Instructor, A **section 118**

SFU Department of Physics

phys102q – Fall 2004 – Assignment 4.
Due Sat, Oct 23, 2004 at 23:59hrs. CAPA ID is 9851

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1. [1 pt.] Two oppositely charged parallel sheets of charge give rise to a field of 8.35×10^{11}N/C between them. The sheets are square and have dimensions 2.05m×2.05m. Assume that the charge distribution and electric field are uniform, as if the sheets were infinite in size, and that the distance between the sheets is much smaller than 2.05m. How much charge must there be on each sheet?

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2. [1 pt.] The resistivity of silver is $1.59\times10^{-8}\Omega$.m. What is the resistance of a section of 10 gauge wire (diameter 0.2591cm.) that is 3.65m long?

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3. [1 pt.] What is the length of a copper wire (of circular cross section) whose resistance is 1.25Ω and whose mass is 2.95kg? (Note that the mass density of copper is 8.9×10^3kg/m^3.)

4. [1 pt.] What is the radius of the copper wire in the previous question?

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5. [1 pt.] A number 12 copper wire has a diameter of 2.053mm. Calculate the resistance of a 43m long piece of that wire. Use $\rho = 1.72\times10^{-8}\Omega$m for the resistivity of copper.

6. [1 pt.] For safety, the National Electrical Code limits the allowable amount of current which such a wire may carry. When used in indoor wiring, the limit is 20 amperes for rubber insulated wire of that size. How much power would be dissipated in the wire of the above problem when carrying the maximum allowable current?

7. [1 pt.] What would be the voltage between the ends of one wire in the last problem?

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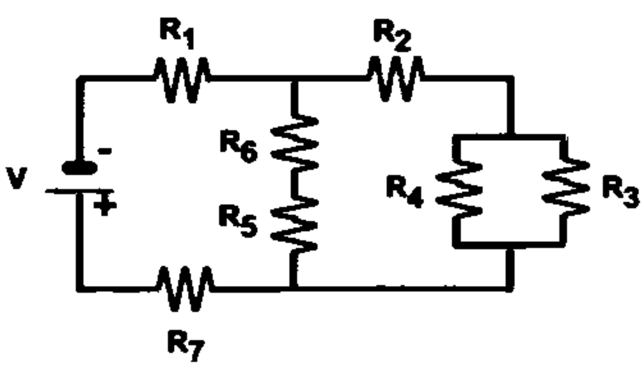
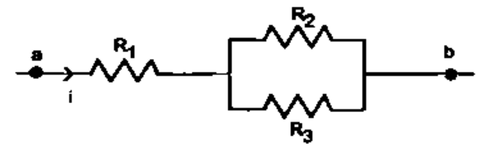
8. [1 pt.] Find the equivalent resistance of the circuit as shown in the diagram below; where, R_1=3Ω, R_2=3Ω, R_3=2Ω, R_4=2Ω, R_5=4Ω, R_6=2Ω, and R_7=1Ω.





9. [1 pt.] In the section of circuit above, $R_1 = 4.618\,\Omega$, $R_2 = 1.480\,\Omega$ and the voltage difference $V_a - V_b = 2.600$V. The current i =0.500A. Find the value of R_3.

10. [1 pt.] What is the current through R_3 ?

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11. [1 pt.] An uncharged 2.65-μF capacitor is in series, through a switch, with a 5.55-MΩ resistor and a 28.8-V battery (with negligible internal resistance.) The switch is closed at t=0 and a current of I_i immediately appears. Determine I_i.

12. [1 pt.] How long will it take for the current in the circuit to drop to $0.37I_i$?

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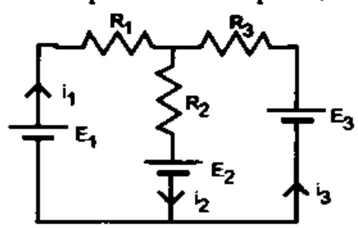
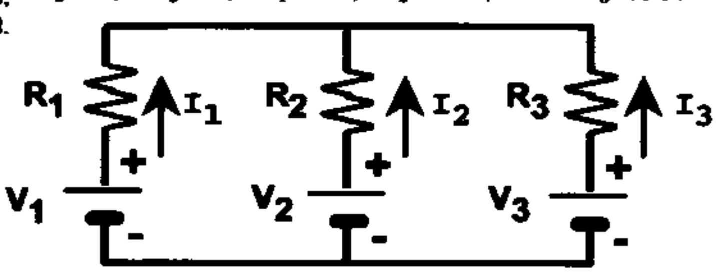
13. [1 pt.] Consider the following diagram and choose the expressions that are correct. (Give all correct answers in alphabetical order, for example, if A, B and D were correct then input ABD - no spaces, no commas.)



