

Lecture 4

Physics 1502: Lecture 11 Today's Agenda

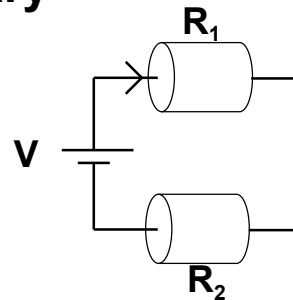
- **Announcements:**
 - Lectures posted on:
www.phys.uconn.edu/~rcote/
 - HW assignments, solutions etc.
- **Homework #4:**
 - On Masterphysics : due next Friday at 8:00 AM
 - Go to masteringphysics.com

Summary

- **Resistors in series**

- the current is the same in both R_1 and R_2
- the voltage drops add

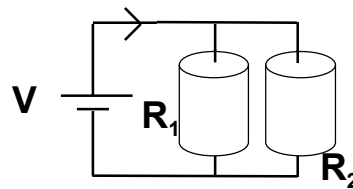
$$R = R_1 + R_2$$



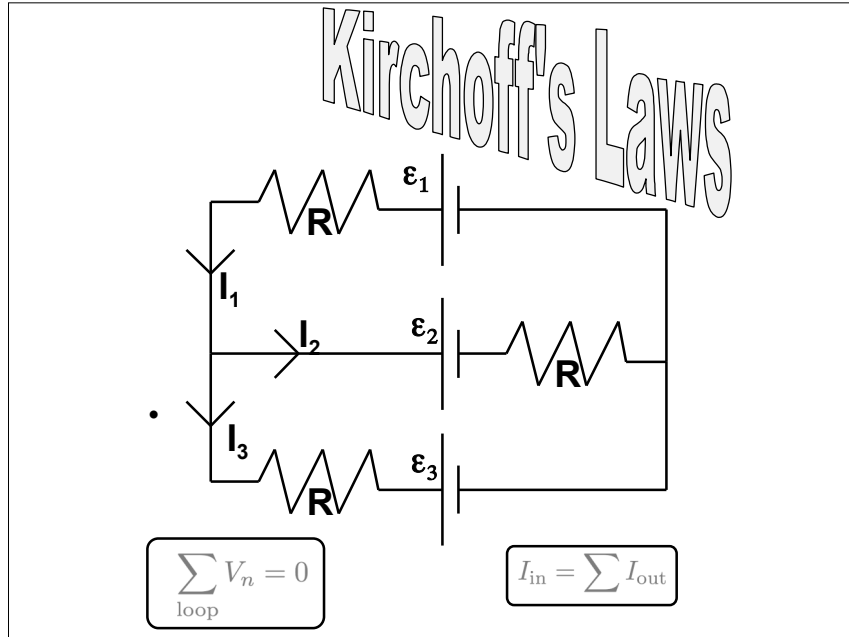
- **Resistors in parallel**

- the voltage drop is the same in both R_1 and R_2
- the currents add

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$



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Kirchoff's First Rule

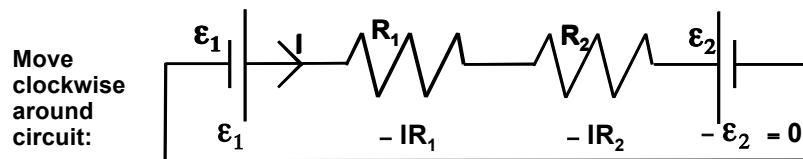
"Loop Rule" or "Kirchoff's Voltage Law (KVL)"

"When any closed circuit loop is traversed, the algebraic sum of the changes in potential must equal zero."

KVL:
$$\sum_{\text{loop}} V_n = 0$$

- This is just a restatement of what you already know: that the potential difference is independent of path!
- RULES OF THE ROAD:

We will follow the convention that voltage gains enter with a + sign and voltage drops enter with a - sign in this equation.



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Kirchoff's Second Rule

"Junction Rule" or "Kirchoff's Current Law (KCL)"

- In deriving the formula for the equivalent resistance of 2 resistors in parallel, we applied Kirchoff's Second Rule (the junction rule).

"At any junction point in a circuit where the current can divide (also called a node), the sum of the currents into the node must equal the sum of the currents out of the node."

$$I_{\text{in}} = \sum I_{\text{out}}$$

- This is just a statement of the conservation of charge at any given node.

