Phy 4B 5/23

Tuesday, May 23, 2017 3:07 PM

Last Lecture: Goals for the Lecture:

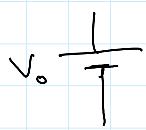
1) Understand the terms current, drift velocity, and charge carrier
2) Understand Ohm's Law and how to find resistance of a conductor
3) Understand how temperature changes resistance in common conductive materials and in semiconductors and superconductors
4) Pay particular attention to equations: 27.1-27.3, 27.7-27.8, 27.10, 27.20, and 27.21-27.22
5) Be able to use series and parallel rules for resistor to solve circuit problems
6) Be able to use Kirchhoff's Rules to solve circuit problems

Goals for the Lecture:

1) Understand power dissipated in electrical devices and how to use it in solving problems
2) Understand EMF and internal resistance of batteries and power supplies
3) Understand RC circuits and their time constant, τ
4) Be able to do calculations involving time to charge and discharge capacitors in RC circuits

Battery and EMF:

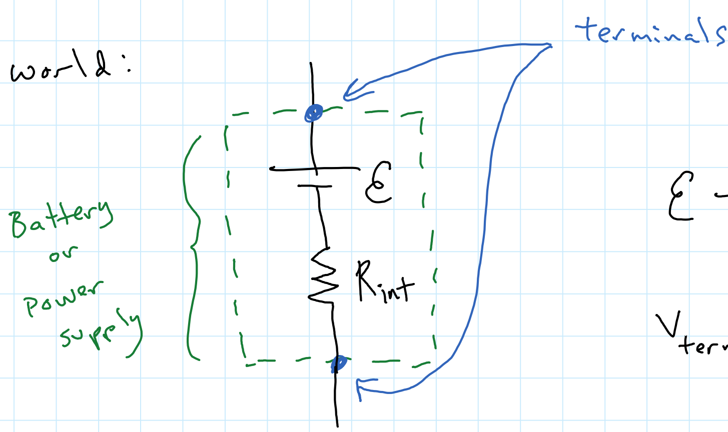
Ideal:



= Ideal battery or voltage source

No internal resistance so, it always provides the set voltage, V_0, no matter the current flow

Real world:



$\mathcal{E} \rightarrow$ EMF max voltage

$V_{terminal} \leq \mathcal{E}$

$V_{terminal} = \mathcal{E} - I R_{int}$

Worksheet p. 99

1) $V_A = V_{battery}$

$V_B = \frac{1}{2} V_{battery}$

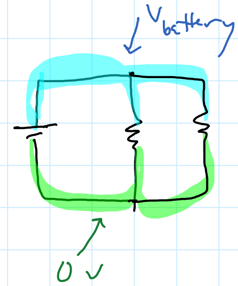
$V_A > V_B > V_C$

$V_B = \frac{1}{2} V_{battery}$

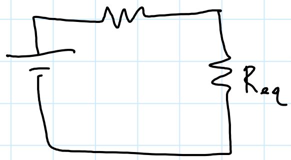
$V_c = \frac{1}{3} V_{battery}$

V_A V_B c

2) $V_A = V_B = V_c = V_{battery}$



3)



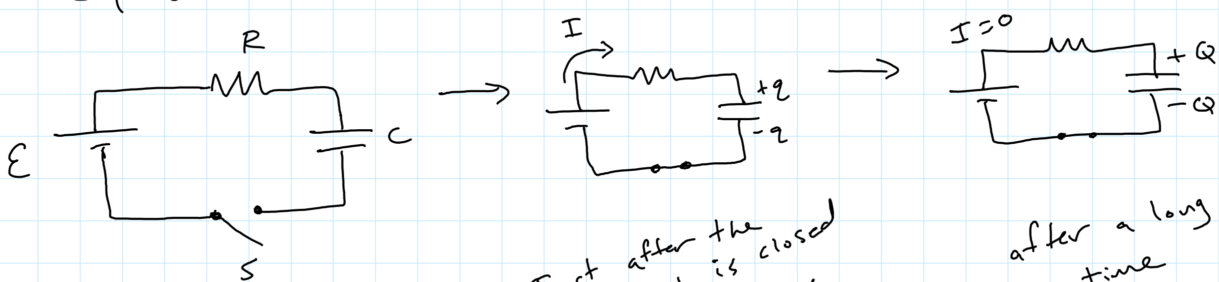
$$(R_{eq})_A > (R_{eq})_B > (R_{eq})_c$$

$$V_c > V_B > V_A$$

(V_c ↑ largest current)

