Test about Voltage - A Basic Term in Electricity

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Date:.....

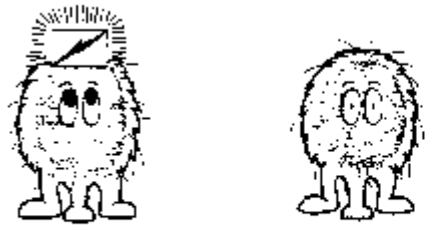
School: .....or University: .....

Class: ..... Semester: .....

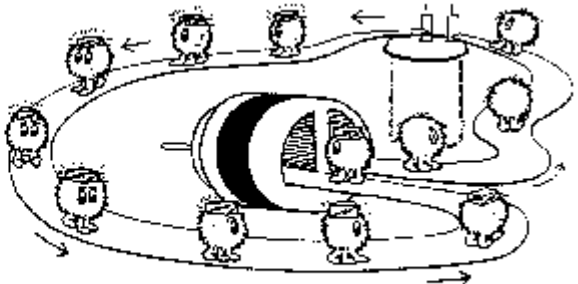
..... Subject: .....

Item 1:

In some books a causal model for an electric circuit is presented as shown in the following picture.



Electron with and without energy



Electrons carrying energy from the battery to the motor

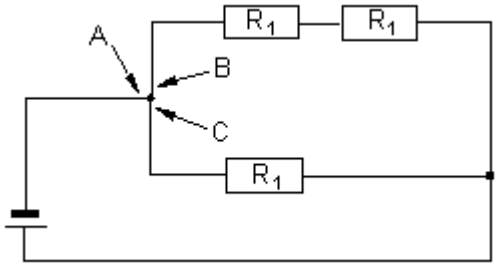
On the line from the battery to the motor the electrons carry the energy to drive the motor. On the line back to the battery, the electrons are without energy and need to be reloaded.

Which of the following statements is correct?

- 1) This model for the electric current is acceptable. It corresponds with the definition: voltage or potential difference = energy per charge ..... ☐
- 2) This model is only partly acceptable because the electrons on their way back to the battery are not completely without energy as shown in the figure but rather they have some energy. However, they have less energy than on their way to the motor. ..... ☐
- 3) This model is not acceptable because in a good model the electrons in both lines should play equally important roles in respect to energy and to drive the motor. ..... ☐

Item 2:

In an electric circuit with a branching point, the current is split up at the branching point according to the resistors within the different parallel branches.



The larger the resistor in such a branch, the smaller the current through this branch and vice versa.

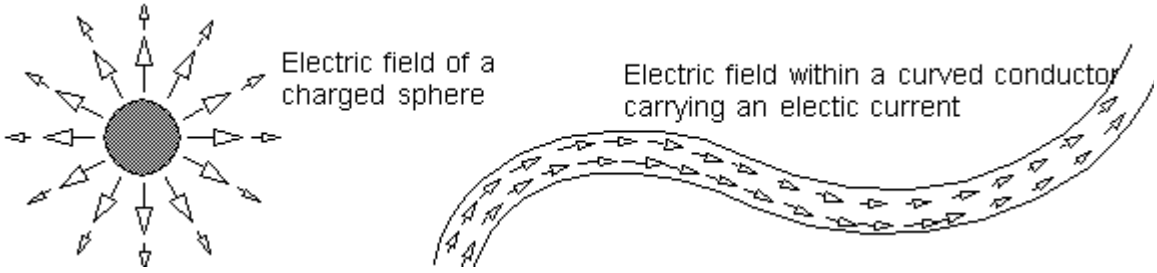
Question: Is there any difference in the physical state of the wires at A, B and C, adjoining the branching point from different sides, which can explain the correct splitting of the stream of electrons?

Which of the following answers do you think is correct or makes sense to you?

