

Electronics Principles and Concepts (ACDA4015)

Dr. Gary Jones

Leena Ali

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Basic Electrical Quantities in Circuits

1

The power source of a circuit provides the force to drive a current around the circuit. This is known as what?



☒ EMF

☐ Polarity

☐ Resistance

☐ Potential difference

Answer Guide

The force that drives current round a circuit is Electromotive Force, or EMF.

2

Which of the following is essential for a circuit to operate?



☐ A power supply of exactly 6 V

☒ A complete circuit between the positive and negative of a power supply

☐ The inclusion of a lamp in the circuit

☐ No resistance within the circuit

Answer Guide

A complete circuit is needed for current to flow.

3

EMF can be provided by what? Select all the correct answers.



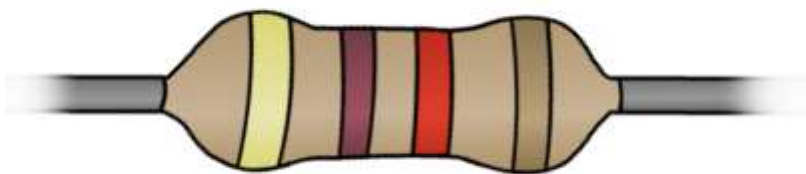
- ☒ A battery
- ☒ A lamp
- ☐ A resistor
- ☒ A cell
- ☐ A power supply
- ☐ Connecting wire

Answer Guide

EMF can be provided by batteries (group of cells), cells, or a power supply.

4

All components have some form of resistance. Resistance is measured in ohms. If a resistor measures 4.7 kΩ, how many ohms resistance would it have? Give your answer in ohms.



ohms (Enter your answer as a number and press return)

Answer Guide

The k prefix denotes 1,000. Therefore 4.7 kΩ is $4.7 \times 1,000 = 4,700 \Omega$

5

Most electronic circuits have small currents flowing through them, measured in milliamps (mA). If an ammeter measured current flow in a circuit as 0.24 A, how many milliamps would this be?



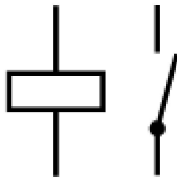
mA (Enter your answer as a number and press return)

Answer Guide

There are 1,000 milliamps in 1 amp.

Circuit Diagrams

1 What does this symbol represent?



☐ A lamp

☒ A relay

☐ A resistor

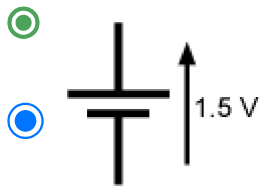
☐ A capacitor

Answer Guide

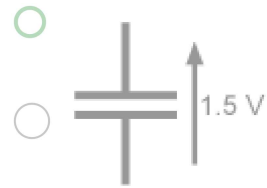
This is the symbol for a relay.

2

Which of these is the symbol for a 1.5 V cell?



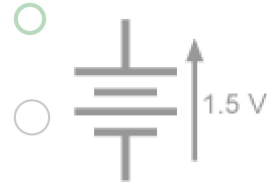
A



B



C



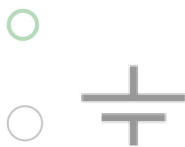
D

Answer Guide

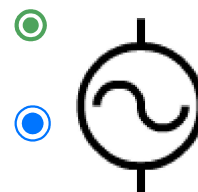
A is the correct symbol.

3

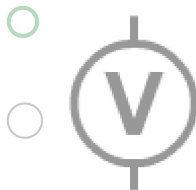
Which of these is the symbol for an AC voltage supply?



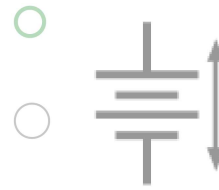
A



B



C



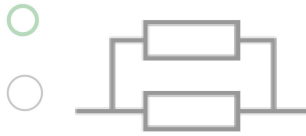
D

Answer Guide

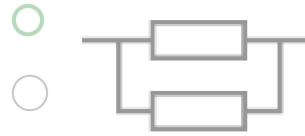
B is the correct symbol.

4

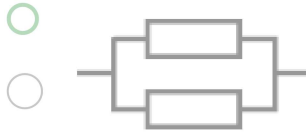
Which of these is NOT correctly drawn to meet the standards of an electrical circuit diagram?



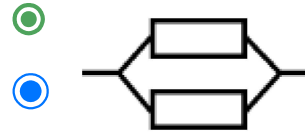
A



B



C



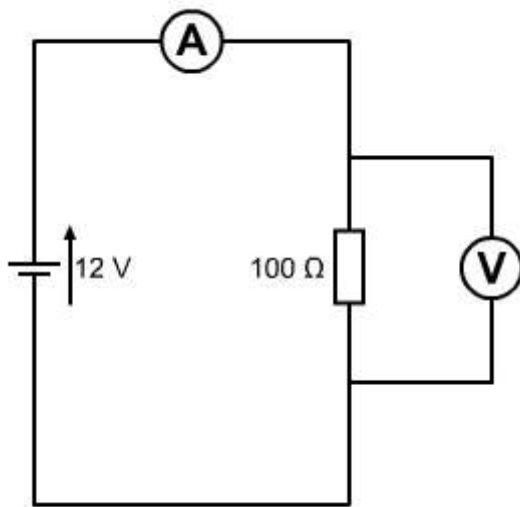
D

Answer Guide

Drawing D is not correct. Lines should be at right angles to each other.

5

What is wrong with the drawing of this circuit diagram?



- ☐ The symbol for the resistor is incorrectly drawn.
- ☒ There is no switch in the circuit.
- ☐ The components should be evenly spaced.
- ☐ There is no fault in this circuit.

Answer Guide

There is no fault with this circuit.

Calculation of Resistors in Parallel

1

As a quick check that a calculation for the total resistance of a pair of parallel resistor is correct, what can be said about the total resistance?



- ☐ It is always greater than the largest value resistor.
- ☐ It is always between the values of resistors in the pair.
- ☐ It is always equal to one of the individual resistor values.
- ☒ It is always smaller than the lowest value resistor.

Answer Guide

When working with resistors in parallel, the total resistance is always smaller than the lowest value resistor.

2

What is the equivalent resistance of a 2 kΩ resistor connected in parallel with a 4 kΩ resistor. Give your answer in kΩ to 1 d.p.



kΩ (Enter your answer as a number and press return)

Answer Guide

For two resistors connected in parallel, the total resistance is given by the equation:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{R_T} = \frac{1}{2 \times 10^3 \Omega} + \frac{1}{4 \times 10^3 \Omega}$$

$$\frac{1}{R_T} = \frac{2}{4 \times 10^3 \Omega} + \frac{1}{4 \times 10^3 \Omega}$$

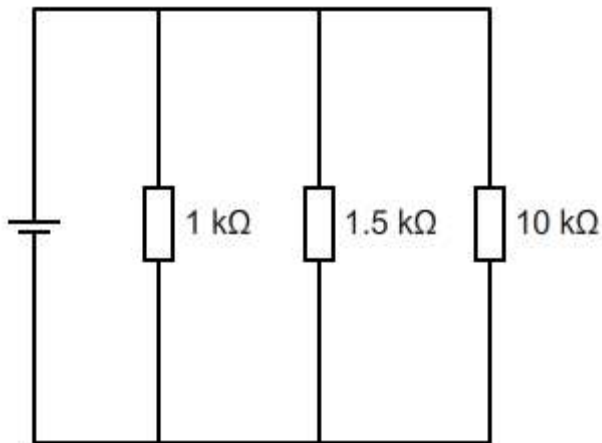
$$\frac{1}{R_T} = \frac{3}{4 \times 10^3 \Omega}$$

$$R_T = \frac{4 \times 10^3 \Omega}{3}$$

$$R_T = 1.3 \text{ k}\Omega$$

3

What is the approximate total resistance of the arrangement shown?


☒ 570 Ω

☐ 820 kΩ

☐ 870 Ω

☐ 950 Ω

Answer Guide

For three resistors connected in parallel, the total resistance is given by this equation:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$\frac{1}{R_T} = \frac{1}{1 \times 10^3 \Omega} + \frac{1}{1.5 \times 10^3 \Omega} + \frac{1}{10 \times 10^3 \Omega}$$

$$\frac{1}{R_T} = \frac{30}{30 \times 10^3 \Omega} + \frac{20}{30 \times 10^3 \Omega} + \frac{3}{30 \times 10^3 \Omega}$$

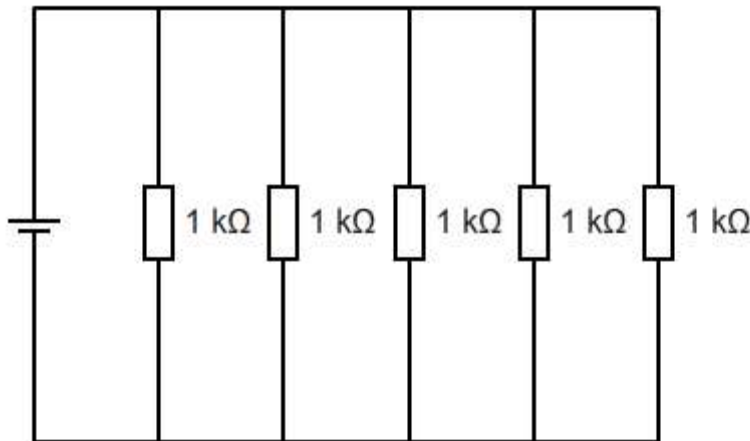
$$\frac{1}{R_T} = \frac{53}{30 \times 10^3 \Omega}$$

$$R_T = \frac{30 \times 10^3 \Omega}{53}$$

$$R_T = 570 \Omega$$

4

What is the total resistance of the arrangement shown? Enter your answer as a whole number in Ω .



