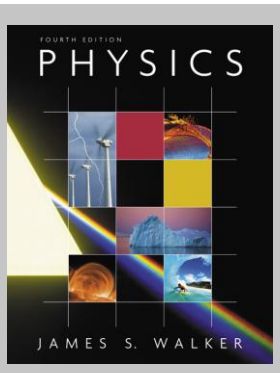


ConcepTest Clicker Questions

Chapter 21

Physics, 4th Edition

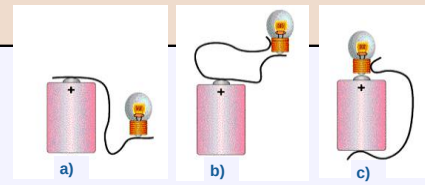
James S. Walker

Question 21.1 Connect the Battery

Which is the correct way to light the lightbulb with the battery?

d) all are correct

e) none are correct



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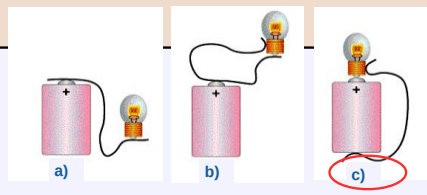

Current can flow only if there is a continuous connection from the negative terminal through the bulb to the positive terminal. This is the case for only Fig. (3).

Question 21.2 Ohm's Law

You double the *voltage* across a certain conductor and you observe the *current* increases three times. What can you conclude?

a) Ohm's law is obeyed since the current still increases when *V* increases

b) Ohm's law is not obeyed

c) this has nothing to do with Ohm's law

Question 21.2 Ohm's Law

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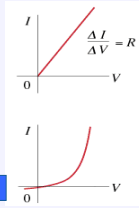
b) Ohm's law is not obeyed

c) this has nothing to do with Ohm's law

Ohm's law, $V = IR$ states that the relationship between voltage and current is linear. Thus, for a conductor that obeys Ohm's law, the current must double when you double the voltage.



Follow-up: Where could this situation occur?

Question 21.3a Wires I

Two wires, A and B, are made of the same metal and have equal length, but the resistance of wire A is four times the resistance of wire B. How do their diameters compare?

a) $d_A = 4d_B$

b) $d_A = 2d_B$

c) $d_A = d_B$

d) $d_A = 1/2d_B$

e) $d_A = 1/4d_B$

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d) $d_A = 1/2d_B$
e) $d_A = 1/4d_B$

The resistance of wire A is greater because its area is less than wire B. Since area is related to radius (or diameter) squared the diameter of A must be two times less than the diameter of B

$$R = \rho \frac{\ell}{A}$$

Question 21.3b Wires II

A wire of resistance *R* is stretched uniformly (keeping its volume constant) until it is twice its original length. What happens to the resistance?

a) it decreases by a factor of 4
b) it decreases by a factor of 2
c) it stays the same
d) it increases by a factor of 2
e) it increases by a factor of 4

Question 21.3b Wires II

A wire of resistance *R* is stretched uniformly (keeping its volume constant) until it is twice its original length. What happens to the resistance?

a) it decreases by a factor of 4
b) it decreases by a factor of 2
c) it stays the same
d) it increases by a factor of 2
e) it increases by a factor of 4

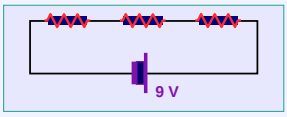
Keeping the volume (= area x length) constant means that if the length is doubled the area is halved.

Since $R = \rho \frac{\ell}{A}$ this increases the resistance by a factor of 4.

Question 21.4a Series Resistors I

Assume that the voltage of the battery is 9 V and that the three resistors are identical. What is the potential difference across each resistor?

a) 12 V
b) zero
c) 3 V
d) 4 V
e) you need to know the actual value of *R*

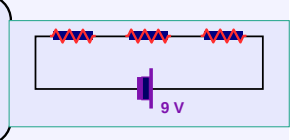


Question 21.4a Series Resistors I

Assume that the voltage of the battery is 9 V and that the three resistors are identical. What is the potential difference across each resistor?

a) 12 V
b) zero
c) 3 V
d) 4 V
e) you need to know the actual value of *R*

Since the resistors are all equal, the voltage will drop evenly across the 3 resistors, with 1/3 of 9 V across each one. So we get a 3 V drop across each.

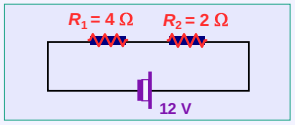


Follow-up: What would be the potential difference if $R = 1\ \Omega, 2\ \Omega, 3\ \Omega$?