D) $V_A = V_B = V_{battery} > V_c = \frac{V_{battery}}{2}$

Charging a capacitor:



Switch open
No charge on Cap.
No current

Just after the switch is closed
current flows
cap. begins to charge

after a long time
Cap. is fully charged
No current flow

Loop rule:

$$\varepsilon - IR - \frac{q}{c} = 0$$

q and I vary in time

$$I = \frac{dq}{dt}$$

$$I = \frac{dq}{dt}$$

$$I = \frac{\mathcal{E}}{R} - \frac{q}{RC}$$

$$\frac{dq}{dt} = \frac{\mathcal{E}}{R} - \frac{q}{RC} = -\frac{q - C\mathcal{E}}{RC}$$

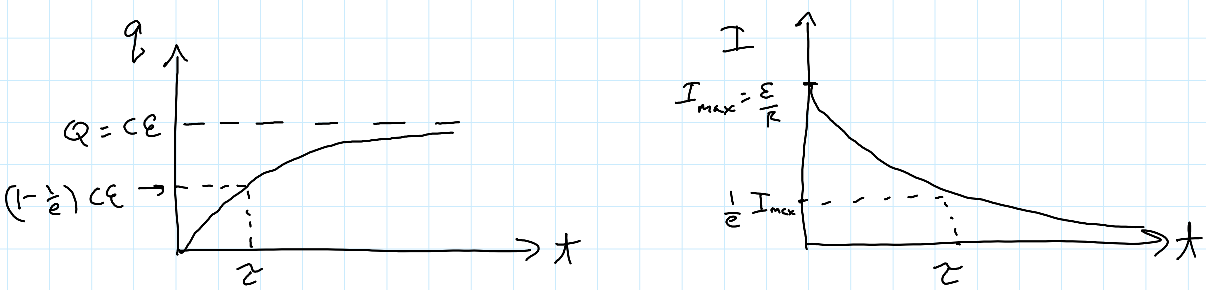
$$\int \frac{dq}{q - C\mathcal{E}} = \int -\frac{1}{RC}\, dt$$

$$\ln\left(\frac{q - C\mathcal{E}}{-C\mathcal{E}}\right) = -\frac{t}{RC}$$

$$q(t) = Q\left(1 - e^{-\frac{t}{RC}}\right)$$

$$I(t) = \frac{\mathcal{E}}{R}\, e^{-t/RC}$$

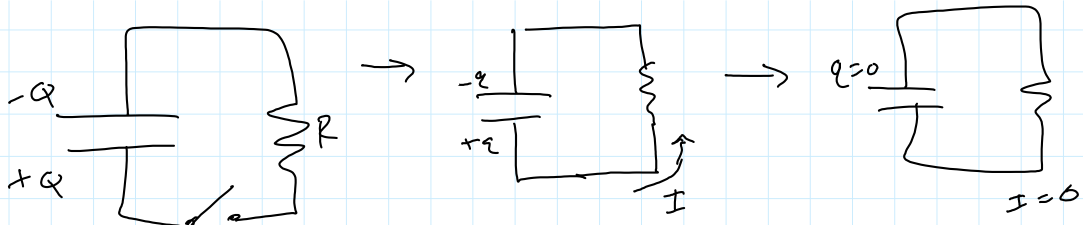
↑ I_{max}



when $t = RC$ $\quad q = (1 - \frac{1}{e})\, Q_{max}$

Time constant: $\tau = RC$

Discharging:



Switch open
Cap. fully charged
No current

Just after switch is closed
current flows
Cap. begins to discharge

after a long time
Cap is fully discharged
No current

Loop Rule:

$$-\frac{q}{C} - IR = 0$$

$$I = \frac{dq}{dt}$$

$\vdots$

$$q(t) = Q\, e^{-\frac{t}{RC}}$$

$$I(t) = -I_{max}\, e^{-t/RC} \qquad I_{max} = \frac{Q}{RC}$$

↑ indicates direction of discharging current is opposite the charging current

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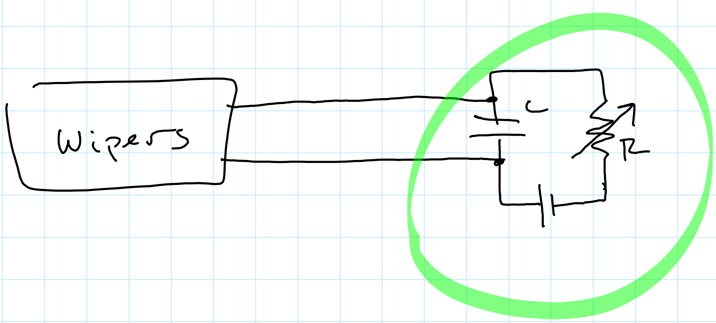
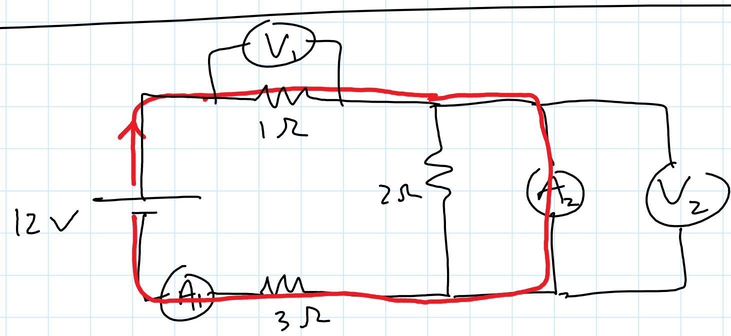
Application: Intermittent Windshield Wipers



$$\tau = RC$$

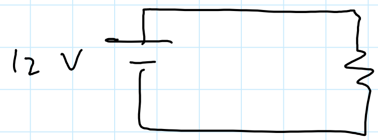
(V_1)



what does each ideal meter read:

