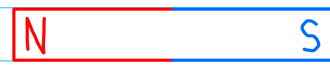
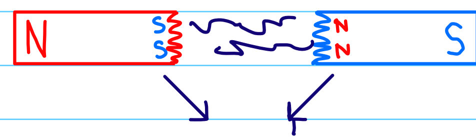
APR 18

Magnetic forces and fields

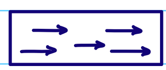
① Magnetic poles

- 2 types (North & south)





no such thing as a magnetic monopo



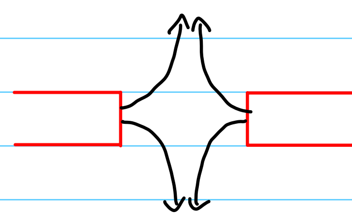
atoms are arranged in a certain way
cutting up the magnet doesn't
change its internal structure

Like poles repel

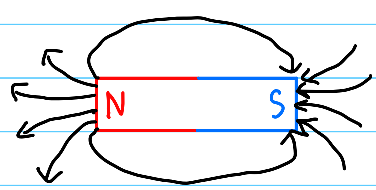
unlike poles attract

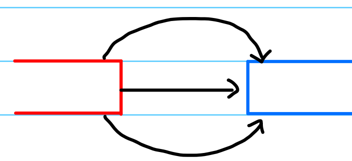
② Magnetic fields ($\vec{B}$)

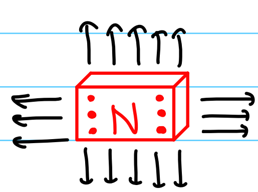
- direction North to South
- units Tesla (T)



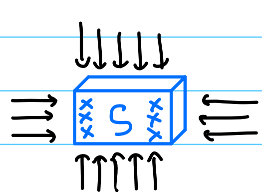
asymptote





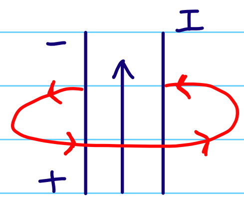


• dots mean coming out of the page

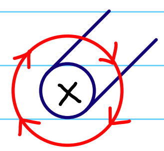


× exs mean going into the page

③ Electric Current produces magnetic field!

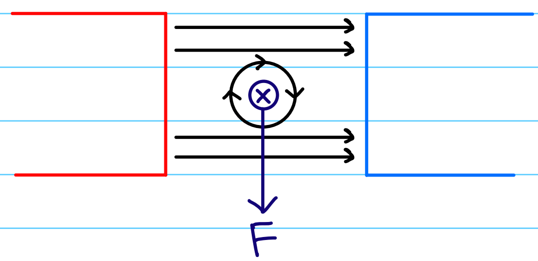


magnetic fields go counter-clockwise



Right hand rule
thumb → conventional current
fingers curl in magnetic field

④ Force on an electric current



2nd right hand rule
thumb: conventional current
fingers: external magnetic field N→S
palm: force