Question 21.4b Series Resistors II

In the circuit below, what is the voltage across R_1?

a) 12 V
b) zero
c) 6 V
d) 8 V
e) 4 V

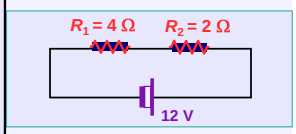


Question 21.4b Series Resistors II

In the circuit below, what is the voltage across R_1?

a) 12 V
b) zero
c) 6 V
d) 8 V
e) 4 V

The voltage drop across R_1 has to be twice as big as the drop across R_2. This means that $\Delta V_1 = 8$ V and $\Delta V_2 = 4$ V. Or else you could find the current $I = V/R = (12\text{ V})/(6\ \Omega) = 2$ A, and then use Ohm's law to get voltages.

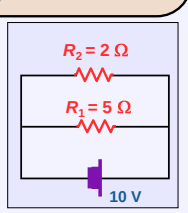


Follow-up: What happens if the voltage is doubled?

Question 21.5a Parallel Resistors I

In the circuit below, what is the current through R_1?

a) 10 A
b) zero
c) 5 A
d) 2 A
e) 7 A

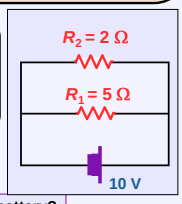


Question 21.5a Parallel Resistors I

In the circuit below, what is the current through R_1?

a) 10 A
b) zero
c) 5 A
d) 2 A
e) 7 A

The *voltage* is the *same* (10 V) across each resistor because they are in parallel. Thus, we can use Ohm's law, $\Delta V_1 = I_1 R_1$ to find the current $I_1 = 2$ A.

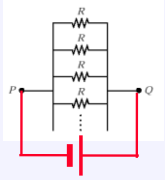


Follow-up: What is the total current through the battery?

Question 21.5b Parallel Resistors II

Points P and Q are connected to a battery of fixed voltage. As more resistors R are added to the parallel circuit, what happens to the total current in the circuit?

a) increases
b) remains the same
c) decreases
d) drops to zero



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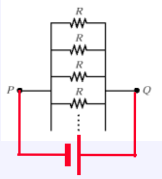
Points P and Q are connected to a battery of fixed voltage. As more resistors R are added to the parallel circuit, what happens to the total current in the circuit?

a) increases
b) remains the same
c) decreases
d) drops to zero

As we add parallel resistors, the overall resistance of the circuit drops. Since $\Delta V = IR$, and ΔV is held constant by the battery, when resistance decreases, the current must increase.

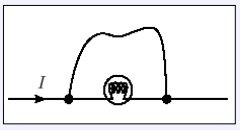


Follow-up: What happens to the current through each resistor?

Question 21.6a Short Circuit I

Current flows through a lightbulb. If a wire is now connected across the bulb, what happens?

a) all the current continues to flow through the bulb
b) half the current flows through the wire, the other half continues through the bulb
c) all the current flows through the wire
d) none of the above



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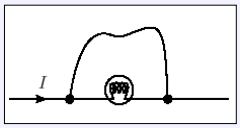
a) all the current continues to flow through the bulb
b) half the current flows through the wire, the other half continues through the bulb
c) all the current flows through the wire
d) none of the above

The current divides based on the ratio of the resistances. If one of the resistances is zero, then *ALL* of the current will flow through that path.

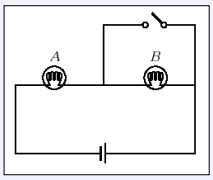


Follow-up: Doesn't the wire have SOME resistance?

Question 21.6b Short Circuit II

Two lightbulbs A and B are connected in series to a constant voltage source. When a wire is connected across B, bulb A will:

a) glow brighter than before
b) glow just the same as before
c) glow dimmer than before
d) go out completely
e) explode



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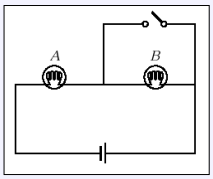
Two lightbulbs A and B are connected in series to a constant voltage source. When a wire is connected across B, bulb A will:

a) glow brighter than before
b) glow just the same as before
c) glow dimmer than before
d) go out completely
e) explode

Since bulb B is bypassed by the wire, the total resistance of the circuit decreases. This means that the current through bulb A increases.

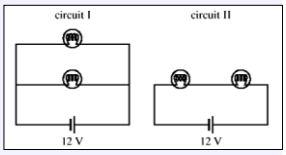


Follow-up: What happens to bulb B?