Ω (Enter your answer as a number and press return)

Answer Guide

For five equal resistors connected in parallel, the total resistance is given by the equati

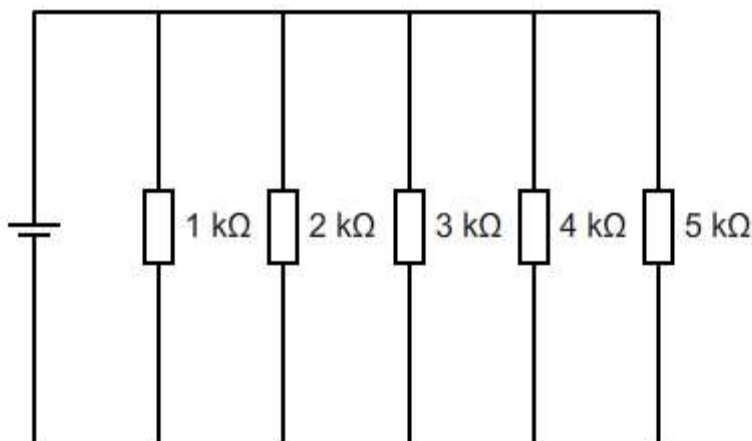
$$R_T = \frac{R_1}{\text{Number of resistors}}$$

$$R_T = \frac{1 \times 10^3 \Omega}{5}$$

$$R_T = 200 \Omega$$

5

What is the approximate total resistance of the arrangement shown? Enter your answer as a whole number to the nearest Ω .



437

Ω (Enter your answer as a number and press return)

Answer Guide

For five resistors connected in parallel it is easiest to combine in pairs, working out the total resistance of each pair using the product over sum method:

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

Take the first two resistors as a pair and calculate the total resistance:

$$R_a = \frac{R_1 \times R_2}{R_1 + R_2}$$

$$R_a = \frac{1\text{ k}\Omega \times 2\text{ k}\Omega}{1\text{ k}\Omega + 2\text{ k}\Omega}$$

$$R_a = 666\ \Omega$$

Take the next two resistors as a pair and calculate the total resistance:

$$R_b = \frac{R_3 \times R_4}{R_3 + R_4}$$

$$R_b = \frac{3\text{ k}\Omega \times 4\text{ k}\Omega}{3\text{ k}\Omega + 4\text{ k}\Omega}$$

$$R_b = 1.714\text{ k}\Omega$$

Combine R_a and R_b as a pair and calculate the total resistance:

$$R_c = \frac{R_a \times R_b}{R_a + R_b}$$

$$R_c = \frac{666 \Omega \times 1.714 \text{ k}\Omega}{666 \Omega + 1.714 \text{ k}\Omega}$$

$$R_c = 479 \Omega$$

Combine R_c and R_5 as a pair and calculate the total resistance of the circuit:

$$R_T = \frac{R_c \times R_5}{R_c + R_5}$$

$$R_T = \frac{479 \Omega \times 5 \text{ k}\Omega}{479 \Omega + 5 \text{ k}\Omega}$$

$$R_T = 437 \Omega$$

Calculation of Resistors in Series

1

What is the total resistance of five 2 kΩ resistors connected in series?



Give your answer in kΩ to 1 d.p.

kΩ (Enter your answer as a number and press return)

Answer Guide

Five 2 kΩ resistors connected in series have a total resistance of 10 kΩ:

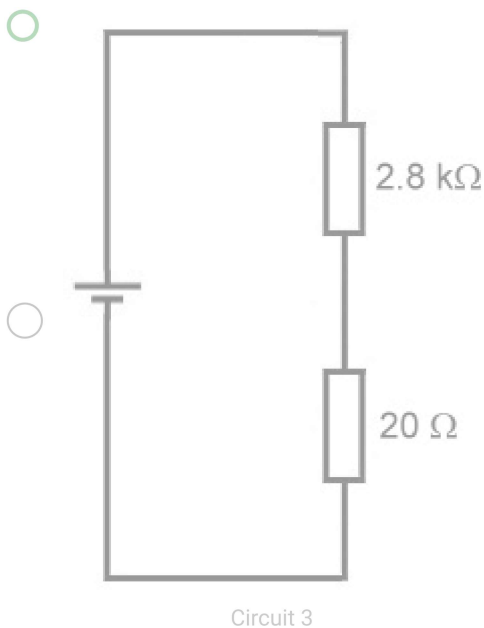
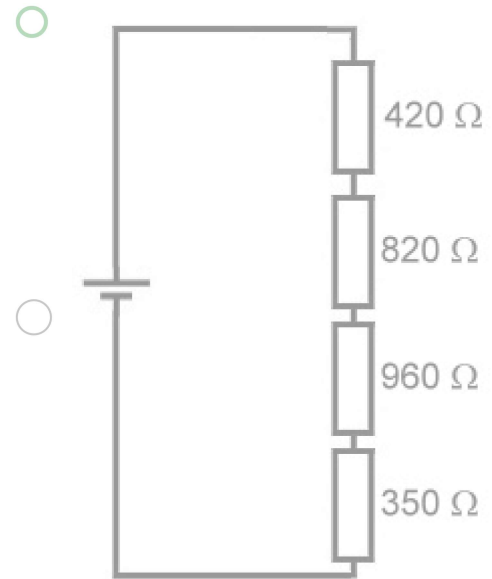
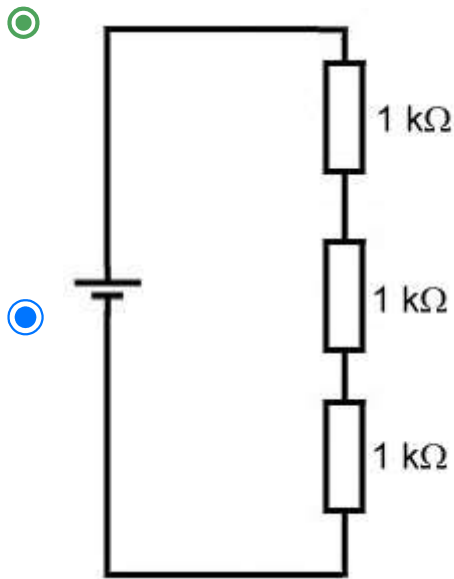
$$R_T = R_1 + R_2 + R_3 + R_4 + R_5$$

$$R_T = 2 \text{ k}\Omega + 2 \text{ k}\Omega + 2 \text{ k}\Omega + 2 \text{ k}\Omega + 2 \text{ k}\Omega$$

$$R_T = 10.0 \text{ k}\Omega$$

2

Which of the following circuits has the largest total resistance?



☐ All circuits have the same total resistance.

Answer Guide

Circuit 1 has the largest total resistance at 3.0 kΩ.

The total resistance for each circuit is calculated as follows:

Circuit 1

$$R_T = R_1 + R_2 + R_3$$

$$R_T = 1 \text{ k}\Omega + 1 \text{ k}\Omega + 1 \text{ k}\Omega$$

$$R_T = 3.0 \text{ k}\Omega$$

Circuit 2

$$R_T = R_1 + R_2 + R_3 + R_4$$

$$R_T = 420 \, \Omega + 820 \, \Omega + 960 \, \Omega + 350 \, \Omega$$

$$R_T = 2,550 \, \Omega$$

$$R_T = 2.55 \, \text{k}\Omega$$

Circuit 3

$$R_T = R_1 + R_2$$

$$R_T = 2,800 \, \Omega + 20 \, \Omega$$

$$R_T = 2,820 \, \Omega$$

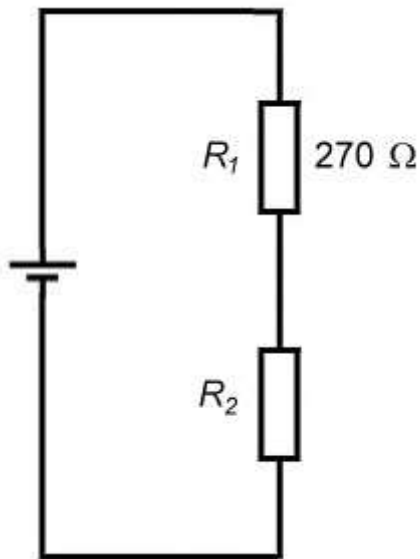
$$R_T = 2.82 \, \text{k}\Omega$$

3

If the total resistance in the following circuit is $630 \, \Omega$, what is the value of resistor R_2 ?



Give your answer in Ω .



