Physics 2220
Spring 2005
George A. Williams

FIRST MIDTERM

4

Name:______________________________

Discussion Instructor (circle): Gillman   Rodriguez   Shepherd   Webb

Student ID #:______________________

SHOW ALL WORK!!!!!
REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

A very long cylinder of non-conducting material has a radius R_o and a volume charge density given by $\rho = BR^3$ for $R < R_o$ and $\rho = 0$ for $R > R_o$. B is a constant.

(a) Using Gauss' Law, calculate the electric field a distance R from the axis of the cylinder where $R > R_o$.
(b) Using Gauss' Law, calculate the magnitude of the electric field at an arbitrary point ***within*** the cylinder a distance R from the cylinder axis. $R < R_o$
(c) Calculate the magnitude of the potential difference between the wall of the cylinder and its axis $[V(R_o) - V(0)]$.
(d) If the sign of the charge on the cylinder is negative, state clearly the sign of $V(R_o) - V(0)$, and give a physical reason for it.

$A = 2\pi r L$

L= Length of Cylinder $\rho = Br^3$ $dv = 2\pi r L\,dr$

$$\oint \bar{E}\cdot d\bar{A} = \frac{1}{\varepsilon_0}\int \rho\, dv = \frac{1}{\varepsilon_0}\int_0^{R_0} 2\pi r L B r^3\, dr = \frac{2\pi B L R_0^5}{5\varepsilon_0}$$

a) $E(2\pi r L) = \frac{2\pi B L R_0^5}{5\varepsilon_0} \Rightarrow Er = \frac{BR_0^5}{5\varepsilon_0} \Rightarrow E = \frac{BR_0^5}{5\varepsilon_0 r}$

(If we want it in terms of Q then $E = \frac{Q}{2\pi L\varepsilon_0 r}$ where $\Rightarrow Q = \frac{2\pi B L R_0^5}{5}$)

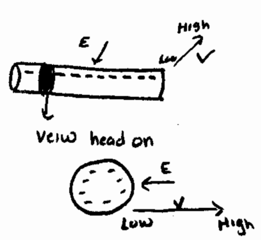
b) changing $\int_0^{R_0}$ to $\int_0^{r}$ we get $\frac{2\pi B L r^5}{5\varepsilon_0}$ then we solve

$E(2\pi r L) = \frac{2\pi B L r^5}{5\varepsilon_0} \Rightarrow Er = \frac{Br^5}{5\varepsilon_0} \Rightarrow E = \frac{Br^4}{5\varepsilon_0}$

c) $\Delta V = V(R_0) - V(0) = -\int_0^{R_0} \frac{Br^4}{5\varepsilon_0}\, dr = -\left(\frac{1}{5}\right)\frac{BR_0^5}{5\varepsilon_0} = -\frac{BR_0^5}{25\varepsilon_0}$ and the magnitude is

$\left|-\frac{BR_0^5}{25\varepsilon_0}\right| \Rightarrow \frac{BR_0^5}{25\varepsilon_0}$

D) $V(R_0) - V(0) > 0$, The Electric field is directed inward, therefore the Potential (v) increases the further away from the center you go. The Potential difference is positive.



Charge → ← wind = Electric Field

It is more difficult to walk against the wind, It requires more work to move to a Higher Potential

Charge ← ← wind

It is easier to walk with the wind, you are able to move without much resistance. Therefore it is easier to move to a Lower Potential.