Griffiths. 4.5

$\cancel{\vec p =}\ \Phi = \frac{\vec p\cdot\vec x}{x^3} = \frac{\vec p\cdot\hat r}{r^2}$

$\Phi_1 = \frac{p_1\cos\theta}{r^2}$ $\qquad -\frac{\partial\Phi_1}{\partial r} = \frac{2p_1\cos\theta}{r^3}$

$\frac{1}{r}\left(-\frac{\partial\Phi_1}{\partial\theta}\right) = \frac{p_1\sin\theta}{r^3}$

$\Rightarrow \vec E = \frac{2p_1\cos\theta}{r^3}\hat r + \frac{p_1\sin\theta}{r^3}\hat\theta.$

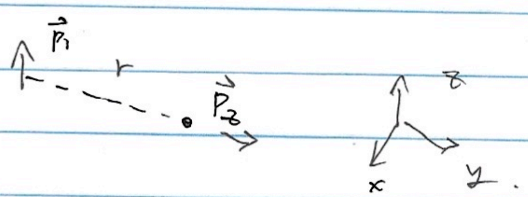
23 − 32 $\hat 1$

$\vec N = \vec p\times\vec E = r\times\frac{dp}{dt} = \vec r\times\vec F.$

12 − 21. $\hat 3$

~~13 − 31.~~

31 − 13. $\hat 2$.



$\vec p_2 = p_2\hat y$

$\vec E_1 = \frac{2p_1\cos\theta}{r^3}\hat r + \frac{p_1\sin\theta}{r^3}\hat\theta.$

~~at~~ $\vec x_2 = (r,\theta,\phi) = (r,\frac{\pi}{2},0)$

$\Rightarrow \vec E_1(\vec x_2) = \frac{p_1}{r^3}\hat\theta = \frac{p_1}{r^3}\hat z.$

because $\hat\theta = \hat z$ at $(r,\frac{\pi}{2},0)$

$\vec p_2 = p_2\hat y,\quad \vec p_2\times\vec E_1(\vec x_2) = (p_2\hat y)\times\left(\frac{p_1}{r^3}\hat z\right)$

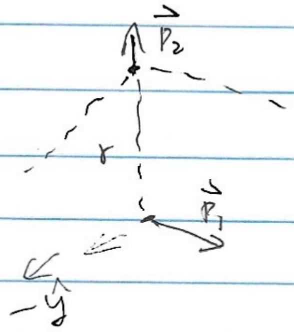
$= \boxed{\frac{p_2 p_1}{r^3}\hat x} +$

$\Rightarrow$

Torque on $\vec p_2$ by $\vec p_1$.

Griffiths 4.5

$$\vec{E}_2 = \frac{2p_2\cos\theta}{r^3}\hat{r} + \frac{p_2\sin\theta}{r^3}\hat{\theta}$$ with new coordinate system.



coordinate of $\vec{p}_1$: $(r, \pi, 0)$.

$$\Rightarrow \vec{E}_2 = -\frac{2p_2}{r^3}\hat{r}.$$

At $(r, \pi, 0)$, $\hat{r} = -\hat{z}$.

$$\vec{p}_1 = p_1\hat{x}$$

$$\vec{p}_1 \times \vec{E}_2 = \cancel{-\frac{2p_2}{r^3}\left[-\hat{z}\right]} \times \left(p_1\hat{x}\right) \times \left[\frac{2p_2}{r^3}\hat{z}\right]$$

$$= \frac{2p_1p_2}{r^3}(-\hat{y}).$$

If we go back to the original coordinate system,

$$\frac{2p_1p_2}{r^3}(-\hat{y}) \longrightarrow \boxed{\frac{2p_1p_2}{r^3}(-\hat{x})}$$

in