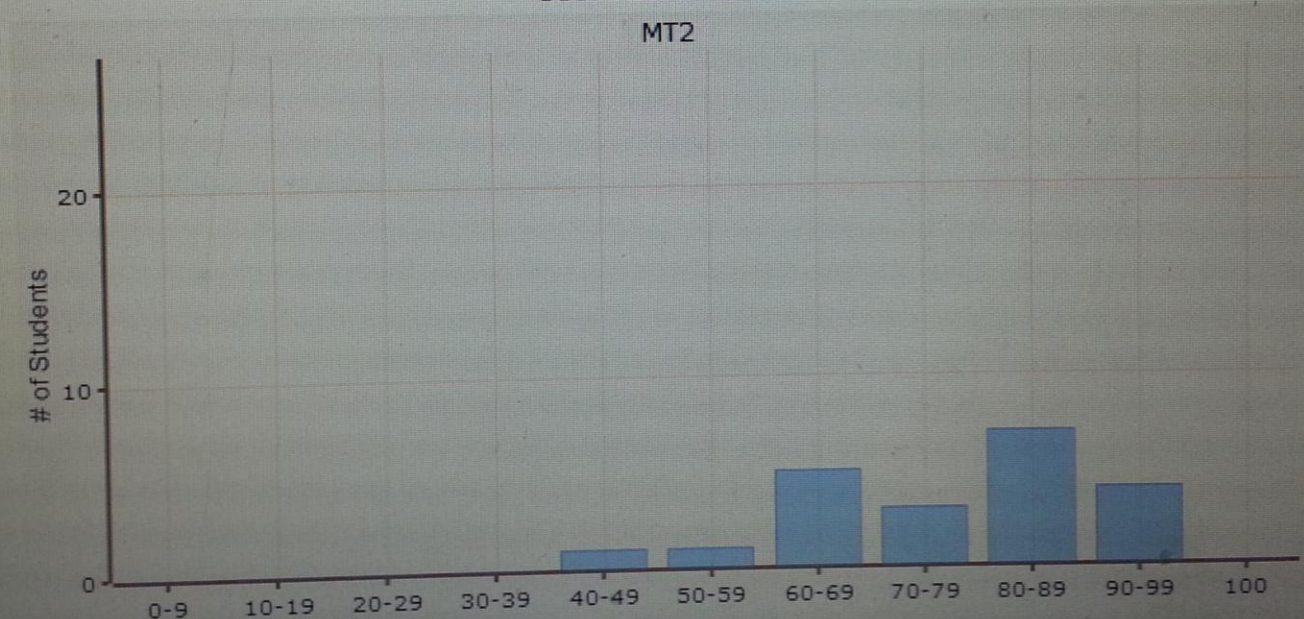
Score Distribution & Statistics: MT2

Course: Phy 303L (57970) / Engineering Physics II

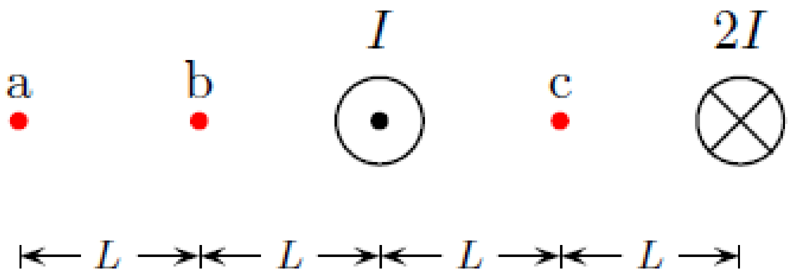
Assignment Statistics

	positive scores only	all scores
Students participating:	21.0	24.0
Class median:	80%	73.33%
Class average:	75.56%	66.11%
Quest average:	46	46
Average points earned:	113.33	99.17
Standard deviation:	21.23	42.42

Score Distribution



The figure represents two long, straight, parallel wires extending in a direction perpendicular to the page. A current $2I$ in the right wire runs into the page and a current I in the left runs out of the page. All the points and wires are a distance L apart as shown.