Question 21.7a Circuits I

The lightbulbs in the circuits below are identical with the same resistance *R*. Which circuit produces more light? (brightness $\Longleftrightarrow$ power)

a) circuit I
b) circuit II
c) both the same
d) it depends on *R*

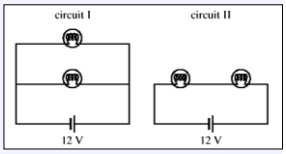


Question 21.7a Circuits I

The lightbulbs in the circuits below are identical with the same resistance *R*. Which circuit produces more light? (brightness $\Longleftrightarrow$ power)

a) circuit I
b) circuit II
c) both the same
d) it depends on *R*

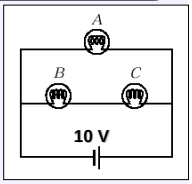
In circuit I, the bulbs are in parallel, lowering the total resistance of the circuit. Thus, circuit I will draw a higher current, which leads to more light, because $P = I\Delta V$.



Question 21.7b Circuits II

The three lightbulbs in the circuit all have the same resistance of 1 Ω. By how much is the brightness of bulb B greater or smaller than the brightness of bulb A? (brightness $\Longleftrightarrow$ power)

a) twice as much
b) the same
c) 1/2 as much
d) 1/4 as much
e) 4 times as much



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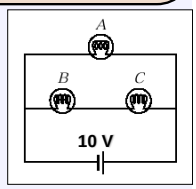
a) twice as much
b) the same
c) 1/2 as much
d) 1/4 as much
e) 4 times as much

We can use $P = V^2/R$ to compare the power:

$P_A = (\Delta V_A)^2/R_A = (10\ V)^2/1\ \Omega = 100\ W$

$P_B = (\Delta V_B)^2/R_B = (5\ V)^2/1\ \Omega = 25\ W$

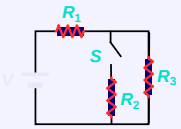


Follow-up: What is the total current in the circuit?

Question 21.8a More Circuits I

What happens to the voltage across the resistor R_1 when the switch is closed? The voltage will:

a) increase
b) decrease
c) stay the same

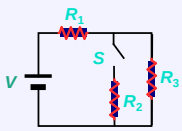


Question 21.8a More Circuits I

What happens to the voltage across the resistor R_1 when the switch is closed? The voltage will:

a) increase
b) decrease
c) stay the same

With the switch closed, the addition of R_2 to R_3 decreases the equivalent resistance so the current from the battery increases This will cause an increase in the voltage across R_1

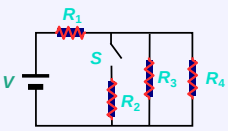


Follow-up: What happens to the current through R_3?

Question 21.8b More Circuits II

What happens to the voltage across the resistor R_4 when the switch is closed?

a) increases
b) decreases
c) stays the same

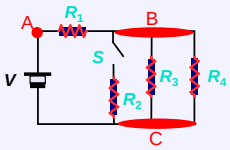


Question 21.8b More Circuits II

What happens to the voltage across the resistor R_4 when the switch is closed?

a) increases
b) decreases
c) stays the same

We just saw that closing the switch causes an increase in the voltage across R_1 (which is V_{AB}). The voltage of the battery is constant so if V_{AB} increases then V_{BC} must decrease

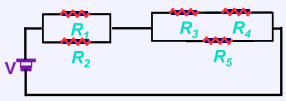


Follow-up: What happens to the current through R_4?

Question 21.9 Even More Circuits

Which resistor has the greatest current going through it? Assume that all the resistors are equal.

a) R_1
b) both R_1 and R_2 equally
c) R_3 and R_4
d) R_5
e) all the same

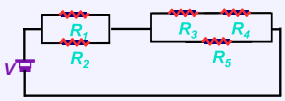


Question 21.9 Even More Circuits

Which resistor has the greatest current going through it? Assume that all the resistors are equal.

a) R_1
b) both R_1 and R_2 equally
c) R_3 and R_4
d) R_5
e) all the same

The same current must flow through left and right combinations of resistors. On the LEFT, the current splits equally, so $I_1 = I_2$. On the RIGHT, more current will go through R_5 than $R_3 + R_4$ since the branch containing R_5 has less resistance.



Follow-up: Which one has the smallest voltage drop?

