University Physics 227N/232N
Review / Office Hours / General Levity

Exam #2 this Wednesday
Something amusing this Friday (but NO quiz)
Spring Break next week!

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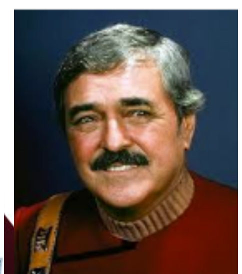


Monday, March 3 2014

Happy Birthday to Jessica Biel, Jackie Joyner-Kersee, Robyn Hitchcock, Star Trek's original Scotty (James Doohan), Georg Cantor, and Brian Cox!

Exam #2 This Wednesday

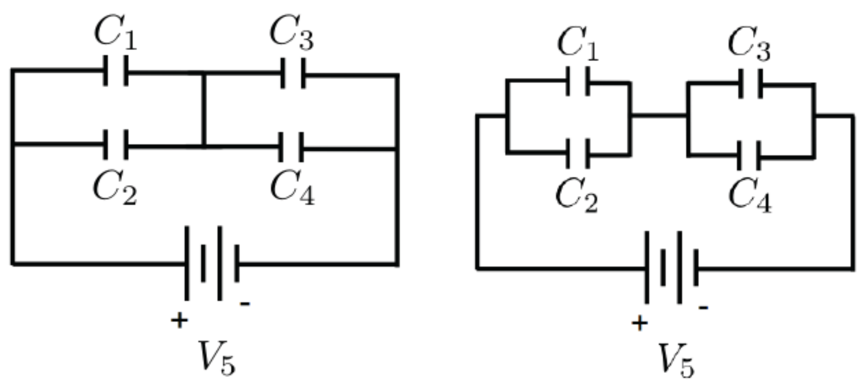
- Covers chapters 23-25 of the text
  - Capacitors and capacitance
  - Electrostatic stored energy
  - Current
  - Ohm's Law
  - Resistors and resistance
  - Kirchhoff's circuit rules

  - No RC, time-dependent circuits
  - We'll revisit that with inductors later in the semester

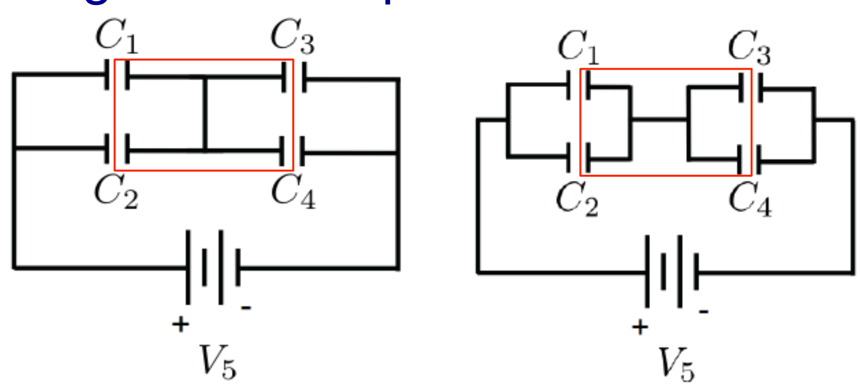
- Sample exam and solutions posted to class website

Useful tips

- Wires are equipotentials
  - They can be moved and redrawn as equivalent circuits as long as you don't change the elements they connect to
  - So, for example, these two figures are equivalent:



- Isolated wires have no net charge
  - So the charges on all capacitors attached to them must add up to zero