What is the direction of the magnetic field created by these wires at locations a, b and c? Assume that the length of the wires is $\gg L$.

up, down, up

zero, down, up

down, down, up

down, zero, up

Chapter 19

A Microscopic View of Electric Circuits

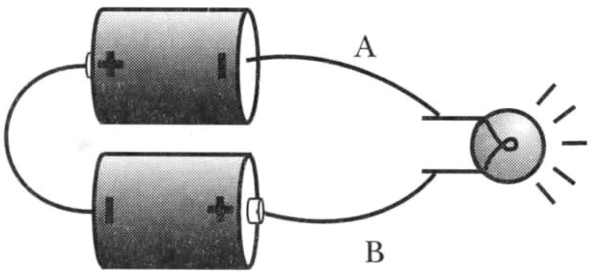
Current in a Circuit

A microscopic view of electric circuits:

- Are charges used up in a circuit?
- How is it possible to create and maintain a nonzero electric field inside a wire?
- What is the role of the battery in a circuit?

In an electric circuit the system does not reach equilibrium!

Steady state and static equilibrium



Static equilibrium:

- no charges are moving

Steady state (Dynamic Equilibrium):

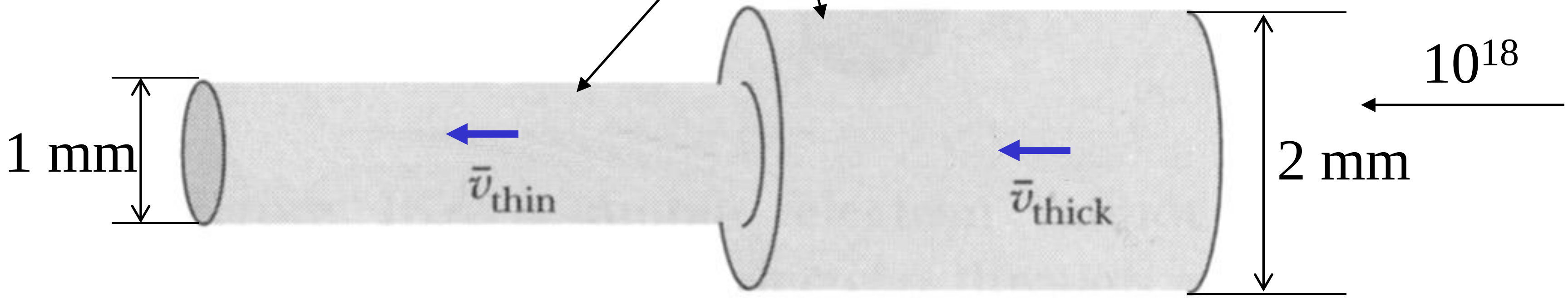
- charges are moving
- their velocities at any location do not change with time
- no change in the deposits of excess charge anywhere

Question

$i = nA\bar{v}$

$1.5 \cdot n_1 = n_2$

$2 \cdot u_1 = u_2$



Every second 10^{18} electrons enter the thick wire.
How many electrons exit from the thin wire every second?

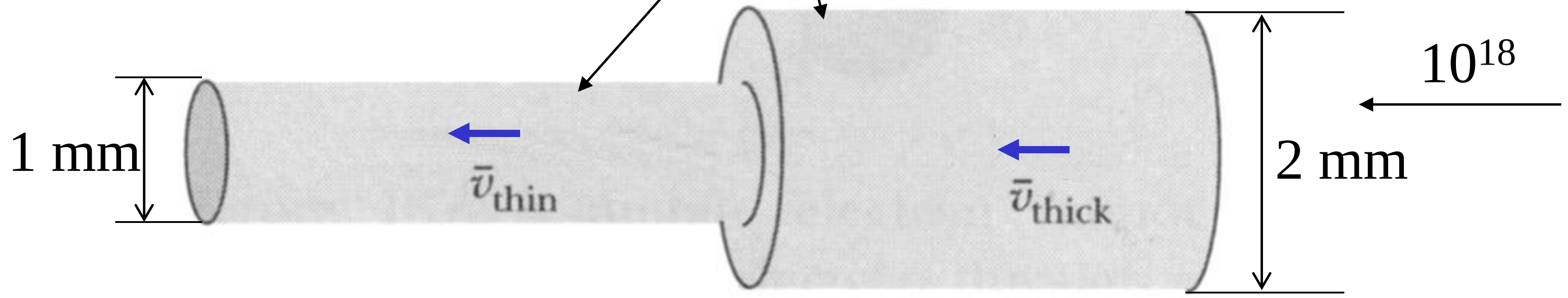
A) 10^{18}
B) 1.5×10^{18}
C) 2×10^{18}
D) 4×10^{18}
E) 12×10^{18}