A) $E_2 - E_1 = i_1R_1 - i_2R_2$
B) $i_1 + i_2 = -i_3$
C) $i_1 = i_2 - i_3$
D) $E_1 - E_3 = i_1R_1 + i_3R_3$
E) $E_1 - E_2 = i_1R_1 + i_2R_2$
F) $E_3 - E_1 = i_3R_3 - i_1R_1$
G) $E_2 - E_3 = -i_3R_3 - i_2R_2$

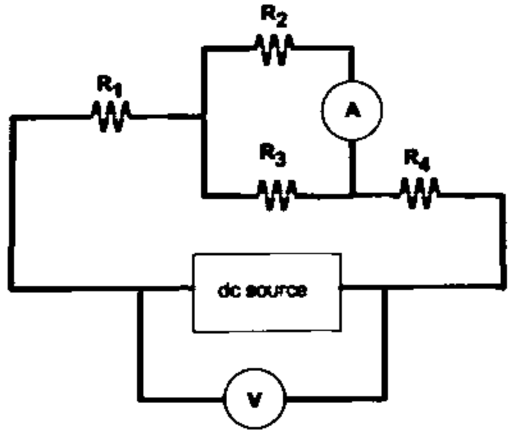
The diagram below shows a circuit where; R_1=3Ω, R_2=4Ω, R_3=4Ω, V_1=9.0V, V_2=14.0V, and V_3=10.0V.



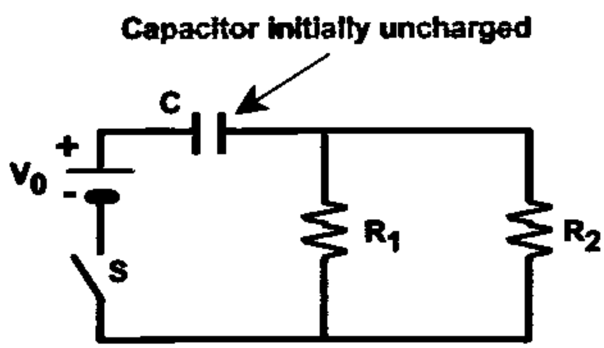
14. [1 pt.] What is the value of I_1?

15. [1 pt.] What is the value of I_2?

16. [1 pt.] What is the value of I_3?



17. [1 pt.] Given that the ammeter in the diagram above reads 2.85A and that R_1=7.90Ω, R_2=8.10Ω, R_3=4.10Ω, and R_4=5.00Ω, what is the emf of the ideal dc source as indicated by the voltmeter?



The diagram above depicts an RC-circuit where C=8.40μF, R_1=11.0Ω, R_2=18.5Ω, and V_0=20.0V.

18. [1 pt.] What is the current through R_1 immediately after the switch S is closed?

19. [1 pt.] What is the current through R_2 immediately after the switch S is closed?

20. [1 pt.] What is the current through the capacitor immediately after the switch S is closed?

21. [1 pt.] What is the current through R_1 after the switch S has been closed for a very long time? (Assume that the battery does not go dead.)

22. [1 pt.] What is the current through R_2 after the switch S has been closed for a very long time? (Assume that the battery does not go dead.)

Physics 102

CAPA set 4 solutions.

