Last time...

Kirchoff's junction law

Equivalent resistance (parallel, series)

Kirchoff's loop law \( \sum \Delta V = 0 \)

Exam 2 is Tuesday Oct. 28
5:30-7 pm, 2103 Ch (here)

Students w/ scheduled academic conflict please stay after class Tues. Oct. 21 to arrange alternate time.

Covers: all material since exam 2.

Bring:
Calculator
One (double-sided) 8 1/2 x 11 note sheet

Exam review: Thursday, Oct. 23, in class

Resistor-capacitor circuit

- What happens to charges on the capacitor after switch is closed?
- Why does the charge flow through the resistor?
- Why does the charge on the capacitor change in time?

Discharging the capacitor

Kirchoff's loop law
\( (V_a - V_b) + (V_b - V_c) = 0 \)

\[ \Delta V = \frac{Q}{C} \]

\[ -IR \]

\[ \Rightarrow I = \frac{Q}{RC} \]

Charges in the current \( I \) come from capacitor:

\[ I = \frac{dQ}{dt} \]

RC discharge

- RC time constant
  \( \tau = RC \)
  \[ Q = Q_0 e^{-t/\tau} \]
  \[ I = I_0 e^{-t/\tau} \]

Charging a capacitor

- Again
  Kirchoff's loop law:
  \[ E - IR - Q/C = 0 \]
  \[ \Rightarrow I = E/R - Q/C \]

Time \( t = 0 \): \( Q = 0 \Rightarrow I = E/R \)

Time \( t \) increases: \( Q > 0 \Rightarrow I < E/R \)

Looks like resistor & battery: uncharged cap acts like short circuit

\( V_c \) increases, so \( V_a \) decreases

Time \( t = \infty \): \( V_a = E \Rightarrow V_c = 0 \Rightarrow I = 0 \)

Fully charged capacitor acts like open circuit

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Fully charged capacitor acts like open circuit
Discharging a capacitor

\[ Q = Q_{\text{max}} (1 - e^{-t/\tau}) \]

Question

The circuit contains three identical light bulbs and a fully-charged capacitor. Which is brightest?

A. A
B. B
C. C
D. A & B
E. All equally bright

Human capacitors

- Cell membrane:
  - ‘Empty space’ separating charged fluids (conductors)
  - ~ 7 - 8 nm thick
  - In combination w/fluids, acts as parallel-plate capacitor

Magnetism

Cell Membrane

RC circuit

Nerve signal is an action potential that propagates down RC cell-membrane network
Magnets and magnetic fields

Magnetic dipoles

- Magnetic charges (monopoles) have never been observed.
- Magnetic dipole characterized by dipole moment $\vec{\mu}$
- Torque on magnetic dipole $\vec{t} = \vec{\mu} \times \vec{B}$

(Compare electric dipole: $\vec{t} = \vec{p} \times \vec{E}$)

Torque tends to aligns magnetic dipole with magnetic field

Magnets

- Clearly magnets interact with each other
- Sometimes attracting, sometimes repelling
- But the magnetic particles are sort of a ‘composite’ positive and negative ‘magnetic charge’.
- Visualized as a bar with positive pole (North) at one end and negative pole (South) at other.
- These ‘magnetic charges’ cannot be broken apart — always appear in N-S pairs.

Let’s Break A Magnet!

- North Pole and South Pole
- Are inseparable

Magnetic field

- Similar in spirit to electric field
- Exerts torque on a magnetic dipole
  - Magnetic field exerts a torque on compass needle
  - Aligns it with magnetic field lines.
- Magnetic field lines indicate direction of local magnetic field
- Field lines
  - leave magnet at N pole
  - enter magnet at S pole

Magnetic Field Lines

- Magnetic Field Lines
  - Arrows give direction
  - Density gives strength
  - Looks like dipole
**Electric vs Magnetic Field Lines**

**Similarities**
- Density gives strength
- Arrow gives direction
  - Leave +, North
  - Enter -, South

**Differences**
- Start/Stop on electric charge
- No Magnetic Charge, lines are continuous!
- Convention for 3-D situations:
  - \[\text{x x x x x x} \quad \text{INTO Page}\]
  - \[\text{**********} \quad \text{OUT of Page}\]

**Magnetism: Permanent magnets**

- North Pole and South Pole
- This is the elementary magnetic particle
- Called magnetic dipole (North pole and South pole)
- Poles interact with each other similar to charges.

**The Earth is a magnet**

- Earth is a bar magnet.
- North magnetic pole - at south geographic pole
- A compass is a bar magnet
- Compass needle aligns with local Earth field

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Thur. Oct. 16, 2008  Physics 208 Lecture 14