Question 21.10 Dimmer

When you rotate the knob of a light dimmer, what is being changed in the electric circuit?

a) the power
b) the current
c) the voltage
d) both a) and b)
e) both b) and c)

Question 21.10 Dimmer

When you rotate the knob of a light dimmer, what is being changed in the electric circuit?

a) the power
b) the current
c) the voltage
d) both a) and b)
e) both b) and c)

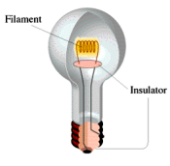
The voltage is provided at 120 V from the outside. The light dimmer increases the resistance and therefore decreases the current that flows through the lightbulb.

Follow-up: Why does the voltage not change?

Question 21.11a Lightbulbs

Two lightbulbs operate at 120 V, but one has a power rating of 25 W while the other has a power rating of 100 W. Which one has the greater resistance?

a) the 25 W bulb
b) the 100 W bulb
c) both have the same
d) this has nothing to do with resistance

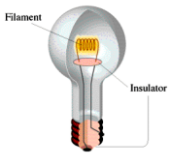


Question 21.11a Lightbulbs

Two lightbulbs operate at 120 V, but one has a power rating of 25 W while the other has a power rating of 100 W. Which one has the greater resistance?

a) the 25 W bulb
b) the 100 W bulb
c) both have the same
d) this has nothing to do with resistance

Since $P = V^2 / R$, the bulb with the lower power rating has to have the higher resistance.



Follow-up: Which one carries the greater current?

Question 21.11b Space Heaters

Two space heaters in your living room are operated at 120 V. Heater 1 has twice the resistance of heater 2. Which one will give off more heat?

a) heater 1
b) heater 2
c) both equally

Question 21.11b — Space Heaters

Two space heaters in your living room are operated at 120 V. Heater 1 has twice the resistance of heater 2. Which one will give off more heat?

a) heater 1
b) heater 2
c) both equally

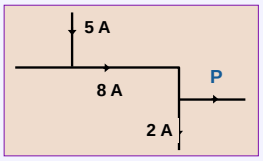
Using $P = V^2 / R$, the heater with the smaller resistance will have the larger power output. Thus, heater 2 will give off more heat.

Follow-up: Which one carries the greater current?

Question 21.12 — Junction Rule

What is the current in branch P?

a) 2 A
b) 3 A
c) 5 A
d) 6 A
e) 10 A

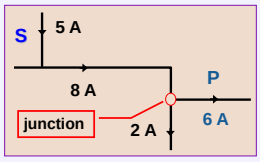


Question 21.12 — Junction Rule

What is the current in branch P?

a) 2 A
b) 3 A
c) 5 A
d) 6 A
e) 10 A

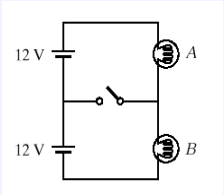
The current entering the junction in red is 8 A, so the current leaving must also be 8 A. One exiting branch has 2 A, so the other branch (at P) must have 6 A



Question 21.13 — Kirchhoff's Rules

The lightbulbs in the circuit are identical. When the switch is closed, what happens?

a) both bulbs go out
b) intensity of both bulbs increases
c) intensity of both bulbs decreases
d) A gets brighter and B gets dimmer
e) nothing changes

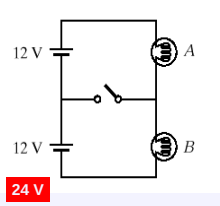


Question 21.13 — Kirchhoff's Rules

The lightbulbs in the circuit are identical. When the switch is closed, what happens?

a) both bulbs go out
b) intensity of both bulbs increases
c) intensity of both bulbs decreases
d) A gets brighter and B gets dimmer
e) nothing changes

When the switch is open, the point between the bulbs is at 12 V. But so is the point between the batteries. If there is no potential difference, then no current will flow once the switch is closed!! Thus, nothing changes.



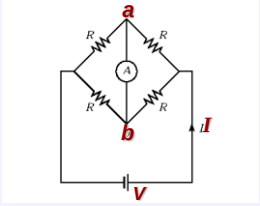
24 V

Follow-up: What happens if the bottom battery is replaced by a 24 V battery?

