Problem #1

Two pendulums each of length l are initially situated as in Fig. 1 The first pendulum is released and strike the second. Assume that the collision is completely inelastic and neglect the mass of the strings and any frictional effects. How high does the center of mass rise after collision? (10%)

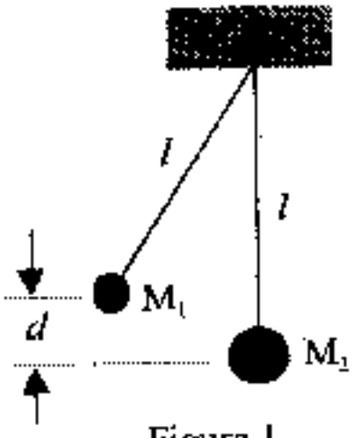

Figure 1

Problem #2

Consider a solid sphere of mass M and radius R rolling down an inclined plane without slipping (see Fig. 2). Find the speed of its center of mass when cylinder reaches the bottom. (10%)

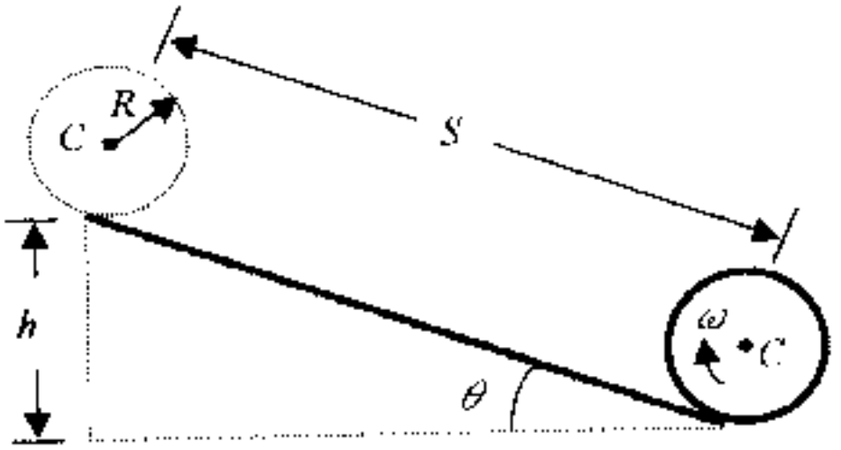

Figure 2

Problem #3

(a) An infamous problem of gravitation is that you dig a tunnel through earth from one side to the other along a diameter and a particle dropped into the tunnel will exhibit simple harmonic motion. Now we drop two particles of different masses, M_1 *and* M_2, into the tunnel. What is the difference in period of motion between these two particles? You ***must*** justify your answer. (8%)

(b) How does your answer for (*a*) change if the tunnel is dug in moon? (5%)

Problem #4

Figure 3 shows an LCR circuit containing a constant-voltage battery V_0. Find out the transient current I as a function of time t if switch S is closed at $t = 0$. It is assumed that $R^2 > 4L/C$. (15%)

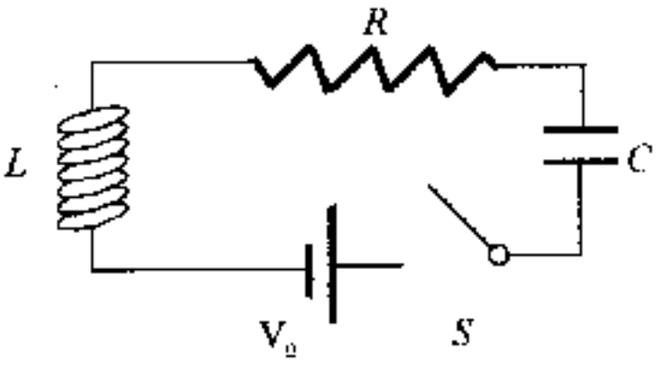

Figure 3

Problem #5

A rigid body formed by three rods (ab, ao, bo) is rotating around point O with an angular velocity ω, where ab is a metallic rod and ao and bo are insulators. An uniform magnetic induction $\boldsymbol{B}$ and the rotation axis are perpendicular to abo plane, as shown in Fig. 4. The lengths of ab, ao and bo are d_1, d_2 and d_3. The Lorentz relation is $\vec{F} = q\left(\vec{E} + \vec{v} \times \vec{B}\right)$. Find out the voltage developed between points a and b. (*Hint*: Consider the driving force along the radial direction.) (15%)

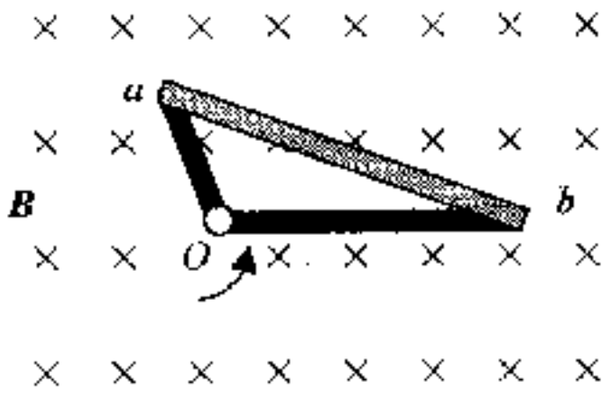

Figure 4

Problem #6

Two equal masses of aluminum (Al) are at different temperatures, 200℃ and 25℃. They are connected together and allowed to reach thermal equilibrium. Calculate the change in entropy. The mass of Al = 20 g and the specific heat of Al = $0.21\ \mathrm{cal/g \cdot ^\circ C}$. (7%)

Problem #7

A drop of oil is added to one surface of prism shown in Fig. 5. The index of refraction of the oil is just large enough so that the total reflection at the surface no longer occurs. Determine the index of refraction of oil if $n_{glass} = 1.50$. (7%)

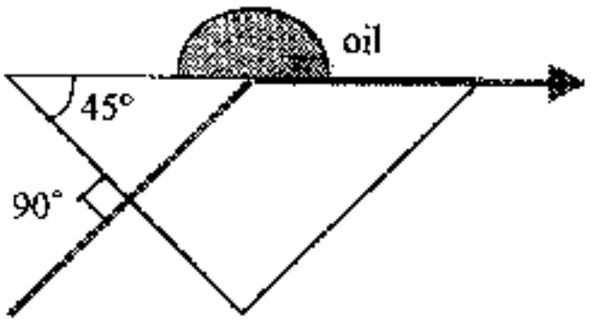

Figure 5

Problem #8

(a) Magnesium fluoride (MgF_2, index of refraction = 1.38) is a popular antireflection coating material on glass. Determine the thickness of MgF_2 coating on glass so that the best antireflection effect of light with $\lambda_{\text{in vacuum}} = 5500$ Å can be obtained. (6%)

(b) Explain why we often see faint purple color on coated lenses. (5%)

Problem #9

(a) Explain the origin of diffraction from crystalline solids. (6%)

(b) Establish an *X*-ray experiment to determine the lattice constants of a sodium chloride (*NaCl*) single crystal. List the physical parameters required and describe your method of calculation. (6%)