Question

$i = nA\bar{v}$ $\bar{v} = uE$

$1.5 \cdot n_1 = n_2$

$2 \cdot u_1 = u_2$

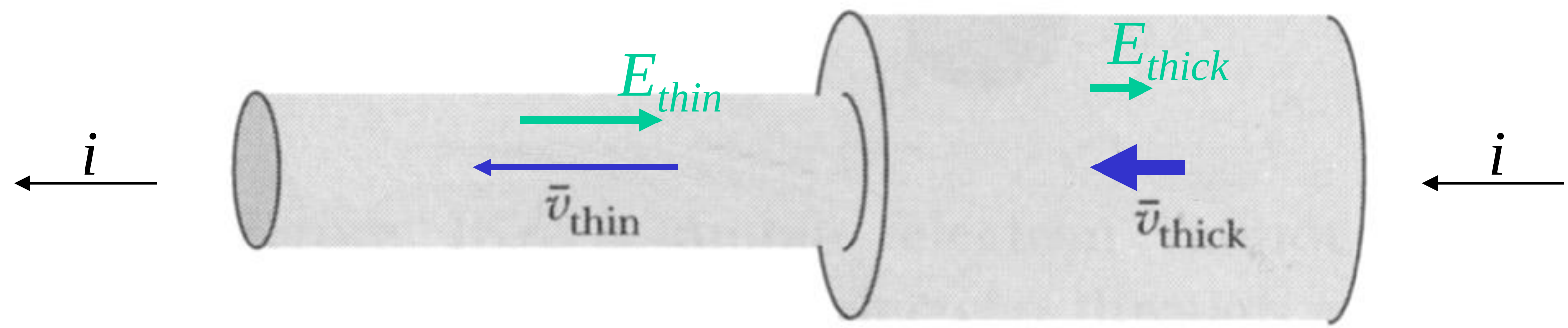


What is the ratio of the electric field, E_1/E_2?

A) 3:1
B) 6:1
C) 8:1
D) 12:1

E and Drift Speed

In steady state current is the same everywhere in a series circuit.



What is the drift speed?

$$i = nA\bar{v} \longrightarrow nA_{thin}\bar{v}_{thin} = nA_{thick}\bar{v}_{thick} \longrightarrow \boxed{\bar{v}_{thin} = \frac{A_{thick}}{A_{thin}}\bar{v}_{thick}}$$

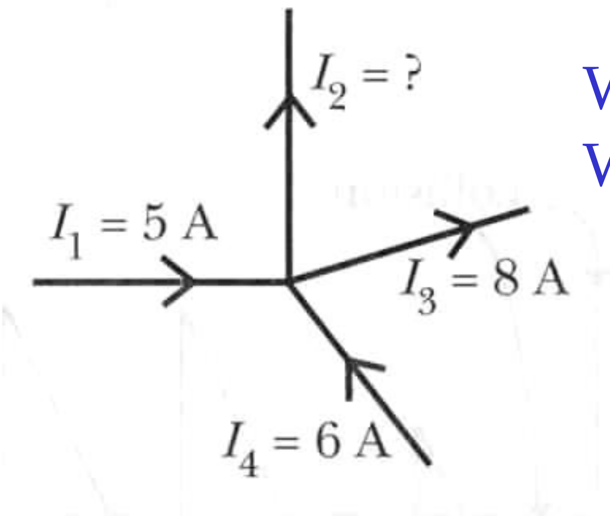
Note: density of electrons *n* cannot change if same metal

What is *E*?

$$\bar{v} = uE$$

$$uE_{thin} = \frac{A_{thick}}{A_{thin}} uE_{thick} \longrightarrow \boxed{E_{thin} = \frac{A_{thick}}{A_{thin}} E_{thick}}$$

