PHYS 212 Spring 2012 Test #3 Name: KEY

$i = \frac{dq}{dt}$ Power = P = iv = $v^2/R = i^2R$ Ohm's law: v = iR $R = \rho\frac{L}{A}$

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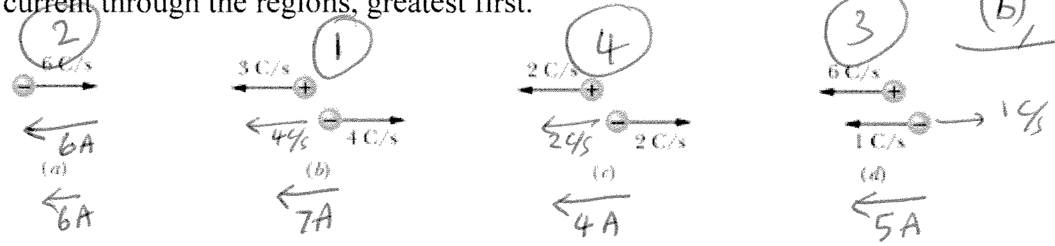
1. Figure below shows four situations in which positive and negative charges move horizontally and gives the rate at which each charge moves. Rank the situations according to the effective current through the regions, greatest first.

(b), (a), (d), (c)



2. A 180 W light bulb is plugged into a standard 120 V outlet. Assume electrical energy costs US$ 0.06/kW · h.

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(a) How much does it cost in dollars per year to leave the light turned on one hour every month?
(b) What is the resistance of the bulb?
(c) What is the current in the bulb?

(a) P = 180 W = 0.180 KW
Hours = 12 H ⟶ 0.180 KW × 12 H = 2.16 KWH
cost = \$0.13 or 13 cents

(b) $R = \frac{V}{i} = \frac{120}{1.5} = 80\,\Omega$

(c) $P = iV \rightarrow i = P/V = \frac{180}{120} = 1.5\,A$

3. A 4.0 kW heater element from a dryer has a length of 38 cm. If an 8.0 cm section is removed, what power is used by the now shortened element at 120 V?

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$P = \frac{V^2}{R}$; $R = \frac{\rho L}{A}$

$P = \frac{V^2}{\rho L/A} = \frac{V^2 A}{\rho L}$

$P_1 = \frac{V^2 A}{\rho L_1}$

$P_2 = \frac{V^2 A}{\rho L_2}$

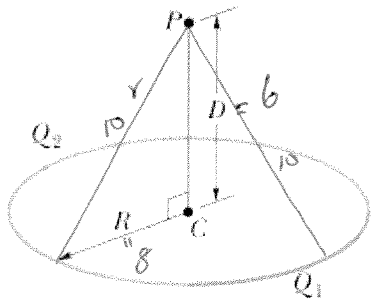
$\frac{P_1}{P_2} = \frac{L_2}{L_1}$

$P_2 = \frac{L_1}{L_2} \cdot P_1 = \frac{38}{30} \times 4\,kW$

$P_2 = 5.07\,kW$

$V = \frac{kq}{r}$ (k = Coulomb's constant = 9×10^9 N.m^2/C^2) $E_s = -\frac{\partial V}{\partial s}$.

4. A plastic rod has been bent into a circle of radius R = 8 cm. It has a charge Q_1 = +4 pC uniformly distributed along one-quarter of its circumference and a charge Q_2 = - 24 pC uniformly distributed along the rest of the circumference. With V = 0 at infinity, what is the electric potential at point P, on the central axis of the circle at distance D = 6 cm from the center?



$r = \sqrt{8^2 + 6^2} = 10$ cm

$V = V_1 + V_2$

$= \frac{kQ_1}{r} + \frac{kQ_2}{r}$

$= \frac{9\times10^9 \times 4\times10^{-12}}{0.1} - \frac{9\times10^9\times24\times10^{-12}}{0.1}$

$= -\frac{9\times10^9\times 20\times10^{-12}}{0.1} = -1.8$ Volt

-12

5. What is the electric field in unit vector notation and its magnitude at the point ($3\hat{i} - 2\hat{j} - \hat{k}$) m if the electric potential is given by $V = 3xy^2z^3$, where V is in volts and x, y, and z are in meters?

