

1. D

2. B

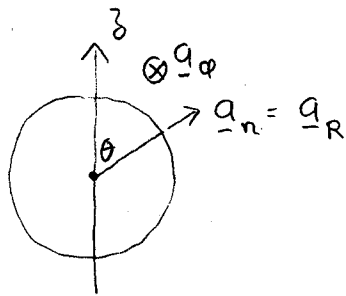
$$P_A = \underline{E} \cdot \underline{J} = \frac{|J|^2}{\sigma_A} < \frac{|J|^2}{\sigma_B} = P_B$$

3. A

$$G = \frac{I}{V} = \frac{1}{5} \text{ S} \quad \frac{C}{G} = \frac{\epsilon}{\sigma} \Rightarrow C = G \frac{\epsilon}{\sigma} = G \frac{\epsilon_0}{\sigma}$$

$$\text{So } C = \frac{(\frac{1}{5}) (\frac{1}{36\pi}) (10^{-9})}{0.1} = \underline{\underline{17.68 \text{ pF}}}$$

4. A



$$\begin{aligned} \underline{J}_{ms} &= \underline{M} \times \underline{a}_n = M_0 \underline{a}_z \times \underline{a}_r \\ &= \underline{\underline{M_0 \underline{a}_\phi \sin\theta}} \end{aligned}$$

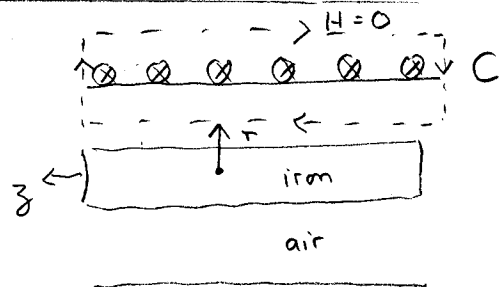
5. (a)

$$\text{Assume: } \underline{H} = H_z(r) \underline{a}_z$$

$$\begin{aligned} \oint_C \underline{H} \cdot d\underline{\ell} &= \text{Current} \\ \Rightarrow \int_C H_z \ell &= NI \end{aligned}$$

$$\Rightarrow H_z = NI/\ell \quad (\text{same in iron and air})$$

$$\Rightarrow \underline{B} = \mu_0 \frac{NI}{\ell} \underline{a}_z \quad \text{in air} ; \quad \underline{B} = \mu_r \mu_0 \frac{NI}{\ell} \underline{a}_z \quad \text{in iron}$$



$$(b) \quad W_{\text{air}} = \frac{1}{2} \int \underline{B} \cdot \underline{H} \, dV = \frac{\mu_0}{2} \int_{z=0}^{\ell} \int_{\phi=0}^{2\pi} \int_{r=a}^b H_z^2 \, dr \, r d\phi \, dz$$

$$= \frac{1}{2} \mu_0 \ell \, 2\pi \left(\frac{b^2 - a^2}{2} \right) \left(\frac{NI}{\ell} \right)^2 = \mu_0 \pi \frac{(b^2 - a^2)}{2} \frac{N^2 I^2}{\ell} //$$

$$W_{\text{iron}} = \frac{\mu_0 \mu_r}{2} \int_{z=0}^{\ell} \int_{\phi=0}^{2\pi} \int_{r=0}^a \left(\frac{NI}{\ell} \right)^2 \, dr \, r d\phi \, dz = \mu_0 \mu_r \frac{\pi a^2}{2} \frac{N^2 I^2}{\ell} //$$

$$(c) \quad W_m = \frac{1}{2} LI^2$$

$$\Rightarrow \frac{1}{2} LI^2 = W_{\text{air}} + W_{\text{iron}}$$

$$= \mu_0 \frac{N^2 I^2}{l} \frac{\pi}{2} [b^2 - a^2 + \mu_r a^2]$$

$$\Rightarrow L = \mu_0 \frac{N^2}{l} \pi [b^2 + (\mu_r - 1) a^2]$$

