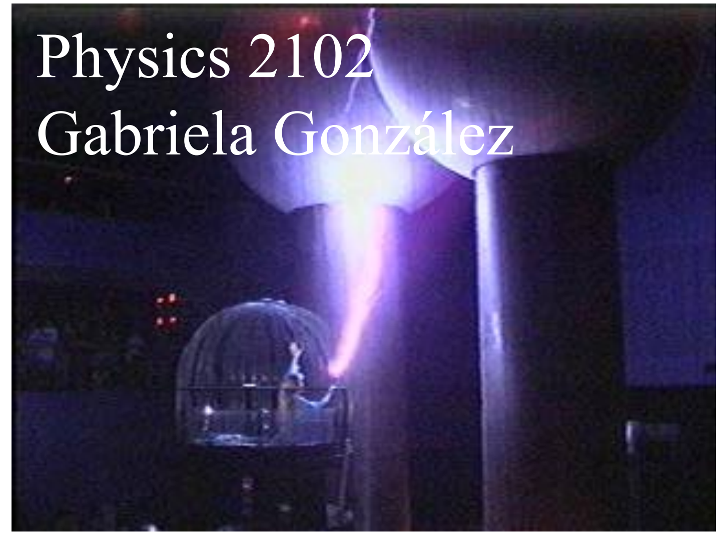
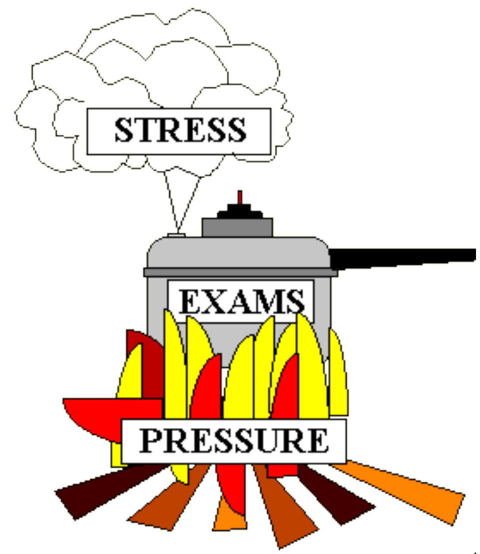


Physics 2102

Exam 2: review session

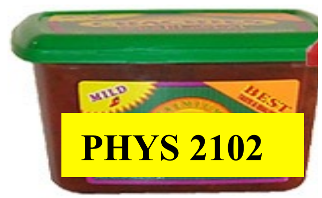


Exam stress doesn't help!!
Look up strategies for managing exam stress.

Some advice

Mild (~low C):

- revisit homework sets;
- revisit your quizzes;
- read chapter summaries;
- read formula sheet



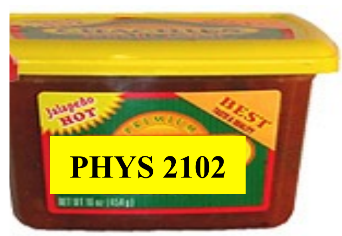
Sleep well, and save some time to relax before the exam!!

Medium (~C):

- read class slides;
- revisit class problems;
- do all checkpoints,
- solve ~1/2 questions;
- read all problems;
- solve a few old exams

Hot (~B):

- read whole chapters;
- solve all questions;
- solve ~1/2 problems
- solve many old exams



Tabasco hot (~A!):

- solve ALL problems,
- *invent* new problems
- solve all old exams

What are we going to learn?
A road map

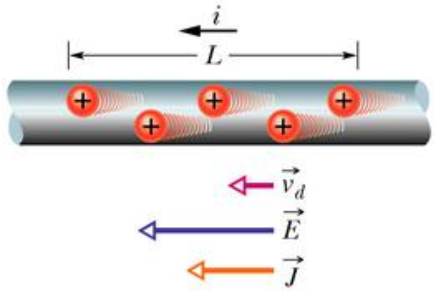
- Electric *charge*
    - Electric *force* on other electric charges
    - Electric *field*, and electric *potential*
- Moving electric charges : current
- Electronic circuit components: batteries, resistors, capacitors
- Electric currents
    - Magnetic field
    - Magnetic force on moving charges
- Time-varying magnetic field
    - Electric Field
- More circuit components: inductors
- All together: Maxwell's equations
- Electromagnetic waves
- Optical images
- Matter waves

