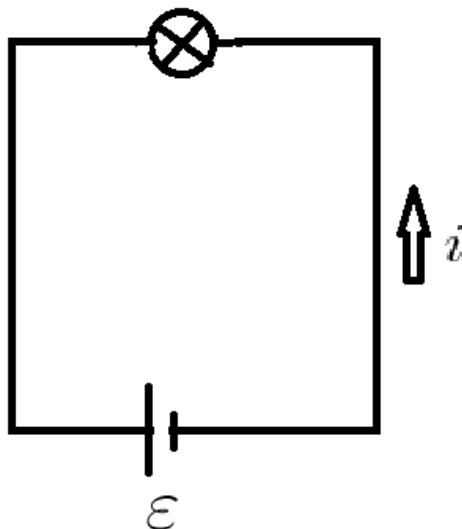
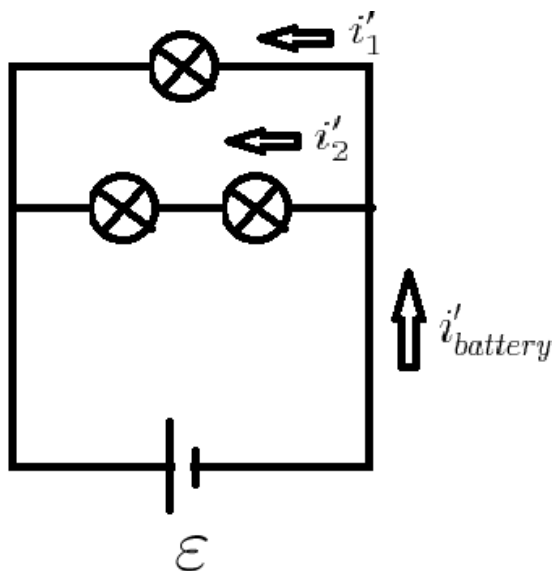


This print-out should have 15 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

001 (part 1 of 2) 5.0 points



(a)



(b)

From a microscopic point of view, the important quantities in a circuit analysis are the fields and the electron currents. This problem concerns the circuits shown in figures (a) and (b). The bulbs in both circuits are identical and have a filament length L , while the bat-

teries are also identical with emf, $\mathcal{E}$. 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: $\mathcal{E} = EL$ 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. Ib, IIa, IIIb
2. Ia, IIb, IIIb
3. Ia, IIa, IIIa
4. Ib, IIb, IIIb
5. Ia, IIa, IIIb
6. Ia, IIb, IIIa
7. Ib, IIa, IIIa
8. Ib, IIb, IIIa

002 (part 2 of 2) 5.0 points

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, IIa, IIIa

2. Ib, IIb, IIIb

3. Ia, IIa, IIIa

4. Ib, IIa, IIIb

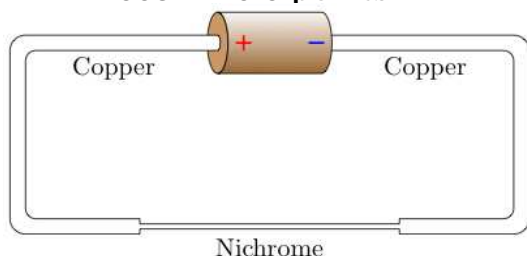
5. Ia, IIb, IIIa

6. Ia, IIa, IIIb

7. Ia, IIb, IIIb

8. Ib, IIb, IIIa

003 10.0 points



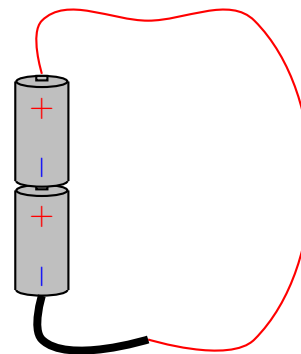
In the circuit shown, two thick copper wires connect a 1.5 V battery to a Nichrome wire. Each copper wire has radius $R = 9$ mm and is $L = 19$ cm long. Copper has 8.4×10^{28} mobile electrons per cubic meter and an electron mobility of 4.4×10^{-3} (m/s)/(V/m). The Nichrome wire is $l = 9$ cm long and has radius $r = 5$ mm. Nichrome has 9×10^{28} mobile electrons/m³ and an electron mobility of 7×10^{-5} (m/s)/(V/m).

What is the magnitude of the electric field in the copper wire?

Answer in units of N/C

004 (part 1 of 5) 2.0 points

The following questions correspond to the figure shown, consisting of two flashlight batteries and two Nichrome wires of different lengths and different thicknesses as shown (corresponding roughly to your own thick and thin Nichrome wires).



The thin wire is 54 cm long, and its diameter is 0.18 mm. The thick wire is 20 cm long, and its diameter is 0.42 mm.

The emf of each flashlight battery is 1.1 V. Determine the steady-state electric field inside each Nichrome wire. Remember that in the steady state you must satisfy both the current node rule and energy conservation. These two principles give you two equations for the two unknown fields.