$\boxed{\vec{F} = \vec{B} I L \sin\theta}$ magnetic force

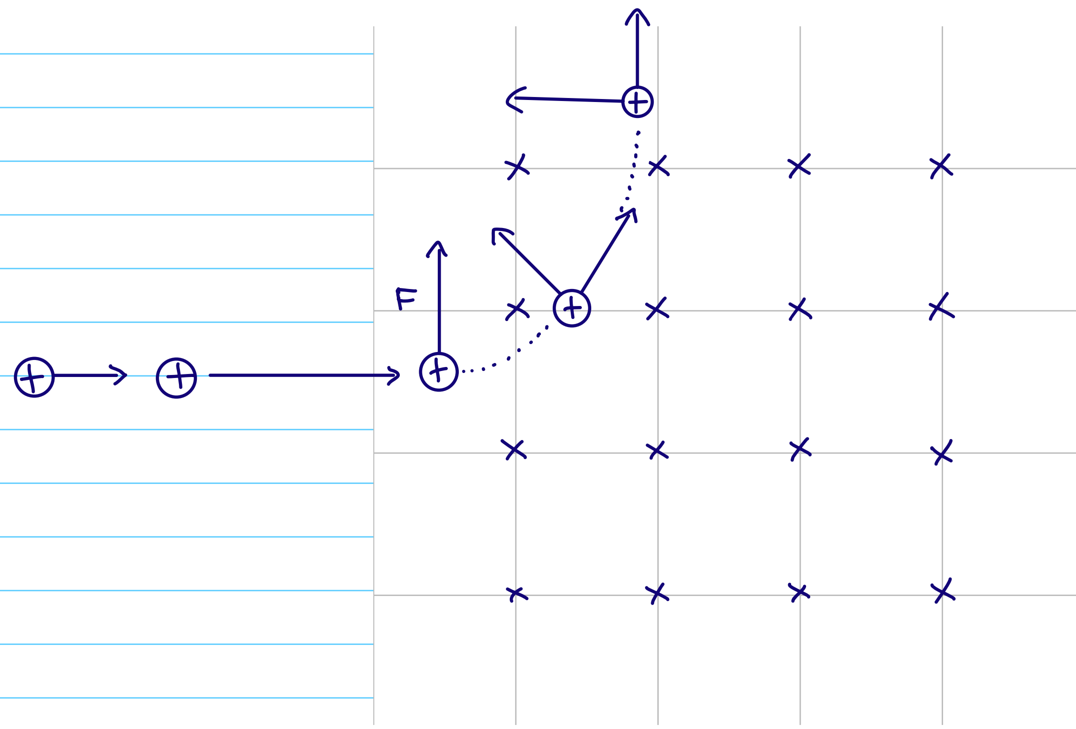
Assignment p. 616 #3, 4, 11, 12

APR 24 ① Force on an electric charge in $\vec{B}$ field
A moving positive charge is just a tiny conventional current

Recall $\vec{F} = \vec{B} I L \sin\theta$

$$\vec{F} = B\left(\frac{q}{t}\right) L \sin\theta$$

$$\boxed{\vec{F} = q\vec{v} B \sin\theta}$$



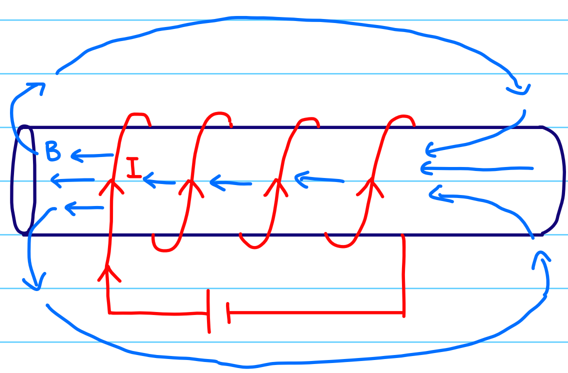
If it continues to move in the mag field
it will move in a circle

$$F_c = \frac{mv^2}{r} = q\vec{V}B$$

assume $\theta = 90°$
↳ $\sin\theta = 1$

$$r = \frac{mv}{qB}$$ radius of charges in circular path

Magnetic field in a solenoid (coil)



There is a uniform
magnetic field inside

$$\boxed{\vec{B} = \mu_0 \frac{N}{L} I}$$

N → number of coils or loops or turns

L → length of solenoid

I → current

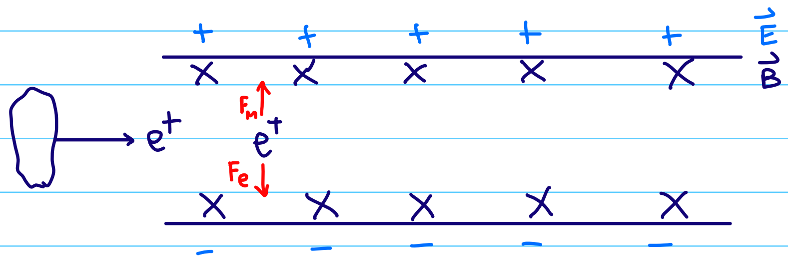
μ_0 → permeability of free space 4×10^{-7} Tm/A

Ex① A thin 0.10m long solenoid has a total of 400 turns of wires and carries 2A of current. What is the $\vec{B}$ inside?

$$B = \mu_0 \frac{N}{L} I$$
$$= 4\pi \times 10^{-7} \left(\frac{400}{0.10}\right) 2A$$
$$= 0.01\,T$$