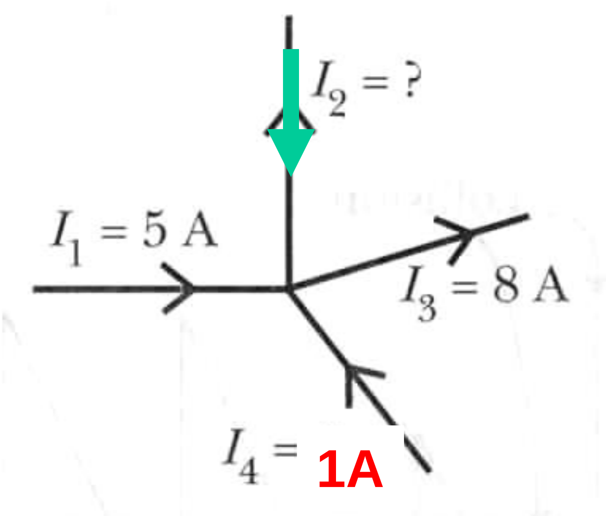
Exercise



Write the node equation for this circuit.
What is the value of I_2?

$$I_1 + I_4 = I_2 + I_3$$

$$I_2 = I_1 + I_4 - I_3 = 3\text{A}$$



What is the value of I_2 if I_4 is 1A?

$$I_1 + I_4 = I_2 + I_3$$

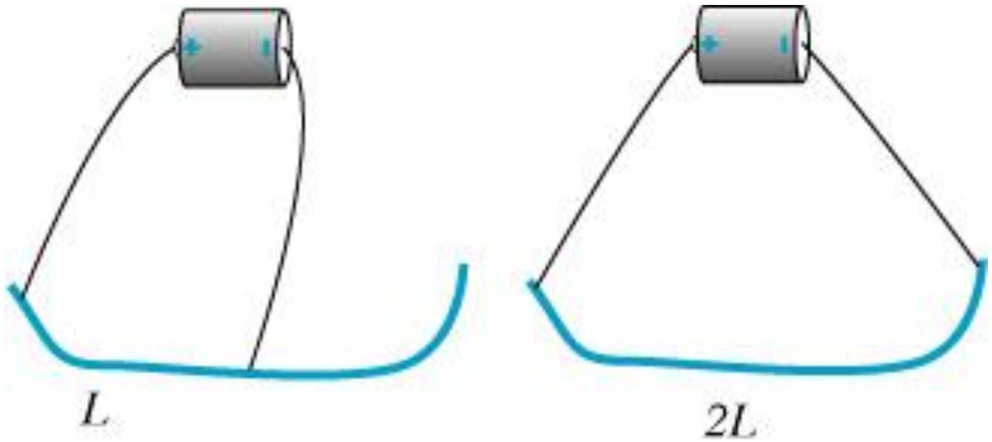
$$I_2 = I_1 + I_4 - I_3 = -2\text{A}$$

Charge conservation:

$$\sum_i I_i = 0$$

$I_i > 0$ for incoming
$I_i < 0$ for outgoing

Twice the Length

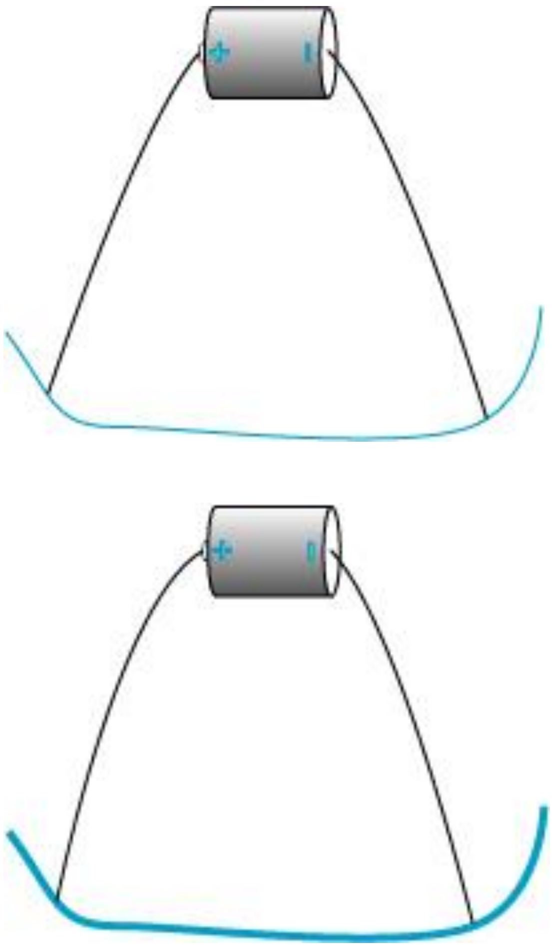


Nichrome wire (resistive)

$$i = nAuE = nAu\frac{\Delta V}{L} \longrightarrow i_{2L} = \frac{1}{2}i_L$$

Current is halved when increasing the length of the wire by a factor of 2.