Ω (Enter your answer as a number and press return)

Answer Guide

$$R_T = R_1 + R_2$$

$$R_2 = R_T - R_1$$

$$R_2 = 630 \, \Omega - 270 \, \Omega$$

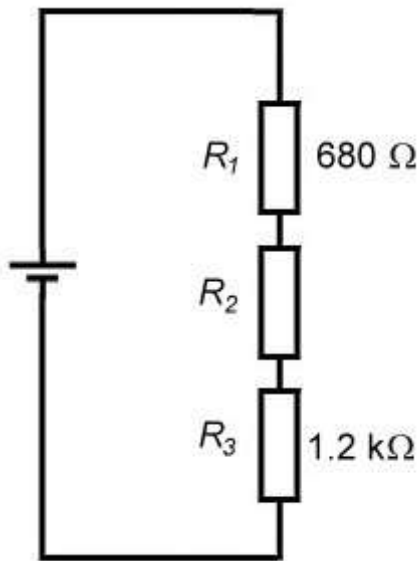
$$R_2 = 360 \, \Omega$$

4

If the total resistance in the following circuit is 5.18 k Ω , what is the value of resistor R_2 ?



Give your answer in k Ω to 1 d.p.



k Ω (Enter your answer as a number and press return)

Answer Guide

$$R_T = R_1 + R_2 + R_3$$

$$R_2 = R_T - R_1 - R_3$$

$$R_2 = 5,180 \, \Omega - 680 \, \Omega - 1,200 \, \Omega$$

$$R_2 = 3,300 \, \Omega$$

$$R_2 = 3.3 \, \text{k}\Omega$$

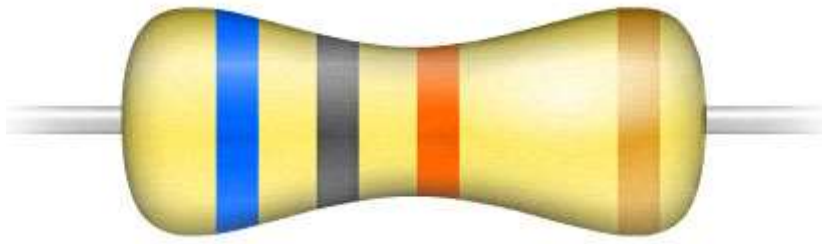
Colour Code and Tolerance

Use this resistor colour code table if you need help answering the questions.

0	Black	
1	Brown	
2	Red	10 %
3	Orange	5 %
4	Yellow	
5	Green	1 %
6	Blue	2 %
7	Violet	
8	Grey	
9	White	

1

What is the value of this resistor?



- ☐ 58 k Ω 2 % tolerance
- ☒ 68 k Ω 5 % tolerance
- ☐ 290 k Ω 1 % tolerance
- ☐ 6.8 M Ω 5 % tolerance

Answer Guide

$68 \times 10^3 \Omega = 68 \text{ k}\Omega$ 5 % tolerance

2

What is the five band colour code of a 240 Ω 2 % resistor

- ☐ Yellow, red, brown, grey, gold
- ☐ Red, red, orange, red, red
- ☐ Blue, white, green, black, brown
- ☒ Red, yellow, black, black, red

Answer Guide

Red, yellow, black, black, red

3

What would be the first three bands of the colour code for a four band 820 Ω resistor?



- ☒ Grey, red, brown
- ☐ White, black, red
- ☐ Yellow, orange, blue
- ☐ Brown, black, red

Answer Guide

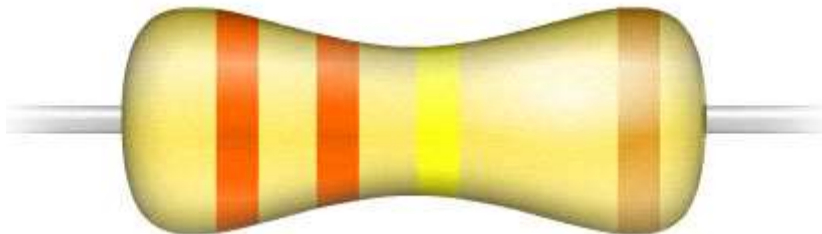
Grey, red, brown

4

What is the nominal value of this resistor?



Give your answer in k Ω .



k Ω (Enter your answer as a number and press return)

Answer Guide

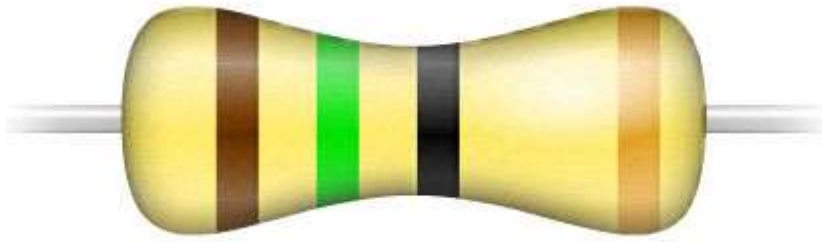
$33 \times 10^4 \Omega = 330 \text{ k}\Omega$

5

What is the nominal value of this resistor?



Give your answer in Ω .



Ω (Enter your answer as a number and press return)

Answer Guide

$$15 \times 10^0 \Omega = 15 \Omega$$

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Capacitors

1 Which of the following types of capacitor is a polarised capacitor?



- ☐ Mica
- ☐ Ceramic
- ☒ Electrolytic
- ☐ Polyester

Answer Guide

The two types of polarised capacitor are electrolytic and tantalum. They must be connected the right way round in circuits.

2 How many microfarads are there in one farad?



- ☐ 100
- ☐ 1,000
- ☐ 10,000
- ☐ 100,000
- ☒ 1,000,000

Answer Guide

There are one million microfarads in a farad.

$$1,000,000 \mu\text{F} = 1 \text{ F}$$

$$1 \mu\text{F} = 1 \times 10^{-6} \text{ F}$$

3 Why is there a dielectric between the plates of a capacitor?



- ☐ To prevent the charge escaping
- ☒ To prevent the plates touching and increase the capacitance
- ☐ To allow the charge to pass between the plates
- ☐ To allow the working voltage to discharge

Answer Guide

The dielectric between the plates of a capacitor prevents the plates from touching and increases the capacitance. Charge does not cross the gap between the plates as dielectrics are insulators.

4

What will happen to the value of a capacitor if the voltage doubles?



- ☒ It will stay the same
- ☐ It will be reduced by half
- ☐ It will double
- ☐ It will increase four times

Answer Guide

The value of a capacitor and its voltage are related by this formula.

$$C = \frac{Q}{V}$$

If the voltage increases, more charge will be moved around the circuit, but the value of capacitor is controlled by its physical construction and it is not affected by the voltage (unless the voltage exceeds the working voltage).

5

Which factor does NOT affect the capacitance of a capacitor?



- ☐ The area of the plates
- ☐ The distance between the plates
- ☐ The type of material between the plates
- ☒ The type of metal used for the plates

Answer Guide

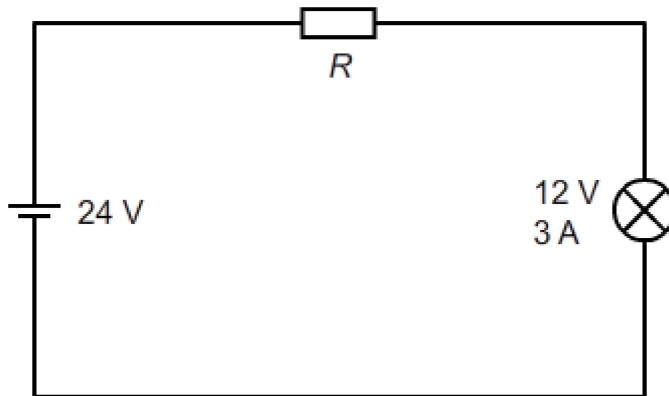
The first three factors all affect the capacitance of a capacitor. The type of metal does affect the capacitance.

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Applications of Ohm's Law

1

A 12 V, 3 A lamp is to be used on a 24 V supply, as shown in the diagram. What value resistor must be used in series with this lamp?

☐ 2 Ω ☒ 4 Ω ☐ 6 Ω ☐ 8 Ω

Answer Guide

Voltage across the lamp is:

$$24 \text{ V} - 12 \text{ V} = 12 \text{ V}$$

The current through the lamp must be the same as required by the lamp which is 3 A.

$$R = \frac{V}{I}$$

$$R = \frac{12 \text{ V}}{3 \text{ A}}$$

$$R = 4 \Omega$$

2

A blue LED requires a forward voltage of 3.4 V at a typical current of 20 mA. What series resistor would be used when this LED is operated on a 5 V DC supply.



☐ 20 Ω

☐ 40 Ω

☐ 60 Ω

☒ 80 Ω

Answer Guide

Voltage across the resistor is:

$$5 \text{ V} - 3.4 \text{ V} = 1.6 \text{ V}$$

The current through the resistor is the same as the LED, which is 20 mA.

$$R = \frac{V}{I}$$

$$R = \frac{1.6 \text{ V}}{20 \text{ mA}}$$

$$R = \frac{1.6 \text{ V}}{20 \times 10^{-3} \text{ A}}$$

$$R = 80 \Omega$$

3

A filament lamp of maximum voltage 4.5 V and typical current 60 mA is to be operated from a 6 V supply. What value series resistor will it need? Give your answer in Ω .



