UNIVERSITY OF OTTAWA
Principles of Physics
PHY1322 Winter 2016
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STUDENT #: ________________	
NAME: ____________________	

ASSIGNMENT 2: Capacitance and RC circuits

Released: Jan 22 Due: Feb 7 4PM

1 An air-filled capacitor consists of two parallel plates, each with an area of 7.60 cm^2, separated by a distance of 1.80 mm. A 20.0-V potential difference is applied to these plates. Calculate (b) the energy stored in the capacitor, (b) the capacitance, and (c) the charge on each plate.

(a) $$C = \frac{\epsilon_0 A}{d} = \frac{(8.85\times10^{-12}\ \mathrm{C^2/N\cdot m^2})(7.60\ \mathrm{cm^2})(1.00\ \mathrm{m}/100\ \mathrm{cm})^2}{1.80\times10^{-3}\ \mathrm{m}} = \boxed{3.74\ \mathrm{pF}}$$

(b) U=

(d) $$\Delta V = \frac{Q}{C} \qquad Q = (20.0\ \mathrm{V})(3.74\times10^{-12}\ \mathrm{F}) = \boxed{74.7\ \mathrm{pC}}$$

2 A 50.0-m length of coaxial cable has an inner conductor that has a diameter of 2.58 mm and carries a charge of 8.10 μC. The surrounding conductor has an inner diameter of 7.27 mm and a charge of −8.10 μC. (a) What is the capacitance of this cable? (b) What is the potential difference between the two conductors? Assume that the region between the conductors is air.

(a) $$C = \frac{\ell}{2k_e \ln\left(\frac{b}{a}\right)} = \frac{50.0}{2(8.99\times10^9)\ln\left(\frac{7.27}{2.58}\right)} = \boxed{2.68\ \mathrm{nF}}$$

(b) Method 1: $$\Delta V = 2k_e\lambda \ln\left(\frac{b}{a}\right)$$

$$\lambda = \frac{q}{\ell} = \frac{8.10\times10^{-6}\ \mathrm{C}}{50.0\ \mathrm{m}} = 1.62\times10^{-7}\ \mathrm{C/m}$$

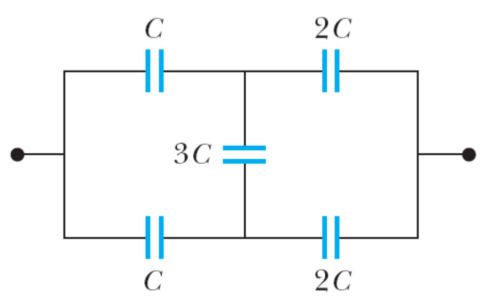
$$\Delta V = 2(8.99\times10^9)(1.62\times10^{-7})\ln\left(\frac{7.27}{2.58}\right) = \boxed{3.02\ \mathrm{kV}}$$

Method 2: $$\Delta V = \frac{Q}{C} = \frac{8.10\times10^{-6}}{2.68\times10^{-9}} = \boxed{3.02\ \mathrm{kV}}$$

3. A) Determine the equivalent capacitance of the combination shown below

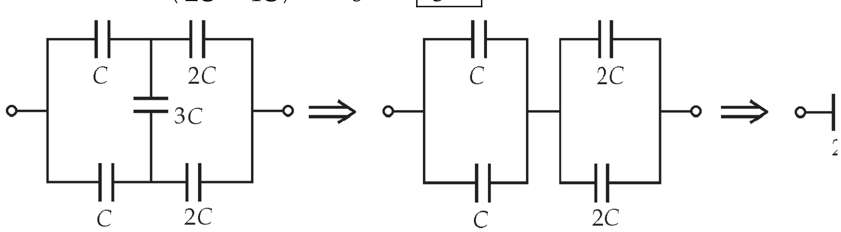
B) Find the energy stored in this system for C=20uF if the potential difference of 200V exists between the two end terminals

C) Find the charge on 3C capacitor in that case.



A) By symmetry, the potential difference across $3C$ is zero, so the circuit reduces to

$$C_{eq} = \left(\frac{1}{2C} + \frac{1}{4C}\right)^{-1} = \frac{8}{6}C = \boxed{\frac{4}{3}C}.$$



B) $$E = U = \frac{1}{2}CV^2 = \frac{1}{2}\frac{4}{3}20\times10^{-6}\times200^2(FV^2) = \frac{2}{3}(8)(0.1)J = 0.533J$$

C) Q=0

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4 An aluminum rod has a resistance of 1.234 Ω at 20.0°C.alculate the resistance of the rod at 120°C by accounting for the changes in both the resistivity and the dimensions of the rod.

