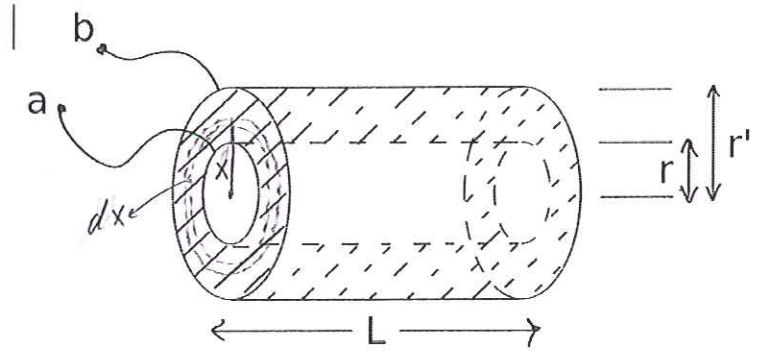
PHYS 102: General Physics - KOÇ UNIVERSITY
College of Sciences
Quiz 5 Nov 11, 2016

Closed book. No calculators are to be used for this quiz.
Quiz duration: 15 minutes
Name: ID #: Signature:

Q. The (shaded) volume between two coaxial conducting cylinders with radii r and r' ($r < r'$) is filled with a material with resistivity ρ. Express the resistance R_{ab} measured between the cylinders as an integral. Hint: Consider the object as composed of stacked cylindrical sheets of infinitesimal thickness which are connected in series.



$A = 2\pi x L$

$$dR = \frac{\rho dx}{2\pi x L} \Rightarrow R = \frac{\rho}{2\pi L}\int_{r}^{r'}\frac{dx}{x} = \frac{\rho}{2\pi L}\ln\left(\frac{r'}{r}\right)$$

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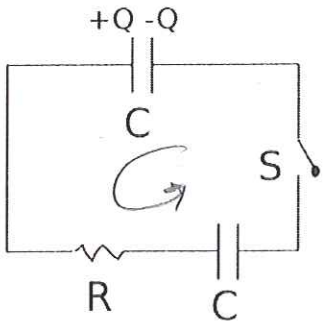
Q. The upper capacitor in the circuit below carries an initial charge of Q while the lower capacitor is initially uncharged. The switch is closed at $t = 0$. Write down the differential equation for the charge $q(t)$ on the lower capacitor by using Kirchoff's loop rule.



$q(t)$ is the charge of lower capacitor, Then the charge of upper capacitor is $Q - q(t)$.

Loop: $\frac{Q - q(t)}{C} - IR - \frac{q(t)}{C} = 0$

$I = \frac{dq(t)}{dt} \Rightarrow \frac{Q - q(t)}{C} - R\frac{dq(t)}{dt} - \frac{q(t)}{C} = 0$

$\frac{dq(t)}{dt} + \frac{2}{RC} q(t) - \frac{Q}{RC} = 0$ Differential equation

solution $\Rightarrow q(t) = \frac{Q}{2}(1 - e^{-2t/RC})$

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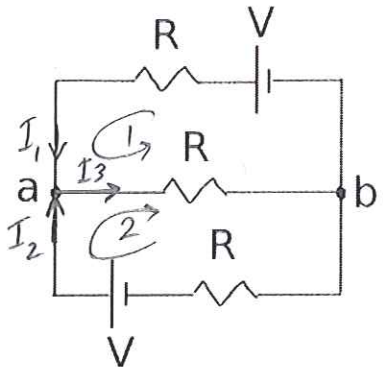
Q. Find the electric potential difference V_{ab} in the circuit below.



Point a : $I_1 + I_2 = I_3$

Loop 1 : $V - I_1 R - I_3 R = 0$

Loop 2 : $V - I_3 R - I_2 R = 0$

$\Rightarrow I_1 = \frac{1}{3}\frac{V}{R}$, $I_2 = \frac{1}{3}\frac{V}{R}$, $I_3 = \frac{2}{3}\frac{V}{R}$

$\Rightarrow V_a - I_3 R = V_b \longrightarrow V_{ab} = V_a - V_b = I_3 R = \frac{2}{3} V$

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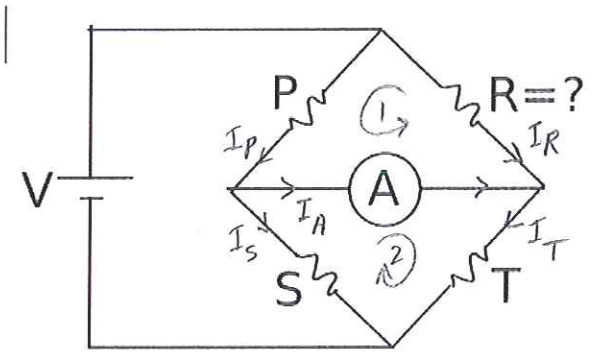
Q. The circuit below is called a *Wheatstone Bridge*. It is used to find the resistence of an unknown resistor (here R). Express R in terms of the resistances P, S, T, if these three are chosen such that the ammeter in the middle reads zero current (that is, there is zero potential difference across its terminals).



$$\begin{cases} I_P = I_A + I_S \\ I_R + I_A = I_T \end{cases}$$

$$\begin{cases} \text{loop 1}: -I_P P - I_A R_A + I_R R = 0 \\ \text{loop 2}: I_S S - I_A R_A - I_T T = 0 \end{cases}$$

$$\text{when } I_A = 0 \Rightarrow \begin{cases} I_R R = I_P P \\ I_S S = I_T T \end{cases} \Rightarrow R = \frac{I_P P I_T T}{I_R I_S S}$$

$$\Rightarrow R = \frac{P \cdot T}{S}$$