- 1) There is NO difference in the physical state of the three wires near the point of branching, besides the amount and direction of the drifting electrons. ..... ☐
- 2) There must be a difference, but I cannot say what it is. ..... ☐
- 3) The density of electrons throughout the 3 cross sections forming the electric current is different. ..... ☐
- 4) The density of electrons at the surface of the 3 cross sections is different.. ☐
- 5) The electrons at the 3 cross sections have different energy. ..... ☐

Item 3:

Coulomb´s law states that the electric field of a point charge is depending on distance according to $1/r^2$. Based on this law the field of charged objects can be calculated and it follows that in practically all cases the static electric field around such objects is also depending on distance.



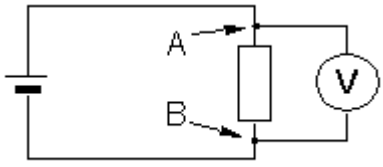
In a uniform curvilinear resistive wire of constant diameter, which carries an electric current, the electric field within the wire, which is driving the current, is NOT depending on distance. It is constant and always directed parallel to the axis of the wire, whatever be the curvature of its bending. This seems to be in contradiction with the fact, stated above, that the electric field around a charged object is depending on distance.

Which of the following answers makes sense to you?

- 1) I do not see a contradiction between these two cases. One case is static, the other is dynamic and the two cases cannot be compared. ..... ☐
- 2) There must be something along the wire which causes the field to be constant and parallel to the axis of the wire, but I do not know what it is. ..... ☐
- 3) The surface of the wire is charged in such a way as to produce this pattern of electric field ..... ☐
- 4) The density of the free electrons inside of the conductor, forming the electric current, varies along the wire and causes the electric field to be constant and parallel to the axis of the wire. ..... ☐

Item 4:

As shown in the circuit, there is a potential difference across a resistor, if it is connected to a battery and a current is flowing.



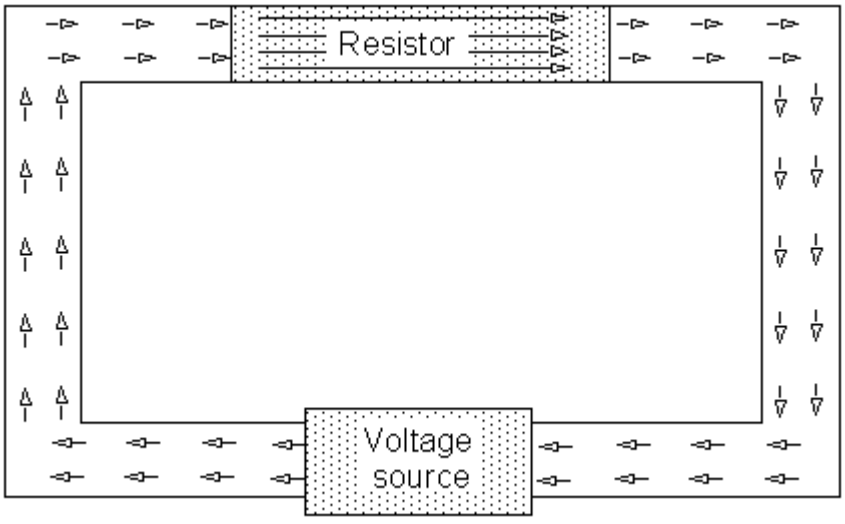
Question:
Is there any difference in the physical state between the contact points A and B on the opposite sides of the resistor?

Which of the following answers do you think is correct or makes sense to you?

- 1) There is no difference in the physical state between the contact points A and B. ..... ☐
- 2) There must be a difference, but I cannot say what it is. ..... ☐
- 3) Throughout the cross-section of the wires at A and B the density of the free electrons, forming the electric current, is different. ..... ☐
- 4) The surface of the wire at A and B is charged differently. ..... ☐
- 5) The free electrons at A and B, forming the electric current, have different energy. ..... ☐

Item 5:

Within a simple electric circuit a constant current is flowing through a resistor. For reasons of simplicity the diameters of the conductors and the resistor are given to be the same.



Since there is practically no potential difference along the conductors but mainly across the resistors, it can be concluded that the electric field within the resistor will be much larger than within the conductors.