Exam 2

- (Ch 26) **Current and Resistance**: current, current density and drift velocity; resistance and resistivity; Ohm's law.
- (Ch 27) **Circuits**: emf devices, loop and junction rules; resistances in series and parallel; DC single and multiloop circuits, power; RC circuits.
- (Ch 28) **Magnetic Forces**: magnetic and electric forces on a point charge; magnetic force on a current-carrying wire; magnetic torque on a magnetic dipole.
- (Ch 29) **Magnetic Fields due to Currents**: Biot-Savart's law and Ampere's law; forces between currents; solenoids; magnetic dipoles.
- (Ch 30.1-5): **Induction and Inductance**: Faradays' law, Lenz's law.

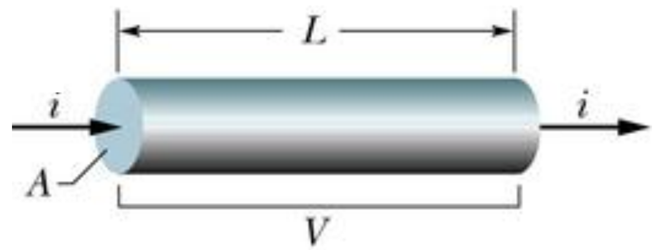
Current and resistance

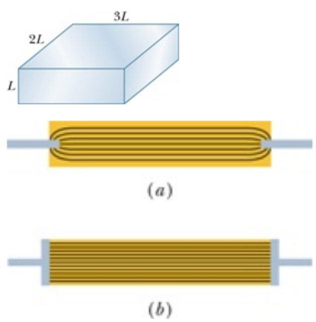
$i = dq/dt$

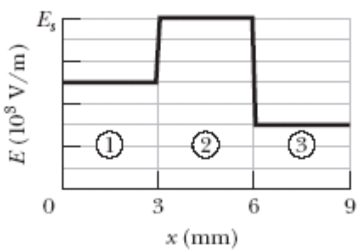


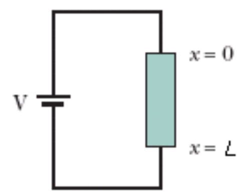
$\mathbf{J} = ne\mathbf{v}_d$

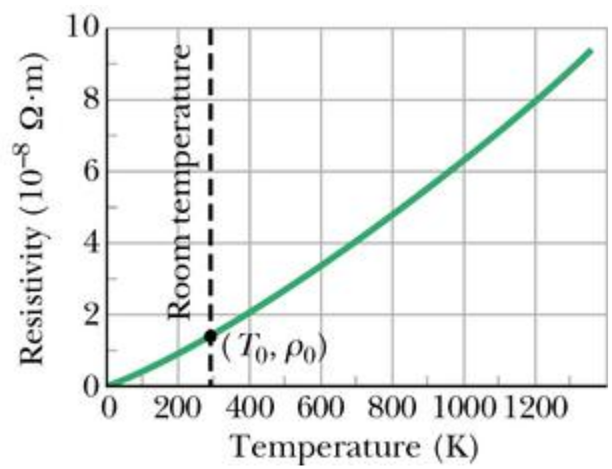
$R = \rho L/A$

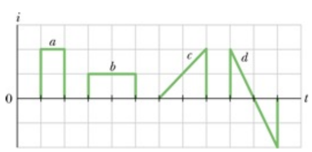


