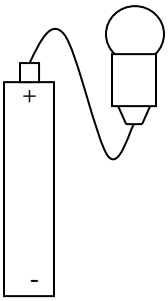
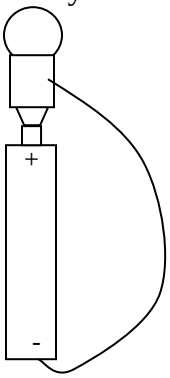
CTR-1.
What is the correct way to connect the battery to the light bulb to make it light up?

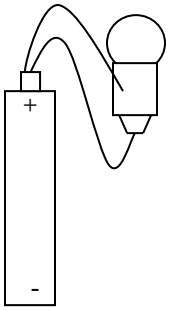
A)



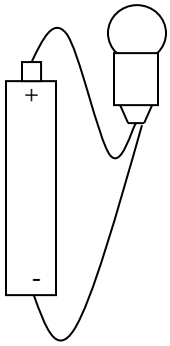
B)

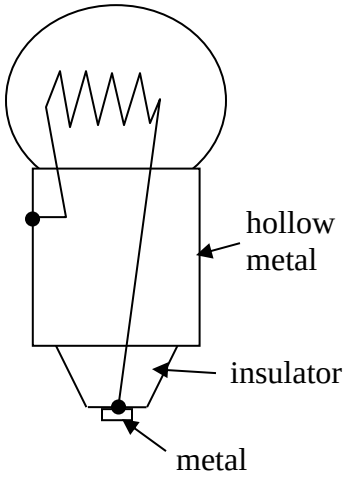


C)



D)





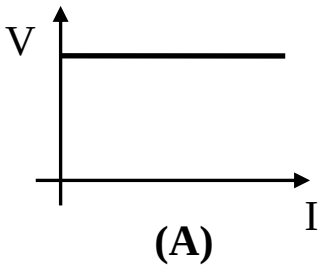
E) None of these will work

Answer: Circuit (B) is the only one that will work. There must be a complete circuit which includes the light bulb filament.

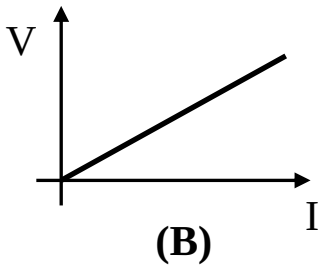
CTR-2.
The instructor goes crazy and grabs the terminals of a fully-charged 12V car battery. He will ..
A) immediately be killed.
B) not be killed, but he will start hollering because it really hurts.
C) not feel anything. This action is harmless.

Answer: He will not feel anything. His body's resistance R is very large (mega-ohms), so the current through him (I = V/R) is very small (micro-amps).

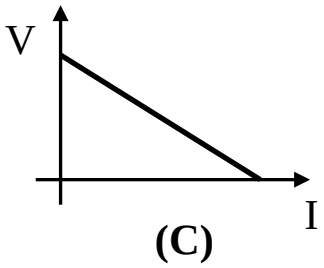
CTR-3. Which graph of voltage vs. current shows the behavior of an "ohmic" resistor (a resistor obeying Ohm's Law).



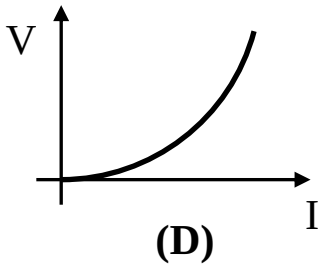
(A)



(B)



(C)

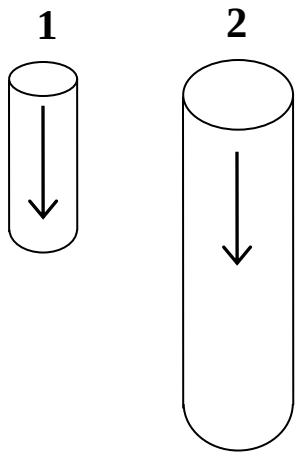


(D)

(E) None of these

Answer: Graph B. The slope of this graph is V/I = R. This graph shows constant slope, so it shows constant resistance R. Ohm's Law says that R = constant.

CTR-4. Two cylindrical resistors are made of the same material (same resistivity ρ). Resistor 2 is twice as long and has twice the diameter of resistor 1. What is the ratio $\frac{R_2}{R_1}$? (The arrow shows the direction of current flow.)