Question:
Where does this extra field within the resistors come from?

Which of the following answers do you think is correct or makes sense to you?

- 1) The strong field inside of the resistor is produced by the battery which drives the current. ..... ☐
- 2) There should be extra electrons at one end and positive charges at the other end of the resistor, but I am not sure. ..... ☐
- 3) There are extra electrons at one end and positive charges at the other end of the resistor. ..... ☐
- 4) The energy of the drifting electrons, forming the electric current, is different at both ends of the resistor. ..... ☐

Item 6:

Within an electric circuit, consisting of a battery and a single resistor, a constant current is flowing according to Ohm's law.

If the resistivity of the resistor is increased, the current is decreased to a new steady state and vice versa.

Question:

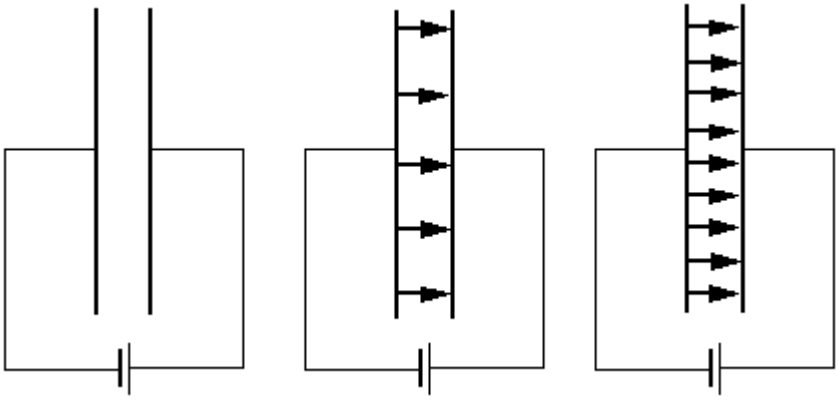
What kind of process takes place as transition between such steady states?

Which of the following statements about the underlying transition process is correct or makes sense to you?

- 1) I have never heard about transitions between steady states of currents in electric circuits. ..... ☐
- 2) There must be some kind of process, but I do not know what it is. ..... ☐
- 3) A change in density of the drifting electrons, forming the current, is travelling as a wave front along the wire to establish a new steady state. ..... ☐
- 4) A change in density of the surface charges is travelling like a wave front along the wire to establish a new steady state. ..... ☐

Item 7:

When a capacitor is being charged, the electric field inside is increasing from zero to its maximal value, which is determined by the applied voltage and the capacitance C.



Increasing field strength within a capacitor when being charged

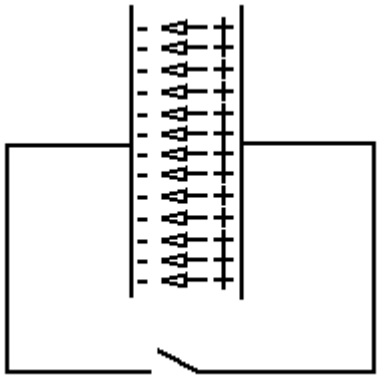
On one side of the capacitor, electrons flow through the connecting wire to the inner surface and on the other side electrons flow from the surface to the connecting wire - leaving positive ions on the surface behind.
The following statements relate to the process of change of the electric field inside of the capacitor.

Please indicate which statement does correspond with what you know about this process.

- 1) The electric field inside the capacitor is formed starting from the appearing negative electrons at one side to the appearing positive ions at the other side. ..... ☐
- 2) The electric field inside the capacitor is formed starting from the appearing positive ions at one side to the negative electrons at the other side. ..... ☐
- 3) The electric field inside the capacitor is formed starting symmetrically from both appearing charge carriers to the middle. ..... ☐
- 4) The electric field inside of the capacitor is formed due to charges on the surface of the connecting wires. ..... ☐

Item 8:

A capacitor consists basically of two large metallic surfaces with a separating isolating and rather thin medium. When charged the density of oppositely charged charge carriers on both surfaces can be very large due to the strong attractive Coulomb forces between them and the small distance.



