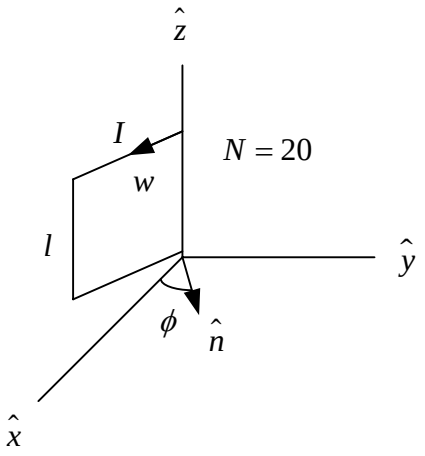
5-6



a)

$l = 0.15,\ w = 0.05,\ z = 10A$

$\vec{B} = 0.02(\hat{x} + 2\hat{y})$

torque on vertical arm

$$F_B = (I\vec{l} \times \vec{B})N = (10)(0.15)(0.02)\left\{-\hat{z} \times (\hat{x} + 2\hat{y})\right\}(20)$$

$$= 0.6\left\{-\hat{y} + 2\hat{x}\right\}$$

$$\vec{\tau} = \vec{r} \times \vec{F} = (0.05)(0.6)(\sin\phi\hat{x} - \cos\phi\hat{y}) \times (-\hat{y} + 2\hat{x})$$

$$\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \sin\phi & -\cos\phi & 0 \\ 2 & -1 & 0 \end{vmatrix} = z(-\sin\phi + 2\cos\phi) = 0.03(2\cos\phi - \sin\phi)\hat{z}(N\text{-}m)$$

b)

$\tau = 0$ when $2\cos\phi = \sin\phi$

$\Rightarrow \tan\phi = 2 \Rightarrow \phi = 63.43^o$

note: this is the same angle of $\vec{B}$

i.e. when $\vec{B} \,||\, \hat{n}$ (or $\vec{B}\ \perp$ to loop) $\Rightarrow \tau = 0$

c)

τ is max when $\vec{B}\ \perp \hat{n} \Rightarrow 63.43^o \pm 90^o$

or take $\dfrac{\partial \vec{E}}{\partial \phi} = 0$ to get max