Assignment p. 616 #9, 10, 13–18

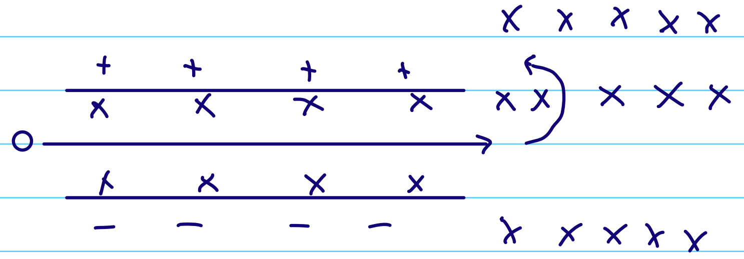
Velocity selector for particles



Balance push between Electric Field & Mag field

$$F_E = F_B$$
$$qE = qvB$$
$$E = vB$$
$$v = \frac{E}{B}$$

Mass spectrometer



$$\frac{mv^2}{r} = qvB_2$$

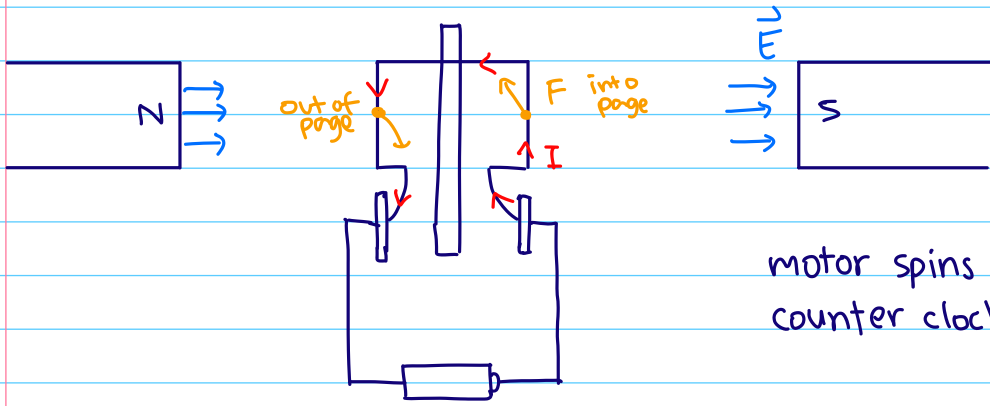
$$m = \frac{qB_2r}{v} \qquad V = \frac{E}{B_1} \text{ from vel selector}$$

$$m = \frac{qB_1B_2r}{E}$$

How do you measure the age of a fossil

Measure the amount of Carbon-14 using a mass spectrometer

Apr 30 Electric DC Motor



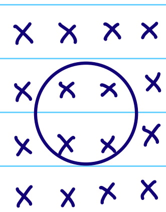
motor spins
counter clockwise

May 10 Electromagnetic Induction

1) Induced EMF (ε)

- EMF (think voltage) put across a wire or coil by changing magnetic field
  - → leads to an induced current
  - → constant or steady $\vec{B}$ will not induce EMF

2) Faraday's law



Magnetic flux ϕ
→ how much the magnetic field penetrates through a given surface

$\phi = \vec{B} A \cos\theta$

↳ angle between $\vec{B}$ and normal of coil

$$\varepsilon = -N \frac{\Delta\phi}{\Delta t}$$

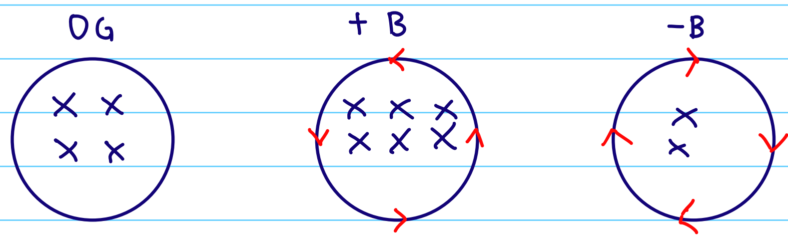
"Electromotive force" → ε : EMF induced in coil

$\Delta\phi$: change in magnetic flux through a loop

N : # of turns or loops

Δt : time while change in ϕ occurs

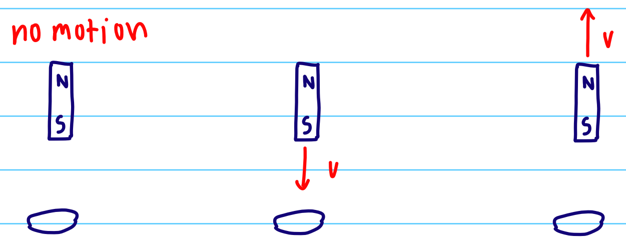
3) Lenzs law : induced EMF always gives rise to a current whose magnetic field opposes the original change in flux



