Physics 4B
Fall 2022

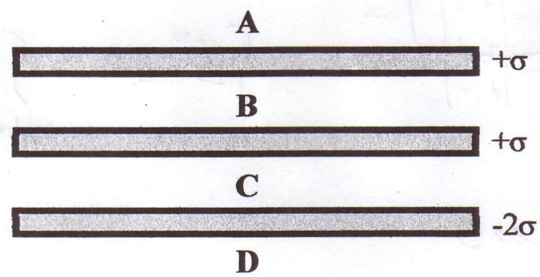
one. = 5.0
σ = 2.7

Name: Answer Key

Lab (circle one): 8:00 am 11:15 am 2:30 pm

Quiz #3: Gauss' Law

Problem 1 (2 points)
The figure shows sections of three *infinite nonconducting sheets* with uniform surface charge densities of either +σ or −2σ as indicated. In which region (A, B, C, or D) is the magnitude of the electric field the greatest? What is that magnitude?



$E = \sigma/2\varepsilon_0$ $E = \sigma/2\varepsilon_0$ $E = \frac{2\sigma}{2\varepsilon_0}$

C

a) region **B**: $E = \sigma/\varepsilon_0$
b) region **B**: $E = 2\sigma/\varepsilon_0$
c) region **C**: $E = 2\sigma/\varepsilon_0$
d) region **C**: $E = 4\sigma/\varepsilon_0$
e) none of the above

$A \rightarrow E = \sigma/2\varepsilon_0 + \sigma/2\varepsilon_0 - 2\sigma/2\varepsilon_0 = 0$

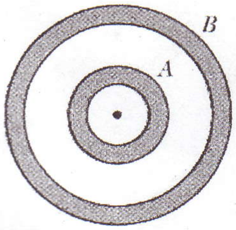
$B \rightarrow E = -\sigma/2\varepsilon_0 + \sigma/2\varepsilon_0 - 2\sigma/2\varepsilon_0 = 2\sigma/2\varepsilon_0 = \sigma/\varepsilon_0 (-\hat{j})$

$C \rightarrow E = -\sigma/2\varepsilon_0 - \sigma/2\varepsilon_0 - 2\sigma/2\varepsilon_0 = 2\sigma/\varepsilon_0 (-\hat{j})$

$D \rightarrow E = -\sigma/2\varepsilon_0 - \sigma/2\varepsilon_0 + 2\sigma/2\varepsilon_0 = 0$

Problem 2 (3 points)
A particle of charge q = -25 μC is at the center of two concentric conducting spherical shells as shown in the figure below. Shell A has a net charge of +10 μC and shell B has a charge of -35 μC. What is the charge on the inner and outer surfaces of each shell?

place Gaussian surface inside shell A:



$\oint \vec{E} \cdot d\vec{A} = 0$ so $q_{encl} = 0$ $\quad q_{encl} = q_{charge} + q_{A,inner} = 0$

$\downarrow$

$\vec{E} = 0$ inside conductor

$q_{A,inner} = -q = +25\,\mu C$

$q_A = q_{inner} + q_{outer}$

$q_{outer} = q_A - q_{inner} = -15\,\mu C$

	Inner surface	Outer surface
Charge on shell A:	+ 25 μC	− 15 μC
Charge on shell B:	+ 15 μC	− 50 μC

* repeat same process for shell B except $q_{encl} = q + q_A$

Problem 3 (5 points)
A very long, solid conducting cylinder has a radius of 5.0 cm and charge density is $\lambda = 1.80$ nC/m. Point A is 12.0 cm from the central axis of the cylinder and point B is 4.0 cm from the central axis of the cylinder. Use Gauss' law to find the electric field (magnitude and direction) at points A and B.

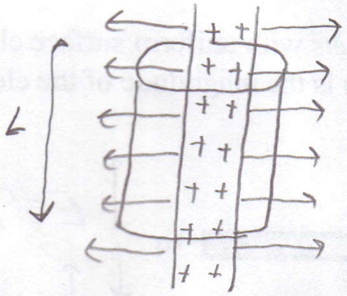
Note: You must show all work starting with the expression for Gauss' Law.

$R = 5.0$ cm

$\lambda = 1.80$ nC/m

$r_A = 12.0$ cm

$r_B = 4.0$ cm



choose cylinder centered on the conducting cylinder as Gaussian surface

$$\oint \vec{E}\cdot d\vec{A} = \int_{\text{cylinder}} \vec{E}\cdot dA + \int_{\text{top cap}} \vec{E}\cdot dA + \int_{\text{bottom cap}} \vec{E}\cdot d\vec{A}$$

top cap $= 0$ because $d\vec{A} \perp \vec{E}$; bottom cap $= 0$ because $d\vec{A} \perp \vec{E}$

$$\oint \vec{E}\cdot d\vec{A} = \int_{\text{cylinder}} E\,dA\cos\theta$$

$$= E\int dA = E(2\pi r L)$$

$$\oint \vec{E}\cdot d\vec{A} = q_{encl}/\varepsilon_0 \longrightarrow E(2\pi r L) = q_{encl}/\varepsilon_0 \longrightarrow E = \frac{(q/L)}{2\pi\varepsilon_0 r}$$

$$\boxed{E = \frac{\lambda}{2\pi\varepsilon_0 r}}$$

(a) $$E = \frac{(1.80\times10^{-9}\ \text{C/m})}{2\pi(8.85\times10^{-12}\ \text{C}^2/\text{Nm}^2)(0.12\text{m})} = 269.6\ \text{N/C}$$

$$\boxed{E = 2.7\times10^{2}\ \text{N/C radially outward}}$$

b) $\oint \vec{E}\cdot d\vec{A} = q_{encl}/\varepsilon_0$ $q_{encl} = 0$ since we are inside conductor

$$\oint \vec{E}\cdot d\vec{A} = 0 \longrightarrow \boxed{\vec{E} = 0}$$

in electrostatic equilibrium, $\vec{E} = 0$ inside a conductor