1. Riding a rectangular board of area $A$ and thickness $d$, you hydroplane across a layer of water of thickness $\delta x$. Your mass plus the mass of the board is $m$. The water has viscosity $\eta$. [You may assume the velocity differential between the top of the water layer and the bottom of the water layer is your velocity.] Write Newton’s second law equation for the motion and find $x(t)$, assuming $x(0) = 0$ and $v(0) = v_0$. What is the maximum value for $x$?

2. (a) A vertical wheel of mass $M$ and radius of gyration $k$ is mounted on a fixed horizontal axle. A mass $m$ is attached to the wheel at a distance $2k$ from the axle, and $\theta = 0$ is defined as the orientation of the wheel when the mass is directly above the axle (see diagram). Find the moment of inertia of the wheel/mass combination.

(b) If a coiled spring attached to the axle exerts a torque $\tau = -K\theta$ that tends to restore the wheel to its equilibrium position $\theta = 0$, find the potential energy $V$ of the system as a function of $\theta$ (including the effects of gravity). For the special case $K = 4mgk/\pi$ sketch $V(\theta)$ and determine the equilibrium positions. Are they stable or unstable? Find the frequencies of small oscillations about the stable equilibrium positions.

3. A mass $m$ slides without friction with velocity $v = v_0 \hat{x}$ on a horizontal flat plane. A bar of mass $M$, length $L$ and negligible other dimensions is initially at rest. The mass hits the bar a distance $h$ from the center; the initial velocity is perpendicular to the bar (see diagram).

(a) Assuming the collision is perfectly elastic, use conservation of momentum and energy to find the velocity of the mass, and the velocity and angular velocity of the bar immediately after the collision. You may assume that the impulsive force exchanged between the objects acts along the $x$ direction. [Hint: the velocity of the center of mass of the bar and the angular velocity of the bar are related because the they are caused by the same impulsive force.]

(b) For what values of $h$ will the point B on the opposite end of the bar (from where the mass hits the bar) be going forward immediately after the collision?