A) 2 B) 4

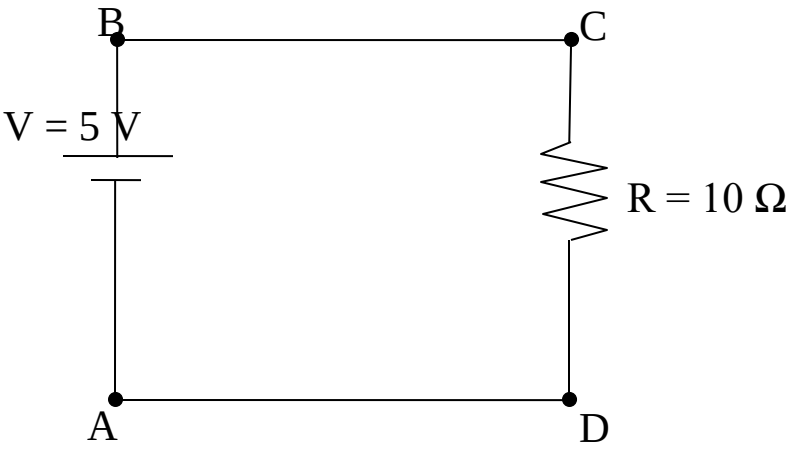
C) 1/2 D) 1/4

E) 1

Answer: The ratio is 1/2. $\frac{R_2}{R_1} = \frac{\frac{\rho L_2}{A_2}}{\frac{\rho L_1}{A_1}} = \frac{L_2}{L_1}\frac{A_1}{A_2} = 2 \times \frac{1}{4} = \frac{1}{2}$. The area is proportional to (radius)^2 or (diameter)^2.

When the diameter is doubled, the area increases by a factor of 4.

CTR-5.
A battery with emf or voltage V is attached to a resistor of resistance R. The circuit diagram is shown below. The point A is at zero volts.

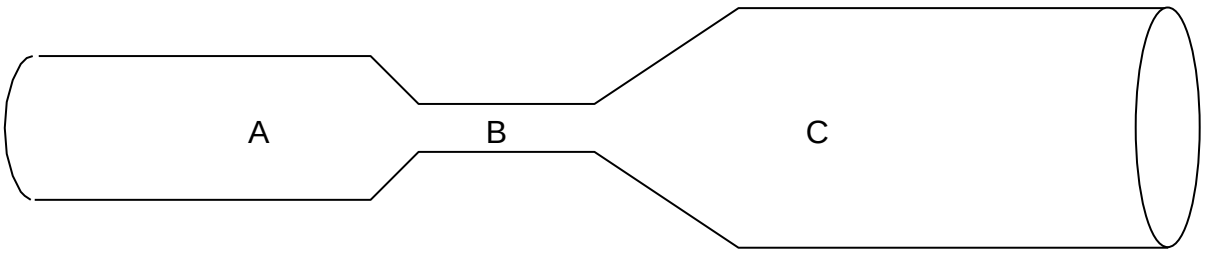


The correct voltages at the points B, C, and D are:

A) $V_B = 0V,\ V_C = 5V,\ V_D = 0V.$
B) $V_B = 5V,\ V_C < 5V,\ V_D > 0V.$
C) $V_B = 5V,\ V_C < 5V,\ V_D = 0V.$
D) $V_B = 5V,\ V_C = 5V,\ V_D = 0V.$
E) None of these.

Answer: D. In a circuit diagram, a line represents a wire of zero resistance. There is no voltage change along a zero-resistance wire because $\Delta V_{wire} = I \cdot R_{wire} = I \cdot 0 = 0$. So the voltage at B is the same as at C, and the voltage at D is the same as at A.

CTR-6. A copper cylinder is machined to have the following shape. The ends are connected to a battery so that a current I flows through the copper.



Which region A, B, or C has the greatest magnitude current I?
A B C D) all three have the same I.

Which region A, B, or C has the greatest magnitude current density J?
A B C D) all three have the same J.

Which region has the greater conductivity σ?
A B C D) all three have the same σ.

Which region A, B, or C has the greatest magnitude electric field E?
A B C D) all three have the same E

Which region A, B, or C has the greatest drift speed, v_{drift} ?
A B C D) all three have the same E

Which region A, B, or C has the greatest carrier density n (#carriers/volume) ?
A B C D) all three have the same E

Answers: All 3 regions have the same current I.

Region B has the largest current density J = I/A. All 3 regions have the same current I, so the region with the smallest A has the largest J.

