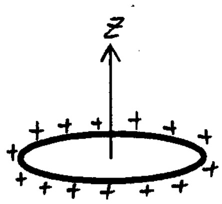
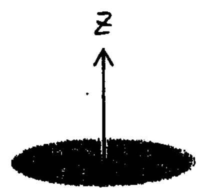
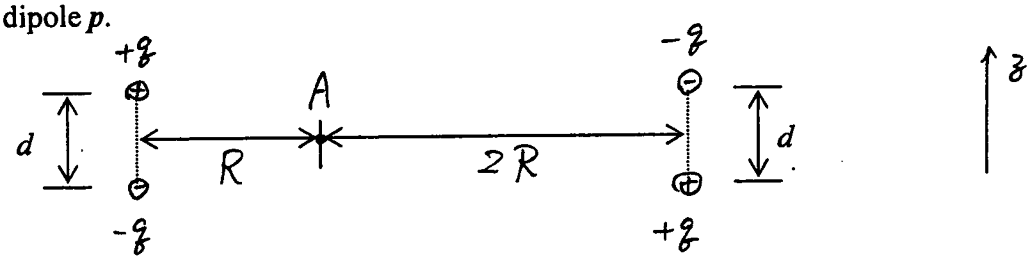
1. **(15 Points)** (a) Calculate the electric potential $V(z)$ at a point z along the axis of a charged ring of radius a which contains a total charge Q. (b) Find the z-component of the electric field (E_z) at the point z. (c) Where is the maximum E_z for this charged ring? (d) From the result of (a), calculate the electric potential $V(z)$ at a point z along the axis of a charged disk of radius a which contains a total charge Q. (e) Find the z-component of the electric field (E_z) at the point z. (f) Where is the maximum E_z for this charged disk?

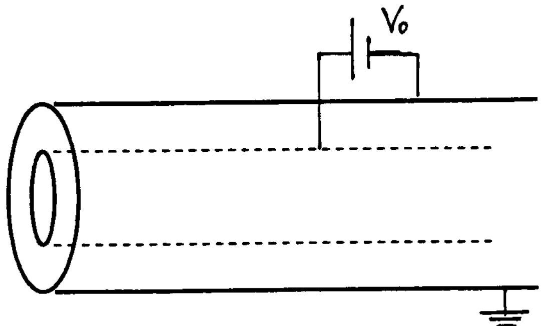




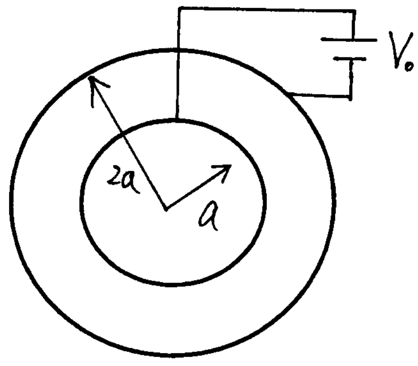
2. **(15 Points)** (a) Evaluate the electrostatic energy for the configuration shown below. (b) Calculate the electric field intensity $\boldsymbol{E}$ at point A as $R >> d$. Express your answer in terms of the definition of electric dipole $\boldsymbol{p}$.



3. **(10 Points)** Assuming that the space between the inner and outer conductors of a long coaxial cylindrical structure is filled with an electron cloud having a volume density charge $\rho(r) = A/r$ for $a < r < 2a$, where a and $2a$ are the radii of the inner and outer conductors respectively. The inner conductor is maintained at a constant potential V_o while the outer conductor is grounded. Determine the potential distribution in the region $a < r < 2a$ by solving the Poisson's equation.

