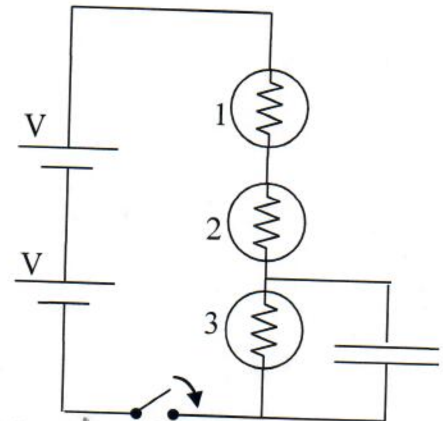
Question 1 and 2. (6 points combined)

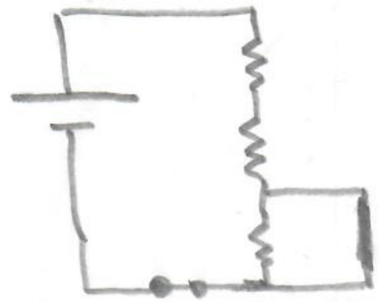
The next TWO problems refer to the circuit at right. There are two ideal batteries (voltage **[Birth Month]** V each), and three identical ideal bulbs. Initially the capacitor is uncharged, and the switch is open.

5V



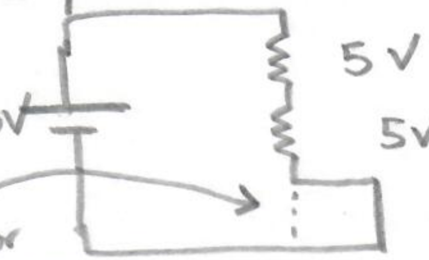
1. *Immediately after* the switch is closed, the absolute value of the voltage difference **across bulb #1** is equal to: (**3 pts**)

We want to figure out how an RC circuit behaves Immediately after Switch is closed & at $t \to \infty$ (Long time)



Redrawing circuit

capacitor acts Like a wire



By passes Resistor

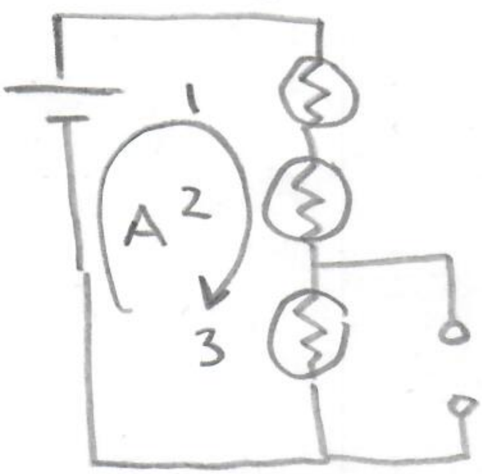
$Q = C\Delta V$

zero zero

Bulb #1 has 5 Volts

2. *A very long time after* the switch is closed, the absolute value of the potential difference **across the capacitor** is equal to (**3 pts**)

After a Long time capacitor acts Like an open circuit



capacitor is fully charged (No more charge)