Ω (Enter your answer as a number and press return)

Answer Guide

Voltage across the resistor is:

$$6\text{ V} - 4.5\text{ V} = 1.5\text{ V}$$

The current through the resistor is the same as the lamp, which is 60 mA.

$$R = \frac{V}{I}$$

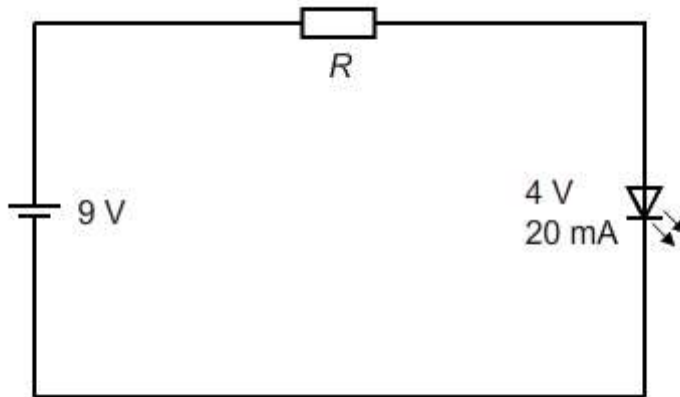
$$R = \frac{1.5\text{ V}}{60\text{ mA}}$$

$$R = \frac{1.5\text{ V}}{60 \times 10^{-3}\text{ A}}$$

$$R = 25\ \Omega$$

4

What series resistor is needed to operate this white LED from a 9 V supply?
Give your answer in Ω .



Ω (Enter your answer as a number and press return)

Answer Guide

Voltage across the resistor is:

$$9\text{ V} - 4\text{ V} = 5\text{ V}$$

The current through the resistor is the same as the LED, which is 20 mA.

$$R = \frac{V}{I}$$

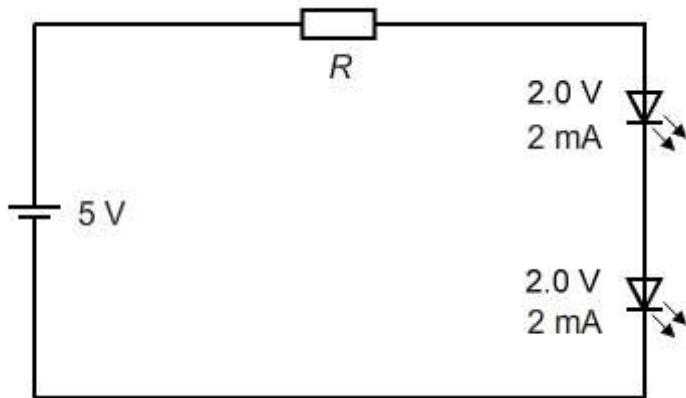
$$R = \frac{5\text{ V}}{20\text{ mA}}$$

$$R = \frac{5\text{ V}}{20 \times 10^{-3}\text{ A}}$$

$$R = 250\ \Omega$$

5

In this circuit, two low current LEDs are connected in series with a single resistor and a 5 V supply. Each LED can take a maximum current of 2 mA when the maximum voltage of 2.0 V is applied across each. What is the value of the series resistor? Give your answer in Ω .



500

 Ω (Enter your answer as a number and press return)

Answer Guide

Voltage across each LED is 2.0 V so the voltage across the resistor is:

$$5\text{ V} - (2.0\text{ V} + 2.0\text{ V}) = 1\text{ V}$$

Maximum current through the resistor is 2 mA.

$$R = \frac{V}{I}$$

$$R = \frac{1\text{ V}}{2\text{ mA}}$$

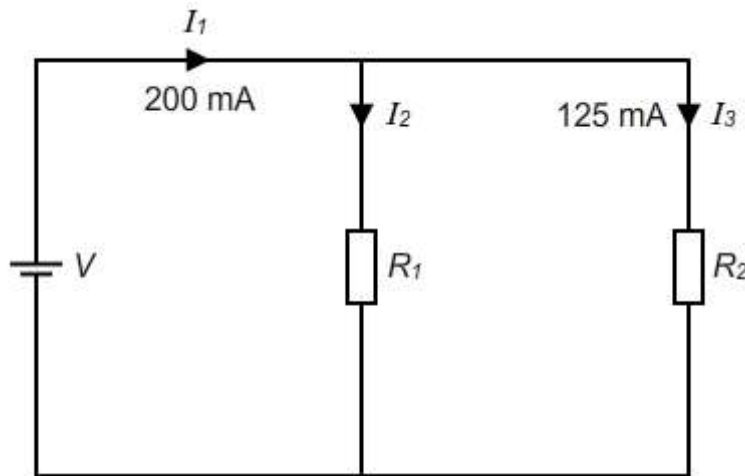
$$R = \frac{1\text{ V}}{2 \times 10^{-3}\text{ A}}$$

$$R = 500\ \Omega$$

Kirchhoff's First Law

1

Use Kirchhoff's First Law to determine the current through R_1 . Give your answer in mA.



mA (Enter your answer as a number and press return)

Answer Guide

Kirchhoff's First Law states:

'The sum of currents entering a node is equal to the sum of currents leaving that node

$$I_1 = I_2 + I_3$$

$$200 \text{ mA} = I_2 + 125 \text{ mA}$$

$$I_2 = 200 \text{ mA} - 125 \text{ mA}$$

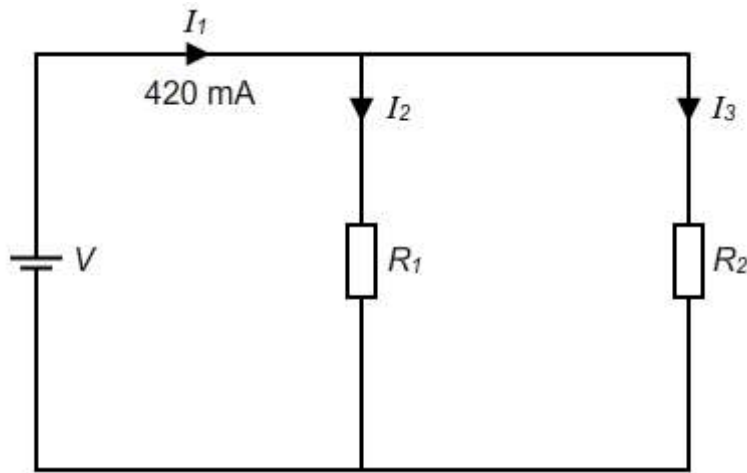
$$I_2 = 75 \text{ mA}$$

2

In the following circuit $R_1 = R_2$. Use Kirchhoff's First Law to determine the current I_2 .



Give your answer in mA.



mA (Enter your answer as a number and press return)

Answer Guide

Kirchhoff's First Law states:

'The sum of currents entering a node is equal to the sum of currents leaving that node

$$I_1 = I_2 + I_3$$

Since the resistors are the same value:

$$I_2 = I_3$$

Therefore:

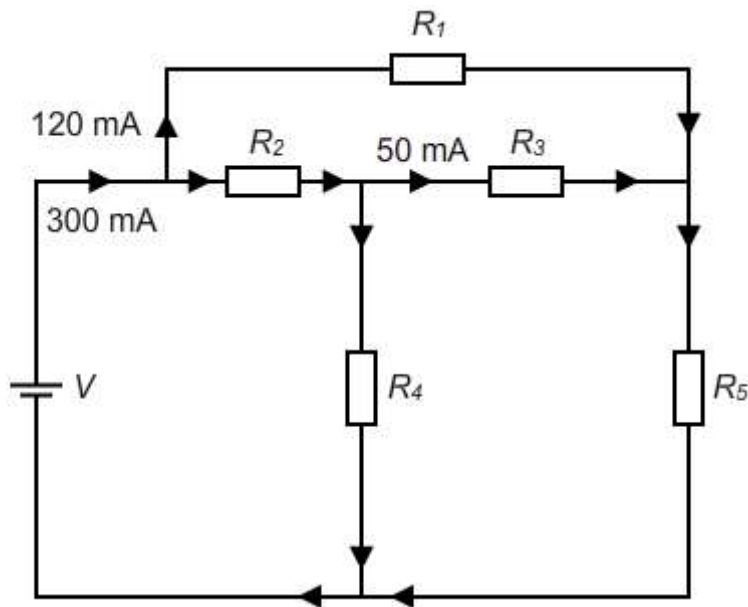
$$I_1 = I_2 + I_2$$

$$I_1 = 2 I_2$$

$$420 \text{ mA} = 2 I_2$$

$$I_2 = 210 \text{ mA}$$

Use the following circuit to answer the next 3 questions.

**3**

What is the current through R_2 ?



Give your answer in mA.

mA (Enter your answer as a number and press return)

Answer Guide

The current entering a node is the same as the current leaving a node.

$$300 \text{ mA} = 120 \text{ mA} + I_{R2}$$

$$I_{R2} = 300 \text{ mA} - 120 \text{ mA}$$

$$I_{R2} = 180 \text{ mA}$$

4

What is the current through R_4 ?

Give your answer in mA.

mA (Enter your answer as a number and press return)

Answer Guide

The current entering a node is the same as the current leaving a node. Having calculated current of 180 mA through R_2 , the current through R_4 can be calculated:

$$180 \text{ mA} = 50 \text{ mA} + I_{R4}$$

$$I_{R4} = 180 \text{ mA} - 50 \text{ mA}$$

$$I_{R4} = 130 \text{ mA}$$

5

What is the current through R_5 ?

Give your answer in mA.

mA (Enter your answer as a number and press return)

Answer Guide

The current entering a node is the same as the current leaving a node.