Junction Example

Junction:

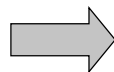
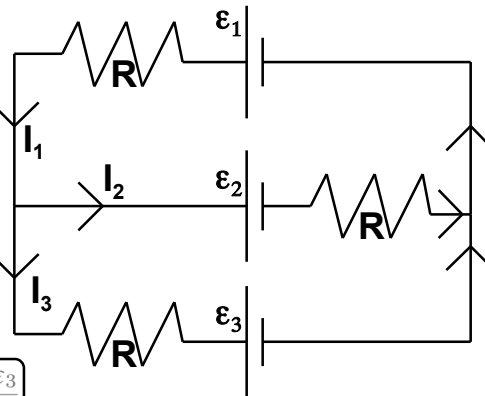
$$I_1 = I_2 + I_3$$

Outside loop:

$$\varepsilon_1 - \varepsilon_3 - I_1 R - I_3 R = 0$$

Top loop:

$$\varepsilon_1 - I_1 R - \varepsilon_2 - I_2 R = 0$$



$$I_1 = \frac{2\varepsilon_1 - \varepsilon_2 - \varepsilon_3}{3R}$$

$$I_2 = \frac{\varepsilon_1 + \varepsilon_3 - 2\varepsilon_2}{3R}$$

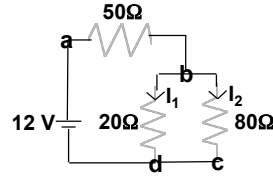
$$I_3 = \frac{\varepsilon_1 + \varepsilon_2 - 2\varepsilon_3}{3R}$$



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Chapter 11, ACT 1

- Consider the circuit shown:



2A

- What is the relation between $V_a - V_d$ and $V_a - V_c$?

- (a) $(V_a - V_d) < (V_a - V_c)$
(b) $(V_a - V_d) = (V_a - V_c)$
(c) $(V_a - V_d) > (V_a - V_c)$

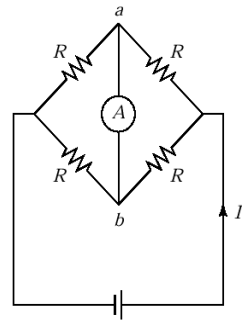
2B

- What is the relation between I_1 and I_2 ?

- (a) $I_1 < I_2$ (b) $I_1 = I_2$ (c) $I_1 > I_2$

Chapter 11, ACT 2

- An ammeter A is connected between points a and b in the circuit below, in which the four resistors are identical. The current through the ammeter is

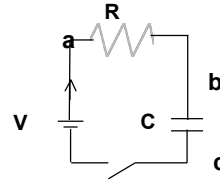


- A) I B) $I/2$ C) $I/4$ D) $I/8$ E) 0

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RC Circuits

- Consider the circuit shown:
 - What will happen when we close the switch ?
 - Add the voltage drops going around the circuit, starting at point a.



$$IR + Q/C - V = 0$$

- In this case neither I nor Q are known or constant. But they are related,

$$I = \frac{dQ}{dt}$$
$$\Rightarrow \frac{dQ}{dt}R + \frac{Q}{C} = V$$

- This is a simple, linear differential equation.

RC Circuits

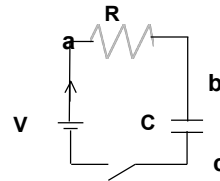
- We do a little bit of algebra and separate dq and dt.

$$\frac{dQ}{dt} = \frac{Q - CV}{RC}$$

$$\frac{dQ}{Q - CV} = \frac{dt}{RC}$$

$$\int_{Q_1}^{Q_2} \frac{dQ}{Q - CV} = \frac{1}{RC} \int_{t_1}^{t_2} dt$$

$$\ln \left(\frac{Q_2 - CV}{Q_1 - CV} \right) = -\frac{t_2 - t_1}{RC}$$



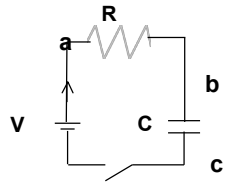
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RC Circuits

- **Case 1: Charging**

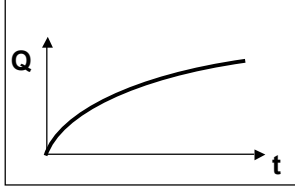
$Q_1 = 0, Q_2 = Q$ and $t_1 = 0, t_2 = t$

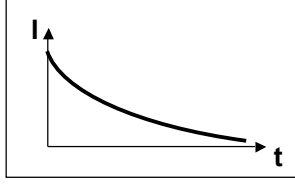
$$\ln\left(\frac{Q_2 - CV}{-CV}\right) = -\frac{t}{RC}$$