A_1	3 A
A_2	3 A
V_1	3 V
V_2	0 V

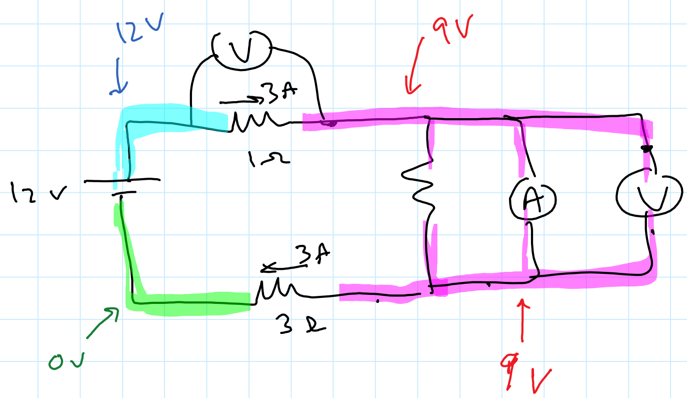
2 Ω Resistor is shorted out



$R_{eq} = 4\ \Omega$

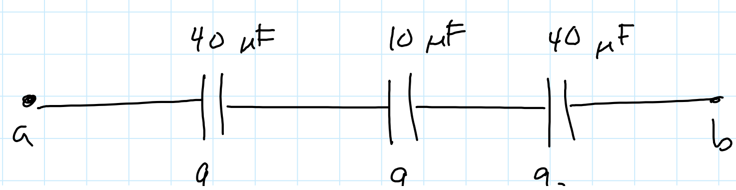
$V = IR$

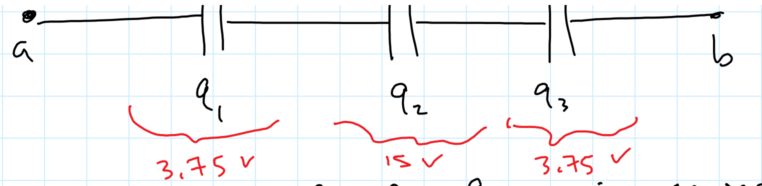
$I = \frac{12\ V}{4\ \Omega} = 3\ A$



ch 26 - 48

If any one cap breaks down at 15 V find V_{ab} max for this configuration





$q_1 = q_2 = q_3$ in series

so, $\Delta V_{10} > \Delta V_{40}$

10 μF is first to break down

Let $\Delta V_{10} = 15$ V and solve for ΔV_{ab}

$$Q = CV = (10\ \mu F)(15\ V) = 150\ \mu C$$

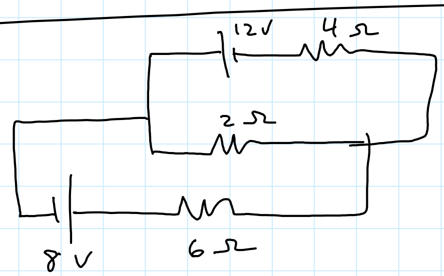
$$Q_{40} = 150\ \mu C = (40\ \mu F)(\Delta V_{40})$$

$$\Delta V_{40} = \frac{15}{4} = 3.75\ V$$

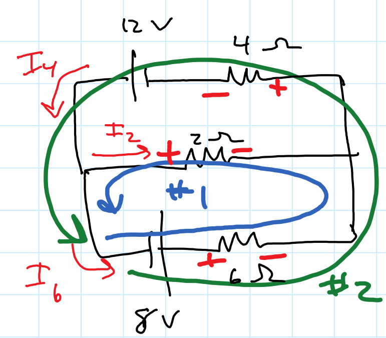
$$\Delta V_{ab} = \Delta V_{40} + \Delta V_{10} + \Delta V_{40}$$

$$= 22.5\ V$$

Ch. 28-24



Same →



Find the current through each resistor

Junction: $I_4 = I_2 + I_6$

Loop 1: $8V - I_6(6) + I_2(2) = 0$

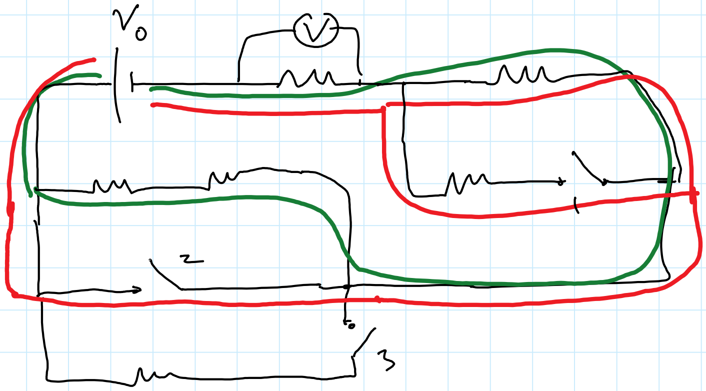
Loop 2: $8V - I_6(6) - I_4(4) + 12 = 0$

$I_2 = 909$ mA

$I_6 = 1.64$ A

$I_4 = 2.549$ A

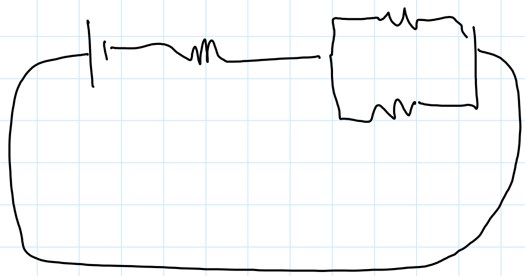
Worksheet p. 107



	S_1	S_2	S_3
A	open	open	open
G	closed	closed	open

A) $V = \frac{1}{4} V_0$

G)



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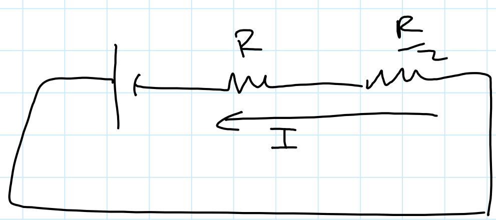

$$\begin{cases} V_R + V_{\frac{R}{2}} = V_0 \\ V_R = 2 V_{\frac{R}{2}} \end{cases}$$

$V = \frac{2}{3} V_0$