Homework #5 due tonight 11:59 PM
Homework #6 due Tuesday 10/29 11:59 PM

SUNDAY Nov 17: SECOND HOUR EXAM 6:10-7:30 PM in SEC 111 (Ch. 25-29) -- no recitations the previous Friday and following Monday

COME UP AND PLAY WITH DEMOS
RC CIRCUIT – charge and discharge the capacitor
Compare time when 2nd capacitor is switched in
MAGNETISM –
play with lodestone, compass, color TV
RC circuits

![RC circuit diagram](image)

**Fig. 27-15** When switch $S$ is closed on $a$, the capacitor is **charged** through the resistor. When the switch is afterward closed on $b$, the capacitor **discharges** through the resistor.

The time it takes for the current to decrease by a factor of $e$ is the **time constant** $\tau = RC$.

The equation for the current $i(t)$ is:

$$i = \frac{dq}{dt} = \left(\frac{\mathcal{E}}{R}\right)e^{-t/RC}$$

$RC \ln 2$ = the time it takes for the current to decrease by a factor of 2.
Demo: charging circuit to potential $E$

Measure time for light to “go out”

Reset
Insert 2\textsuperscript{nd} capacitor in parallel
Charge to potential $E$
If I put a second identical capacitor in parallel with the original what will happen to the time it takes for the current in the charging capacitor circuit to drop by a factor of 2?

(a) Doubles
(b) Stays the same
(c) Decreases by a factor of two
(d) None of the above
Discharge a charged capacitor: \( q(t=0) = q_0 \)

\[ R \frac{dq}{dt} + \frac{q}{C} = 0 \]

\[ q = q_0 e^{-\frac{t}{RC}} \]

\[ i = \frac{dq}{dt} = -\left( \frac{q_0}{RC} \right) e^{-\frac{t}{RC}} \]

the time it takes for the current to decrease by a factor of \( e \)

“time constant”

\( RC \ln 2 = \text{the time it takes for the current to decrease by a factor of 2} \)
Demo: discharging circuit
Starting from potential $E$

Measure time for light to “go out”
Quantitative: time for voltage to drop by factor of 2

Charge to potential $E$
Insert 2$^{nd}$ capacitor in parallel
What happens to the potential?
Demo: discharging circuit
Starting from potential 

Measure time for light to “go out”
Quantitative: time for voltage to drop by factor of 2

Charge to potential 
Insert 2\textsuperscript{nd} capacitor in parallel
What happens to the potential?
It goes down by a factor of 2
Clicker (to be answered with the demo– have to look at the ammeter rather than the light)

If I put a second identical capacitor in parallel with the original AFTER the capacitor is charged, what will happen to the time it takes for the current to drop by a factor of 2?

(a) Doubles
(b) Stays the same
(c) Decreases by a factor of two
(d) None of the above
Clicker (to be answered with the demo – have to look at the ammeter rather than the light)

If I put a second identical capacitor in parallel with the original AFTER the capacitor is charged, what will happen to the time it takes for the current to drop by a factor of 2?

(a) Doubles
(b) Stays the same
(c) Decreases by a factor of two
(d) None of the above
Chapter 29

Magnetic Field and Forces
A DIFFERENT TYPE OF FORCE

Two metal bars attract
If one is flipped over, they repel
A DIFFERENT TYPE OF FORCE

Two metal bars attract
If one is flipped over, they repel

NOT GRAVITY – ALWAYS ATTRACTIVE
A DIFFERENT TYPE OF FORCE

Two metal bars attract
If one is flipped over, they repel

NOT ELECTRIC – ELECTRIC FIELD IS ZERO
Associated with certain materials: Earliest known is LODESTONE

Alignment of lodestone needles: Force comes from nearby lodestone

Lodestone needles align N-S in the absence of a nearby lodestone COMPASS (Earth = lodestone)
Magnetism as a mysterious “lodestone” force:
Lodestones exert forces on other lodestones

Known for thousands of years
Force is exerted by lodestone or bar magnet on moving charges.

DEMO: cathode ray tube in TV. Beam of electrons from back of device hits the screen and makes it glow. Bar magnet deflects the beam.
Force is exerted by lodestone or bar magnet ON MOVING CHARGES

DEMO: BULB
Beam of electrons glows in gas
Bar magnet deflects the beam
Force is exerted by lodestone or bar magnet ON MOVING CHARGES

DEMO: BULB
Beam of electrons glows in gas
Current in big loop deflects the beam
Charged objects exert forces by creating a vector field called the electric field \( \vec{E}(r) \) producing a force \( \vec{F} = q\vec{E}(r) \).

Lodestone and bar magnets exert forces by creating a vector field called the magnetic field \( \vec{B}(r) \).

Bar magnet field: \[ \text{S} \quad \text{N} \] (near ends)

**Today:** start with a given magnetic field and find the magnetic force on moving electric charges

**Next week:** learn about currents inside atoms in lodestones

Magnetic force on the lodestone the magnetic field is produced by currents (lodestones, wires)
The magnetic force on a charged particle in a magnetic field $\vec{B}(\vec{r})$

**Magnitude:**
- Proportional to magnitude of $B$ at $\vec{r}$
- Proportional to magnitude of charge $|q|$
- Proportional to speed $v$ -> zero force if not moving
- Depends on angle between $\vec{v}$ and $\vec{B}$
  - zero if $\vec{v}$ and $\vec{B}$ are parallel or antiparallel

Magnitude $= |q| \cdot v \cdot B \cdot \sin \phi$

Units of $B$: $1 \text{ N/(C m/s)} = 1 \text{ T (Tesla)}$
The magnetic force on a charged particle in a magnetic field $\vec{B}(\vec{r})$
Magnitude: $|q| v B \sin \phi$

**Direction:**
Perpendicular to direction of $\vec{v}$
Perpendicular to direction of $\vec{B}$
$\rightarrow$ normal to the plane defined by $\vec{v}$ and $\vec{B}$

Two choices – use right-hand rule to choose
Thumb along $v$; fingers along $B$: *out of palm*

To put it all together: $\vec{F} = q\vec{v} \times \vec{B}$
Cross product of two vectors