$\Delta V_3 = \Delta V_C$

Loop A

$+10V - \Delta V_1 - \Delta V_2 - \Delta V_3 = 0$

but $\Delta V_1 = \Delta V_2 = \Delta V_3$

$10V - 3\Delta V_3 = 0$

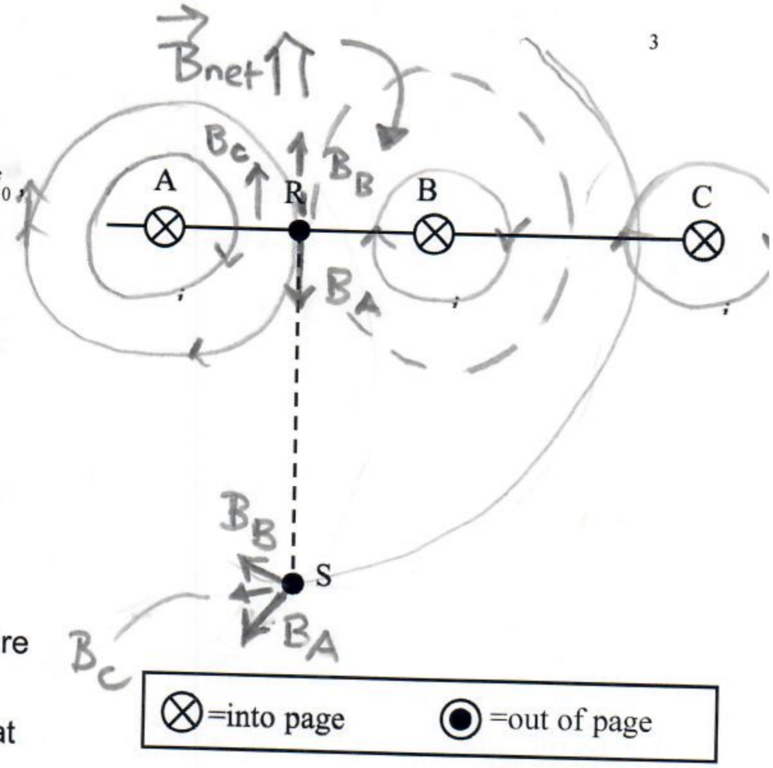
$10V = 3\Delta V_3$

$\boxed{\Delta V_3 = \frac{10V}{3}}$

Final Celebration of Knowledge Physics 4B

Question 3 (12 points)

3. Three infinitely long wires, each with a current i_0, are arranged in a line. Points R and S lie on a line equidistant from wires A and B as shown.



In the figure, somewhere very near point R, please draw 4 separate arrows as follows (and label each one clearly). Be sure the relative lengths of your 4 arrows are physically reasonable. If any of these are zero, state that explicitly.

(4 points)

✓ 1. One arrow shows the magnetic field at point R caused by JUST the current in wire A. (Label this B_A.)

✓ 2. Another arrow shows the magnetic field at point R caused by current B. (Label this B_B.)

✓ 3. The third arrow shows the field at point R caused by current C (Label this B_C.)

✓ 4. Lastly, draw an arrow labeled B_{net} which shows the total net magnetic field at point R caused by all the currents. ⇈ B_{net}

For parts I and II below suppose the wires A and B are now removed, leaving only wire C.

I. (4 points) Will the magnitude of the magnetic field at point *R increase*, *decrease*, or *stay the same*? Write *increase*, *decrease*, or *stay the same*: (VECTORS)

Explain. If wires A & B are removed $B_A\downarrow$ and $B_B\uparrow$ will not be there. $\vec{B}_{net} = \uparrow B_C$

But B_{net} was $\underset{\downarrow}{B_A} + \underset{\uparrow}{B_B} + \underset{\uparrow}{B_C} = \uparrow$ $\vec{B}_A$ & $\vec{B}_B$ are Same magnitude but in opposite directions

SO B_{net} REMAINS THE SAME

II. (4 points) Will the magnitude of the magnetic field at point S *increase*, *decrease*, or *stay the same?* Write *increase*, *decrease*, or *stay the same*:

Explain.

The B_{net} with the 3 Magnetic Vectors was giving a Net $\vec{B}_{net}$ that was greater

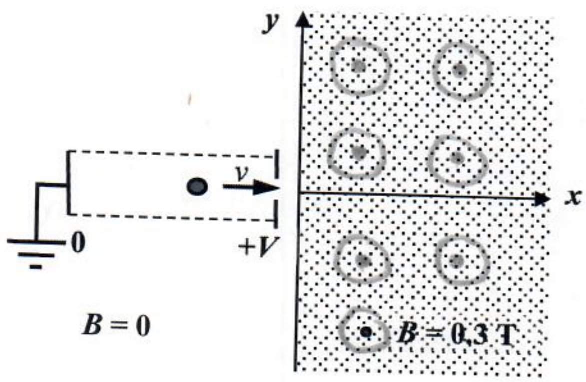
But with $\vec{B}_A$ and $\vec{B}_B$ gone only B_C Remains!

