectly elastic. The collision is "head on," i.e., this is a one-dimensional problem. Find the velocity of the *both* balls after the collision if:
   a. The mass of the second ball is 250 grams.
   b. The mass of the second ball is 300 grams.
   c. The mass of the second ball is 350 grams.
2. Consider once again the billiard balls in the previous problem. Now, the second ball's mass is 350 grams. Once again, the impact is perfectly elastic, the second ball is initially at rest, and the first ball's velocity is $5\frac{\text{meters}}{\text{second}}\hat{x}$. But now the impact is not head-on. The first ball's velocity after the collision is directed 27° from the *x* axis. Now, what are the velocities of the two balls?
3. One more time for the billiard balls. Now, the balls hit head on. They have the same mass. The initial velocity of the first ball is $5\frac{\text{meters}}{\text{second}}\hat{x}$ and the second ball is at rest. But now someone has coated the second ball with a layer of glue so that the balls stick together (no, they don't stick to the table!). What is the velocity of the pair after impact?
4. A cannon shoots a cannonball at $200\frac{\text{meters}}{\text{second}}$ at an angle 30 degrees above the horizontal (i.e., pointed up 30 degrees). Two seconds after being shot, the cannonball explodes into two, equally sized pieces—call them "A" and "B". Relative to the original cannonball at the instant of the explosion, piece "A" has a velocity of $100\frac{\text{meters}}{\text{second}}$ exactly horizontal. How long after the original cannonball is shot will piece "A" hit the ground? If the cannon is at $x=0$, what is the *x* coordinate where piece "A" will hit the ground?

5. A "ballistic pendulum" is a low-tech way of determining the speed of a bullet. This is pictured below. A bullet traveling exactly horizontally strikes a log hanging from a pair of long strings and embeds itself in the log. The mass of the bullet is 20 grams. The mass of the log is 10 kg. The strings are 2 meters long. If the speed of the bullet is $500\,\frac{\text{meters}}{\text{second}}$, how high will the log rise? (Hint: The kinetic energy of the bullet is not conserved. Find the momentum of the log after impact and then use conservation of energy for the *log* to find its height.) This is a terrific example in which K.E. is not conserved but momentum is.





6. A thin metal hoop and a solid disk both roll down an incline, starting at the same point. The masses of the two objects are the same—call it M. The incline makes an angle θ relative to the horizontal. The objects roll without sliding. Find a mathematical expression for the speed of each of the objects as a function of their position, x, along the incline. It is highly recommended that you use energy conservation to do this.

7. A rod is exactly one meter long. There is a 0.75 kg mass on each end of it. A man attempts to support it by placing his finger under the rod 20 cm from one end. The rod can be considered to have zero mass. What is the total torque on the rod? (You may express the direction of the torque as “up”, “down”, “right”, “left”, “into the page”, or “out of the page” making reference to the above picture.) As an ungraded variation: Repeat the calculation using masses that are different.
8. Refer again to the rod in problem #7. The man is exerting enough force to keep the rod from falling down (if it didn’t rotate). Pick the mass on the left as the “special point” about which the torques are calculated. Calculate the total torque on the rod using this point.
9. What is the angular speed of the Earth? Using this, what is the speed (not angular) of Edwardsville?