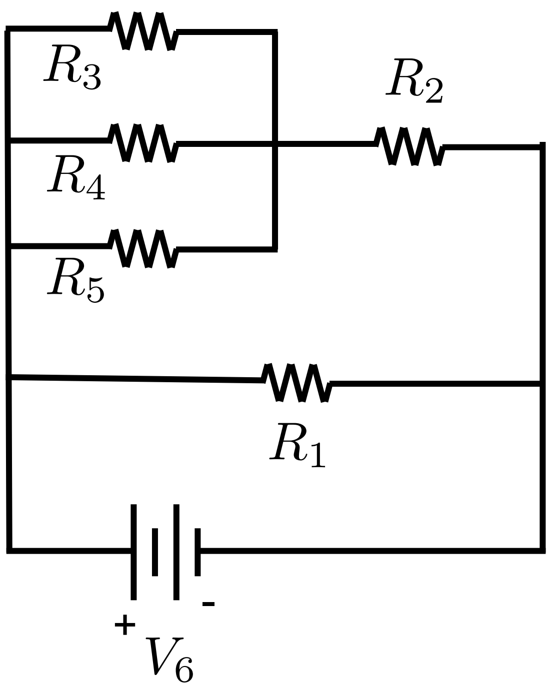


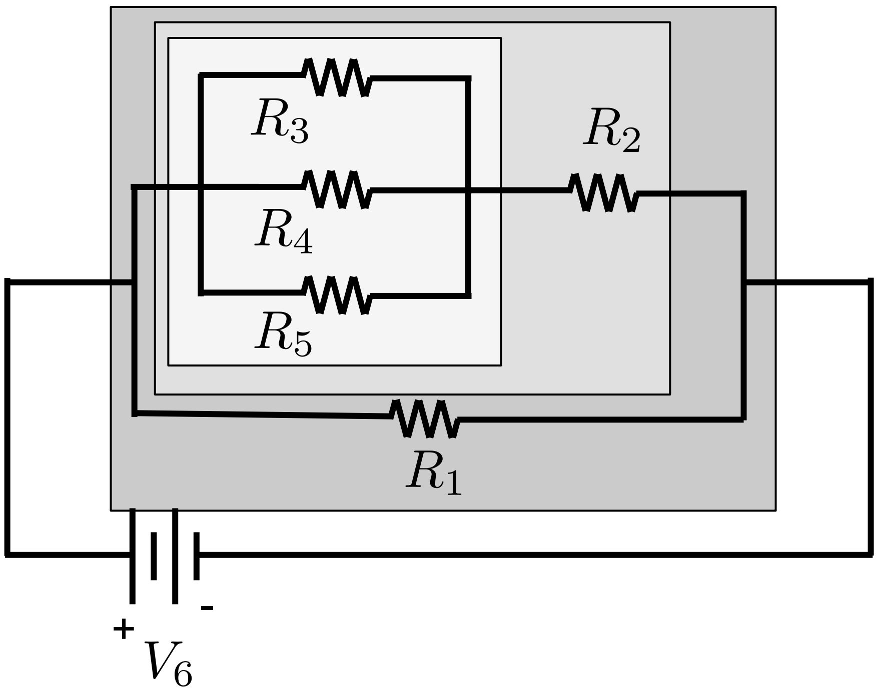
$$Q_1 + Q_2 + Q_3 + Q_4 = 0$$

$$(Q_{12} + Q_{34} = 0)$$

For Circuits with Series/Parallel Elements

- It sometimes helps to redraw the circuit in a line
  - "Follow the electrons" around from the EMF
  - These two circuits are equivalent but the right one is easier to analyze





Handy Cheat Sheet Reminders

Definition of capacitance: $C \equiv \frac{Q}{V}$

Capacitance of a parallel plate capacitor: $C = \kappa \frac{A}{4\pi k d}$ (κ: dielectric constant)

Capacitors in parallel: $C_{\text{equiv}} = C_1 + C_2 + \ldots$

Capacitors in series: $\frac{1}{C_{\text{equiv}}} = \frac{1}{C_1} + \frac{1}{C_2} + \ldots$

Energy stored in capacitor: $U_{\text{stored}} = \frac{1}{2} C V^2$

Definition of current: $I \equiv \frac{dQ}{dt}$

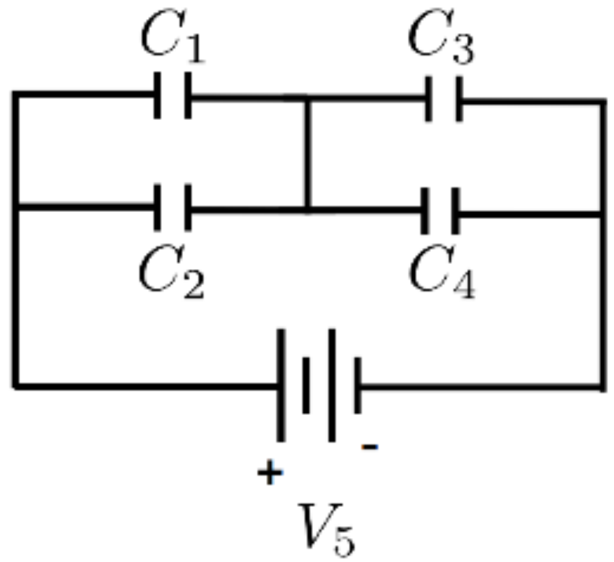
Ohm's Law, voltage drop across a resistor: $V = IR$

Power dissipated by a resistor: $P = IV = I^2 R$ (1 Watt = (1 Coulomb)(1 Volt))

Resistors in series: $R_{\text{equiv}} = R_1 + R_2 + \ldots$

Resistors in parallel: $\frac{1}{R_{\text{equiv}}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$

Sample Exam Question 1



The circuit shown above has capacitors $C_1 = 1.0\,\mu$F, $C_2 = 2.0\,\mu$F, $C_3 = 3.0\,\mu$F, and $C_4 = 4.0\,\mu$F connected by perfectly conducting wires. The EMF V_5 has a voltage across its terminals of $V_5 = 12.0$ V, and the circuit is in a state where the capacitors are charged.

(a) (3 points) Find the equivalent capacitance of the capacitors.

(b) (3 points) Find the charges Q_1, Q_2, Q_3, and Q_4 of each capacitor.

(c) (4 points) Find the voltages V_1, V_2, V_3, and V_4 across each capacitor. Are they consistent with the voltage across the EMF?

Sample Exam Question 2

An incandescent light bulb has a resistance of $140\,\Omega$ when it is lit and $9.5\,\Omega$ when it is not lit. It is plugged into a DC power supply that provides a constant voltage of 120V.