$\swarrow \vec{B}_C$ ↘ SMALL

Question 4 (6 points)

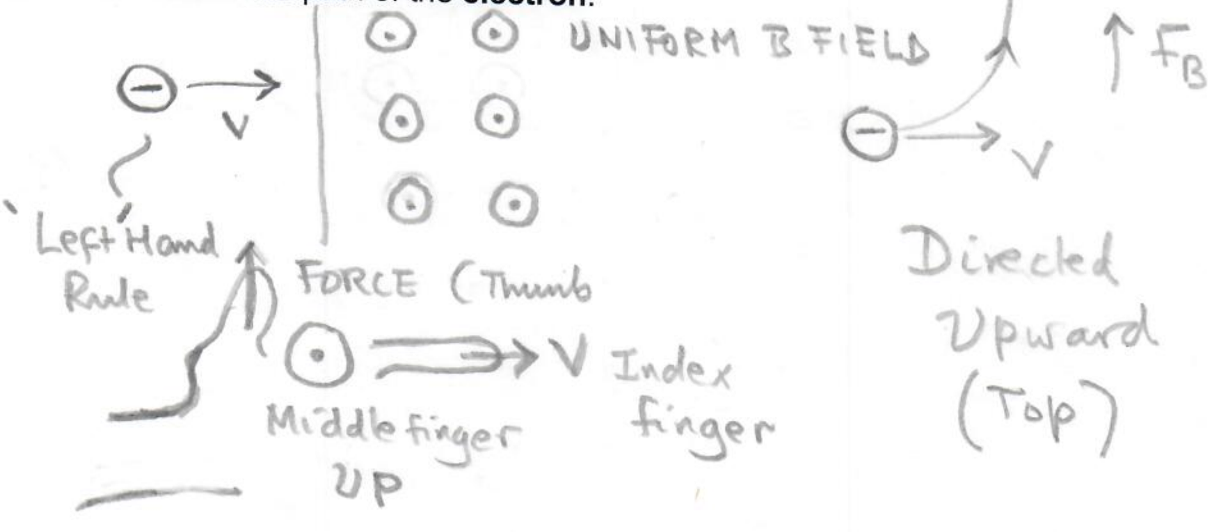
An electron of mass *m* and charge *q* is accelerated to the right (in the plane of the page) from rest through a potential difference *V*. The electron then enters a region, defined by $x > 0$, containing a uniform magnetic field. (**show your work**)

AN ASIDE
For our Homework a velocity selector has $F_B = F_E$



$V = 1500$ V
$B = 0.3$ T out of page
$q = -1.6 \times 10^{-19}$ C
$m = 9.1 \times 10^{-31}$ kg

4. I) When the electron enters the region with the magnetic field where is the force on it ~~is~~ directed (**3 points**) top/bottom/into the page etc.
Explain-> Also sketch the path of the **electron**.



Directed Upward (Top)

II) When the electron is in the magnetic field region does its speed *v* ***increase, decrease,*** *or* ***stay the same?*** (**3 points**) **Explain.**

First off Magnetic field is Uniform

The Electron Moves upward and moves in a near Circular Loop • The velocity direction changes but the Magnitude does Not change • Speed remains the same

$F_B = qVB = ma_c = mv^2/R$

Question 5 (6 points)

5. A square loop of conductor of sides 20 cm (0.2 m) is in a uniform external B=0.75 (T) field. The current in the loop is 8.00 A.