Doubling the Cross-Sectional Area



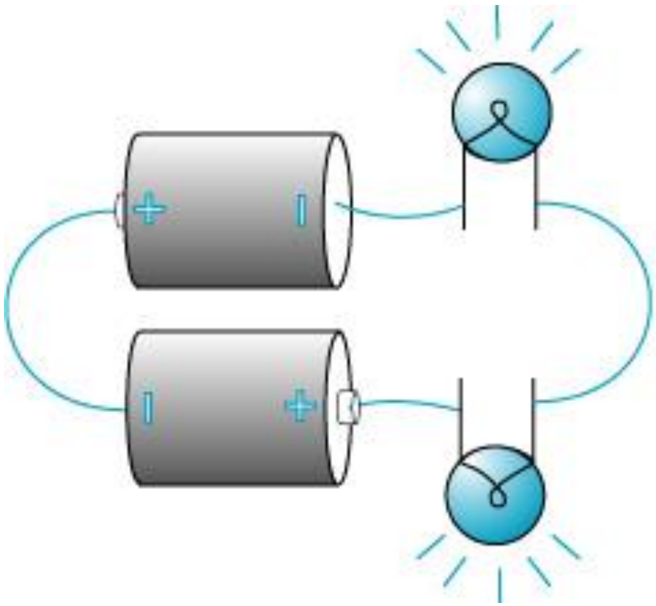
Nichrome wire

$$i = nAuE$$

Loop: *emf - EL = 0* $\quad E = \frac{emf}{L}$

Electron current in the wire increases by a factor of two if the cross-sectional area of the wire doubles.

Two Identical Light Bulbs in Series



Identical light bulbs

$$i = nAuE = nAu\frac{\mathrm{D}V}{L}$$

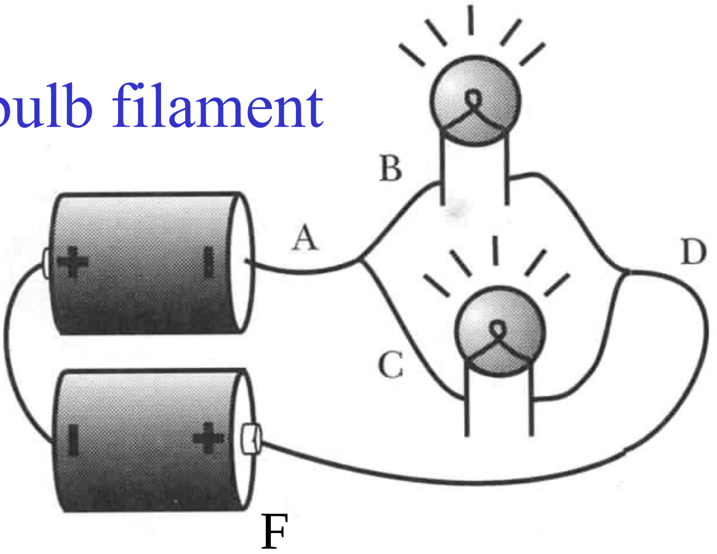
Two identical light bulbs in series are the same as one light bulb with twice as long a filament.

The filament lengths add … $R_{eq} = R_1 + R_2$

Two Light Bulbs in Parallel

$$i = nAuE = nAu\frac{\Delta V}{L}$$

L … length of bulb filament



1. Path ABDFA:

$$-2(emf) + E_B L = 0 \longrightarrow E_B = \frac{2(emf)}{L}$$

2. Path ACDFA:

$$-2(emf) + E_C L = 0 \longrightarrow E_C = \frac{2(emf)}{L} \longrightarrow E_B = E_C$$

$i_B = i_C$
$i_{batt} = 2i_B$

3. Path ABDCA:

$$E_B L - E_C L = 0 \longrightarrow E_B = E_C$$

We can think of the two bulbs in parallel as equivalent to increasing the cross-sectional area of one of the bulb filaments.