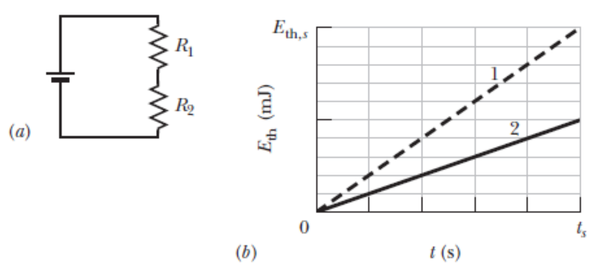


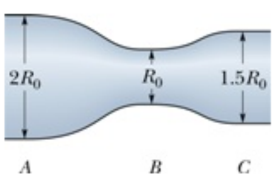






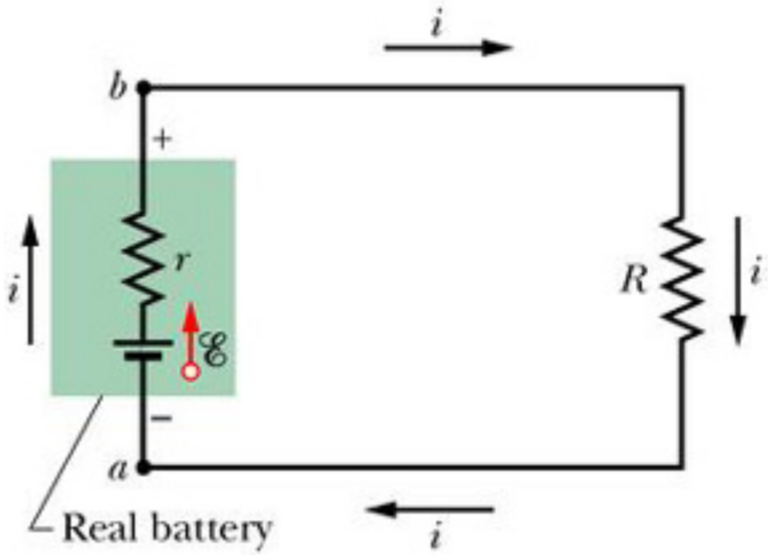




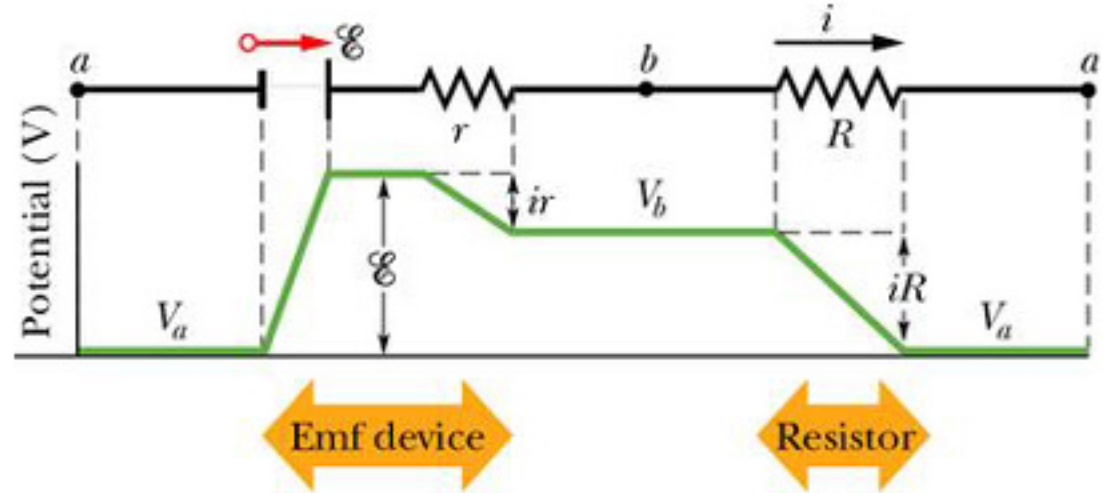


$\rho = \rho_0(1+\alpha(T-T_0))$

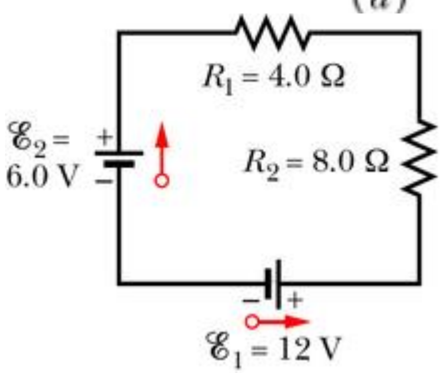
Circuits



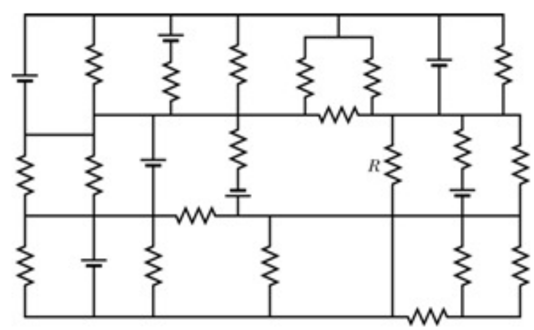
(a)

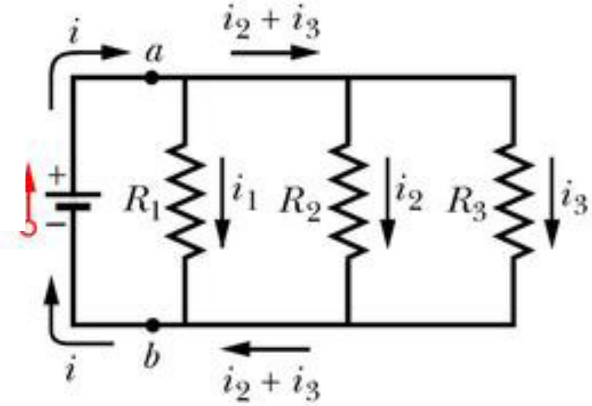


(b)



Single loop





Multiloop

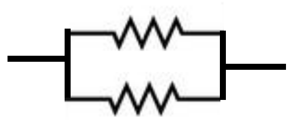
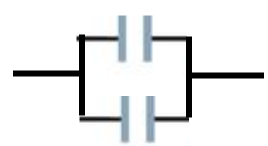
V = *i*R