1.

$$E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{A\varepsilon_0}$$

$$Q = A\varepsilon_0 E = 2.05 \times 2.05 \times 8.85\times10^{-12} \times 8.35\times10^{11} = 31.1 \text{ C}$$

2.

$$R = \rho\frac{l}{A} = \rho\frac{l}{\pi\left(\frac{d}{2}\right)^2} = \frac{1.59\times10^{-8}\times 3.65}{\pi\,(2.591\times10^{-3}/2)^2} = 1.10\times10^{-2}\ \Omega$$

3.

$$R = \rho\frac{L}{A}, \quad m = \rho_m L A \quad (\rho_m \text{ — mass density})$$

$$L = \frac{RA}{\rho} \qquad A = \frac{m}{\rho_m L}$$

$$\therefore\ L = \frac{Rm}{\rho\rho_m L}. \qquad L = \sqrt{\frac{Rm}{\rho\rho_m}}$$

$$L = \sqrt{\frac{1.25\times 2.95}{1.72\times10^{-8}\times 8.9\times10^{3}}} = 155 \text{ m}.$$

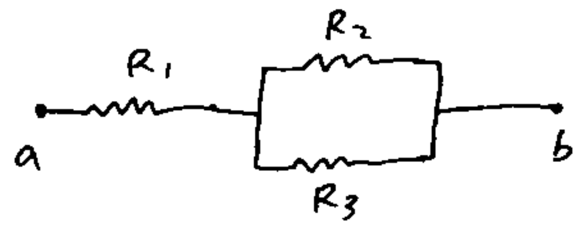
4.

$$R = \rho\frac{L}{A} = \rho\frac{L}{\pi r^2}.$$

$$\frac{1}{r} = \sqrt{\frac{\pi R}{\rho L}} = \sqrt{\frac{\pi\times1.25}{1.72\times10^{-8}\times155}} = 1212$$

$$r = 8.24\times10^{-4} \text{ m}$$

9.



$$R = R_1 + (R_2 // R_3)$$

$$= R_1 + \frac{R_2 R_3}{R_2 + R_3}$$

$$i = \frac{V_a - V_b}{R} = \frac{V_a - V_b}{R_1 + \frac{R_2 R_3}{R_2 + R_3}}$$

$$i R_1 + \frac{i R_2 R_3}{R_2 + R_3} = V_a - V_b$$

$$i R_1 R_2 + i R_1 R_3 + i R_2 R_3 = (V_a - V_b) R_2 + (V_a - V_b) R_3$$

$$i (R_1 + R_2) R_3 - (V_a - V_b) R_3 = (V_a - V_b) R_2 - i R_1 R_2$$

$$R_3 = \frac{(V_a - V_b) R_2 - i R_1 R_2}{i (R_1 + R_2) - (V_a - V_b)}$$

$$= \frac{(2.6)(1.48) - (0.5)(4.618)(1.48)}{(0.5)(4.618 + 1.48) - 2.6}$$

$$= \frac{3.848 - 3.41732}{3.049 - 2.6}$$

$$= 0.960\ \Omega$$

10. $V_a - V_b = i R_1 + i_3 R_3$.

$$i_3 = \frac{(V_a - V_b) - i R_1}{R_3} = \frac{2.6 - 0.5 \times 4.618}{0.960} = 0.303\ A.$$

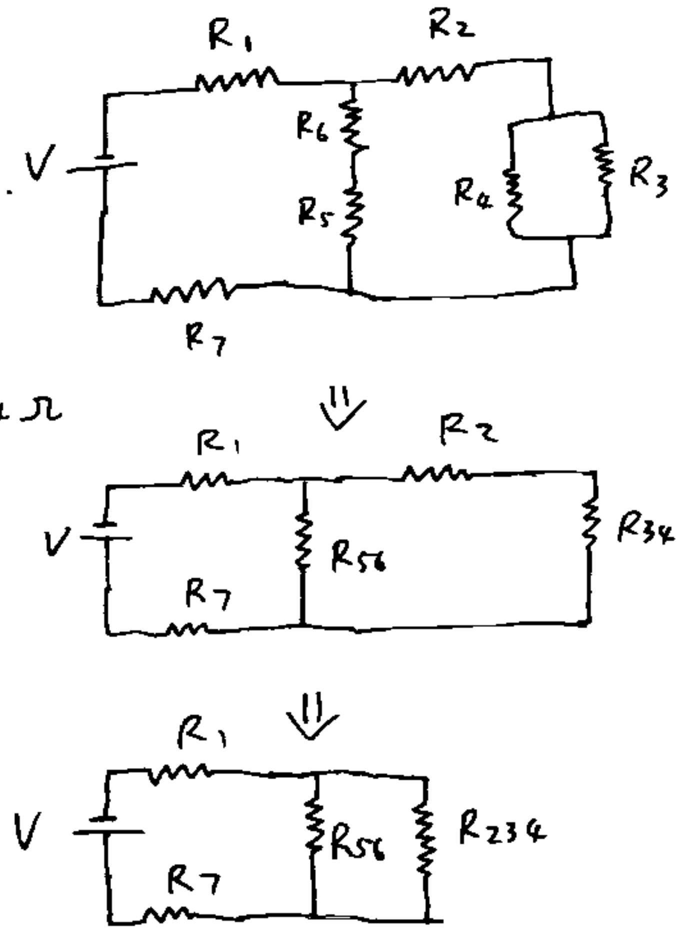
5. $R = \rho \frac{L}{A} = \rho \frac{L}{\pi (\frac{d}{2})^2}$