All three regions have the same conductivity σ. Conductivity σ is a property of the composition, not of the shape of the sample. n

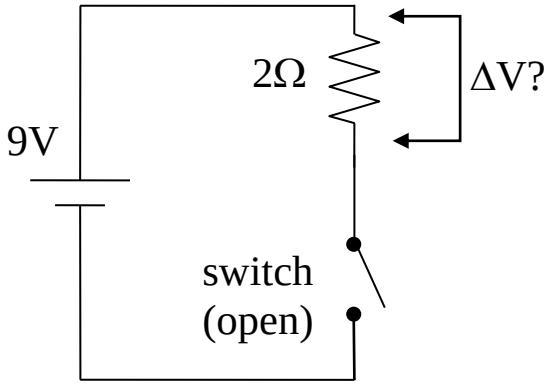
Region B has the largest E-field. $J = \sigma E$, J is largest is region B (from the 1st part of this question), σ is constant for all regions, so E must be max where J is max, in region B.

Region B has the largest drift speed, $J = n q v_{drift}$ (n and q are constants independent of location in the copper cylinder)

All three regions have the same charge carrier density (which is equal to 1 charge carrier per atomic volume)

CTR-7. A 9V battery is in series with a 2Ω resistor and an open switch. What is the voltage difference ΔV across the resistor?

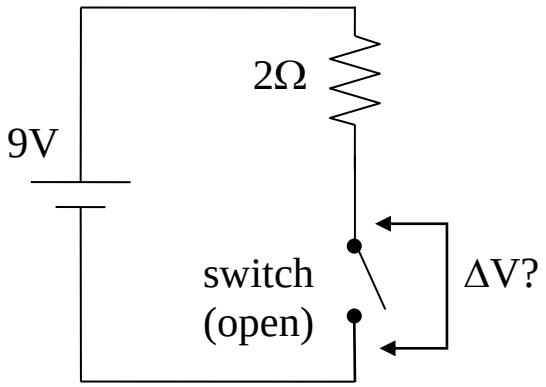
A) 0 V
B) 4.5 V
C) 9 V
D) 18 V
E) None of these



Answer: 0 V The current I in the circuit is zero. Ohm's Law says $\Delta V = I\,R = 0 \times 2\Omega = 0$ V

CTR-8. A 9V battery is in series with a 2Ω resistor and an open switch. What is the voltage difference ΔV across the open switch?

A) 0 V
B) 4.5 V
C) 9 V
D) 18 V
E) None of these



Answer: 9 V Let's set the voltage at the bottom of the battery to be 0V, so the top of the battery is at 9V. The current I in the circuit is zero, so the voltage drop across the 2-ohm resistor is zero volts. Therefore, the voltage at the bottom of the 2Ω resistor (the top of the switch) is the same as the voltage at the top of the battery, 9V. We can regard the open switch as a resistor with R = ∞. So Ohm's Law says $\Delta V_{switch} = I\,R_{switch} = 0 \times \infty =$ indeterminant.

CTR-9. In how many of the following 4 situations is there a current I (a conventional current) to the right?

i) an positive ion (+Q) moves to the right
ii) a neutral hydrogen (proton +e, electron -e) moves right
iii) a beam of electrons in a TV tubes shoots to the left

iv) in an ionic solution, massive positive ions flow right, an equal number of electrons flow left.

A) None B) 1 C) 2 D) 3 E) 4

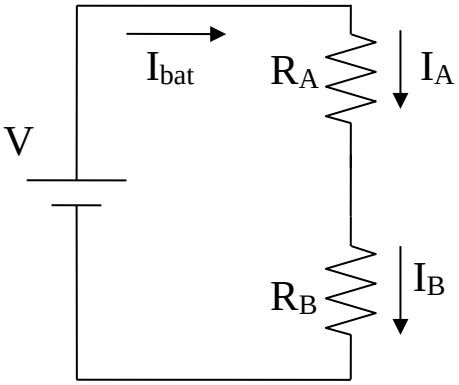
Answer: Three: i , iii, and iv

CTR-10.
A 60W light bulb and a 100W light bulb each has a filament with a certain resistance (when the bulb is on and hot). How do the resistances of the filaments compare?
A) $R_{60W} = R_{100W}$.
B) $R_{60W} > R_{100W}$
C) $R_{60W} < R_{100W}$
D) Impossible to tell without further information.

Hint: When a light bulb is plugged in, it is essentially attached to a battery with constant voltage = 120V.