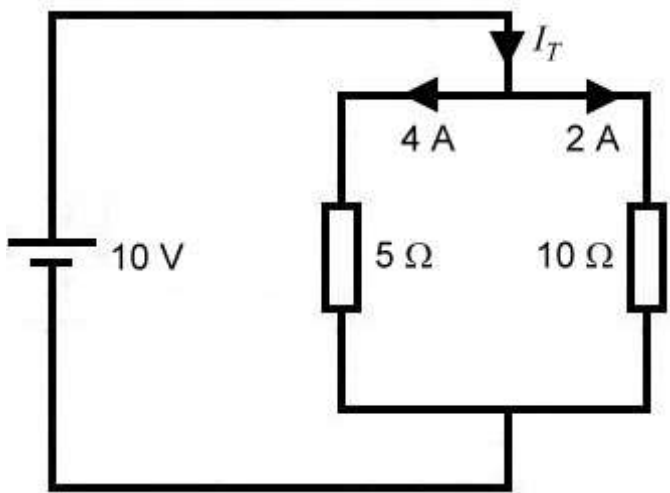
Current through R_5 comes from the node with 50 mA entering from one branch and 120 mA entering from another.

The total entering the node is 170 mA, so there must be 170 mA leaving the node and passing through R_5 .

Calculations using Kirchhoff's First Law

1

What is the current I_T ? Give your answer in A.



A (Enter your answer as a number and press return)

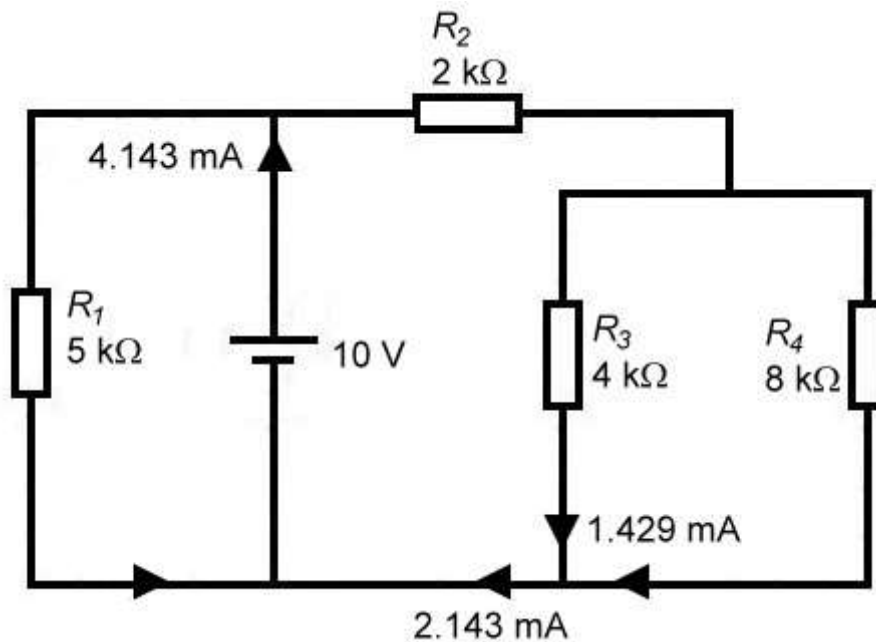
Answer Guide

The sum of currents entering a node is equal to the sum of currents leaving that node.

$$I_T = 4\text{ A} + 2\text{ A}$$

$$I_T = 6\text{ A}$$

Use the following circuit to answer the next two questions.



2

What is the current through R_1 ? Give your answer in mA.



mA (Enter your answer as a number and press return)

Answer Guide

The sum of currents entering a node is equal to the sum of currents leaving that node. Using the node below the battery:

$$2.143 \text{ mA} + I_{R1} = 4.143 \text{ mA}$$

$$I_{R1} = 4.143 \text{ mA} - 2.143 \text{ mA}$$

$$I_{R1} = 2 \text{ mA}$$

3

What is the current through R_4 ? Give your answer in mA to 3 d.p.



mA (Enter your answer as a number and press return)

Answer Guide

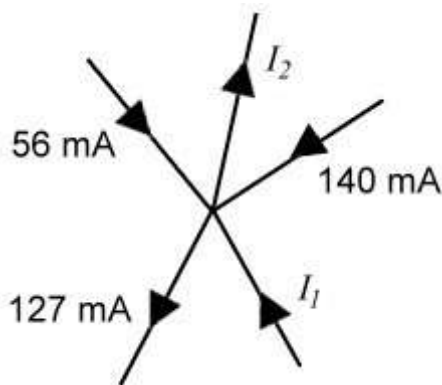
The sum of currents entering a node is equal to the sum of currents leaving that node.
Using the node below R_3 :

$$1.429 \text{ mA} + I_{R4} = 2.143 \text{ mA}$$

$$I_{R4} = 2.143 \text{ mA} - 1.429 \text{ mA}$$

$$I_{R4} = 0.714 \text{ mA}$$

Use the following diagram for the next two questions. The total current entering the node is 325 mA.



4What is current I_1 ? Give your answer in mA.

mA (Enter your answer as a number and press return)

Answer Guide

The sum of currents at a node is equal to zero:

$$\Sigma(I) = 0$$

Currents entering a node are positive and currents leaving a node are negative. Given the sum of currents entering the node is 325 mA, I_1 can be calculated:

$$325 \text{ mA} = 56 \text{ mA} + 140 \text{ mA} + I_1$$

$$I_1 = 325 \text{ mA} - 56 \text{ mA} - 140 \text{ mA}$$

$$I_1 = 129 \text{ mA}$$

5What is current I_2 ? Give your answer in mA.

mA (Enter your answer as a number and press return)

Answer Guide

The sum of currents leaving a node is equal to the sum of currents entering that node. Therefore, the sum of currents leaving the node must equal 325 mA.

$$325 \text{ mA} = 127 \text{ mA} + I_2$$

$$I_2 = 325 \text{ mA} - 127 \text{ mA}$$

$$I_2 = 198 \text{ mA}$$

Kirchhoff's Second Law

1

What does Kirchhoff's Second Law state?



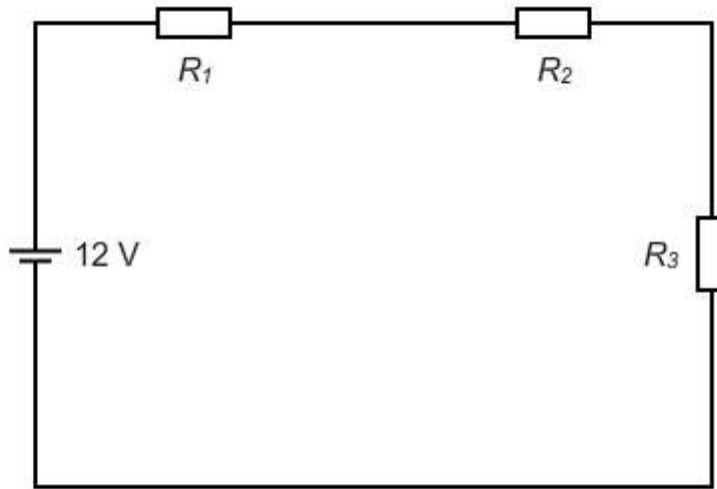
- ☐ The sum of all the voltages in a circuit is equal to the voltage of the power supply.
- ☐ The sum of all the currents is zero.
- ☐ The sum of all the closed loop voltages is approximately equal to the voltage of the power supply.
- ☒ The sum of the voltages in each closed loop is equal to zero.

Answer Guide

Kirchhoff's Second Law states, "The sum of the voltages in each closed loop is equal to zero." This can also be expressed as the voltage of the power supply is equal to the sum of the other voltages in each closed loop.

2

What will be the voltage across R_3 if all resistors are $100\ \Omega$?



☐ 12 V

☐ 8 V

☒ 4 V

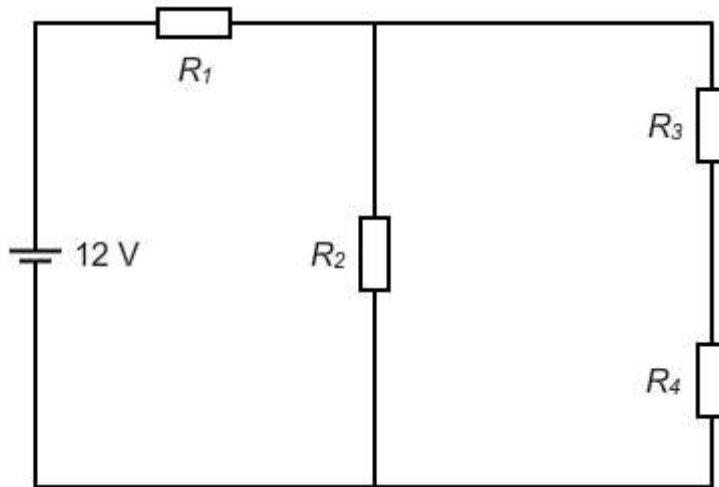
☐ 3 V

Answer Guide

The sum of the individual voltages will equal 12 V. There are 3 identical resistors, so the voltage is shared equally making 12 V divided by 3, which is 4 V.

3

In this circuit, the voltage across R_1 is equal to 6 V. What is the voltage across R_2 ?