3 $E_x = -\frac{\partial v}{\partial x} = -\frac{\partial}{\partial x}(3xy^2z^3) = -3y^2z^3 = -3(-2)^2(-1)^3 = +12$

3 $E_y = -\frac{\partial v}{\partial y} = -\frac{\partial}{\partial y}(3xy^2z^3) = -6xyz^3 = -6(3)(-2)(-1)^3 = -36$

3 $E_z = -\frac{\partial v}{\partial z} = -\frac{\partial}{\partial z}(3xy^2z^3) = -9xy^2z^2 = -9(3)(-2)^2(-1)^2 = -108$

$\vec{E} = 12\hat{i} - 36\hat{j} - 108\hat{k}$

3 $|\vec{E}| = \sqrt{12^2 + (-36)^2 + (-108)^2} = 114.5$ N/C $\simeq$ V/m

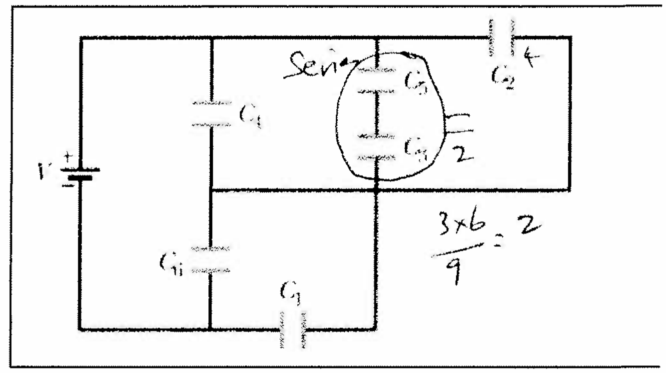
$q = CV$, $C = \frac{K\epsilon_0 A}{d}$ $\quad C_{eq} = \sum_{j=1}^{n} C_j$ (*n* capacitors in parallel) and $\frac{1}{C_{eq}} = \sum_{j=1}^{n} \frac{1}{C_j}$ (*n* capacitors in series).

6. Below: $V = 12$ V, $C_1 = C_4 = 2.0$ μF, $C_2 = 4.0$ μF, $C_3 = 3.0$ μF, $C_5 = 6.0$ μF, and $C_6 = 9.0$ μF.

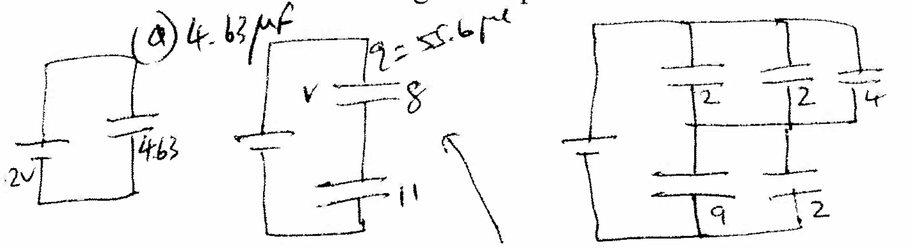
a. What is the equivalent capacitance?

b. What is the charge on the equivalent capacitance?

c. What is the charge on capacitor 2?



(a) 4.63 μF



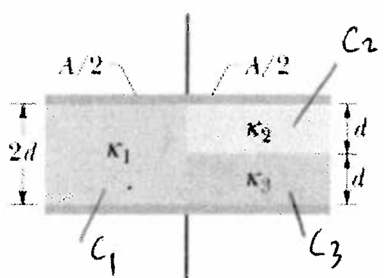
$q = CV = 4.63\,\mu F \times 12\,V = 55.6\,\mu C$

$V_2 = V_4 = \frac{q}{C} = \frac{55.6\,\mu C}{8\,\mu F} = 6.95$ Volt

$q_2 = C_2 V_2 = 4\,\mu F \times 6.95$ volt

$q_2 = 27.8\,\mu C$

7. Figure below shows a parallel-plate capacitor of plate area $A = 10.5$ cm^2 and plate separation $2d = 7.12$ mm. The left half of the gap is filled with material of dielectric constant $\kappa_1 = 21.0$; the top of the right half is filled with material of dielectric constant $\kappa_2 = 42.0$; the bottom of the right half is filled with material of dielectric constant $\kappa_3 = 58.0$. What is the capacitance? ($\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/(N.m^2)$)



$C_1 = \frac{K_1 \epsilon_0 A/2}{2d} = \frac{K_1 \epsilon_0 A}{2\times 2d} = \frac{21 \times 8.85\times10^{-12} \times 10.5\times10^{-4}}{2\times 7.12\times10^{-3}} = 13.7$ pF

$C_2 = \frac{K_2 \epsilon_0 A/2}{d} = \frac{K_2 \epsilon_0 A}{2d} = \frac{42\times 8.85\times10^{-12} \times 10.5\times10^{-4}}{7.12\times10^{-3}} = 54.8$ pF

$C_3 = \frac{K_3 \epsilon_0 A/2}{d} = \frac{K_3 \epsilon_0 A}{2d} = \frac{58\times 8.85\times10^{-12} \times 10.5\times10^{-4}}{7.12\times10^{-3}} = 75.7$ pF

C_2 & C_3 are in Series → $C_{23} = \frac{C_2 \times C_3}{C_2 + C_3} = \frac{54.8 \times 75.7}{(54.8 + 75.7)} = 31.8$ pF

C_1 & C_{23} are in parallel →

$C_{123} = C_1 + C_{23} = (13.7 + 31.8)$ pF

$C_{123} = 45.5$ pF $= 45.5 \times 10^{-12}$ F

$C_{123} = 4.55 \times 10^{-11}$ F