P = *i*V

Loop rule

Junction rule

Resistors
in series and in parallel

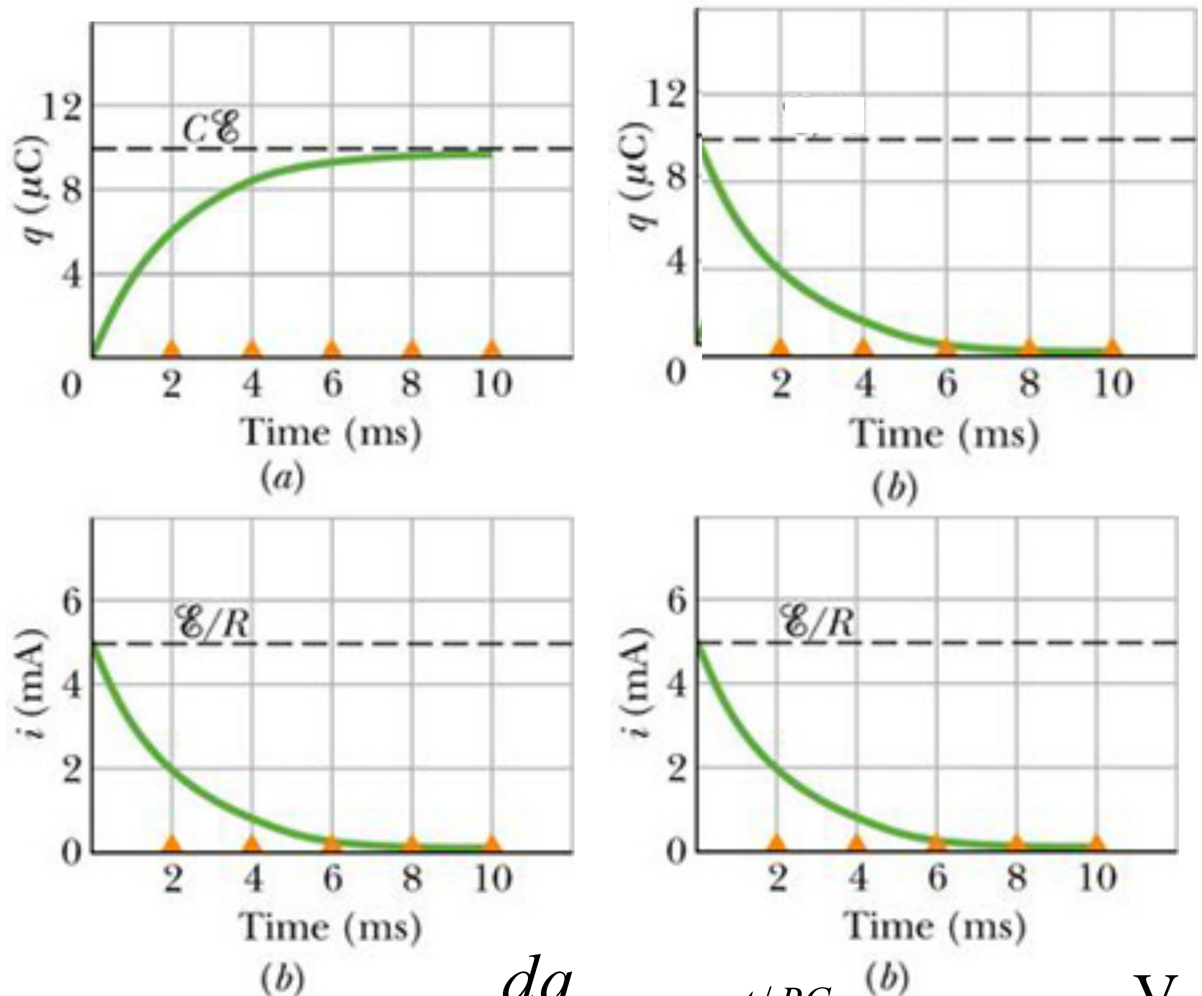
	Resistors	Capacitors
		
Key formula:	$V=iR$	$Q=CV$
In series:	same current	same charge
	$R_{eq}=\sum R_j$	$1/C_{eq}=\sum 1/C_j$
		
In parallel:	same voltage	same voltage
	$1/R_{eq}=\sum 1/R_j$	$C_{eq}=\sum C_j$
		

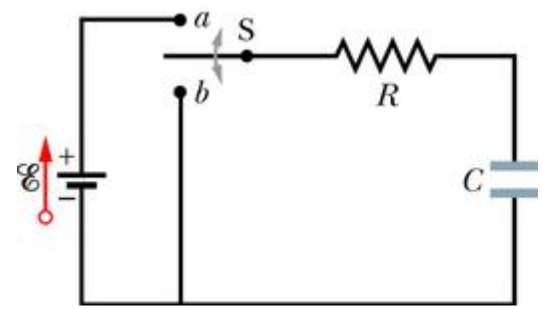
RC circuits

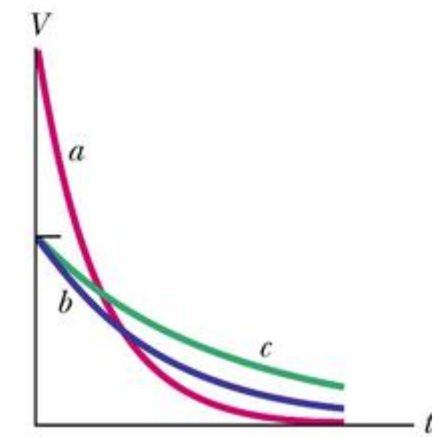
Time constant: τ=RC
Charge is 63% of final charge, or 37% of initial charge