$= 1.72 \times 10^{-8} \frac{43}{\pi (2.053 \times 10^{-3}/2)^2} = 0.223\ \Omega$.

6. $P = RI^2 = 0.223 \times 20^2 = 89.2\ W$

7. $V = IR = 0.223 \times 20 = 4.46\ V$

8. $R_{34} = \frac{R_3 R_4}{R_3 + R_4} = \frac{2 \times 2}{2+2} = 1\Omega$.



$R_{56} = R_5 + R_6 = 4 + 2 = 6\ \Omega$.

$R_{234} = R_2 + R_{34} = 3\Omega + 1\Omega = 4\Omega$

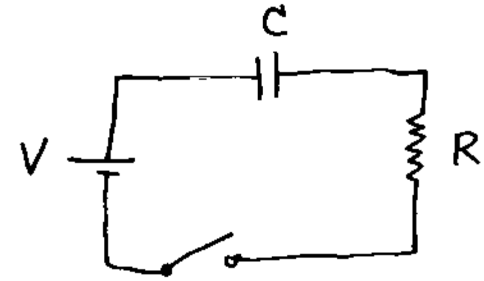
$R_{56} // R_{234} = \frac{6 \times 4}{6 + 4} = 2.4\ \Omega$

$R = R_1 + R_{56} // R_{234} + R_7$

$= 3 + 2.4 + 1$

$= 6.4\ \Omega$

11. When the switch is just closed, $t=0$.



$$I = I_0 e^{-t/RC}.$$

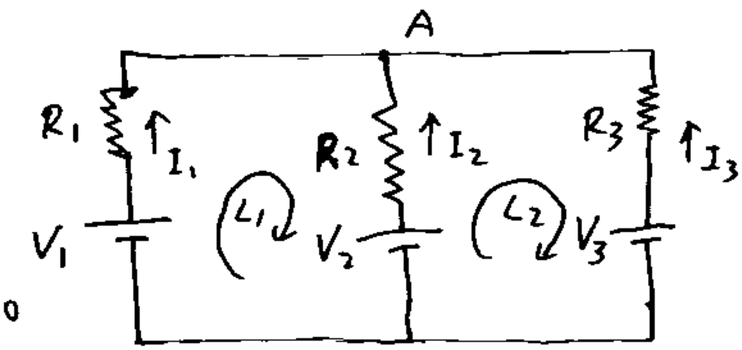
where $I_0 = \frac{V}{R}$.

at $t=0$: $I_i = \frac{V}{R} = \frac{28.8}{5.55\times10^{6}} = 5.19\times10^{-6}$ A

12. $RC = 5.55\times10^{6}\times 2.65\times10^{-6} = 14.7$ s.

13. CFFG.

14.



① Node: $I_1 + I_2 + I_3 = 0$

② L_1: $V_1 - I_1R_1 + I_2R_2 - V_2 = 0$

③ L_2: $V_2 - I_2R_2 + I_3R_3 - V_3 = 0$

$$\therefore \begin{cases} I_1 + I_2 + I_3 = 0 & ① \\ -I_1R_1 + I_2R_2 = V_2 - V_1 & ② \\ -I_2R_2 + I_3R_3 = V_3 - V_2 & ③ \end{cases}$$

solve for I_1, I_2, I_3.

