Chapter 24/25

- Capacitors
  - oppositely charged conductors, store energy in $\vec{E}$ between
  - $V_{ab} = V_a - V_b$ = Voltage difference

$\boxed{Q} = \left(\varepsilon_0 \frac{A}{d}\right) V_{ab} = \boxed{C \cdot V_{ab}}$

Capacitance [F]

Can fill gap w/ insulator
$C = K \cdot \varepsilon_0 = \varepsilon \frac{A}{d}$

$U = \frac{1}{2} CV^2 = \frac{1}{2} \varepsilon_0 E^2$

C

In Parallel
$Q_{total} = (C_1 + C_2 + C_3 \ldots + C_n) V_{ab} = C_{eq} \cdot V_{ab}$

Tip/Tip
↓
Tail/Tail

In Series
$Q_{total} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \ldots + \frac{1}{C_n}\right)^{-1} V_{ab}$

Tip/Tail
↓
Tip/Tail

- Conducting Wire
  - I = "current" [A] amps
  - carries current w/o resistance
  - $Q(t) = Q_0 + It$ if I is constant
  - $Q(t) = Q_0 + \int_0^t I(t')\,dt'$

- Resistor
  - $E = \frac{V_{ab}}{L}$ $\quad I = \frac{A}{\rho L} V_{ab} \longrightarrow \boxed{V_{ab} = IR}$

resistance of Device [Ω]

R

In parallel
$I = V_{ab} \left(\frac{1}{R_1} + \frac{1}{R_2} + \ldots + \frac{1}{R_n}\right)^{-1}$

In Series
$I = V_{ab} (R_1 + R_2 + \ldots + R_n)$

- Battery/EMF
  electro motive force
  - $\mathcal{E}$ is difference between V_a and V_b

$\mathcal{E}$

- Power
  - rate of energy transformation
  - $[P] = \frac{J}{s} = W$ "watts"
  - $P = I \Delta V$
  - For a battery $P = I\mathcal{E}$ — rate of which energy is supplied by battery
  - For a resistor $P = I^2 R$ — rate of which energy is being burned in a resistor

Solving Circuit Problems

1) Facts/Fundamentals about circuit elements
2) recognize serial vs. parallel connections → can often be redrawn as simpler circ…
3) Kirchhoff
   ↑ time independent circuits ↑ Also hold for time dependent RC circuits
   ↓ switch toggle between 2 networks
4) invoke #1–#3 twice, just after switching and very long after switching ← Need to …
5) cross between these initial and final values as either $\alpha e^{-t/\tau}$ or $\alpha(1-\ldots$
   current, V_R
   Q(t) of discharging
   V_C

Junction rule for determining currents
Loop rule for solving all unknowns

Magnetic Forces

Magnets (moving charges)
- create magnetic fields

Magnetic force on a moving charge

$F = q\vec{v} \times \vec{B}$ $\quad F = qvB\sin\phi$ in direction of $\vec{v} \times \vec{B}$

✱ F = 0 if $\vec{v}$ and $\vec{B}$ are ∥
q > 0 in direction of $\vec{v} \times \vec{B}$
q < 0 opposite direction of $\vec{v} \times \vec{B}$

If $\vec{v} \perp B$, uniform circular motion $\quad F = ma \rightarrow F = m \cdot \frac{v^2}{r}$

V/ -

Magnetic Fields

$\vec{B} = \frac{\mu_0}{4\pi} \frac{q\vec{v} \times \hat{r}}{r^2}$ Single charge moving at velocity … field at $\hat{r}$ away

$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\,d\vec{l} \times \hat{r}}{r^2}$ (Biot Savart) segment … field …

very long
For a ↓ wire $B = \frac{\mu_0 I}{\ldots}$

→ Try to compute R_{eq} and I_{total}

→ Try to compute C_{eq} and V_{total}

...t, relationships might change/form after switch is flipped

1. Compute everything right after switch is closed — capacitor basically isn't even there

...now where you start/finish 2. Compute everything long after switch is closed — capacitor is fully charged, no curr...

$e^{-t/\tau}$) where $\tau = RC$

Q(t) if charging

V_c

$\vec{v}$ (for a point scales by $\frac{1}{r^2}$ like coulombs law)

...l of current I, the magnetic

...r away

if $\vec{v} \perp B$, uniform circular motion $\quad F = ma \rightarrow F = m \cdot \frac{v^2}{r}$

Wires

$F_{on\ wire} = I \vec{L} \times \vec{B} \qquad d\vec{F} = I\, d\vec{l} \times \vec{B}$

length of wire where orientation is based off of direction of current flow

Torques

$\vec{\tau} = \vec{\mu} \times \vec{B} \qquad |\vec{\mu}| = I \cdot Area$

$= I \cdot Area \cdot B \cdot \sin\phi$

Potential Energy $= -\vec{\mu} \cdot \vec{B}$

for a very long wire, $B = \frac{\mu_0 I}{2\pi x}$ ← distance mea... measuring ...

Field @ center of a current loop

$B = \frac{\mu_0 I}{2a}$ ← radius of circle

– Scales for whatever fr...