$$q(t) = C\mathcal{E}\left(1 - e^{-t/RC}\right)$$

$$q(t) = q_0 e^{-t/RC}$$



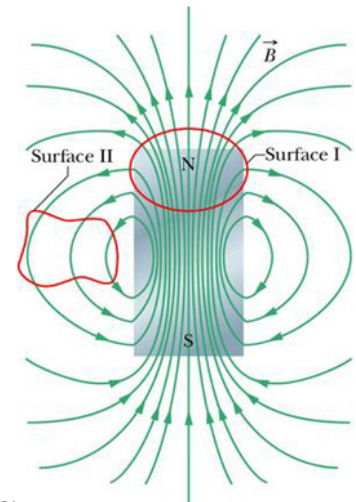




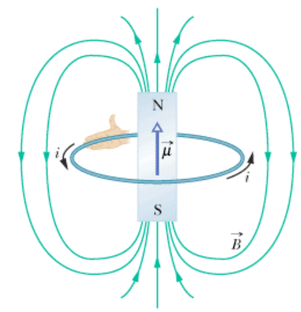
$$i(t) = \frac{dq}{dt} = i_0 e^{-t/RC}$$

$V_C(t)=q(t)/C$; $V_R(t)=i(t)R$

Magnetic Fields

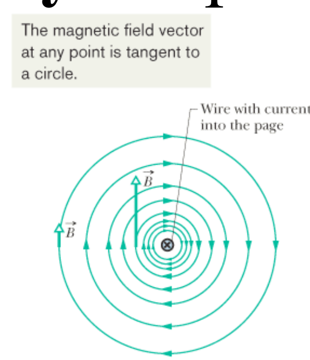


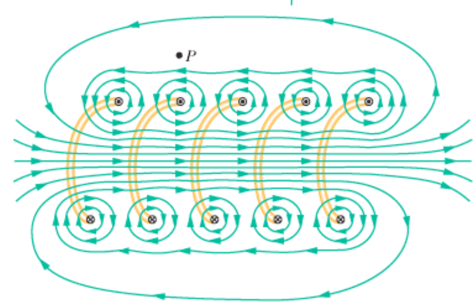
- Magnetic fields are created by magnetic materials or by electric currents.
- Magnetic field lines: always closed!
- **Magnetic fields** created by currents: wires, loops, solenoids (Biot-Savart's law, Ampere's law)
- Magnetic dipoles: field produced **by** a dipole

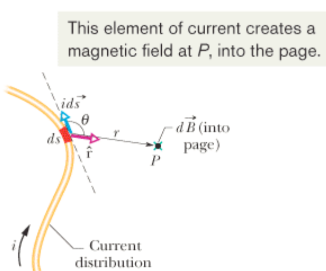


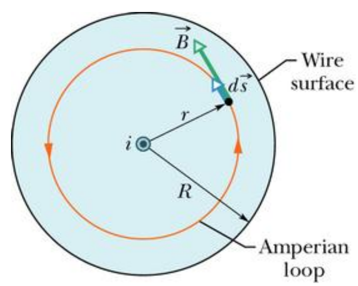
$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{i d\vec{l} \times \vec{r}}{r^3}$$

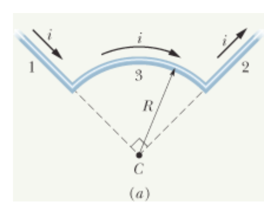
$$\oint_C \vec{B} \bullet d\vec{l} = \mu_0 I$$