If the capacitor is shorted by some external wires a process of discharge will be initiated in spite of the strong attracting forces between the charge carriers within the capacitor.

Question:

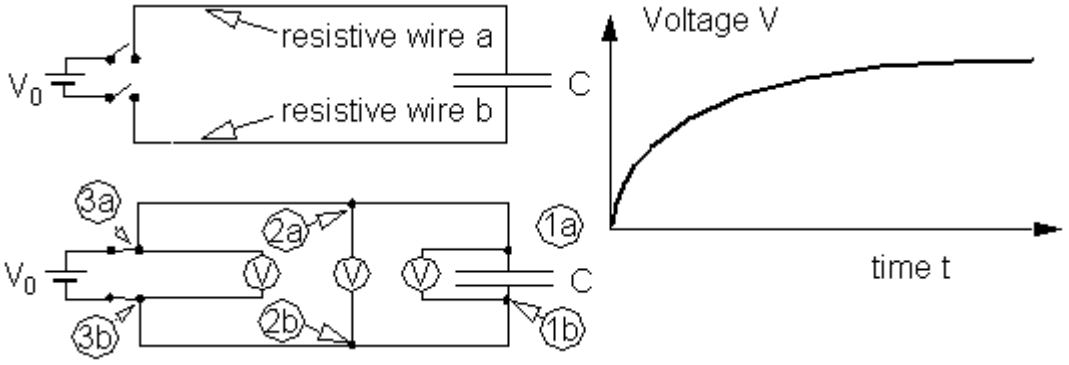
What is the cause that initiates this process of discharge?

Chose one of the following statements which correspond with what you know about this process.

- 1) The attracting Coulomb forces are overcome by internal atomic forces between electrons and lattice ions at the point where the external wires are shorted. ☐
- 2) The process of discharge of the capacitor is caused by a pressure which exists perpendicular to the field lines within the capacitor. ..... ☐
-
- 3) The process of discharge of the capacitor is due to surface charges on the external wires. ..... ☐
- 4) The repulsion between charge carriers of the same polarity on each single plate is stronger than the attractive forces between the charge carriers of opposite charge on opposite plates..... ☐

Item 9:

A capacitor is connected to a voltage source by resistive wires (resistance $R_{a/b}$). For this circuit the voltage across the capacitor is starting from zero and is then increasing in time. This time dependence is influenced by $R_{a/b}$ and C.



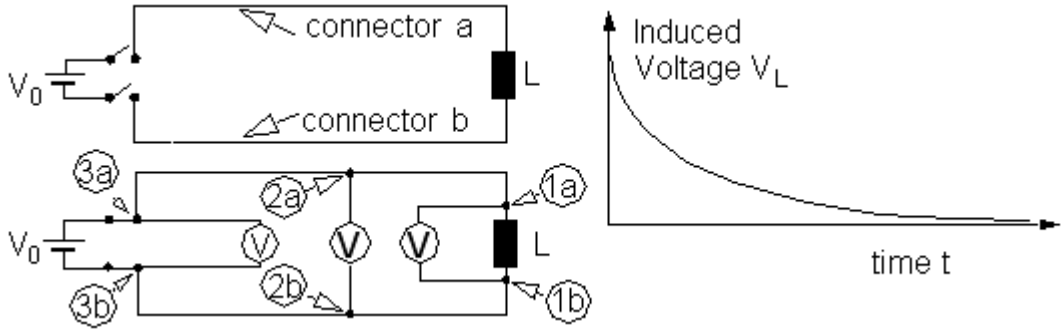
Question:
Where can this time-depending voltage be measured?

Which of the following statements corresponds with what you know about this process.