Question 21.14 — Wheatstone Bridge

An ammeter A is connected between points *a* and *b* in the circuit below, in which the four resistors are identical. The current through the ammeter is:

a) *I*
b) *I/2*
c) *I/3*
d) *I/4*
e) zero



Question 21.14 Wheatstone Bridge

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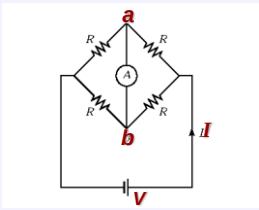
a) I
b) $I/2$
c) $I/3$
d) $I/4$
e) zero

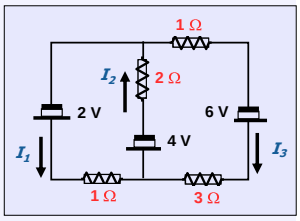
Since all resistors are identical the voltage drops are the same across the upper branch and the lower branch. Thus, the potentials at points *a* and *b* are also the same. Therefore, no current flows.



Question 21.15 More Kirchhoff's Rules

Which of the equations is valid for the circuit below?

a) $2 - I_1 - 2I_2 = 0$
b) $2 - 2I_1 - 2I_2 - 4I_3 = 0$
c) $2 - I_1 - 4 - 2I_2 = 0$
d) $I_3 - 4 - 2I_2 + 6 = 0$
e) $2 - I_1 - 3I_3 - 6 = 0$



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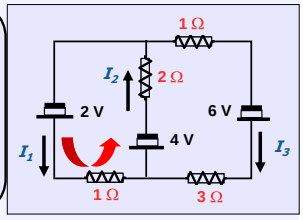
e) $2 - I_1 - 3I_3 - 6 = 0$

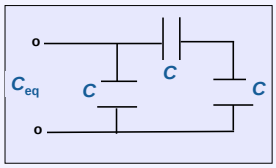
Eqn. 3 is valid for the left loop
The left battery gives +2V, then there is a drop through a 1Ω resistor with current I_1 flowing. Then we go through the middle battery (but from + to – !), which gives –4V. Finally, there is a drop through a 2Ω resistor with current I_2.



Question 21.16a Capacitors I

What is the equivalent capacitance, C_{eq}, of the combination below?

a) $C_{eq} = 3/2C$
b) $C_{eq} = 2/3C$
c) $C_{eq} = 3C$
d) $C_{eq} = 1/3C$
e) $C_{eq} = 1/2C$



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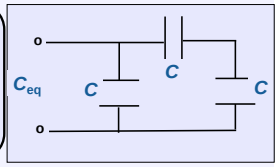
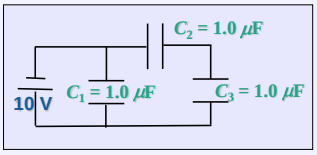
The 2 equal capacitors in series add up as inverses, giving 1/2C. These are parallel to the first one, which add up directly. Thus, the total equivalent capacitance is 3/2C.



Question 21.16b Capacitors II

How does the voltage V_1 across the first capacitor (C_1) compare to the voltage V_2 across the second capacitor (C_2)?

a) $V_1 = V_2$
b) $V_1 > V_2$
c) $V_1 < V_2$
d) all voltages are zero



Question 21.16b — Capacitors II

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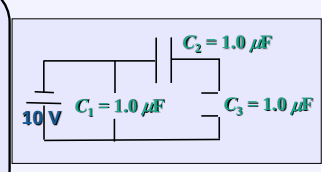
a) $V_1 = V_2$
b) $V_1 > V_2$
c) $V_1 < V_2$
d) all voltages are zero

The voltage across C_1 is 10 V. The combined capacitors $C_2 + C_3$ are parallel to C_1. The voltage across $C_2 + C_3$ is also 10 V. Since C_2 and C_3 are in series, their voltages add. Thus the voltage across C_2 and C_3 each has to be 5 V, which is less than V_1.

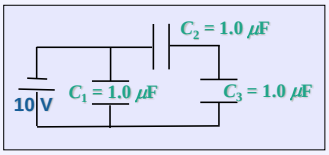


Follow-up: What is the current in this circuit?

Question 21.16c — Capacitors III

How does the charge Q_1 on the first capacitor (C_1) compare to the charge Q_2 on the second capacitor (C_2)?

a) $Q_1 = Q_2$
b) $Q_1 > Q_2$
c) $Q_1 < Q_2$
d) all charges are zero



Question 21.16c — Capacitors III

How does the charge Q_1 on the first capacitor (C_1) compare to the charge Q_2 on the second capacitor (C_2)?

a) $Q_1 = Q_2$
b) $Q_1 > Q_2$
c) $Q_1 < Q_2$
d) all charges are zero

We already know that the voltage across C_1 is 10 V and the voltage across both C_2 and C_3 is 5 V each. Since $Q = C\Delta V$ and C is the same for all the capacitors, we have $V_1 > V_2$ and therefore $Q_1 > Q_2$