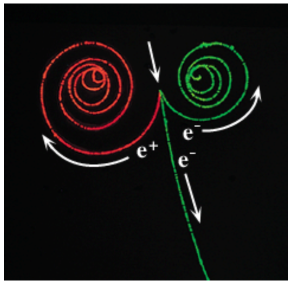






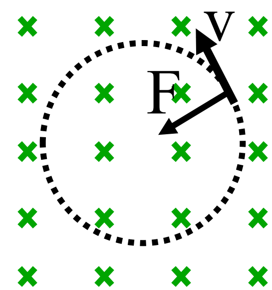




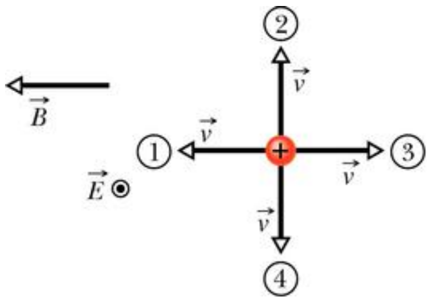


Magnetic forces and torques

$$\vec{F} = q\vec{E} + q\,\vec{v} \times \vec{B}$$

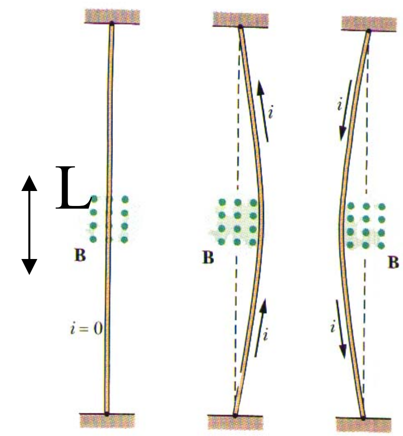


$$r = \frac{mv}{qB}$$



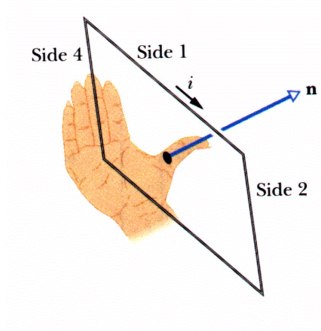
$$d\vec{F} = i\,d\vec{L} \times \vec{B}$$

$$\vec{F} = i\,\vec{L} \times \vec{B}$$

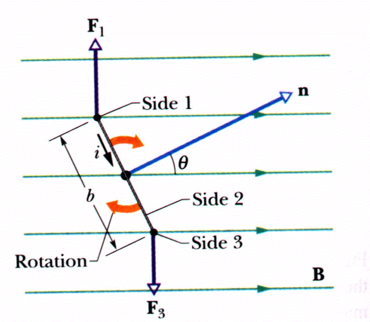


$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

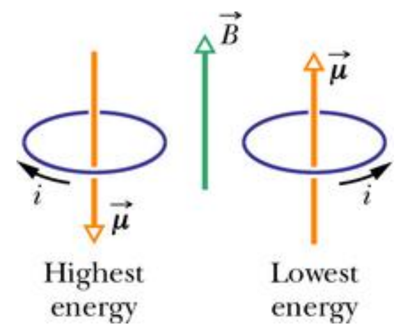
$$U = -\vec{\mu} \bullet \vec{B}$$



(b)



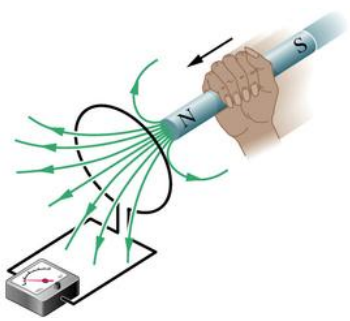
(c)

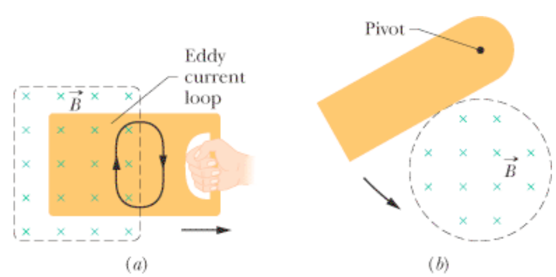


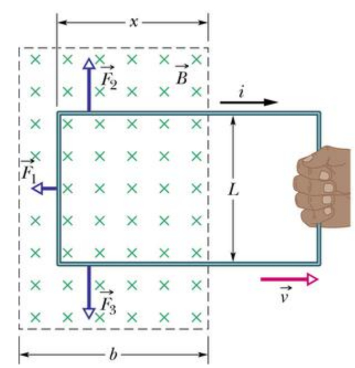
Induced fields

Changing magnetic flux creates an induced electric field (and a current if there is a wire!): Faraday's law