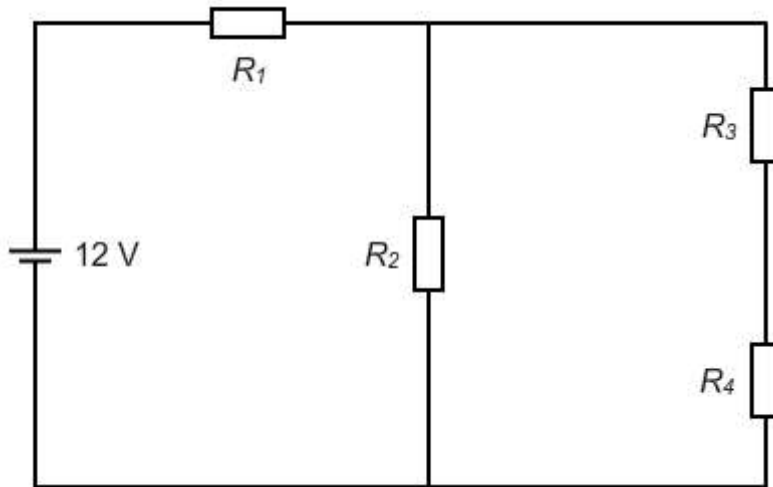
☐ 12 V☐ 8 V☒ 6 V☐ 4 V

Answer Guide

There is a closed loop consisting of the battery, R_1 and R_2 . The sum of voltages in that loop gives us the answer 6 V.

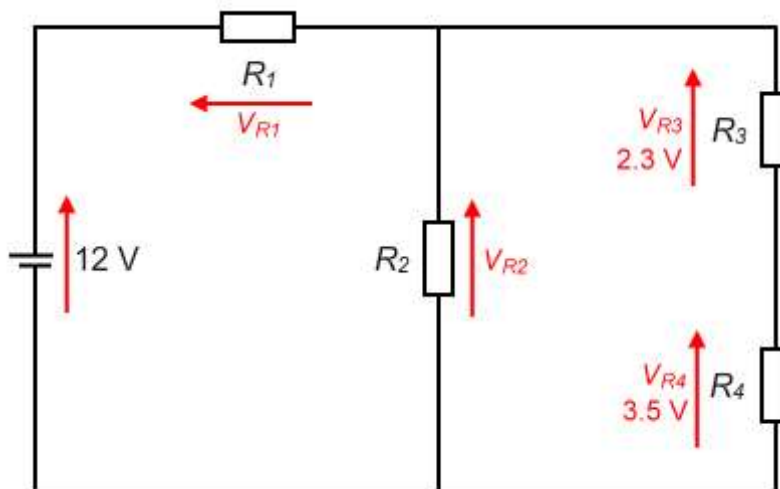
4

In this circuit, the voltage across R_3 is 2.3 V and the voltage across R_4 is 3.5 V. Calculate the voltage across R_2 . Give your answer in V to 1 d.p.



V (Enter your answer as a number and press return)

Answer Guide



First find the voltage across R_1 using the closed loop containing the battery, R_1 , R_3 and

$$\Sigma V = 0$$

$$12\text{ V} + (-V_{R1}) + (-V_{R3}) + (-V_{R4}) = 0$$

$$12\text{ V} - V_{R1} - 2.3\text{ V} - 3.5\text{ V} = 0$$

$$V_{R1} = 6.2\text{ V}$$

Now use the loop which comprises the battery, R_1 and R_2 to find V_{R2} .

$$\Sigma V = 0$$

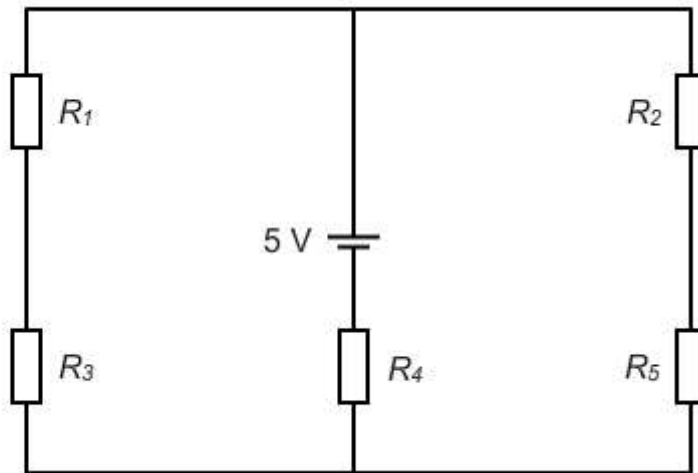
$$12 \text{ V} + (-V_{R1}) + (-V_{R2}) = 0$$

$$12 \text{ V} - 6.2 \text{ V} - V_{R2} = 0$$

$$V_{R2} = 5.8 \text{ V}$$

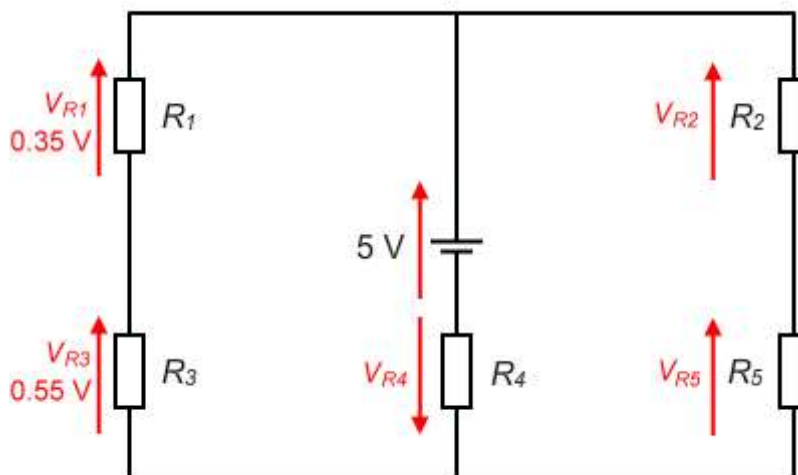
5

In this circuit, the resistors R_2 and R_5 are of equal value. The voltage across R_1 is 0.35 V and across R_3 is 0.55 V. Find the voltage across R_5 .



V (Enter your answer as a number and press return)

Answer Guide



The left-hand loop comprises the battery, R_4 , R_1 and R_3 :

$$\Sigma V = 0$$

$$5\text{ V} + (-V_{R1}) + (-V_{R3}) + (-V_{R4}) = 0$$

$$5\text{ V} - 0.35\text{ V} - 0.55\text{ V} - V_{R4} = 0$$

$$V_{R4} = 4.1\text{ V}$$

The right-hand loop comprises the battery, R_2 , R_5 and R_4 :

$$\Sigma V = 0$$

$$5\text{ V} + (-V_{R2}) + (-V_{R5}) + (-V_{R4}) = 0$$

$$V_{R5} + V_{R2} = 5\text{ V} - 4.1\text{ V}$$

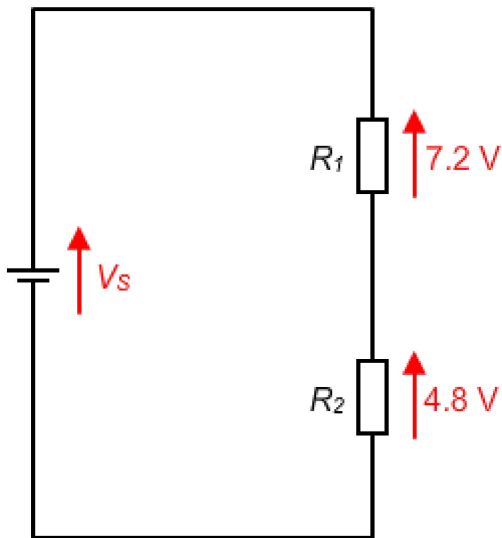
$$V_{R5} + V_{R2} = 0.9\text{ V}$$

Since R_2 and R_5 are of equal value and in the same closed loop, the voltage across the must also be equal.

This makes the voltage across R_5 equal to 0.45 V.

Calculations using Kirchhoff's Second Law

1 What is the supply voltage V_S in this circuit?



V (Enter your answer as a number and press return)

Answer Guide

$$\sum V = 0$$

$$0 = V_S + (-V_{R1}) + (-V_{R2})$$

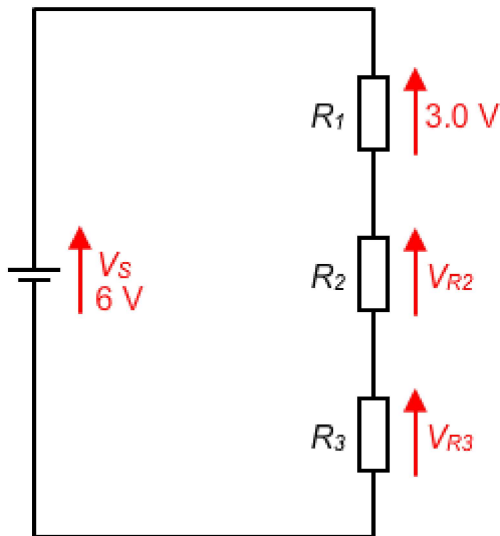
$$V_S = V_{R1} + V_{R2}$$

$$V_S = 7.2 \text{ V} + 4.8 \text{ V}$$

$$V_S = 12 \text{ V}$$

2

If $R_2 = R_3$ in this circuit, what is V_{R2} ?