•To get Current, $I = dQ/dt$

$$Q = CV(1 - e^{-t/RC}) = Q_{\max}(1 - e^{-t/RC}) \quad I = \frac{V}{R}e^{-t/RC}$$





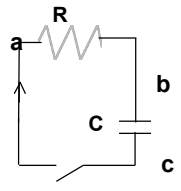
RC Circuits

- **Case 2: Discharging**
- **To discharge the capacitor we have to take the battery out of the circuit**

$$\frac{dQ}{dt}R + \frac{Q}{C} = 0$$

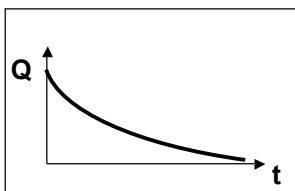
$$\ln\left(\frac{Q}{Q_0}\right) = -\frac{t}{RC}$$

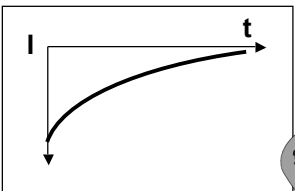
$$Q = Q_0e^{-t/RC}$$




•To get Current, $I = dQ/dt$

$$I = -\frac{Q_0}{RC}e^{-t/RC}$$



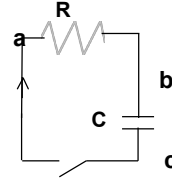




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Chapter 11, ACT 3

- Consider the simple circuit shown here. Initially the switch is open and the capacitor is charged to a potential V_0 . Immediately after the switch is closed, what is the current?



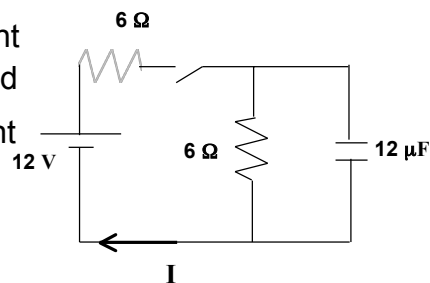
- A) $I = V_0/R$ B) $I = 0$ C) $I = RC$ D) $I = V_0/R \exp(-1/RC)$

Chapter 11, ACT 4

Consider the circuit at right after the switch is closed

- i) What is the initial current I ?

- A) 0 B) 1 A C) 2 A
D) 3 A E) 4 A

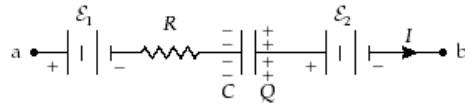


- ii) What is the current I after 2 minutes?

- A) 0 B) 1 A C) 2 A
D) 3 A E) 4 A

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Lecture 11, ACT 5



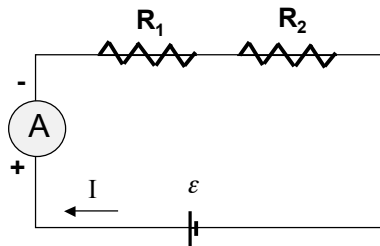
If $R = 3.0 \text{ k}\Omega$, $C = 6.0 \text{ nF}$, $\mathcal{E}_1 = 10.0 \text{ V}$, $Q = 18 \text{ nC}$,
 $\mathcal{E}_2 = 6.0 \text{ V}$, and $I = 5.0 \text{ mA}$, what is the potential
difference $V_b - V_a$?

- a. -13 V
- b. $+28 \text{ V}$
- c. $+13 \text{ V}$
- d. -28 V
- e. $+2.0 \text{ V}$

Electrical Instruments

The Ammeter

The device that measures current is called an *ammeter*.



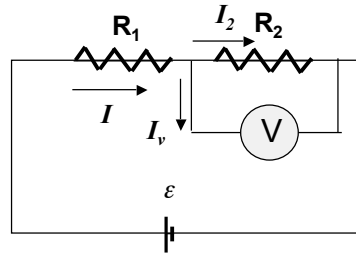
Ideally, an ammeter should have zero resistance so that
the measured current is not altered.

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Electrical Instruments

The Voltmeter

The device that measures potential difference is called a *voltmeter*.



An ideal voltmeter should have infinite resistance so that no current passes through it.

Problem Solution Method:

Five Steps:

- 1) Focus the Problem
 - draw a picture – what are we asking for?
- 2) Describe the physics
 - what physics ideas are applicable
 - what are the relevant variables known and unknown
- 3) Plan the solution
 - what are the relevant physics equations
- 4) Execute the plan
 - solve in terms of variables
 - solve in terms of numbers
- 5) Evaluate the answer
 - are the dimensions and units correct?
 - do the numbers make sense?