A) Find the magnitude and direction of the magnetic force on each segment: Top, bottom and sides. (**4 points total**)

$\vec{F}_B = I\vec{L} \times \vec{B}$ (Left side)

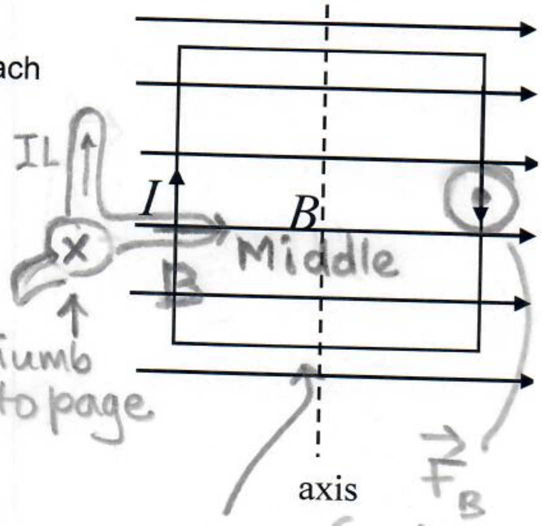
$= ILB \sin 90°$

$= 8A\ 0.2m\ 0.75T\ (1)$

$= 1.2\ TmA = 1.2\ N$ $\quad \dfrac{N \cdot \cancel{m}\cancel{s}}{\cancel{m}\,\cancel{c}\,s}$

$\vec{F}_{B\,(Left)} = \langle 0, 0, -1.2 \rangle N$

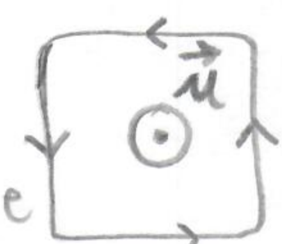
$F_{B\,(Right)} = \langle 0, 0, +1.2 \rangle N$

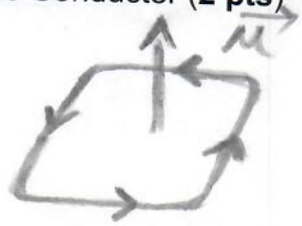


$F_{B\ Top} = 0$

B) Find the Magnetic moment of the Loop of the Conductor (**2 pts**)

$\vec{\mu}$ is out of the Page





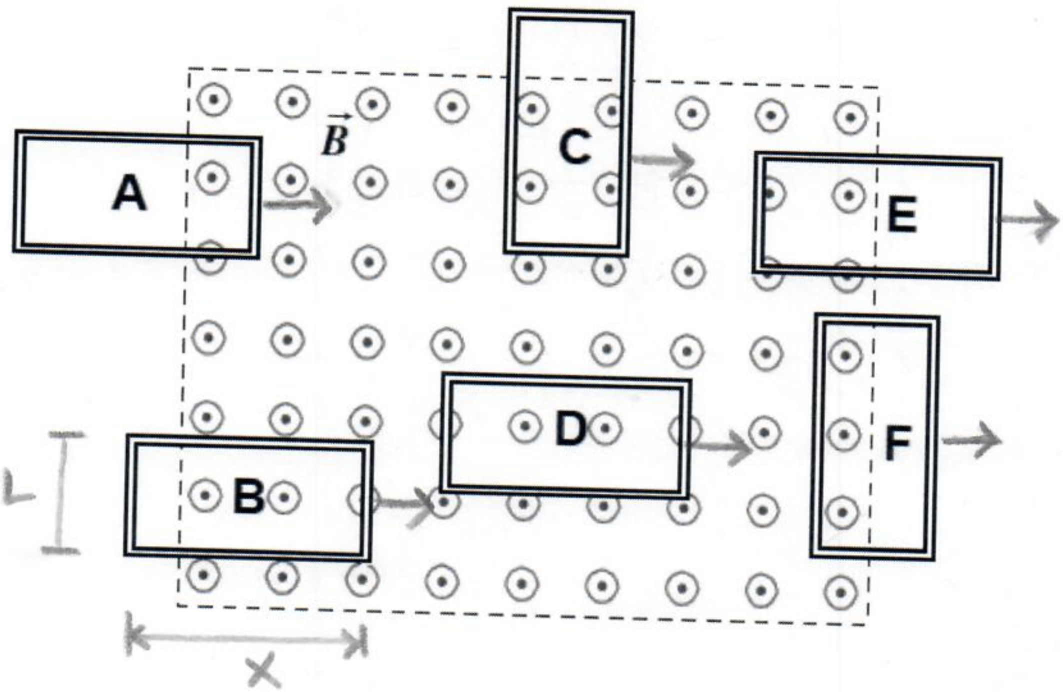
$\vec{\mu} = NI\vec{A}$

$|\vec{\mu}| = 1 \times 8.0A\ 0.2m * 0.2m$

$= 0.32\ Am^2$

$\vec{\mu} = \langle 0, 0, +0.32 \rangle Am^2$

Question 6 (6 points)



