Name and Surname:
Student ID:
Department:
Signature:

Each question worth 20 points. You should show your work. You will lose points if you do not put the right units and put the vector signs for vectors.

1. Comment on the following concepts (Just writing equation will not gain you any points)(4 points each):

   Electric and Magnetic Field

   Field Lines

   Momentum Conservation in Magnetic Interactions

   Dielectric

   Gauss' Law

2. Consider two point charges $-q$ at $z = \pm d/2$ and another point charge of charge $+2q$ at the origin. Calculate the potential energy at a point $\vec{r}$ which is at a large distance from the charges, i.e. $|\vec{r}| >> d$. Using your result for the potential, obtain the components of the Electric field at that point. (20 points)

3. Consider an infinite slab of thickness d made of and insulating material. Suppose, the charge distribution inside the slab is given by $\sigma_0 z(z - \frac{d}{2})$ where z is the distance from the center of the slab. (Note that the charge distribution at the center plate and on the surface is zero.) Using Gauss' law, calculate the electric field everywhere in space. (20 points)

4. Consider a disk of radius R with a charge Q uniformly distributed over the surface. What is the magnetic dipole moment of the disk if it is rotating at an angular frequence w? (20 points)

5. A long copper wire of radius a has a cylindrical hole (radius b) inside. If the distance of the center of the hole from the center of the wire is d, find the magnetic field everywhere inside the hole. (20 points)

6. *Bonus Question*
   Consider a capacitor made of two thin sheets of metal of surface area A and seperated by a distance d. Suppose, you place inside a dielectric substance with the dielectric constant κ. Suppose the dielectric fills the entire volume between the sheets, and that it can slide freely. If you displace the dielectric slightly from its equilibrium position, what will be its subsequent motion? Calculate the frequency for small oscillations. (Hint: $(1 + x)^n \simeq 1 + nx + n(n - 1)/2x^2$) (20 points)