Answer: $R_{60W} > R_{100W}$. Light bulbs are labeled with the wattage they will have when a voltage of 120 VAC (volts AC) is applied. 100W bulbs have more power (when 120VAC is applied) than 60W bulbs. From $P = V^2/R$, we see that smaller R results in bigger P.

CTR-11. Two light bulbs are connected to a battery *in series* (in a chain, one after another). How does the current in upper light bulb A compare to the current in lower light bulb B?
A) IA > IB
B) IA < IB
C) IA = IB
D) answer depends on relative sizes of the R's



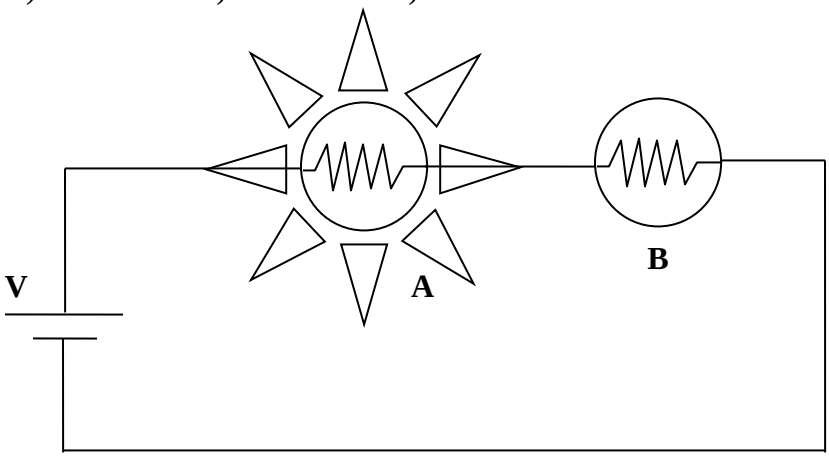
Answer: IA = IB Current is not "used up" in a resistor. Just like water is not "used up" when it flows through your garden hose. Every drop of water that enters your garden hose from the faucet, eventually exits the other end. And if the hose has no leaks and no bubbles, the rate at which water enters the hose from the faucet (in gallons per minutes) is exactly the same as the rate at which it leaves. This is because water is incompressible: in order to make room for a new drop of water from the faucet, one drop of water has to leave the other end. This is how electrons flow through a resistor. The flow of charges into the resistor is exactly equal to the flow

of charges out of the resistor. It is nearly impossible to put more than one conduction electron on each atom, so to make room for one new electron in a wire, one electron has to leave the wire at the other end.

Although current is not used up, there is something that is used up. The electrostatic potential energy of the charges is used up; it is converted into thermal energy.

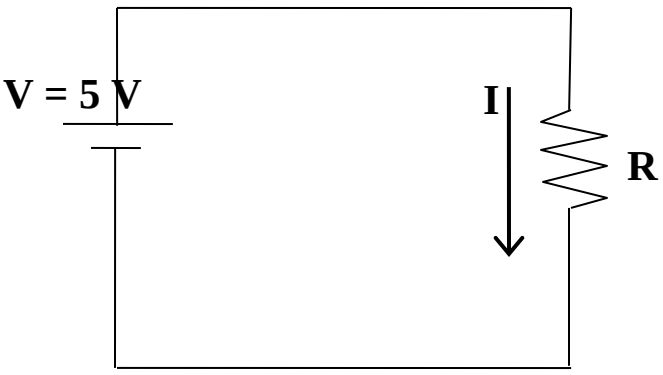
CTR-12. Two light bulbs, A and B, are in series, so they carry the same current. Light bulb A is brighter than B. Which bulb has higher resistance? (HINT: brighter means more power.)

A) A B) B C) Same resistance.



Answer: Since the two bulbs carry the SAME CURRENT, we use the formula $P = I^2R$. Brighter means higher power P. At the same current, the higher P has the higher resistance. Bulb A has the higher resistance.

CTR-13. A light bulb is attached to a battery with constant voltage V. The light filament has resistance R. The circuit diagram is shown below. When the light bulb is first turned on by attaching to the battery, the filament heats rapidly, and as it heats, its resistance R increases (due to increased scattering of electrons by thermal vibrations).



As the light bulb filament heats up, the current I in the filament ...

A) increases B) decreases C) stays the same.

Answer: I decreases. I = V/R. At fixed V, as R increases, I decreases.

CTR-14. The voltage provided by your household wall sockets is....
A) AC voltage
B) DC voltage
C) Depends on the appliance which you plug into the socket.

Answer: AC