$$\oint_C \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$$







Formula sheet – I

- **Current:** $i = \frac{dq}{dt}$ **Current density:** $J = \frac{i}{A}$ **Drift speed of the charge carriers:** $\vec{v}_d = \frac{\vec{J}}{ne}$
- **Definition of resistance:** $R = \frac{V}{i}$ **Definition of resistivity:** $\rho = \frac{|\vec{E}|}{|\vec{J}|}$
- **Resistance in a conducting wire:** $R = \rho\frac{L}{A}$ **Temperature dependence:** $\rho - \rho_\circ = \rho_\circ\alpha(T - T_\circ)$
- **Power in an electrical device:** $P = iV$ **Power dissipated in a resistor:** $P = i^2R = \frac{V^2}{R}$
- **Definition of** *emf* **:** $\mathcal{E} = \frac{dW}{dq}$
- **Resistors in series:** $R_{eq} = \sum R_i$ **Resistors in parallel:** $\frac{1}{R_{eq}} = \sum \frac{1}{R_i}$
- **Loop rule in DC circuits:** the sum of changes in potential across any closed loop of a circuit must be zero.
- **Junction rule in DC circuits:** the sum of currents entering any junction must be equal to the sum of currents leaving that junction.
- **Charging a capacitor, series RC:** $q(t) = C\mathcal{E}(1 - e^{-\frac{t}{\tau_c}})$, time constant $\tau_C = RC$, **Discharging:** $q(t) = q_o e^{-\frac{t}{\tau_c}}$

Formula sheet - II

- **Magnetic Fields:**

  Magnetic force on a charge q: $\vec{F} = q\vec{v} \times \vec{B}$

  Lorentz force: $\vec{F} = q\vec{E} + q\vec{v} \times \vec{B}$

  Circular motion in a magnetic field: $qv_\perp B = \frac{mv_\perp^2}{r}$ with period: $T = \frac{2\pi m}{qB}$

  Magnetic force on a length of wire: $\vec{F} = i\vec{L} \times \vec{B}$

  Magnetic Dipole: $\vec{\mu} = Ni\vec{A}$ **Torque:** $\vec{\tau} = \vec{\mu} \times \vec{B}$ **Potential energy:** $U = -\vec{\mu} \cdot \vec{B}$

- **Generating Magnetic Fields:** $(\mu_0 = 4\pi \times 10^{-7} \frac{\mathrm{T \cdot m}}{\mathrm{A}})$

  Biot-Savart Law: $d\vec{B} = \frac{\mu_0}{4\pi} \frac{i d\vec{s} \times \vec{r}}{r^3}$

  Magnetic field of a long straight wire: $B = \frac{\mu_0}{4\pi} \frac{2i}{r}$ **Magnetic field of a circular arc:** $B = \frac{\mu_0}{4\pi} \frac{i}{r} \phi$

  Force between parallel current carrying wires: $F_{ab} = \frac{\mu_0 i_a i_b}{2\pi d} L$

  Ampere's law: $\oint \vec{B} \cdot d\vec{s} = \mu_0 i_{enc}$

  Magnetic field of a solenoid: $B = \mu_0 i n$ **Magnetic field of a dipole on axis, far away:** $\vec{B} = \frac{\mu_0}{2\pi} \frac{\vec{\mu}}{z^3}$

- **Induction:**

  Magnetic Flux: $\Phi = \int \vec{B} \cdot d\vec{A}$

  Faraday's law: $\mathcal{E} = -\frac{d\Phi}{dt}$ $(= -N\frac{d\Phi}{dt}$ for a coil with N turns)

  Motional emf: $\mathcal{E} = BLv$