**PhD Qualifying Exam**
Spring 2014

DYNAMICS

1. There are a total of 4 problems.
2. Duration: 2.5 hours
3. Closed book, closed notes (one sheet of formulas is allowed).
4. Show your work on these exam sheets. (Add additional sheets, if needed.)
5. You may use a calculator.
6. Laptops and cell phones are not allowed.

1. The pendulum is released from rest when $\theta = 0°$. If the string holding the pendulum breaks when the tension is twice the weight of the bob, at what angle does the string break? Treat the pendulum as a particle, ignore air resistance and let the string be inextensible and massless.
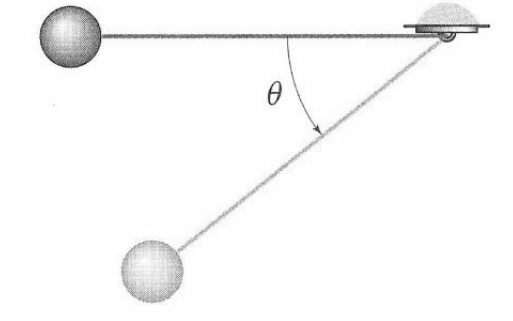
2. A simple model of a crankshaft and piston is shown below. The length of the crankshaft arm is given by *r* and the piston rod by *l*. The crankshaft is rotating at a constant angular velocity of W. Determine the piston velocity, *v* as a function of the crankshaft angular velocity W .

W

j

B

r

A

l

Piston

v

C

Crankshaft
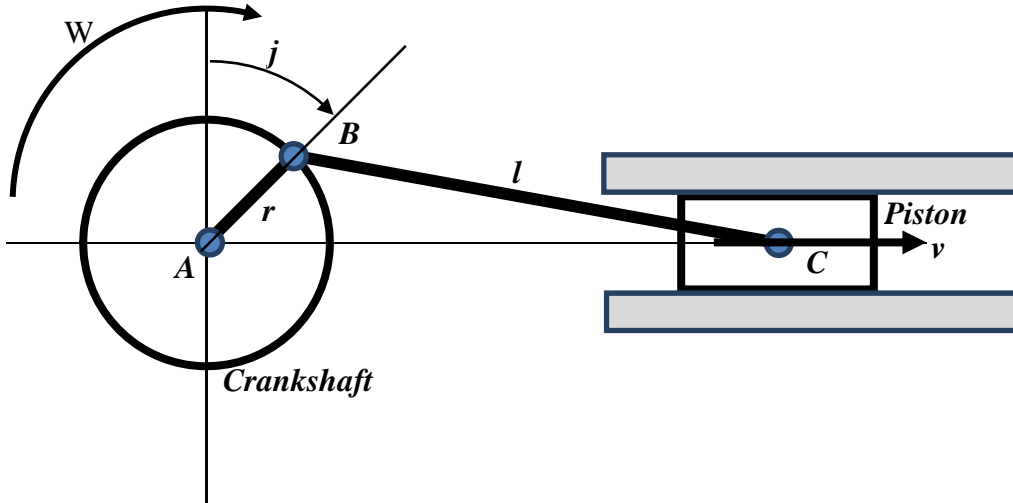
3. A bullet B weighing $147\ gr$ ($1\ lb = 700\ gr$) is fired with a speed V_0 as shown, and becomes embedded in the center of a rubber block of dimensions $h = 4.5\ in$ and $w = 6\ in$ weighing $W_{rb} = 2\ lb$. The rubber block is attached to the end of a uniform thin rod A of length $L = 1.5\ ft$ and weight $W_r = 5\ lb$ that is pinned at O. After the impact, the rod(with the block and the bullet imbedded in it) swings upwards to an angle of $60°$. Determine the speed of the bullet right before impact.

$$\left((I_G)_{rb} = \frac{1}{12}m(h^2 + w^2) \quad , \quad (I_G)_r = \frac{1}{12}mL^2 \right)$$
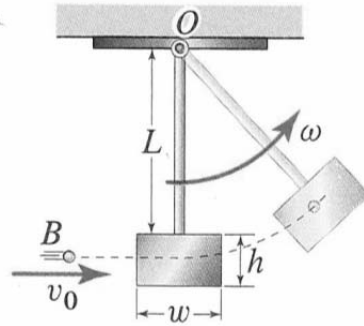
4. A thin ring and a homogeneous circular disk, each of mass m and radius R, are released from rest on an inclined surface. Determine the ratio v_{ring} / v_{disk} of the velocities of their centers when they have rolled a distance D.

$$\left((I_G)_{disc} = \frac{1}{2}mR^2 \quad , \quad (I_G)_{ring} = \frac{1}{12}mR^2 \right)$$