1. (10%) A spring of natural length ℓ_0 and whose spring constant is k. The spring is fixed at one end and the other end is attarched to a ring of mass m that can slide on a frictionless rod as shown in Fig.1. If the initial length of the spring is ℓ and the mass of the spring is negligible. Find the speed of the ring when the spring returns to its natural length.

Fig.1

2. (15%) A thin rod of mass M and length ℓ is at rest on a frictionless surface. An impulse $F\Delta t$ is applied at right angle at a distance $\ell/3$ from one end of the rod. Find the linear velocity of the center of mass of the rod and angular velocity of the rod after the impulse has ended.

3. (15%)

(a) What is temperature? Why do we often need to monitor temperature during experiment?

(b) Two moles of ideal diatomic gas ($\gamma = 7/5$) are taken around the cycle as shown in Fig. 2. Please find the heat absorbed or rejected in each segment, the work done per cycle, and the efficiecy of the cycle.

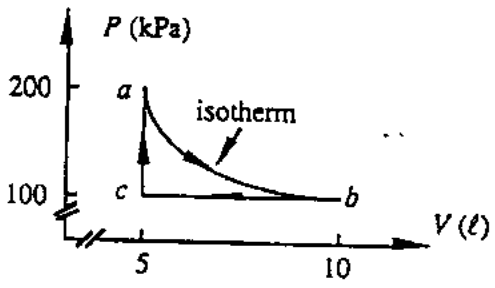

Fig.2

4. (15%) Two very large, flat metal plates are parallel and their separation is d. If the upper plate has charge density $+\sigma$ and the lower plate has surface charge density $-\sigma$.

Please find,

(a) the electric field between the plates, and

(b) the capacitance of the system.

Now, if another uncharged large metal plate of thickness D ($D < d$) is inserted between them.

Please find, again,

(c) the electric field in the gaps, and

(d) the capacitance of the system under this new configuation.

5. (15%) A good conductor is suspended in the mid-air by a very fine silk string. If a quantity of charge Q is introduced onto the conductor. After the charge has reached static equilibrium, please show or explain the following questions:

(a) Why the electric field inside the conductor should be zero?

(b) Why the electric field on the surface should be perpendicular to the surface?

(c) Why does the charage only reside on the surface?

6. (15%) (a) What is the Band theory of solids? (be brief and concise)

(b) If the electronic band structure of a fictitious solid is given in Fig.3. Where r_1 and r_2 are the equilibrium positions under different pressure. Please find the conduction band, the valence band, the band gap, and the electric property (insulator, semiconductior, or metal) for the solid in these two equilibrium postions, based on the information given in the graph.(Note: bands with shading are filled. Band #3 is empty.)

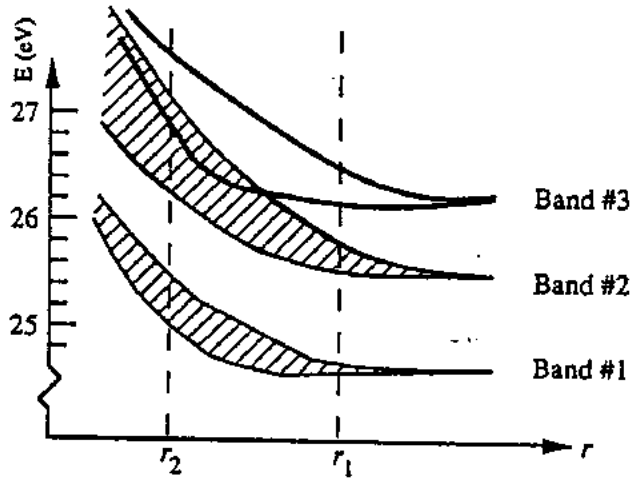

Fig. 3

7. (15%) A torus of inner radius r_i = 18 cm and outer radius r_o = 22 cm has a square cross section. It is wound with N turns of wires (N = 1000) that carry a current I = 1 amp. Please find

(a) the magnetic intensity, H, inside the torus.

Now we, in turns, filled the torus with copper oxide ($\chi_m = 2.6 \times 10^{-4}$) or silver ($\chi_m = -2.4 \times 10^{-4}$). Please anwser the following questions:

(b) What type of the magnetic group will you assign these two materials?(ferromagnetic, diamagnetic or paramagnetic)

(c) Find the magnetic field, B, in the torus for these two materials.

(d) Find the magnetization, M, in the torus for these two materials.