Name: Paul Le

Part II: Problems - Include a logical statement or relevant equation for full credit

Problem 1. A charge of +10.0 nC is placed a distance of 0.050 meters above a very large, flat, grounded, conducting sheet. Calculate the surface charge density on the sheet at a position directly below the charge.

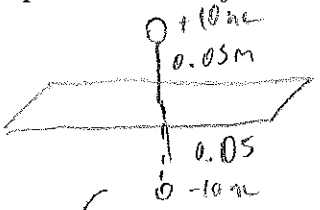


Image Charge

$\vec{E}_t = \vec{E}_+ + \vec{E}_-$

$= \frac{2\,\mathrm{E}{-9}}{4\pi\epsilon_0 (0.05)^2}$

$= 7.19\,\mathrm{E}3\ \mathrm{N/C}\ \hat{k}$

Problem 2. A solid ball of charge with uniform volume charge density ρ and radius R is centered at the origin.

a) Calculate the electric field inside and outside the ball.

Inside = 0
b/c no flux through surface inside sphere

Outside ($R < r$)

$q_{enc} = \rho \frac{4}{3}\pi (R)^3$

$\vec{E} = \frac{1}{4\pi\epsilon_0}$ $\rho \frac{4}{3}\pi R^3$

$\vec{E} = \frac{\rho 4\pi R^3}{12\pi\epsilon_0 r^2}$

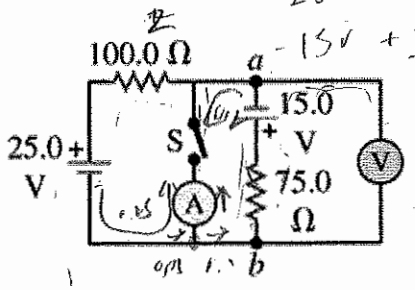
r - distance from center of ball/origin

b) Calculate the electric potential at the origin using a reference at infinity.

$V = k\frac{q}{r} = k\frac{\rho \frac{4}{3}\pi R^3}{r}$

Name: Paul Lee

Problem 3. The figure displays an electrical circuit. All components are ideal.



a) Find the potential difference measured by the voltmeter with the switch open as shown.

$\sum_{i=1}^{N} \Delta V_i = 0$

$\sum_{i=1}^{N} I_i = 0$

$25 - 75 I_1 + 15 + 100 I_2 = 0$

$V_{ab} = 75(0.2) + 15 = 0$

$V_{ab} = 0$

b) Find the power supplied by the 25 V battery to the circuit when the switch is open.

$P = I V$

$P = 0.25(25)$

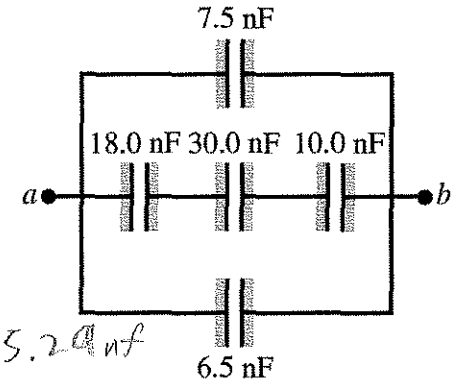
$P = 6.25\ W$

c) Find the current measured by the ammeter with the switch closed.

$0.25 - 0.2 = 0.05\ A$

Name: Paul Lee

Problem 4. For the system of capacitors shown in the figure, a potential difference of 25 V is maintained across ab



a) What is the equivalent capacitance of this system between a and b?

Series $\frac{1}{C_t} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

$\frac{1}{C_t} = \frac{1}{18} + \frac{1}{30} + \frac{1}{10} = \frac{17}{90} = \frac{1}{C_t} \rightarrow C_t = \frac{90}{17} = 5.29\,nf$

Parallel

$C_t = C_1 + C_2 + \ldots$

$C_t = 5.29 + 7.5 + 6.5 =$ **19.29 nF**

b) How much charge is stored by this system?

$Q = C\Delta V$

$19.29(25) = 482.25$

482.25 nC

c) How much charge does the 6.5 nF capacitor store?

$Q = C\Delta V$

$6.5(25)$

$Q =$ **162.5 nF**

d) What is the potential difference across the 10 nF capacitor?

$V_t = V_1 + V_2 + \ldots$ $\quad Q_t = 5.29 \cdot 25V$

$\frac{132.25nC}{5.29nF} = \frac{Q}{18} + \frac{Q}{30} + \frac{Q}{10}$

$Q = 132.25/3$

$V_3 = \frac{49.083nC}{10\,nF} =$ **4.908 V**

Name: Paul Le

Problem 5. The electric potential with respect to infinity inside a sphere with radius $R = 10$ m is given by the function $V(x, y, z) = xz + y^2$

a) What is the electric field inside the sphere?

$\vec{E} = -\nabla V$

$\vec{E} = -\langle z, 2y, x \rangle$

b) What is the volume charge density inside the sphere?

$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$

$\epsilon_0 (\vec{\nabla} \cdot \vec{E}) = \rho$

$z^2 + (2y)^2 + x^2$

$z^2 + 4y + x^2 = C$

c) How much work would be required to bring a point charge $+Q$ from ∞ to $(1, 2, 3)$?