- 1) The time dependence of V, influenced by $R_{a/b}$ and C, can only be measured inside of the capacitor. The voltage between the wires a and b is determined by V_0 ..... ☐
- 2) The time dependence of V, influenced by $R_{a/b}$ and C, can only be measured just outside of the capacitor f.e. between 1a and 1b. ..... ☐
- 3) The time dependence of V, influenced by $R_{a/b}$ and C, can be measured between 1a and 1b and around the points 2a and 2b but not between 3a and 3b. ..... ☐
- 4) The time dependence of V, influenced by $R_{a/b}$ and C, can be measured all along the wires a and b ie between all the pairs of points 1ab, 2ab and 3ab. ..... ☐

Item 10:

When a coil (an inductance) with an inductivity L is connected to a voltage source, a voltage V_L, due to self-inductance, is induced. The voltage V_L is oriented opposite to the applied voltage V_0 and is proportional to the rate of change of the current I. Its time dependence is influenced by L. The internal resistance of the coil can be neglected.



Question:
Where can this time depending voltage V_L be measured?

Please chose one or more of the following statements which correspond with what you know about this process.

- 1) The voltage or potential difference which can be measured across any 2 points of the connecting wires a and b, is only influenced by V_0 and not by L. ..... ☐
- 2) The time dependence of V_L, influenced by L, can only be measured just outside of the coil ie. between 1a and 1b. ..... ☐
- 3) The time dependence of V_L, influenced by L, can be measured between 1a and 1b and around the points 2a and 2b but not between 3a and 3b. ..... ☐
- 4) The time dependence of V_L, influenced by L, can be measured all along the connectors a and b ie between all the pairs of measuring points 1ab, 2ab and 3ab. ..... ☐

Questionnaire related to Test about Voltage

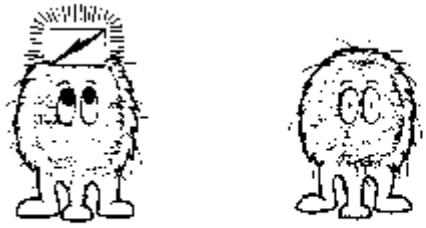
In the following you have the opportunity to rate the items, posed in the test about voltage, regarding the following two questions:

1. Do you consider these questions as important and do you think students, who have finished an electricity course, should know the correct answer?

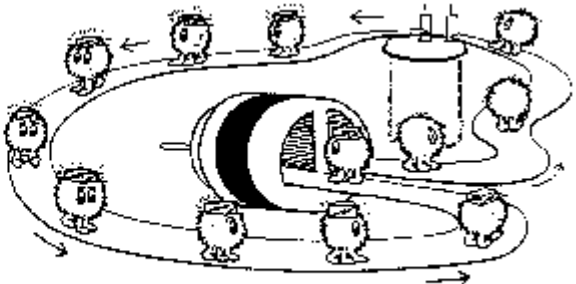
2. Are you interested to know the answer to these questions?

Please mark for each item one of the proposed answers.

To item 1:



Electron with and without energy



Electrons carrying energy from the battery to the motor

Question: Is this an acceptable model for the electric current?
Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.

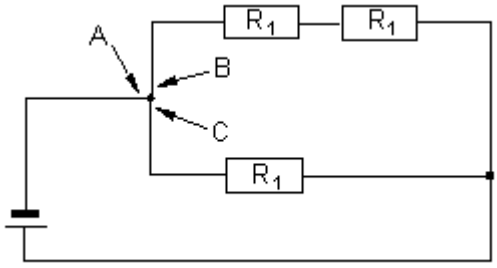
This statement is

correct	only partly correct	partly incorrect	incorrect
☐	☐	☐	☐

Statement 2: The answer to this question is interesting for me.
This statement is

correct	only partly correct	partly incorrect	incorrect
☐	☐	☐	☐

To item 2:



Question: Is there any difference in the physical state of the wires at A, B and C, adjoining the branching point from different sides?
Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.