① × R_1 + ② ⇒ $I_2(R_1+R_2) + I_3R_1 = V_2 - V_1$ ④

$-I_2R_2 + I_3R_3 = V_3 - V_2$ ⑤

④ × R_3 − ⑤ × R_1: $I_2(R_1+R_2)R_3 + I_2R_2R_1 = (V_2-V_1)R_3 - (V_3 - V_2)R_1$

$$I_2 = \frac{(V_2-V_1)R_3 - (V_3-V_2)R_1}{R_1R_3 + R_2R_3 + R_1R_2}$$

$$I_2 = \frac{(14-9)\times 4 - (10-14)\times 3}{3\times 4 + 4\times 4 + 3\times 4} = \frac{32}{40} = 0.8\ A$$

from ②: $$I_1 = \frac{I_2 R_2 - V_2 + V_1}{R_1}$$

$$= \frac{0.8\times 4 - 14 + 9}{3} = -0.6\ A.$$

15: $I_2 = 0.8\ A$.

16. $I_3 = -I_2 - I_1 = -0.8A - (-0.6A) = -0.2\ A$

17. $$R = R_1 + (R_2 /\!/ R_3) + R_4 = R_1 + R_4 + \frac{R_2 R_3}{R_2 + R_3}$$

$IR = V$.

but: $I_2 R_2 = I_3 R_3$, $I_3 = I_2 \frac{R_2}{R_3}$.

$I_2 + I_3 = I$.

$I = I_2 + I_2 \frac{R_2}{R_3} = I_2 \left(1 + \frac{R_2}{R_3}\right)$

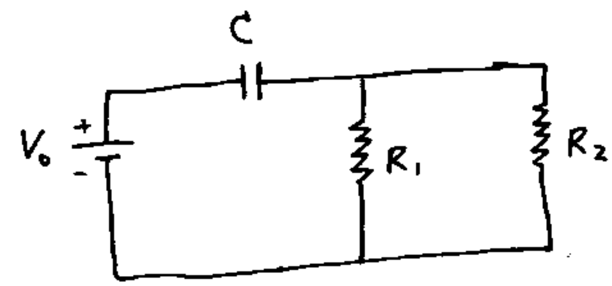
$V = I R$.

$$\therefore V = I_2 \left(1 + \frac{R_2}{R_3}\right) \cdot \left[R_1 + R_4 + \frac{R_2 R_3}{R_2 + R_3}\right]$$

$$= 2.85 \left(1 + \frac{8.1}{4.1}\right)\left[7.9 + 5 + \frac{8.1\times 4.1}{8.1 + 4.1}\right]$$

$$= 132\ V$$

18. $I = I_0 e^{-t/RC} = \frac{V}{R} e^{-t/RC}$.



$t=0$. I_0

$R = R_1 // R_2 = \frac{R_1 R_2}{R_1 + R_2}$

$= \frac{11 \times 18.5}{11 + 18.5}$

$= 6.9\ \Omega$.

$t=0$: $I_0 = \frac{V}{R} = \frac{20\,V}{6.9\,\Omega} = 2.90\ A$

$I_1 R_1 = I_2 R_2$, $I_1 + I_2 = I_0$

$I_2 = I_1 \frac{R_1}{R_2}$. $I_1 = I_2 \frac{R_2}{R_1}$.

$\therefore\ I_1 + I_1 \frac{R_1}{R_2} = I_0$.

$I_1 = \frac{I_0}{1 + \frac{R_1}{R_2}} = \frac{2.90\,A}{1 + \frac{11}{18.5}} = 1.82\,A$.

(OR: at $t=0$. C is just like shorted.

$\therefore\ V_0 = I_1 R_1$. $I_1 = \frac{V_0}{R_1} = \frac{20\,V}{11\,\Omega} = 1.82\,A$.)

19. $I_2 = \frac{V_0}{R_2} = \frac{20}{18.5} = 1.08\ A$. (OR: $I_2 = I_0 - I_1$ [redacted] $= 2.9 - 1.82$ $= 1.08\ A$)

20. $I_0 = 2.90\ A$

21. $I = 0$. $\because$ C is open and fully charged.

22. $I = 0$.