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$$\vec{D} = \varepsilon \vec{E} + \vec{P} \qquad P \propto E$$

$$\vec{H} = \frac{1}{\mu_0}\vec{B} - \vec{M}$$

$$\vec{B} = \mu_0(\vec{H} + \vec{M})$$

$$\vec{M} = \chi_M \vec{H} \qquad \frac{\vec{M}}{\vec{H}}$$

$$\mu = \mu_0(1 + \chi_m)$$

$$\vec{M} = 0 \Rightarrow$$

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I$$

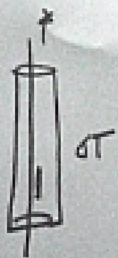
$$B = \frac{\mu_0 I}{2\pi s} \qquad H = \frac{I}{2\pi s}$$

$$H = \frac{I}{2\pi s}$$

$$B = \mu_0(\vec{H} + \vec{M})$$

$$\vec{M} = \chi_m \vec{H}$$

$$\hat{B} = \mu_0(1+\chi_m)\left(\frac{I}{2\pi s}\right)$$



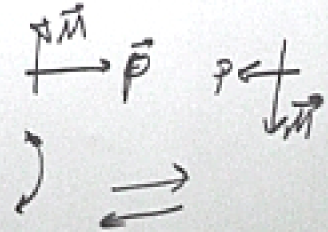
$$\vec{\nabla} \times \left[\frac{1}{\mu_0}\vec{B} - \vec{M}\right] - \varepsilon_0\mu_0 \frac{\partial E}{\partial t} = J_f$$

$$\vec{\nabla} \times \vec{H} - \varepsilon_0\mu_0 \frac{\partial E}{\partial t} = \vec{J}_f$$

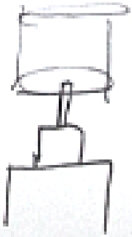
$$\varepsilon_0 \frac{\partial E}{\partial t} = \vec{J}_p = \frac{\partial \vec{P}}{\partial t}$$

$$J_B = \vec{\nabla} \times \vec{M}$$

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}_f + \mu_0 \vec{\nabla} \times \vec{M} + \mu_0 \frac{\partial D}{\partial t}$$



$$\cancel{\vec{\nabla} \times \vec{M}} \quad \cancel{\frac{\partial \vec{M}}{\partial t} = \vec{\nabla} \times \vec{E}}$$



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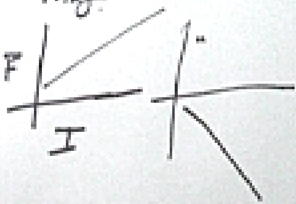

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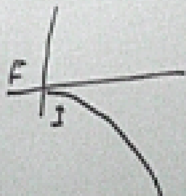

$$\vec{\nabla}\times\vec{A} = \vec{B}$$

$$T \quad \frac{[A]}{m} \Rightarrow [A] = TM$$

$$-\vec{\nabla} V = \vec{E}$$

$$\vec{B} = \vec{\nabla}\times\vec{A}$$

$$\vec{\nabla}\times B = \vec{\nabla}\times(\vec{\nabla}\times\vec{A})$$

$$\vec{\nabla}\times\vec{B} = \mu_0 \vec{J}$$

$$\vec{\nabla}\times(\vec{\nabla}\times\vec{A}) = \vec{\nabla}(\vec{\nabla}\cdot\vec{A}) - \nabla^2\vec{A}$$

$$A \to \vec{A} + \vec{\nabla}\cdot\vec{A}$$

$$\vec{\nabla}\times(\vec{\nabla}\cdot\vec{A}) \equiv 0$$

$$\nabla^2\vec{A} = -\mu_0 \vec{J}$$

$$\Phi_M = \oint \vec{A}\cdot d\vec{l} = \oint \vec{B}\cdot d\vec{a}$$

$$\nabla^2 \vec{A} = -\mu_0 \vec{J}$$

$$\Phi_M = \oint \vec{A}\cdot d\vec{l} = \oiint \vec{B}\cdot d\vec{a}$$

$$\underbrace{\oiint \underbrace{(\vec{\nabla}\times\vec{A})}_{B}\cdot d\vec{a}}_{\Phi_M} = \oint \vec{A}\cdot d\vec{l}$$

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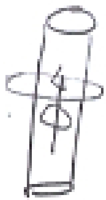
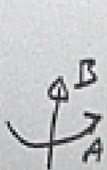


$$\oint \vec{A}\cdot d\vec{L} = A(2\pi s)$$

outside $\Phi_M = \iint \vec{B}\cdot d\vec{A} = B(\pi a^2)$

$$\vec{A} = \frac{Ba^2}{2s}\hat{\theta}$$



inside: $A(2\pi s) = B\cdot \pi s^2$

$$\vec{A} = \frac{Bs}{2}\hat{\theta}$$

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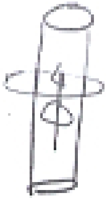
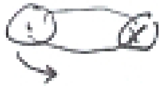
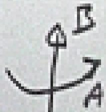




$$\oint \vec{A}\cdot d\vec{L} = A(2\pi s)$$

outside $\Phi_M = \iint \vec{B}\cdot d\vec{A} = B(\pi a^2)$

$$\vec{A} = \frac{Ba^2}{2s}\hat{\phi}$$



inside: $A(2\pi s) = B\cdot\pi s^2$

$$\vec{A} = \frac{Bs}{2}\hat{\phi}$$

$$\vec{A} = \frac{Ba^2}{2s}\hat{\phi}$$

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

$$\vec{A} = \frac{Ba^2}{2s}\hat{\phi}$$

$$\vec{\nabla}\times\vec{A} = \left(\frac{1}{s}\cancel{\frac{\partial A_z}{\partial \phi}} - \cancel{\frac{\partial A_\phi}{\partial z}}\right)\hat{s}$$

