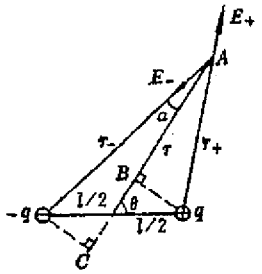
1. For the damped harmonic oscillator with a mass m of 1.0 kg and the spring constant k of 4.0 N/m, how many periods does it take for the amplitude of the motion to drop to one tenth of its initial value? Assume that the friction force is given by $-b\,dx/dt$, where $b = 0.04$ kg/s. (20%)

2. A positive and a negative charge of equal magnitude q are placed a distance l apart, as shown in the following figure. What are the components E_r and $E_\perp$ of the total electric field due to these charges at point A, where E_r is in the r direction and $E_\perp$ is in the direction perpendicular to the r direction, respectively. (Assume $r >> l$) (20%)



3. The Fermi energy E_F for a metal is 3.2 eV at $T = 0$. The density of states for electrons is

$$\rho(E) = \frac{8\pi(2m^3)^{1/2}}{h^3}E^{1/2}$$

(i) Calculate the number of conduction electrons per unit volume in this metal. (15%)

(ii) Is the average electron energy of this metal at 300 K much higher than that at the absolute zero? Is this phenomenon similar to the behavior of the average kinetic energy of the molecules of an ideal gas? Why? (15%)

4. From the viewpoint of the energy band diagrams,

(i) what is the major difference between a conductor and a semiconductor? (5%)

(ii) what is the major difference between an insulator and a semiconductor? (5%)

5. (i) Is the temperature coefficient of resistivity of a metal at 300 K positive or negative? Why? (5%)
(ii) Is the temperature coefficient of resistivity of a semiconductor at 300 K positive or negative? Why? (5%)

6. At what kinetic energy would an electron have the same momentum as a photon of wavelength at 650 nm? (10%)

Note: Planck's constant $h = 6.63 \times 10^{-34}$ joule-sec
Electron rest mass $m = 9.11 \times 10^{-31}$ kg