This statement is

correct	only partly correct	partly incorrect	incorrect
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Statement 2: The answer to this question is interesting for me.
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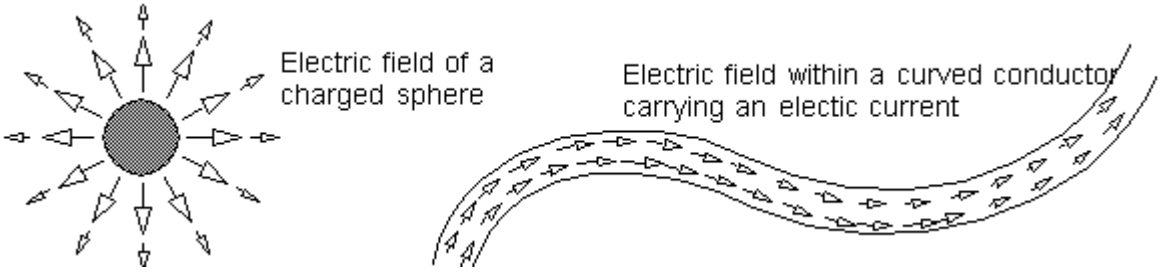
To item 3:



Question: Why is the electric field within the wire constant in magnitude and always oriented parallel to the axis of the wire?
Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.

This statement is

correct	only partly correct	partly incorrect	incorrect
☐	☐	☐	☐

Statement 2: The answer to this question is interesting for me.
This statement is

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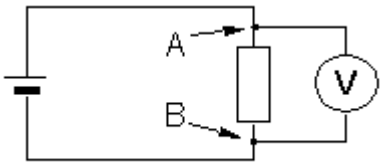
To item 4:



Question: Is there any difference in the physical state between the contact points A and B on the opposite sides of the resistor?
Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.

This statement is

correct	only partly correct	partly incorrect	incorrect
☐	☐	☐	☐

Statement 2: The answer to this question is interesting for me.
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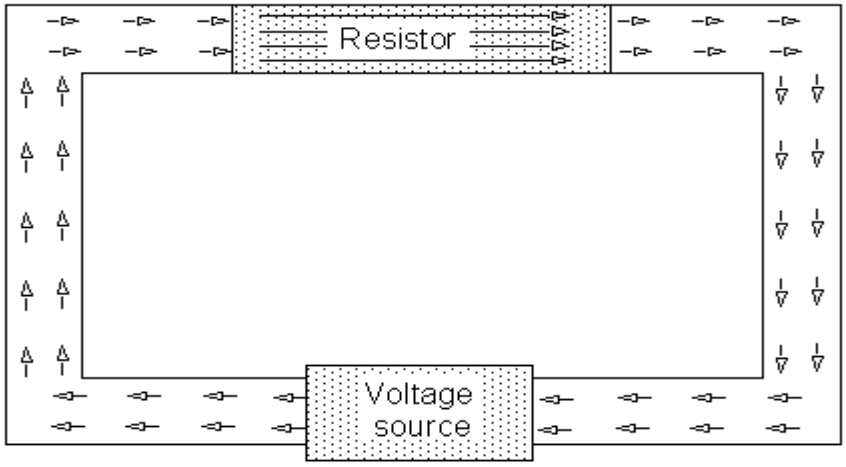
To item 5:



Question: Where does the strong field within the resistors come from?
Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.

This statement is

correct	only partly correct	partly incorrect	incorrect
☐	☐	☐	☐

Statement 2: The answer to this question is interesting for me.
This statement is

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☐	☐	☐	☐

To item 6:

For an electric circuit the focus is set on the transition process between stationary states.

Question: What kind of mechanism drives the transition between stationary states, where Ohm´s law is valid?
Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.

This statement is

correct	only partly correct	partly incorrect	incorrect
☐	☐	☐	☐

Statement 2: The answer to this question is interesting for me.
This statement is

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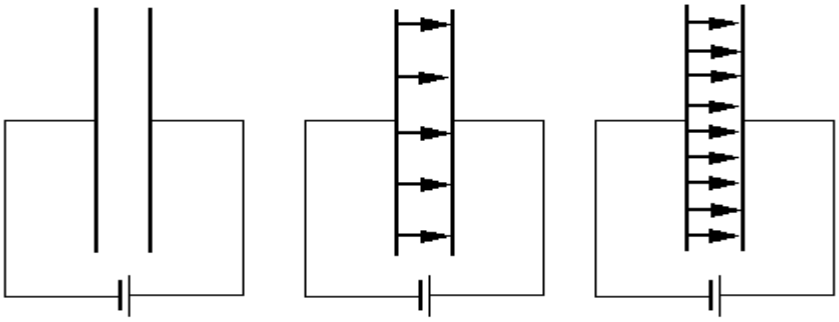
To item 7:



Increasing field strength within a capacitor when being charged

Question: How is the electrical field formed within a capacitor during the loading process?
Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.