B) The rod is cooled down to 20 C. And at that temperature it is stretched to twice its length at 20C. find the new value of the resistance of the rod

For aluminum, Resistance coeff. $\alpha_E = 3.90 \times 10^{-3}\ °C^{-1}$

Length coeff $\alpha = 24.0 \times 10^{-6}\ °C^{-1}$

A) $$R = \frac{\rho \ell}{A} = \frac{\rho_0 (1+\alpha_E \Delta T)\ell(1+\alpha\Delta T)}{A(1+\alpha\Delta T)^2} = R_0 \frac{(1+\alpha_E \Delta T)}{(1+\alpha \Delta T)} = (1.234\ \Omega)\left(\frac{1.39}{1.002\ 4}\right) = \boxed{1.71\ \Omega}$$

B) $$R_1 = \frac{\rho l_1}{A_1}\quad R_2 = \frac{\rho l_2}{A_2} = \frac{(\rho(2l_1))}{(\frac{1}{2}A_1)} = 4R_1 = \boxed{4.936\Omega}$$

5 A 2.00-nF capacitor with an initial charge of 5.10 μC is discharged through a 1.30-kΩ resistor. (a) Calculate the current in the resistor 9.00 μs after the resistor is connected across the terminals of the capacitor. (b) What charge remains on the capacitor after 8.00 μs? (c) What is the maximum current in the resistor?

(a) $I(t) = -I_0 e^{-t/RC}$

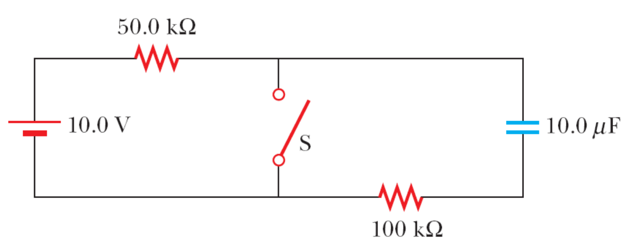
$$I_0 = \frac{Q}{RC} = \frac{5.10 \times 10^{-6}\ \text{C}}{(1\,300\ \Omega)(2.00 \times 10^{-9}\ \text{F})} = 1.96\ \text{A}$$

$$I(t) = -(1.96\ \text{A})\exp\left[\frac{-9.00 \times 10^{-6}\ \text{s}}{(1\,300\ \Omega)(2.00 \times 10^{-9}\ \text{F})}\right] = \boxed{-61.6\ \text{mA}}$$

(b) $$q(t) = Qe^{-t/RC} = (5.10\ \mu\text{C})\exp\left[\frac{-8.00 \times 10^{-6}\ \text{s}}{(1\,300\ \Omega)(2.00 \times 10^{-9}\ \text{F})}\right] = \boxed{0.235\ \mu\text{C}}$$

(c) The magnitude of the maximum current is $I_0 = \boxed{1.96\ \text{A}}$.

4 In the circuit of Figure P21.43, the switch S has been open for a long time. It is then suddenly closed. Determine the time constant (a) before the switch is closed and (b) after the switch is closed. (c) Let the switch be closed at *t* = 0. Determine the current in the switch as a function of time.



(a) $\tau = RC = \left(1.50 \times 10^{5}\ \Omega\right)\left(10.0 \times 10^{-6}\ \text{F}\right) = \boxed{1.50\ \text{s}}$

(b) $\tau = \left(1.00 \times 10^{5}\ \Omega\right)\left(10.0 \times 10^{-6}\ \text{F}\right) = \boxed{1.00\ \text{s}}$

(c) The battery carries current $\dfrac{10.0\ \text{V}}{50.0 \times 10^{3}\ \Omega} = 200\ \mu\text{A}$.

The $100\ \text{k}\Omega$ carries current of magnitude

$$I = I_0 e^{-t/RC} = \left(\frac{10.0\ \text{V}}{100 \times 10^{3}\ \Omega}\right) e^{-t/1.00\ \text{s}}.$$

So the switch carries downward current $\boxed{200\ \mu\text{A} + \left(100\ \mu\text{A}\right)e^{-t/1.00\ \text{s}}}$.