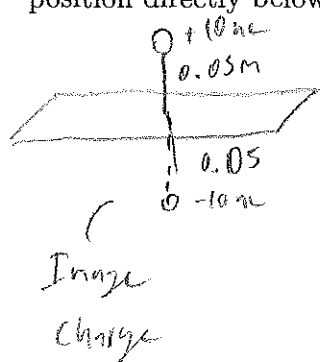


Name: \_\_\_\_\_

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

**Problem 1.** A charge of  $+10.0 \text{ nC}$  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.



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

$$= \frac{20 \times 10^{-9}}{4\pi\epsilon_0 (0.05)^2}$$

$$= 7.19 \times 10^3 \text{ N/C} \cdot \hat{k}$$

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

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

$$E_{\text{inside}} = 0$$

b/c no flux

through surface inside sphere

Outside:  $r > R$

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

$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{\rho \frac{4}{3} \pi R^3}{r^2}$$

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

$r$  - distance from center of ball / origin

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

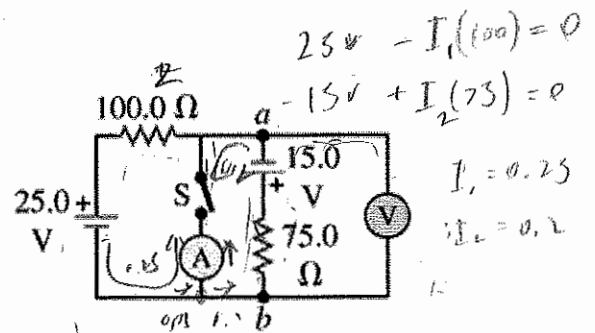
$$V = k \frac{q}{r}$$

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

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.



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

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

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

$$I_1 = 0.25$$

$$I_2 = 0.2$$

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

$V_{ab} = 0$

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

$$P = I V$$

$$P = 0.25 (25)$$

$P = 6.25 \text{ W}$

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

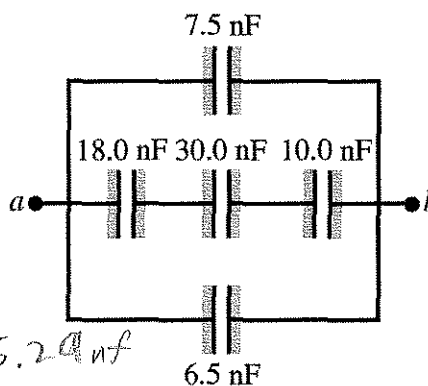
$$0.25 - 0.2 = 0.05 \text{ A}$$

$0.05 \text{ A}$

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

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

Parallel

$$C_t = C_1 + C_2 + \dots$$

$$C_t = 5.29 + 7.5 + 6.5 = 19.29 \text{ nF}$$

b) How much charge is stored by this system?

$$Q = C \Delta V$$

$$19.29(25) = 482.25$$

$$Q = 482.25 \text{ nC}$$

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

$$Q = C \Delta V$$

$$6.5(25)$$

$$Q = 162.5 \text{ nC}$$

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

$$V_E = V_1 + V_2 + \dots$$

$$Q = 5.29 \cdot 25 \text{ V}$$

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

$$Q = 132.25$$

$$V_3 = \frac{44.083 \text{ nC}}{10 \text{ nF}} = 4.408 \text{ V}$$

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?

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\epsilon_0}$$
$$\epsilon_0 (\vec{\nabla} \cdot \vec{E}) = \rho$$
$$z^2 + (2y)^2 + 1^2$$
$$z^2 + 4y + x^2 = \rho$$

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