1. The Compton effect (25%)

   i) Please describe the Compton effect. What is the important concept that this effect confirmed? (5%)

   ii) Please derive the equation of Compton shift $\Delta\lambda = \lambda' - \lambda$, in terms of h, m_0, c, and θ.

$$\Delta\lambda = f(h, m_0, c, \theta)$$

   where

   λ is the incident photon wavelength

   λ' is the scattered photon wavelength

   θ is the angle between the direction of the incident photon and that of the scattered photon

   h is the Plank's constant

   m_0 is electron rest mass

   c is the speed of light.

   [Hint : Use the momentum conservation and the energy conservation.] (20%)

2. Particle moving in a tunnel through the earth (20%)

   i) Suppose a tunnel could be dug through the earth from one side to the other along a diameter. Neglect all frictional force and assume that the earth has a uniform density ρ. Please show that the motion of a particle with mass m dropped into the tunnel is a simple harmonic motion with force constant $k = (4\pi/3)G\rho m$, where G is the gravitational constant. (15%)

   ii) What is the period of this simple harmonic motion in terms of G and ρ. (5%)

3: Identical slits (25%)

Please draw the flux-density pattern for the case of 6 identical slits. The width of the slit is a and the distance between two adjacent slits is $d = 4a$. Answer the question for the case of on axis incident, and assuming that the Fraunhofer diffraction condition is full filled. In your drawing, use $\sin\theta$ as horizontal axis and identify the diffraction part as well as the interference part.(10%) You have to label the locations of all principle maxima and zeros in your drawing (15%).

4. Capacitor (15%)

Consider a parallel-plate capacitor, suppose that the spacing between the plates is d and the area of each plate is A. If we fill dielectrics with the electric susceptibility χ in all of the space between two plates. Please find the capacitance C in terms of A, d, χ and other constants if needed.

5. The Hall effect (15%)

i) Please describe the Hall effect. (10%)

ii) How do you use the Hall effect to determine the sign of the charge carriers in a conductor. (5%)