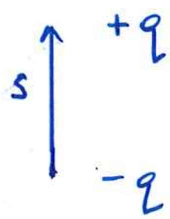
**Quiz 7**

Name: ______________________________

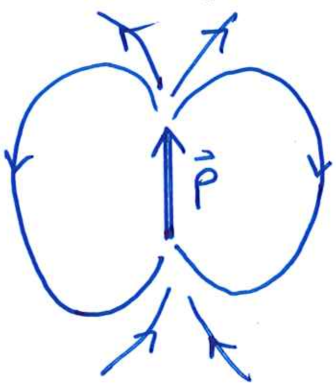
Total = 20 marks

1. (2 marks) Electric Dipole
   a) State the definition of a pure electric dipole.




$$\vec{p} = \lim_{\substack{q\to\infty \\ s\to 0}} q\vec{s} \quad \text{such that } qs \text{ is finite}$$

   b) Sketch the electric field produced by an electric dipole.




2. (4 marks) Bohr magneton
   a) Derive an expression for the Bohr magneton from the definition of the magnetic dipole moment.

$$\mu_B = \frac{IA}{c} = \frac{ev}{2\pi r}\cdot\frac{\pi r^2}{c} = \frac{evr}{2c}$$

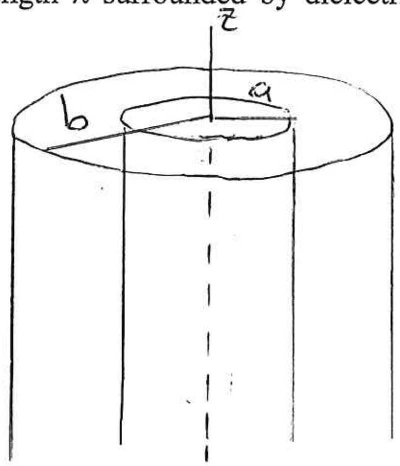
$$\mu_B = \frac{e}{2mc}\,mvr = \frac{e\hbar}{2mc}$$

   b) Evaluate the magnitude in units of erg/gauss.

$$\mu_B = \frac{4.8\times10^{-10}\,\text{esu}\cdot 1\times10^{-27}\,\text{erg sec}}{2\times 9.11\times10^{-28}\,\text{gm}\times 3\times10^{10}\,\text{cm/sec}}$$

$$= 8.78\times10^{-21}\ \text{erg/gauss}$$

3. (8 marks) Consider an infinitely long conducting rod of radius a having constant uniform charge per unit length λ surrounded by dielectric material ε up to radius b as shown below.




a) Find the electric displacement everywhere.

Using Gaussian surface of cylinder of radius $\rho$ one gets:

$$\vec{D}(\rho) = \begin{cases} 0 & \rho < a \\ \frac{2\lambda}{\rho}\hat{\rho} & \rho > a \end{cases}$$

b) Fid the electric field everywhere.

$$\vec{D} = \epsilon \vec{E}$$

$$\therefore \vec{E}(\rho) = \begin{cases} 0 & \rho < a \\ \frac{2\lambda}{\epsilon\rho}\hat{\rho} & a < \rho < b \\ \frac{2\lambda}{\rho}\hat{\rho} & \rho > b \end{cases}$$

c) Find the polarization everywhere.

$$\vec{D} = \vec{E} + 4\pi \vec{P}$$

$$\vec{P} = \frac{\vec{D} - \vec{E}}{4\pi}$$

$$\therefore \vec{P}(\rho) = \begin{cases} 0 & \rho < a \\ \frac{\lambda}{2\pi\rho} \frac{\epsilon - 1}{\epsilon} & a < \rho < b \\ 0 & \rho > b \end{cases}$$

d) Find expressions for the bound charge densities at r = a and at r = b.

$\sigma = \vec{P} \cdot \hat{n}$ where $\hat{n}$ is normal vector to surface

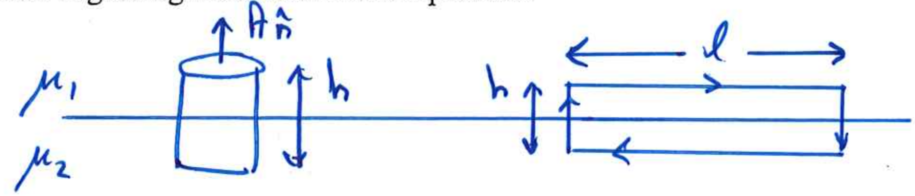
$$\sigma(\rho = b) = \vec{P} \cdot \hat{\rho}$$

$$= \frac{\lambda}{2\pi b} \frac{\epsilon - 1}{\epsilon}$$

$$\sigma(\rho = a) = \vec{P} \cdot (-\hat{\rho})$$

$$= \frac{-\lambda}{2\pi a} \frac{\epsilon - 1}{\epsilon}$$

4. (4 marks) Derive the continuity conditions for $\vec{B}$ and $\vec{H}$ at the interface of 2 magnetic media beginning from Maxwell's equations.




$\underline{\vec{B}}$: Consider pillbox straddling boundary.

$$\int_{\text{Pillbox surface}} \vec{B}\cdot d\vec{a} = 0.$$

$$\underbrace{\int_{Top} \vec{B}\cdot d\vec{a}}_{B_{1n}A} + \underbrace{\int_{side} \vec{B}\cdot d\vec{a}}_{=0 \text{ in } \lim h\to 0} + \underbrace{\int_{Bot} \vec{B}\cdot d\vec{a}}_{-B_{2n}A} = 0.$$

$$\Rightarrow B_{1n} = B_{2n}$$

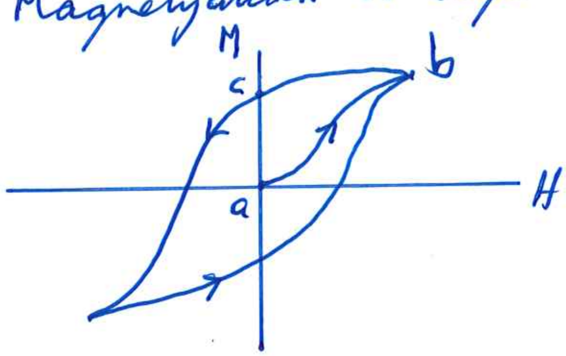
$\underline{\vec{H}}$: Consider integral of $\vec{H}$ around contour.

$$\lim_{h\to 0} \oint \vec{H}\cdot d\vec{l} = 0. \quad \Rightarrow H_{1t} = H_{2t}$$

$$H_{1t}\, l - H_{2t}\, l = 0$$

5. (2 marks) What is hysteresis?

Magnetization $\vec{M}$ depends on history of object.




a) Unmagnetized Fe

b) saturation

c) No H field but many Fe magnetic loops aligned

etc.