Find the electric field in the thin wire first.
Answer in units of V/m

005 (part 2 of 5) 2.0 points

Find the electric field in the thick wire.

Answer in units of V/m

006 (part 3 of 5) 2.0 points

How long does it take an electron to drift through both Nichrome wires if electron mobility in Nichrome is 6×10^{-5} (m/s)(N/C).

Answer in units of s

007 (part 4 of 5) 2.0 points

On the other hand, about how long did it take to establish the steady state when the circuit was first assembled?

1. 0.00246667 s

2. $2.46667 \times 10^{-6} \text{ s}$

3. $2.46667 \times 10^{-9} \text{ s}$

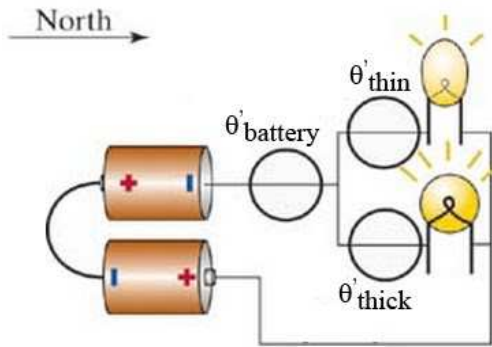
4. 2466.67 s

5. 2.46667 s

008 (part 5 of 5) 2.0 points

There are about 8×10^{28} mobile electrons per cubic meter in Nichrome. How many electrons cross the junction between the two wires every second?

Answer in units of electrons/s

009 10.0 points

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)

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

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

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

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

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

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

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

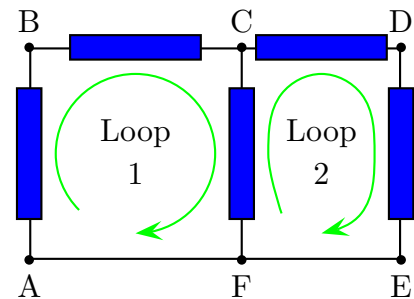
8. $\theta'_{battery} = \theta'_{thin} > \theta_{thick} > \theta_{thin} = \theta'_{thick}$

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

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

010 (part 1 of 2) 5.0 points

In the diagram below, suppose that $V_C - V_F = 6.2 \text{ V}$, and that $V_D - V_E = 4.5 \text{ V}$. What is the potential difference $V_C - V_D$?



Answer in units of V

011 (part 2 of 2) 5.0 points

If the element between C and D is a battery, is the (+) end of the battery at C or at D?

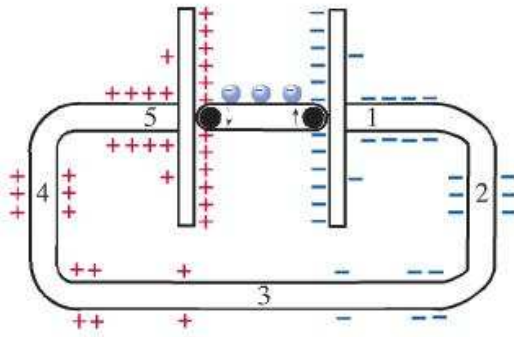
1. C

2. D

3. There is no positive end.

012 10.0 points

In the circuit below, a mechanical battery keeps a steady-state current flowing in a wire that has a rather low electron mobility.

**Figure**

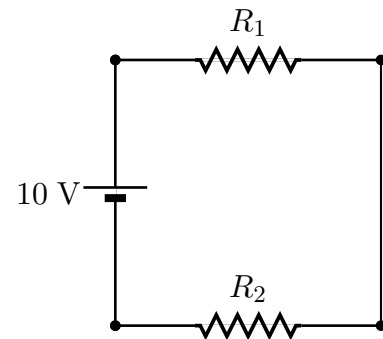
Which of the following statements are true?

- 1 The electric field inside the wire varies in magnitude, depending upon location.
- 2 The electric field is zero at all locations inside the metal wire.
- 3 At location 3, the electric field points to the left.
- 4 The magnitude of the electric field inside the wire is the same at all locations.
- 5 Mobile electrons inside the wire push each other through the wire.
- 6 The nonzero electric field inside the wire is created by the moving electrons in the wire.
- 7 The electric field is parallel to the wire at every location within the wire.