V is the Same

6. Six identical rectangular wire loops are **moving to the right** at the same constant speed. There is a uniform magnetic field coming out of the page in the region enclosed by the dashed line. The rectangular loops are all 5 cm by 10 cm.

Rank the magnitude of the induced current in the rectangular loops **at the instant shown.** Assume there is no
effect or interaction between the loops.

1 Greatest	2	3	4	5	6 Least	OR	All the same	All zero	Cannot determine
F >	B =	A =	E >	D =	C		☐	☐	☐

Explain your reasoning (6 points)

$\mathcal{E}mf = -N \frac{\Delta \Phi_B}{\Delta t}$ for Motional $\mathcal{E}mf$ $\mathcal{E}mf = BLV$

opposes change causing it

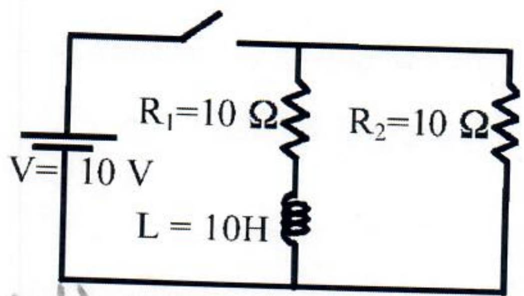
F has Larger L (length) → $\mathcal{E}mf$ greater

Greater I induced

D & C do not have a change in Magnetic flux
Hence $I_{induced} = 0$

B, A and E have a change in flux at same rate because of V (same) so $I_{induced}$ Less than F because F has bigger L.

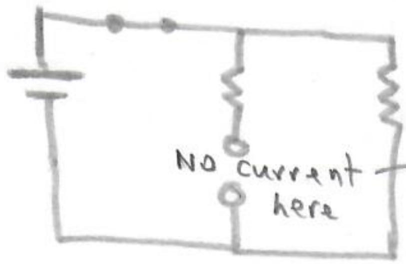
Question 7 (8 points) (Stuff for Tuesday) How Inductors work



The figure below refers to the next three problems.

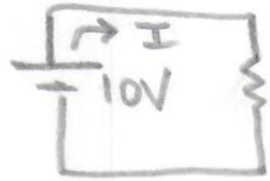
A) The switch is closed. Immediately after the switch is closed, what is the magnitude of the current that flows **through the battery? Explain and show your work (3 pts)**

When t=0 (immediately switch is closed) ⇨ Like an open circuit



↳ Because an Inductor opposes change ($I_i = 0$ Now also zero)

⇨

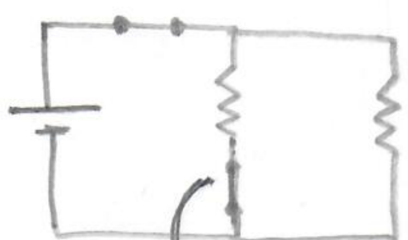


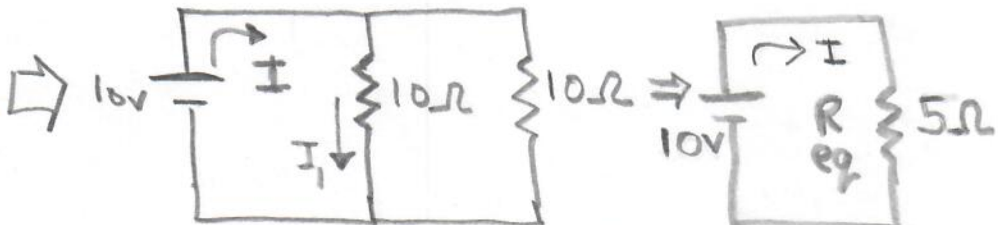
$I = \frac{\Delta V}{R} = \frac{10V}{10\Omega}$

$I = 1$ Amp

B) After a very long time, what is the magnitude of the current **through the battery?** Explain (3 pts)

When t=∞ (Long time) ⇨ Draw Circuit & Remember Inductors Eschew change (Resist).

