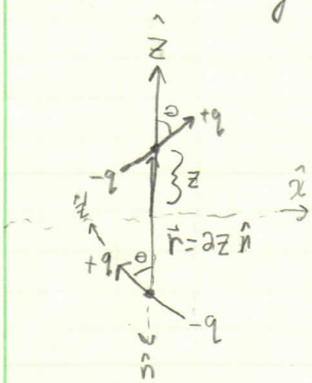
4.6



· Use method of images

· The question then is, what is the $\vec{E}$-field effected by the image?

using eq. (103) from chapter 3,

$\vec{E}(r,\theta) = \frac{p}{4\pi\varepsilon_0 r^3}\left(2\cos\theta\,\hat{r} + \sin\theta\,\hat{\theta}\right)$ in this situation it's clear that $\hat{r} = \hat{z}$, $\hat{\theta} = \hat{x}$

so

$N = \vec{p} \times \vec{E} = (p\sin\theta\,\hat{x} + p\cos\theta\,\hat{z}) \times \frac{p}{4\pi\varepsilon_0 r^3}\left(2\cos\theta\,\hat{z} + \sin\theta\,\hat{x}\right)$

$= \frac{p^2}{4\pi\varepsilon_0 r^3}\left[2\cos\theta\sin\theta\,(\hat{x}\times\hat{z}) + \cos\theta\sin\theta\,(\hat{z}\times\hat{x})\right] = \frac{p^2\left(\sin 2\theta - \frac{1}{2}\sin 2\theta\right)}{4\pi\varepsilon_0\, r^3}\,\hat{y} = \frac{p^2 \sin 2\theta}{8\pi\varepsilon_0 r^3}\,\hat{y}$

Intuitively, we expect the dipole to come to rest when it's parallel w/ its image. to see this mathematically, we set $\vec{N} = 0$, then

$\sin 2\theta = 0 \rightarrow 2\theta = 0, \pi, 2\pi, 3\pi, \ldots$

$\rightarrow \theta = 0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}$