**Physics 302**
Second Midterm Exam

19 November 2010, 10:05-11:20 AM

The Exam is out of 40 points. Each problem is worth 8 points. Show all your work for partial credit.

1. Assume the earth's orbit to be circular and that the sun's mass suddenly decreases by half. What orbit does the earth then have? Will the earth escape the solar system?

2. A projectile is fired horizontally along the earth's surface. Show that to a first approximation, the horizontal angular deviation from the direction of fire, resulting from the Coriolis force varies linearly with time at the rate of $\omega \sin\theta$, where $\omega$ is the earth's angular frequency and $\theta$ is the latitude.

3. A uniform rod slides with its ends on a smooth vertical circle. If the rod subtends an angle of 120° at the center of the circle, show that the equivalent simple pendulum has a length equal to the radius of the circle.

4. A particle of mas $m$ moves in one dimension in a square well potential

$$\begin{aligned} V(x) &= -V_0 \quad 0 < x < a \\ &= 0 \quad x > a \end{aligned}$$

   Under what conditions can the method of action-angle variables be applied? Assuming these conditions hold, use the method of action-angle variables to find the frequency of the motion as a function of the particle's energy $E$, for given fixed values of $a$ and $V_0$.

   Let the initial energy of the particle be $E_0$. Now suppose that $a$ is not constant, but is varied very slowly. What is the final energy of the particle if $a$ is reduced slowly by a factor of two? Explain physically why the energy is changed. Assume that the conditions needed for the method of action-angle variables to be applicable are always satisfied.

5. Prove that for a general rigid body motion about a fixed point, the time variation of the kinetic energy $T$ is given by

$$\frac{dT}{dt} = \omega \cdot \mathbf{N}$$

where $\omega$ is the angular velocity and $\mathbf{N}$ is the torque.