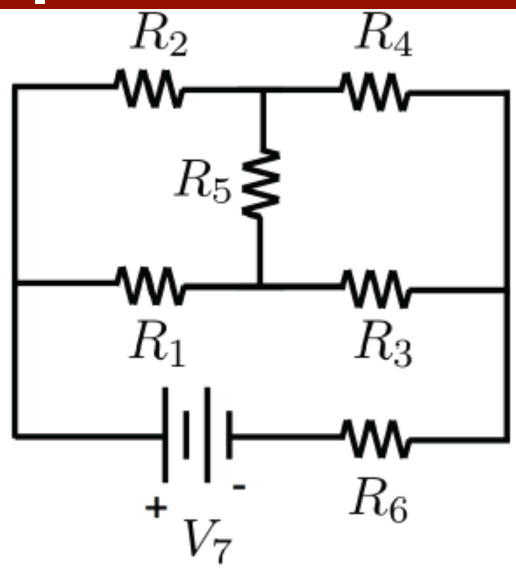
(a) (2 points) What current goes through the bulb just as it is plugged in, when it's not lit? What current goes through the bulb after it's lit?

(b) (2 points) What power does the bulb draw in both cases?

(c) (3 points) How many electrons pass through the bulb per second when it's lit?

(d) (3 points) A second identical light bulb is connected in series with the first one. How much power do both bulbs draw now?

Sample Exam Question 3



The circuit shown above has resistors $R_1 = 1.0\,\Omega$, $R_2 = 2.0\,\Omega$, $R_3 = 3.0\,\Omega$, $R_4 = 4.0\,\Omega$, $R_5 = 5.0\,\Omega$, and $R_6 = 6.0\,\Omega$ connected by perfectly conducting wires. The EMF V_7 has a voltage across its terminals of $V_7 = 12.0\,\text{V}$. This circuit cannot be reduced to just parallel and series capacitors; you have to use Kirchhoff's rules to evaluate it.

(a) (2 points) Draw and label arrows for the six currents in the resistors in the diagram.

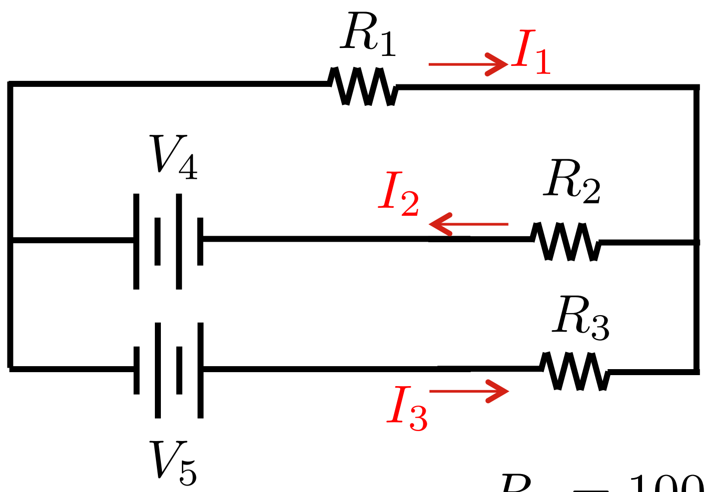
(b) (4 points) There are four nodes in the above diagram. Select three of them and label them A, B, and C in the diagram. Using Kirchhoff's node rule and the currents you have drawn in part (a), write down the current equations for these three nodes.

(c) (4 points) You need three more equations, so draw three Kirchhoff loops. Using Kirchhoff's loop rule, write down the three voltage equations for these loops.

(d) (5 points) Solve the equations in parts (b) and (c) to find the currents in each of the resistors.

Another Kirchhoff Example

http://farside.ph.utexas.edu/teaching/302l/lectures/node66.html



$$\text{Node rule}: I_1 + I_3 = I_2$$

$$\text{Loop rule (top)}: V_4 - I_1 R_1 - I_2 R_2 = 0$$

$$\text{Loop rule (outer)}: V_5 - I_3 R_3 + I_1 R_1 = 0$$

$$R_1 = 100\Omega,\ R_2 = 10\Omega,\ R_3 = 5\Omega,\ V_4 = 12\text{ V}, V_5 = 6\text{ V}$$

$$V_4 - I_1 R_1 - (I_1 + I_3) R_2 = 0 \quad \Rightarrow \quad V_4 - I_1(R_1 + R_2) - I_3 R_2 = 0$$

$$(12\text{ V}) - (110\Omega) I_1 - (10\Omega) I_3 = 0 \quad \Rightarrow \quad 1.2\text{ A} = 11 I_1 + I_3$$

$$6\text{ V} - (5\Omega) I_3 + (100\Omega) I_1 = 0 \quad \Rightarrow \quad 1.2\text{ A} = I_3 + 20 I_1$$

$$\boxed{I_1 = 0\text{ A}} \quad \boxed{I_3 = 1.2\text{ A}}$$

$$\boxed{I_2 = I_1 + I_3 = 1.2\text{ A}}$$