This statement is

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☐	☐	☐	☐

Statement 2: The answer to this question is interesting for me.
This statement is

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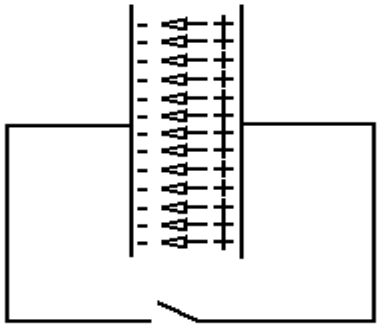
To item 8:



Question: If the charge carriers in a charged capacitor attract each other, why will the capacitor discharge, if it is shortened by some external wires?
Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.
This statement is

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Statement 2: The answer to this question is interesting for me.
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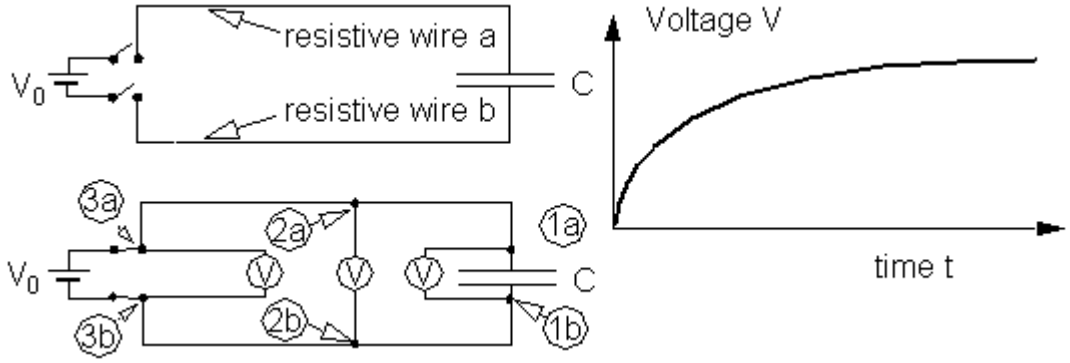

Question: Where can the time-depending voltage be measured?
Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.

This statement is

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Statement 2: The answer to this question is interesting for me.
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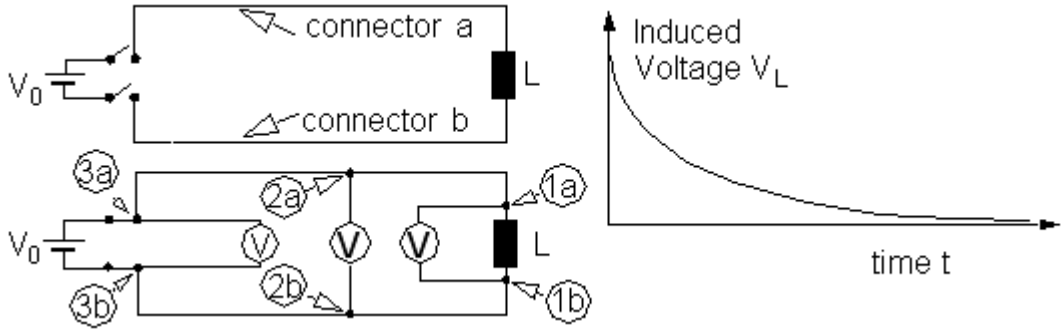
To item 10:



Question: Where can the time depending voltage V_L be measured?

Statement 1: I think this question is an important one. Students, who have finished an electricity course, should know the correct answer.
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