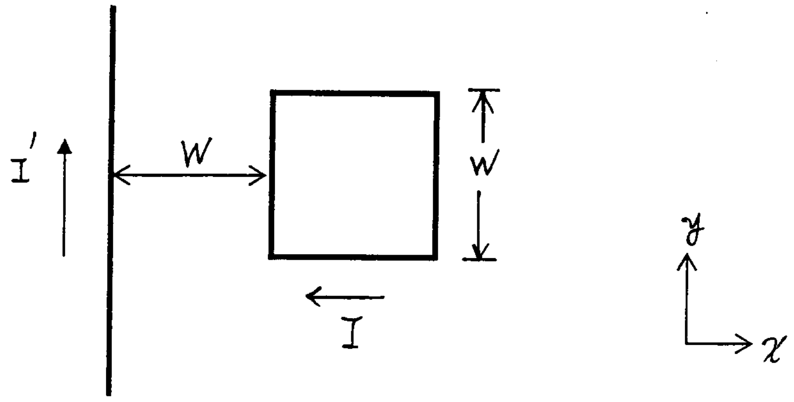


4. **(15 Points)** A resistor is formed by two concentric spherical surfaces of radii a and $2a$. The inner conductor is maintained at a constant potential V_o and the outer conductor is grounded. If the space between the surfaces is filled with a homogeneous and isotropic material having electrical conductivity σ, (a) find the resistance R between inner and outer spherical surfaces. (b) Calculate the power dissipated in this resistor. (c) Determine the current density $\boldsymbol{J}(r)$ and electric field $\boldsymbol{E}(r)$ for $a < r < 2a$.



5. **(15 Points)** (a) Calculate the magnetic flux density $\boldsymbol{B}$ both inside and outside an infinitely long cylindrical conductor of radius a with uniform current density $\boldsymbol{J}$ along the z-axis. (b) Determine the vector magnetic potential $\boldsymbol{A}$ both inside and outside the conductor. Let's choose the boundary condition as $\boldsymbol{A} = 0$ for $r = 0$. (c) Find the magnetic energy per unit length stored in this conductor.

6. **(15 Points)** A very long, straight wire with a dc current I' points to $+y$ direction. A square loop with side W is located at the right hand side of the straight wire. (a) Find the total magnetic flux on the square loop. If the square loop carries current I described below, (b) determine the magnetic dipole moment $\boldsymbol{m}$ of the loop (magnitude and direction). (c) Find the net magnetic force exerted on this loop. (d) Calculate the mutual inductance between the straight wire and the square loop. (e) If the loop moves away from this straight wire at a constant speed v along the $+x$ direction, what induced emf ε is generated?



7. **(15 Points)** The electric field intensity of a plane electromagnetic wave moving alone the *z*-axis in vacuum is given by $\boldsymbol{E} = E_0 \cos(\omega t - kz)\,\hat{y}$ where $E_0 = 6 \times 10^{-2}$ V/m and $k = 2 \times 10^{-2}$ m^{-1}. (a) Write an expression (mathematical) for the magnetic field intensity $\boldsymbol{H}$ associated with the wave. (b) What are the frequency and wavelength of this wave? (c) White an expression (mathematical) for the Poynting vector associated with the wave.

**Useful values and formulas:*

* $\varepsilon_0 = (36\pi \times 10^9)^{-1}$ F/m
* $\mu_0 = 4\pi \times 10^{-7}$ H/m

In cylindrical coordinates:

$$\vec{\nabla} \times \vec{A} = \left(\frac{1}{r}\frac{\partial A_z}{\partial \phi} - \frac{\partial A_\phi}{\partial z}\right)\hat{r} + \left(\frac{\partial A_r}{\partial z} - \frac{\partial A_z}{\partial r}\right)\hat{\phi} + \left(\frac{1}{r}\frac{\partial (rA_\phi)}{\partial r} - \frac{1}{r}\frac{\partial A_r}{\partial \phi}\right)\hat{z}$$

$$\nabla^2 V = \frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V}{\partial r}\right) + \frac{1}{r^2}\frac{\partial^2 V}{\partial \phi^2} + \frac{\partial^2 V}{\partial z^2}$$