The filament areas add … $1/R_{eq} = 1/R_1 + 1/R_2$

Analysis of Circuits

The current node rule (Charge conservation)

Kirchhoff node or junction rule [1st law]:

In the steady state, the electron current entering a node in a circuit is equal to the electron current leaving that node

Electron current: $i = nAuE$

Conventional current: $I = |q|nAuE$

The loop rule (Energy conservation)

Kirchhoff loop rule [2nd law]:

$\Delta V_1 + \Delta V_2 + \Delta V_3 + \ldots = 0$ along any closed path in a circuit

$\Delta V = \Delta U/q$ ← energy per unit charge

Students Questions

I'd like some help with determining what changes in response to when you change the current or cross sectional area.

What exactly is J and how is it derived?

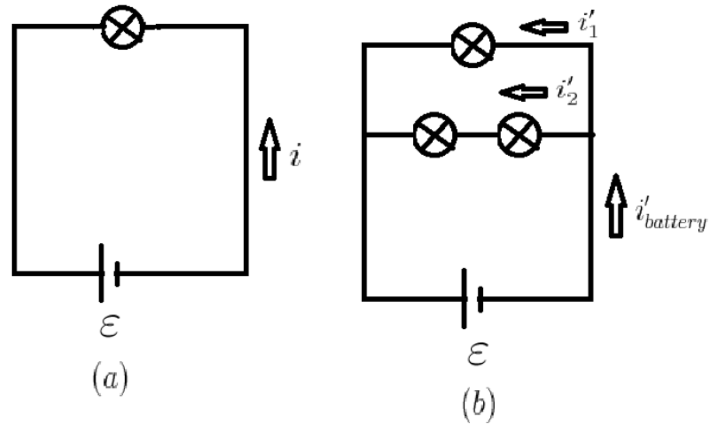
if electrons are moving twice as fast, wouldn't they collide twice as often?

http://www.youtube.com/watch?v=Pphrk6wE5aw☐

Charge carrier density and current density.

does the magnetic field generated from one part of the current effect the electrons on another part of a current?

why do we have homework due over spring break?



The bulbs in both circuits are identical and have a filament length L, while the batteries are also identical with emf, ε. Assume the potential difference along the connecting wires in both circuits is negligible.

For the case of Fig(a), the field in the filament is E. The circuit satisfies the loop equation: $\varepsilon = E\,L$ and the electron current is i.

Now consider the circuit of Fig(b). Define E'_1 to be the electric field through the top bulb, E'_{2L} be the electric field in the lower-left bulb, and E'_{2R} to be the electric field in the lower-right bulb.

Choose the answer that identifies the correct statements from the following list.

(Ia) $E'_1 = E'_{2L}$
(Ib) $E'_1 > E'_{2L}$

(IIa) $E'_{2L} > E'_{2R}$
(IIb) $E'_{2L} = E'_{2R}$

(IIIa) $E'_{2L} + E'_{2R} = E'_1$
(IIIb) $E'_{2L} + E'_{2R} > E'_1$

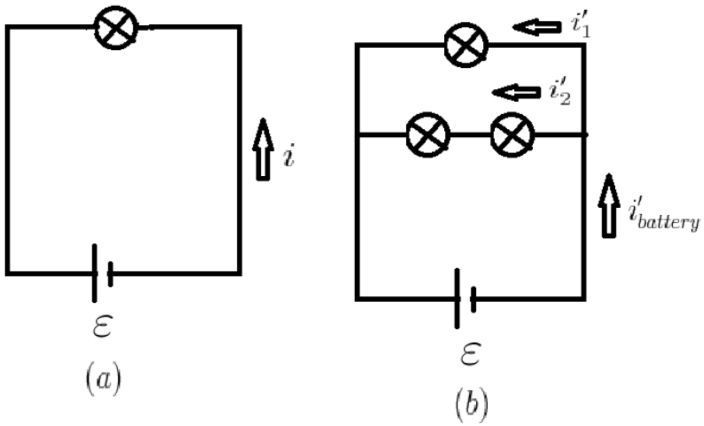
1. Ia, IIb, IIIb

2. Ia, IIa, IIIb

3. Ib, IIa, IIIb

4. Ib, IIa, IIIa

5. Ib, IIb, IIIa



Denote the current through the top branch be i'_1 and the current through the bottom branch to be i'_2.

Choose the answer that identifies the correct statements from the following list.