V (Enter your answer as a number and press return)

Answer Guide

$$\sum V = 0$$

$$0 = V_S + (-V_{R1}) + (-V_{R2}) + (-V_{R3})$$

$$V_{R2} + V_{R3} = 6 \text{ V} - 3 \text{ V}$$

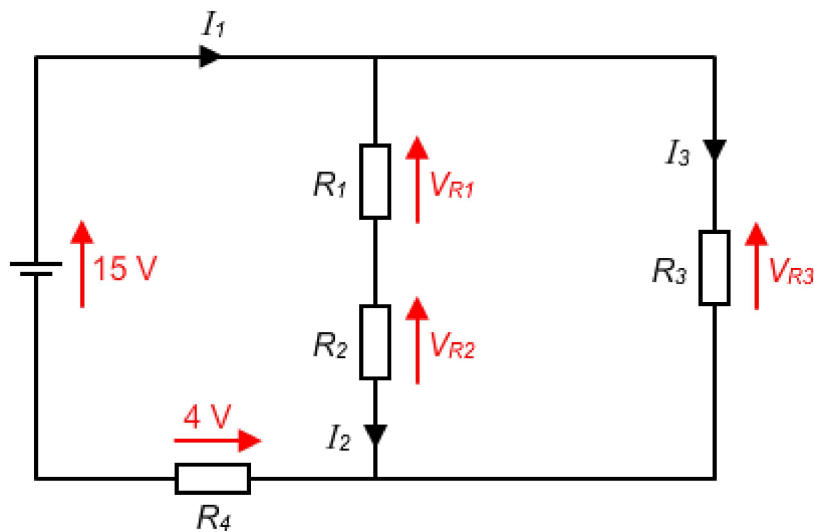
$$V_{R2} + V_{R3} = 3 \text{ V}$$

$$V_{R2} = V_{R3}$$

$$2V_{R2} = 3 \text{ V}$$

$$V_{R2} = 1.5 \text{ V}$$

Use the following circuit to answer the next three questions.



3

One of the closed loops contains the voltage source, R_1 , R_2 and R_4 . Which is the correct equation, derived for Kirchhoff's Second Law, for this loop?



- ☐ $0 = 15 + (-V_{R1}) + (-V_{R2}) + 4$
- ☐ $0 = 15 + V_{R1} + V_{R2} + 4$
- ☐ $0 = 15 + (-V_{R1}) + V_{R2} + 4$
- ☒ $0 = 15 + (-V_{R1}) + (-V_{R2}) + (-4)$

Answer Guide

The first loop includes the supply voltage (15 V) and the voltages V_{R1} , V_{R2} and V_{R4} . The voltage V_{R4} is 4 V.

These voltages around the closed loop sum to zero.

The arrows pointing in the direction of the current flow are assumed to be positive. The arrows pointing in the opposite direction of the current flow are assumed to be negative.

4

What is the value of V_{R3} ? Give your answer in V.



V (Enter your answer as a number and press return)

Answer Guide

The voltages around the second closed loop sum to zero:

$$\sum V = 0$$

$$0 = V_S + (-V_{R3}) + (-V_{R4})$$

$$0 = 15 + (-V_{R3}) + (-4)$$

$$V_{R3} = 15 \text{ V} - 4 \text{ V}$$

$$V_{R3} = 11 \text{ V}$$

5

The ratio of R_1 to R_2 is 6:5. What will be the voltage across R_2 ? Give your answer in V.



V (Enter your answer as a number and press return)

Answer Guide

$$0 = 15 + (-V_{R1}) + (-V_{R2}) + (-4)$$

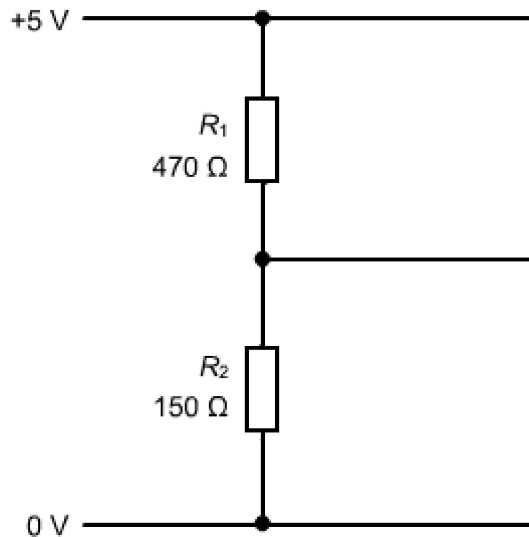
$$V_{R1} + V_{R2} = 15 - 4$$

$$V_{R1} + V_{R2} = 11 \text{ V}$$

Since the ratio is 6:5, there will be 6 V across R_1 and 5 V across R_2 .

The Voltage Divider Principle

Use this circuit to answer the questions that follow.



1

What is the total resistance in the circuit? Give your answer in Ω .



Ω (Enter your answer as a number and press return)

Answer Guide

$$\text{Total Resistance} = R_1 + R_2$$

$$\text{Total Resistance} = 470\ \Omega + 150\ \Omega$$

$$\text{Total Resistance} = 620\ \Omega$$

2

What is the circuit current? Give your answer in mA to 2 d.p.



mA (Enter your answer as a number and press return)

Answer Guide

$$\text{Circuit Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

$$\text{Circuit Current} = \frac{5 \text{ V}}{620 \Omega}$$

$$\text{Circuit Current} = 0.0080645 \text{ A}$$

$$\text{Circuit Current} = 8.06 \text{ mA}$$

3

What is the voltage across R_1 ? Give your answer in volts to 2 d.p.



V (Enter your answer as a number and press return)

Answer Guide

$$\text{Voltage} = \text{Current} \times \text{Resistance}$$

$$\text{Voltage} = 8.06 \text{ mA} \times 470 \Omega$$

$$\text{Voltage} = 3.79 \text{ V}$$

4

What is the voltage across R_2 ? Give your answer in volts to 2 d.p.



V (Enter your answer as a number and press return)

Answer Guide

$$\text{Voltage} = \text{Current} \times \text{Resistance}$$

$$\text{Voltage} = 8.06 \text{ mA} \times 150 \Omega$$

$$\text{Voltage} = 1.21 \text{ V}$$

5

What power is dissipated by R_1 ? Give your answer in mW to 1 d.p.



mW (Enter your answer as a number and press return)

Answer Guide

Power = Voltage $\times$ Current

Power = 3.790 V $\times$ 8.065 mA

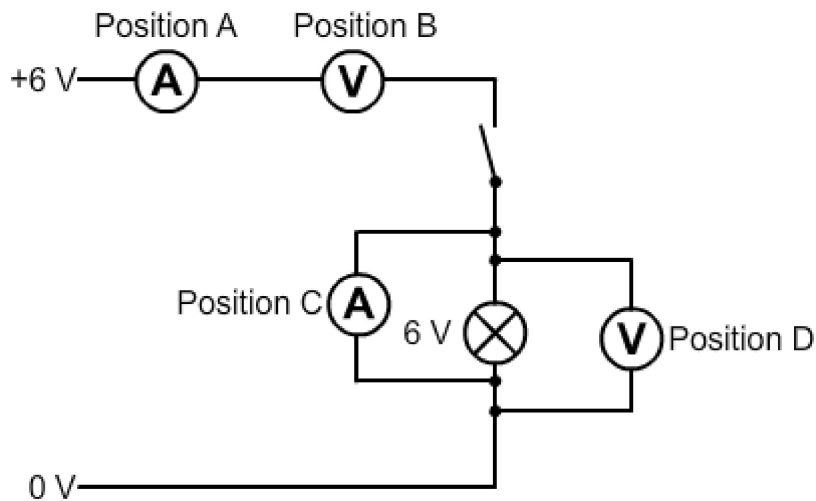
Power = 30.6 mW

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Measuring Voltage

1

Which position in the following diagram shows the correct symbol and placement of a multimeter for measuring voltage?



☐ Position A

☐ Position B

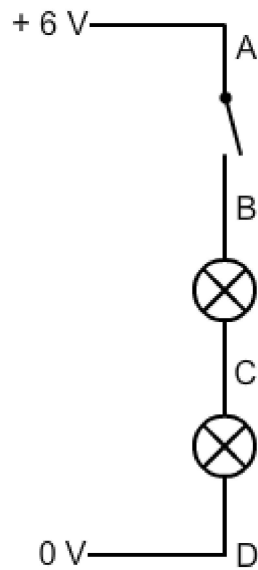
☐ Position C

☒ Position D

Answer Guide

Position D shows a voltmeter connected across the lamp. This is the correct position for measuring voltage.

Use the following diagram to answer the next 4 questions. The two lamps are identical.

**2**

If the switch was closed, what voltage reading would be expected across points A and D? Give your answer in V.



V (Enter your answer as a number and press return)

Answer Guide

With the switch closed the supply voltage will be measured across points A and D. This is 6 V.

3

With the switch closed, what voltage reading would be expected across points B and C?



V (Enter your answer as a number and press return)

Answer Guide

With the switch closed the supply voltage will be divided between the two lamps. 3 V will be dropped across each lamp.

4

With the switch closed, what voltage reading would be expected between points B and D? Give your answer in V.



V (Enter your answer as a number and press return)

Answer Guide

With the switch closed the supply voltage will be measured between points B and D. No voltage will be dropped across the switch.

5

Two technicians are discussing what would happen to voltage measurements in the circuit if the switch was replaced with another identical lamp.



Technician A states that 6 V would now be measured across each lamp.

Technician B states that 3 V would still be measured across each lamp.

Who is correct?

