

FIRST EXAM

Name (print) HARVARD Name (signed) _____

Discussion Instructor (circle one): Emerson Caughan Iguchi Stoops Zhang

Discussion Section #: _____

AVG 12.44

SHOW ALL WORK!!!!

REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!

Use the conversion constants and data given on the front page.

A long cylinder of non-conductor of radius $R_0 = 1.75$ cm, has a charge density given by

$$\rho(r) = Br^3 \quad \text{for } 0 < r < R_0$$

The charge density is zero everywhere else.

- (a) If the total charge per unit length is -3.75×10^{-7} C/m, calculate the numerical value of B.
- (b) Calculate the magnitude of the electric field at a point $r = 0.95$ cm. State the direction of the field.

(a) $\lambda = \frac{Q}{l} = -3.75 \times 10^{-7} \text{ C/m}$

$$Q = \int \rho(r) dV$$

$$(-3.75 \times 10^{-7} \text{ C/m}) l = \int_0^{R_0} Br^3 2\pi r l dr$$

$$(-3.75 \times 10^{-7} \text{ C/m}) = 2\pi B \int_0^{R_0} r^4 dr$$

$$\left(\text{---} \text{ " } \text{---} \right) = 2\pi B \left. \frac{r^5}{5} \right|_0^{0.0175 \text{ m}}$$

$$\left(\text{---} \text{ " } \text{---} \right) = \frac{2\pi B}{5} (0.0175 \text{ m})^5$$

$B = -182 \text{ C/m}^4$

$$\textcircled{b} \int \vec{E} \cdot d\vec{A} = \frac{q_{\text{in}}}{\epsilon_0}$$

$$|E| 2\pi r l = \frac{2\pi l |B| r^5}{5 \epsilon_0}$$

$$|E| = \frac{|B| r^4}{5 \epsilon_0}$$

$$|E| = \frac{182 \text{ C/m}^4 (0.0095 \text{ m})^4}{5 \cdot 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2}$$

$$|E| = 3.35 \times 10^4 \text{ N/C}$$

Direction radially inward