(Ia) $i'_1 = i$
(Ib) $i'_1 < i$

(IIa) $i'_2 = i$
(IIb) $i'_2 = \frac{i}{2}$

(IIIa) $i'_{battery} = \frac{3}{2}i$
(IIIb) $i'_{battery} = 2i$

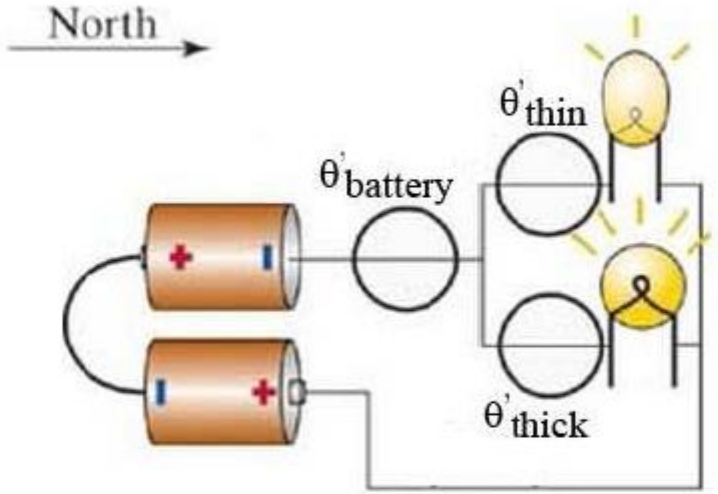
1. Ib, IIb, IIIa

2. Ia, IIa, IIIb

3. Ia, IIb, IIIa

4. Ia, IIb, IIIb

5. Ib, IIb, IIIb



A circuit is assembled that contains a thin-filament bulb and a thick-filament bulb as shown in the figure above, with four compasses placed underneath the wires (we're looking down on the circuit). When the thin-filament bulb is unscrewed from its socket, let the angle of deflection of the compass next to the thick-filament bulb be denoted by θ_{thick}. When the thick-filament bulb is unscrewed from its socket, let the angle of deflection of the compass next to the thin-filament bulb be denoted by θ_{thin}. When both bulbs are screwed in, let the angles of deflection be given as shown on the diagram.

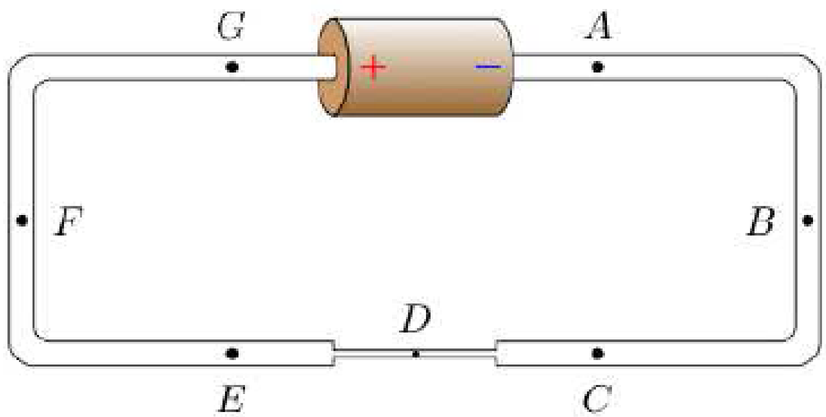
What is the correct ordering of the angles of deflection? (Give your answer in degrees)

$$\theta'_{thin} = \theta'_{thick} = \theta_{thin} = \theta_{thick} > \theta'_{battery}$$

$$\theta'_{thick} > \theta'_{thin} > \theta'_{battery} = \theta_{thick} = \theta_{thin}$$

$$\theta_{thick} > \theta'_{battery} > \theta'_{thin} > \theta'_{thick} = \theta_{thin}$$

$$\theta'_{battery} > \theta'_{thick} = \theta_{thick} > \theta'_{thin} = \theta_{thin}$$



All of the wires in the figure are made of the same material, but one wire has a smaller radius than the others. Which of the following statements are true of this circuit in the steady state?

[**A**] The electron drift speed at D is greater than the drift speed at G.

[**B**] $|\vec{E}|$ is the same at each labeled point.

[**C**] $\vec{E}$ at F points up.

[**D**] $|\vec{E}|$ at G is greater than $|\vec{E}|$ at C.

[**E**] The number of electrons passing B each second is the same as the number of electrons passing D each second.