$$+\left(\cancel{\frac{\partial A_s}{\partial z}} - \cancel{\frac{\partial A_z}{\partial s}}\right)\hat{\phi}$$

$$+\frac{1}{s}\left[\frac{\partial (sA_\phi)}{\partial s} - \cancel{\frac{\partial A_s}{\partial \phi}}\right]\hat{z}$$

$$\cancel{\frac{\partial\left(s\left(\frac{Ba^2}{2s}\right)\right)}{\partial s}} \quad \frac{1}{s}\,\frac{\partial\left(\frac{Bs^2}{2}\right)}{\partial s}$$

$$\frac{1}{s}\cdot Bs = B\hat{z}$$

$$\vec{J} = \frac{I}{\pi R^2}\,\hat{z}$$

IN: $\oint \vec{B}\cdot d\vec{l} = \mu_0 J(\pi s^2)$

$$\Rightarrow B = \frac{\mu_0 I}{\pi R^2}\cdot\frac{\pi s^2}{2\pi s}$$

$$\vec{B} = \frac{\mu_0 I s}{2\pi R^2}\,\hat{\phi}$$

$$\vec{B}_{out} = \frac{\mu_0 I}{2\pi s}\,\hat{\phi}$$

$$\vec{\nabla} \times \vec{A} = \vec{B}$$

$$B\,\hat{\phi} \Rightarrow \vec{\nabla} \times \vec{A} = \left(\frac{\partial A_s}{\partial z} - \frac{\partial A_z}{\partial s}\right)\hat{\phi}$$

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$$-\frac{\partial A_s}{\partial s} = \frac{\mu_0 I s}{2\pi R^2}$$

$$\frac{dA_s}{ds} = -\frac{\mu_0 J s}{2}$$

$$\Rightarrow A_s = -\frac{\mu_0 J s^2}{4} + \text{cons}$$

$$\vec{A} = -\frac{\mu_0 J s^2}{4}\hat{z} + \underline{\vec{\nabla} f(x,y,z)}$$

$$\vec{A} = -\frac{\mu_0 J}{4} s^2 \hat{z}$$

$$\vec{\nabla} \times \vec{A} = -\frac{\partial A_z}{\partial s} \hat{\phi}$$

$$= -\frac{\mu_0 J}{2} s \hat{\phi}$$

$$\vec{B} = \frac{\mu_0 I}{2\pi s} \hat{\phi} \rightarrow \cancel{\vec{A}_{out} = B a^2}$$

$$\cancel{\vec{\nabla} \times \vec{A} = \vec{B} = \left(\frac{\partial (s V_\phi)}{\partial s}\right) \frac{1}{s} \hat{z}}$$

$$\vec{\nabla} \times \vec{A} = \hat{\phi} \quad \frac{\partial A_s}{\partial z}, \boxed{\frac{\partial A_z}{\partial s}}$$

$$= -\frac{\partial A_z}{\partial s} = \frac{\mu_0 I}{2\pi s}$$

$$A_z = -\frac{\mu_0 I}{2\pi} \int_g^s \frac{ds}{s}$$

$$\vec{\nabla} \times \vec{A} = B$$

$$\vec{A} = -\frac{\mu_0 J}{4} s^2 \hat{z}$$

$$\vec{\nabla} \times \vec{A} = -\frac{\partial A_z}{\partial s} \hat{\phi}$$

$$= -\frac{\mu_0 J}{2} s \, \cancel{\hat{z}} \, \hat{\phi}$$

$$\vec{B} = \frac{\mu_0 I}{2\pi s} \hat{\phi} \rightarrow \cancel{\vec{A}_{out} = Ba^2}$$

$$\cancel{\vec{\nabla} \times \vec{A} = \vec{B}} = \left(\frac{\partial (s V_\phi)}{\partial s}\right) \frac{1}{s} \hat{z}$$

$$\vec{\nabla} \times \vec{A} = \hat{\phi} \quad \frac{\partial A_s}{\partial z} \;) \; \boxed{\frac{\partial A_z}{\partial s}}$$

$$-\frac{dA_z}{ds} = -\frac{\partial A_z}{\partial s} = \frac{\mu_0 I}{2\pi s}$$

$$A_z = -\frac{\mu_0 I}{2\pi}\int_g^s \frac{ds}{s}$$

$$= -\frac{\mu_0 I}{2\pi}\left[\left(-\ln(g)\right) + \ln(s)\right]$$

$$\vec{A} = -\frac{\mu_0 I}{2\pi}\ln(s)\,\hat{z}$$

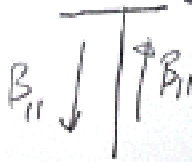
$$\vec{\nabla}\times\vec{A} = \vec{B}$$

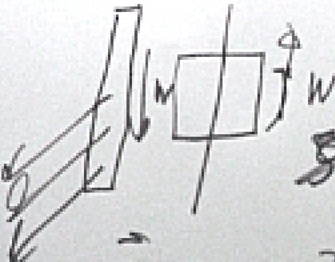
$$\vec{\nabla}^2 \vec{A} = -\mu_0 \vec{J}$$

$$J = J_0 \hat{z}$$

$$\Delta B_{\parallel} = \mu_0 J$$

$$\vec{\nabla}^2 A_z = J_0$$





$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_C$$

$$I_C = J \cdot W$$

$$\vec{A}_{Above} = \vec{A}_{Below} \qquad B(2W) = \mu_0 J W$$

$$= -\mu_0 \qquad B = \frac{\mu_0}{2} J$$