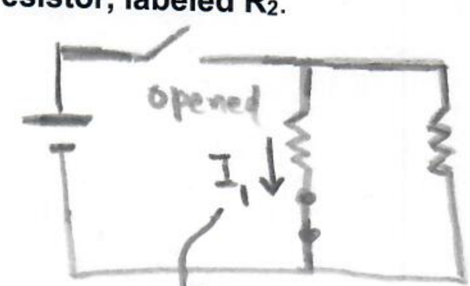




⇨ Now Inductor Acts like a wire

$I = \frac{10V}{5\Omega} = 2$ Amp

C) After being left closed for a very long time, the switch is opened again. (**2 points**) Immediately after the switch is re-opened, describe the current **flowing in the rightmost resistor, labeled R_2**.



I_1 will also flow through R_2

$I_1 = 1$ AMP

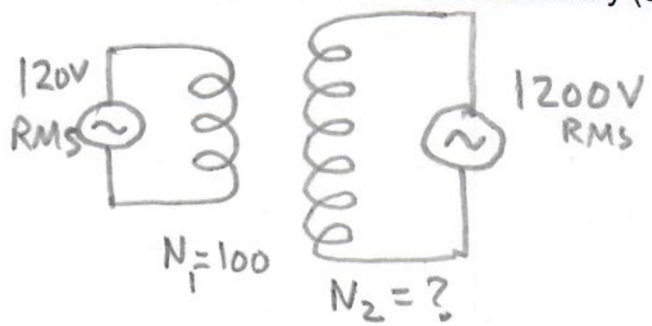
Initially Since Inductor is Slow to Respond :)

I_1 continue being there

Question 8 (6 pts)

The next two problems refer to this situation: a transformer at a power station is designed to step up the voltage from 120 V (RMS, AC) to 1200 V (RMS, AC).
The voltage oscillates with a frequency of 60 Hz.

A) Draw a figure (sketch) of the transformer. If the primary (input) side is a coil with 100 turns, how many turns should the secondary (output) side have? (3 pts)



$$\frac{N_2}{N_1} = \frac{V_2\,(RMS)}{V_1\,(RMS)}$$

$$\frac{N_2}{100} = \frac{\overset{10}{\cancel{1200}}V}{\cancel{120}V}$$

$$N_2 = 100 \times 10$$

(Secondary) $N_2 = 1000$ turns

B) If the station delivers an average power of 120 MW (that's MegaWatts), what is the *maximum* ***instantaneous*** ***(I_{MAX})***current flowing out of the secondary side? (3 pts) (Mega= 10^6)

$$\frac{I_{max}}{\sqrt{2}} = I_{RMS}$$

Remember $= \frac{I_{max}}{\sqrt{2}} \cdot \frac{V_{max}}{\sqrt{2}} = \frac{1}{2} I_{max} V_{max}$

$$\text{Power}_{AVE} = I_{RMS} V_{RMS}$$

$$120 \times 10^6 \text{ watts} = I_{RMS}\, 1200\text{V}$$

$$I_{RMS} = \frac{\overset{10}{\cancel{120}} \times \cancel{10^6}\,10^4 \text{ watts}}{\cancel{12} \times \cancel{10^2}\text{ V}}$$

$$I_{RMS} = 10^5 \text{ A}$$

$$\frac{I_{max}}{\sqrt{2}} = I_{RMS} \qquad I_{max} = I_{RMS}\sqrt{2}$$

$$= 10^5 \text{A}\sqrt{2}$$

$$I_{max} = 1.414 \times 10^5 \text{ A}$$