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HW 6

3) a) $F = 2\pi I R B\cos\theta$, $B = \frac{\mu_0}{4\pi}\frac{3(m\cdot\hat{r})\hat{r} - m_1}{r^3}$ =>

$B\cos = B\cdot\hat{y}$ => $B\cos\theta = \frac{\mu_0}{4\pi}\frac{1}{r^3}\left[3(m_1\cdot\hat{r}(\hat{r}\cdot\hat{y}) - (m_1\cdot\hat{y})\right]$

=>

$m_1\cdot\hat{y} = 0$ & $\hat{r}\cdot\hat{y} = \sin\phi$ & $m_1\cdot\hat{r} = m_1\cos\theta$ =>

$B\cos\theta = \frac{\mu_0}{4\pi}\frac{1}{r^3}3m_1\sin\phi\cos\phi$ =>

$F = \cancel{2\pi} I R \frac{\mu_0}{\cancel{4\pi}}\frac{1}{r^3}3m_1\underbrace{\sin\phi}_{\frac{R}{r}}\underbrace{\cos\phi}_{\sqrt{r^2-R^2}}$

$\underbrace{IR^2\pi}_{m_2}\frac{\mu_0}{2\pi}\frac{1}{r^4}3m_1\sqrt{r^2-R^2}$ =>

$F = \frac{\mu_0}{2\pi}\frac{3m_1m_2}{r^4}\sqrt{r^2-R^2}$

b) $F = \nabla(m_2\cdot B) = (m_2\cdot\nabla)B$ =>

$\frac{m_2}{1}\frac{\partial}{\partial z}\left[\frac{\mu_0}{4\pi}\frac{1}{z^3}\underbrace{(3(m_1\cdot\hat{z})\hat{z} - m_1)}_{2m_1}\right]$ =>

$\frac{\mu_0}{2\pi}m_1m_2\hat{z}\underbrace{\frac{\partial}{\partial z}\left(\frac{1}{z^3}\right)}_{-3\frac{1}{z^4}}$ =>

$F = -\frac{3\mu_0}{2\pi}m_1m_2\hat{z}\frac{1}{z^4}$

* could $\hat{z}$ in b) be equal to $\sqrt{r^2-R^2}$ from a)? & same for $z^4 = r^4$ *

7) $J_b = \nabla \times M = 0$, $K_b = M \times \hat{n} = M\hat{\phi}$

If $K_b = M\hat{\phi}$ then this would make a solenoid from cylindrical coords so the outside is 0

If $B = \mu_0 K_b$ for inside & $K_b = M\hat{\phi}$ then for inside it is $B = \mu_0 M \hat{\phi}$

16) $\oint H \cdot dl = I_{enc}$, $H = \frac{I}{2\pi s}\hat{\phi}$

$B = \mu_0 (1 + X_m)$ =>

$H = \mu_0 (1 + X_m) \frac{I}{2\pi s} \hat{\phi}$

$M = X_m H$ => $H = \frac{X_m I}{2\pi s} \hat{\phi}$

$J_b = \nabla \times M = \frac{1}{s}\frac{\partial}{\partial s}\left(s \frac{X_m I}{2\pi s}\right)\hat{z} = 0$

$K_b = M \times \hat{n} = (X_m I / 2\pi a)\hat{z}$ for $s = a$

&

$(-X_m I / 2\pi b)\hat{z}$ for $s = b$

Amperian loop between cylinders:

$I + \frac{X_m I}{2\pi a} 2\pi a = (1 + X_m) I$,

$\oint B \cdot dl = \mu_0 I_{enc}$ =>

$\mu_0 (I + X_m) I$ => $B = \frac{\mu_0 (1 + X_m) I}{2\pi s} \hat{\phi}$