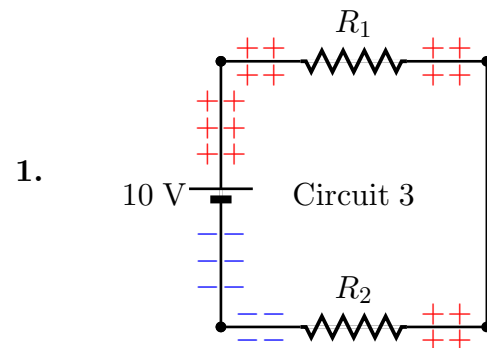
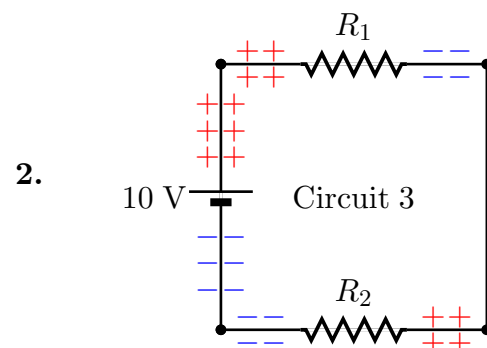
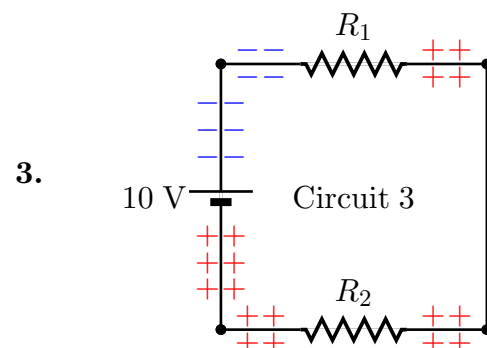
Your answer should be a list of numbers corresponding to the correct statements, with the numbers separated by commas

013 10.0 points

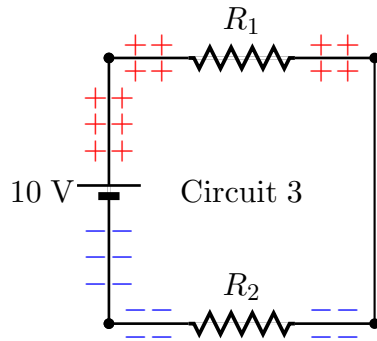
Two resistors, $R_1 = 25 \, \Omega$ and $R_2 = 5 \, \Omega$ are used to construct a circuit as shown the figure below, using a 10 V battery.



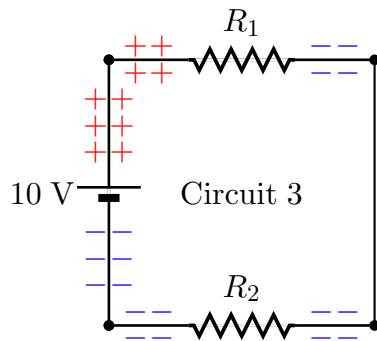
Of the following diagrams, which indicates the correct surface charge distribution of +’s and -’s on the circuit? Use the relation $\Delta V_i = I_i R_i$ (Ohm’s law) to assist in your qualitative reasoning.



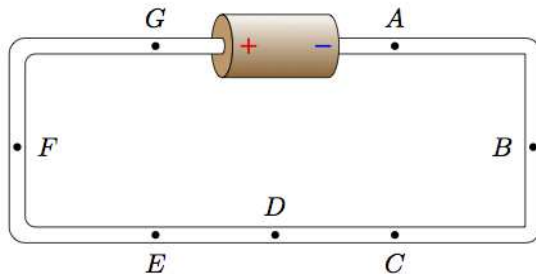
4.



5.



014 10.0 points



A steady-state current flows through the Nichrome wire in the circuit shown in the figure.

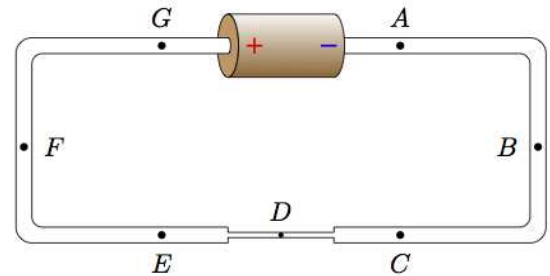
- 1 There is some excess negative charge on the surface of the wire near location B .
- 2 Inside the metal wire the magnitude of the electric field is zero.
- 3 The electric field points to the left at location G .
- 4 There is no excess charge on the surface of the wire.
- 5 The magnitude of the electric field inside the wire is larger at location G than at location C .
- 6 The electric field at location D points to

the left.

- 7 Because the current is not changing, the circuit is in static equilibrium.

Your answer should be a list of numbers corresponding to the correct statements, with the numbers separated by commas

015 10.0 points



In the circuit above, all the wire is made of Nichrome, but one segment has a much smaller cross-sectional area.

Draw a copy of this diagram. On your diagram, draw in the steady-state electric field vectors at the indicated locations, taking care to display relative magnitudes. Use this diagram to select the correct choices from the list below.

- 1 There is a large gradient of surface charge (relative to the rest of the wire) on the wire between locations C and E .
- 2 The electron current is the same at every location in this circuit.
- 3 Fewer electrons per second pass location E than location C .
- 4 The magnitude of the electric field is the same at every location in this circuit.
- 5 The magnitude of the electric field at location D is larger than the magnitude of the electric field at location G .
- 6 There is no surface charge on the wire near location G .

Your answer should be a list of numbers corresponding to the correct statements, with the numbers separated by commas