# VE230 — Electromagnetics I

*Homework 3*

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## P. 3-22

a)

$$\rho_{ps} = \mathbf{P} \cdot \mathbf{a_n}|_{n=L/2} = \frac{1}{2} P_0 L.$$

$$\rho_p = -\nabla \cdot \mathbf{P} = -3P_0.$$

b)

$$Q_s = \oint_S \rho_{ps} dS = \frac{1}{2} P_0 L \cdot 6L^2 = 3P_0 L^3,$$

$$Q_v = \int_v \rho_p dV = \int_{-L/2}^{L/2} \int_{-L/2}^{L/2} \int_{-L/2}^{L/2} \rho_p dz dy dx = -3P_0 L^3,$$

$$Q = Q_s + Q_v = 0.$$

## P. 3-23

Let $\mathbf{P} = \mathbf{a_p} P_0$, $\theta = \langle \mathbf{P}, \mathbf{a_n} \rangle$,

$$\rho_{ps}(\theta) = \mathbf{P} \cdot \mathbf{a_n} = P_0 \cos\theta,$$

$$dE_\theta = dv \cdot \frac{\rho_{ps}}{4\pi\varepsilon_0 R^2} \cdot \cos\theta = 2\pi R^2 \sin\theta d\theta \cdot \frac{P_0 \cos\theta}{4\pi\varepsilon_0 R^2} \cdot \cos\theta = \frac{P_0 \sin\theta \cos\theta^2}{2\varepsilon_0} d\theta.$$

$$|\mathbf{E}| = \int dE_\theta = \int_0^\pi \frac{P_0 \sin\theta \cos\theta^2}{2\varepsilon_0} d\theta = \frac{P_0}{3\varepsilon_0},$$

$$\mathbf{E} = \mathbf{a_p} \frac{P_0}{3\varepsilon_0} = \frac{\mathbf{P}}{3\varepsilon_0}.$$

## P. 3-25