Induced I is counter clockwise

Induced I is clockwise

Ex ①



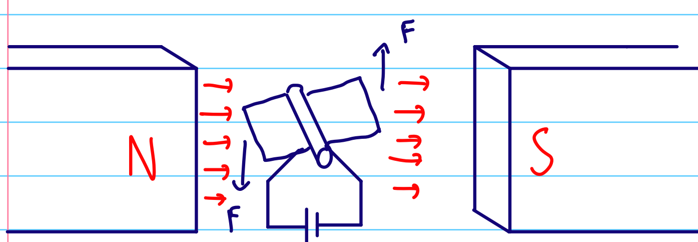
no induced current

clockwise

counterclockwise

May 16 Induction Interactions

BACK EMF



Recall a motor by pushing current carrying wire

- BUT when the loop of wire rotates it changes the flux
- a current is produced to opposed change

$$\boxed{\mathcal{E} - V_{back} = Ir}$$

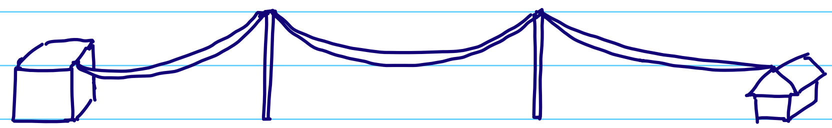
EMF supplied by battery

I through motor at top speed

resistance of motor

Power transmission

A power plant sends out an average of 120 kW (120000 W) to a town 10 km away. The transmission lines have a total resistance of 0.4 Ω. Calculate the power loss if the energy is sent at 240 V vs 24,000 V



$$P = VI = I^2R = \frac{V^2}{R}$$

$$I = \frac{P}{V} \qquad\qquad I = \frac{P}{V}$$

$$I = \frac{120000}{240} \qquad\qquad I = \frac{120000}{24000}$$

$$= 500\ A \qquad\qquad = 5\ A$$

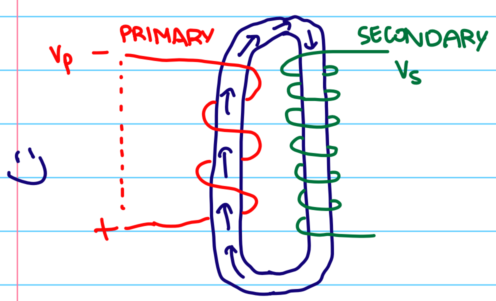
$$P_{loss} = I^2R \qquad\qquad P_{loss} = I^2R$$

$$P_{loss} = 500^2(0.4) \qquad\qquad P_{loss} = 5^2(0.4)$$

$$P_{loss} = 100{,}000\ W \qquad\qquad P_{loss} = 10\ W$$

(80% loss) (0.01 % loss)

Transformers



Step up transformer

The number of coils in the second solenoid is higher so the secondary voltage will be greater

$$V_p = -N_p\frac{\Delta\Phi}{\Delta t} \qquad V_s = -N_s\frac{\Delta\Phi}{\Delta t}$$

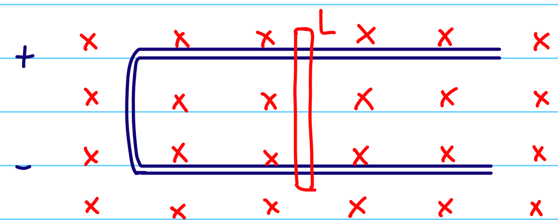
$$\boxed{\frac{V_p}{N_p} = \frac{V_s}{N_s}}$$

Assignment Giancoli p.656 #33-41 odd

May 22

Electromagnetic Induction

Recall: $\varepsilon = N\left(\frac{\Delta\phi}{\Delta t}\right)$ $\Delta\phi = \Delta(\vec{B}A)$



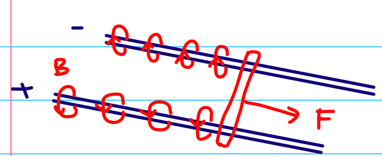
If we have two conducting rails and a rod length L, we can generate EMF if there is a $\vec{B}$ field and the rod moves

$$\varepsilon = \frac{-(1)(\vec{B}\Delta A)}{\Delta t}$$

$$= \frac{-\vec{B}L\Delta x}{\Delta t} \quad \text{ignore negative}$$

$$\boxed{= \vec{B}vL \quad \text{or} \quad N\vec{B}vL}$$

The Rail Gun



A 50.0 g metal projectile (length 1.0 cm) is placed into a 0.60 m long rail gun. There is 100.0 A of current put through the system. Assume a constant magnetic field of 2.0×10^{-3} T. If the projectile moves the length of the gun, what is its final speed?

$$F = BIL$$
$$ma = (2.0\times10^{-3})(100)(0.01)$$
$$0.050a = 0.002$$
$$a = 0.04\ m/s^2$$

$$V_f^2 = V_i^2 + 2ad$$
$$V_f = \sqrt{2(0.04)(0.6)}$$
$$V_f = 0.219\ m/s$$