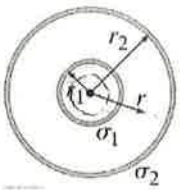
PHYS 212 **Exam 2** **Name** KEY

Problem 1 (33 Points

Two thin concentric spherical shells of radii r_1 and r_2 $(r_1 < r_2)$ contain uniform surface charge densities σ_1 and σ_2 respectively (see Fig. below).

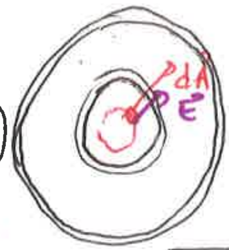


Gauss's Law $\oint \vec{E} \cdot d\vec{A} = \frac{Q_{en}}{\varepsilon_0}$ (3)

Determine the electric field for

(*a*) $0 < r < r_1$, $\oint \vec{E} \cdot d\vec{A} = \int E\, dA \cos\theta =$

$\oint E\, dA \cos 0 = E \oint dA = E A = E(4\pi r^2)$



(10) $Q_{en} = 0$ inside $\Rightarrow \oint \vec{E} \cdot d\vec{A} = \frac{Q_{en}}{\varepsilon_0}$

$E(4\pi r^2) = 0/\varepsilon_0 \Rightarrow$ $\boxed{E = 0}$

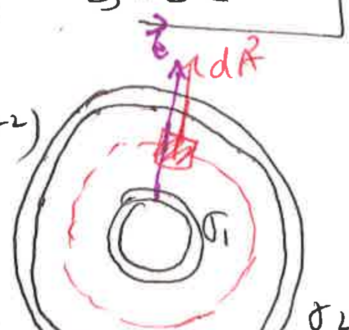
(*b*) $r_1 < r < r_2$,

$\oint \vec{E} \cdot d\vec{A} = \oint E\, dA \cos 0 = E \oint dA = E A = E(4\pi r^2)$

$Q_{en} = \sigma_1 A_1 = \sigma_1 (4\pi r_1^2)$

$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{en}}{\varepsilon_0}$

(10) $E(4\pi r^2) = \frac{\sigma_1 (4\pi r_1^2)}{\varepsilon_0} \Rightarrow$ $\boxed{E = \frac{\sigma_1}{\varepsilon_0} \frac{r_1^2}{r^2}}$



and (*c*) $r > r_2$.

$\oint \vec{E} \cdot d\vec{A}$ stay the same $= E(4\pi r^2)$

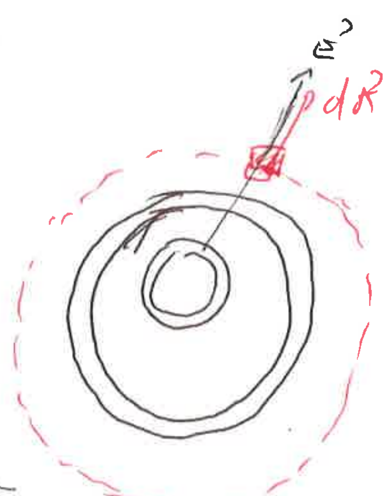
$Q_{en} = \sigma_1 A_1 + \sigma_2 A_2$

(10) $Q_{en} = \sigma_1 (4\pi r_1^2) + \sigma_2 (4\pi r_2^2)$

$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{en}}{\varepsilon_0}$

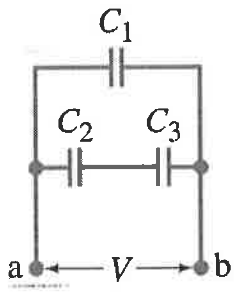
$E(4\pi r^2) = \frac{1}{\varepsilon_0}(\sigma_1 (4\pi r_1^2) + \sigma_2 (4\pi r_2^2))$

$\boxed{E = \frac{\sigma_1 r_1^2 + \sigma_2 r_2^2}{\varepsilon_0 r^2}}$



Problem 2 (34 Points)

(*a*) Determine the equivalent capacitance of the circuit shown in figure below.



$C_2 // C_3 \Rightarrow \frac{1}{C_{23}} = \frac{1}{C_2} + \frac{1}{C_3} = \frac{C_3 + C_2}{C_2 C_3}$

$\Rightarrow C_{23} = \frac{C_2 C_3}{C_3 + C_2}$

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$$C_{eq} = C_1 + \frac{C_2 C_3}{C_3 + C_2}$$

(*b*) If $C_1=C_2=2C_3=24\mu F$, how much charge is stored on each capacitor when $V = 35.0$ V?

$V_{ab} = V_{C_2C_3} = V_{C_1} = 35.0V$

$Q_1 = C_1 V_{C_1} = (24\times10^{-6} F)(35.0V) = 8.4\times10^{-4} C$

$Q_{23} = C_{23} V_{C_2C_3}$

$C_{23} = \frac{C_2 C_3}{C_3 + C_2}$ $\quad C_3 = \frac{1}{2} C_2 = \frac{1}{2} C$ (18

$C_{23} = \frac{C(\frac{1}{2}C)}{\frac{1}{2}C + C} = \frac{1/2\, C^2}{\frac{1}{2}C + \frac{2C}{2}} = \frac{\frac{1}{2}C^2}{\frac{3}{2}C} = \frac{C}{3}$

$Q_{23} = \frac{C}{3} V_{C_2C_3} = \frac{24\times10^{-6}F}{3}(35.0V) = 2.80\times10^{-4} C$

$= Q_2 = Q_3$ (same charge (C_2 & C_3 in serie))

Problem 3 (33 Points)

An extension cord made of two wires of diameter 0.129 cm and of length 2.7 m is connected to an electric heater which draws 15.0 A on a 120-V line. The resistivity of the copper is $1.68 \times 10^{-8} \Omega . m$.

How much power is dissipated in the cord?

$V = 120 V$

$I = 15.0 A$

$l = 2.7 m$

$d = 0.129 cm$

$\rho = 1.68 \times 10^{-8} \Omega . m$

$P = I^2 R$ (5)

$R = \frac{\rho l}{A}$ (5) $\quad A = \pi r^2 = \pi \left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$ (6)

$P = I^2 \frac{\rho l}{A} = \frac{I^2 \rho l}{\frac{\pi d^2}{4}} = \frac{4 I^2 \rho l}{\pi d^2}$ (8)

$l = 2 \times 2.7 m = 5.4 m$ (4)

$P = \frac{4 (15.0 A)^2 (1.68 \times 10^{-8} \Omega m)(5.4 m)}{\pi (0.129 \times 10^{-2} m)^2} = 15.62 W$ (5)