- ☐ Only technician A
- ☐ Only technician B
- ☐ Both technician A and technician B
- ☒ Neither technician A nor technician B

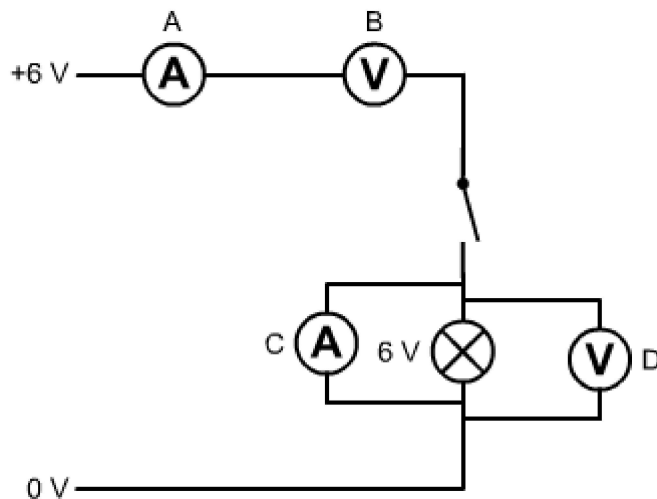
Answer Guide

A total of 6 V would be measured across all 3 lamps. The 6 V would be shared between 3 lamps meaning a measurement of 2 V across each lamp. Neither technician is there correct.

Measuring Current in a Circuit

1

Which position in the following diagram shows the correct placement of a multimeter for measuring current?



☐ Position A

☐ Position B

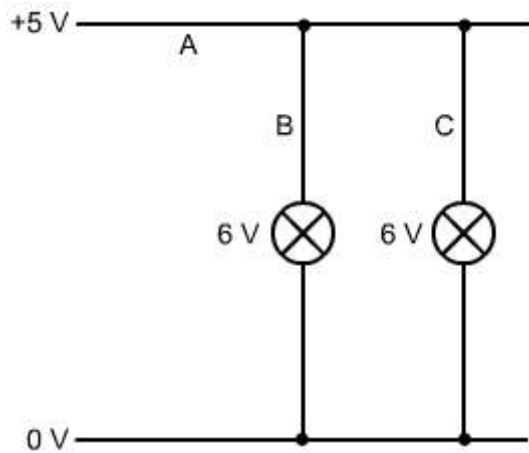
☐ Position C

☒ Position D

Answer Guide

Position A shows an ammeter connected in series. This is the correct position for measuring current.

Use this diagram to answer the next 4 questions.



2

The two lamps in the circuit are identical. If the current measured at point A in the circuit is 1.4 A, what is the current measurement at point B likely to be? Give your answer in A.



A (Enter your answer as a number and press return)

Answer Guide

The current will divide between the two branches of the circuit, proportional to the resistance of each branch. As each branch has identical lamps the resistance of each be equal, so the current will also be equal. Half of the circuit current will be measured in each branch.

3

The two lamps are replaced with 1 k Ω resistors. What is the likely effect of this change? Select all the correct answers.



- ☒ The overall circuit current will be reduced.
- ☐ The current through one branch will be dramatically higher than the other.
- ☐ The current through each branch will be higher than the supply current.

Answer Guide

With the relatively low resistance lamps being replaced with higher resistance resistor overall circuit current will be reduced.

4

Two technicians are discussing what would happen to current measurement in the circuit if another identical resistor was added in parallel to the first 2. Technician A states the current at point A would increase by 50 %. Technician B states the current at points B and C would decrease. Who is correct?



- ☒ Only technician A
- ☐ Only technician B
- ☐ Both technician A and technician B
- ☐ Neither technician A nor technician B

Answer Guide

Adding an additional resistor in parallel means the current through each branch remain the same. To achieve this the total current supplied needs to increase. Adding 50 % more resistors (decreasing the overall resistance) will increase the supply current by 50 %.

Measuring Resistance

1

A multimeter can measure resistance with these full scale settings: 200 Ω , 2 k Ω , 20 k Ω , 200 k Ω and 2 M Ω . Which setting should be used when measuring a resistor of value 4,700 Ω ?



☐ 200 Ω

☐ 2 k Ω

☒ 20 k Ω

☐ 200 k Ω

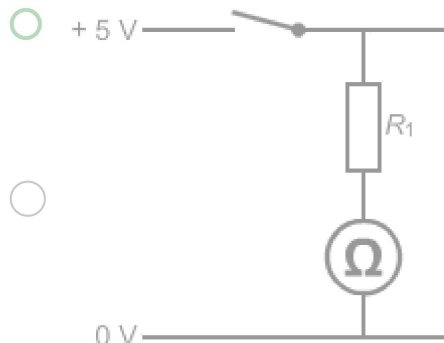
☐ 1 M Ω

Answer Guide

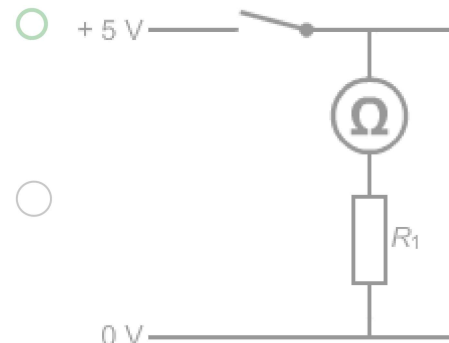
4,700 Ω is equivalent to 4.7 k Ω . The next highest reading is 20 k Ω .

2

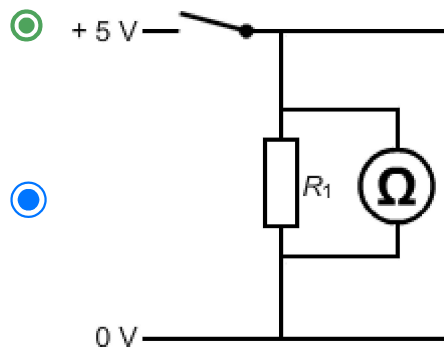
Which diagram shows how to correctly connect a multimeter to measure the resistance of resistor R_1 ?



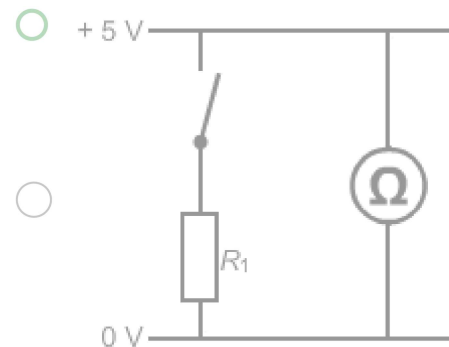
Connection method A



Connection method B



Connection method C



Connection method D

Answer Guide

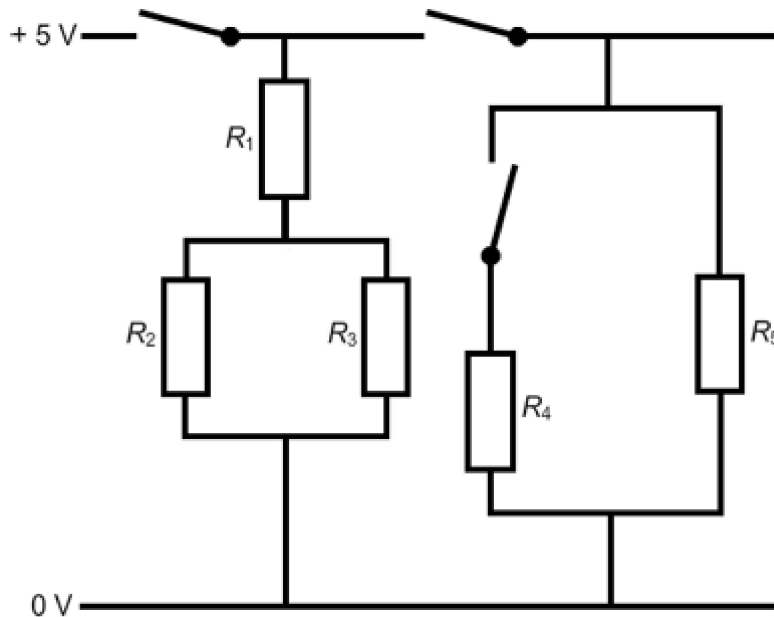
Connection method C - The multimeter, set to measure resistance, is connected across resistor that has no current flowing through it.

3

The diagram shows a circuit containing 5 resistors and three switches. Which resistors cannot be measured while it is in the circuit?



Choose all the right answers.

☐ R_1 ☒ R_2 ☒ R_3 ☐ R_4 ☐ R_5

Answer Guide

There is no way to isolate resistors R_2 and R_3 so it is not possible to measure their resistance directly with a multimeter.

4

The resistance of a 10 k Ω resistor is measured correctly with a multimeter. Which of the following is a possible answer? Choose all the right answers.



- ☐ 10 k Ω
- ☐ Always less than 10 k Ω
- ☐ Always more than 10 k Ω
- ☒ Close to 10 k Ω but never the exact value
- ☒ Close to 10 k Ω including the exact value

Answer Guide

Modern resistors will be close to the right value shown by its code. It may be exact but could also be close. It will never be always greater or always less than the exact value.

5

A technician is attempting to measure a resistor of about 100 k Ω . She connects the meter correctly and has made sure the power supply is off and the resistor is not in a network. However, she has forgotten to change the scale of the meter from its last reading. It is set to 2k. What will she see?

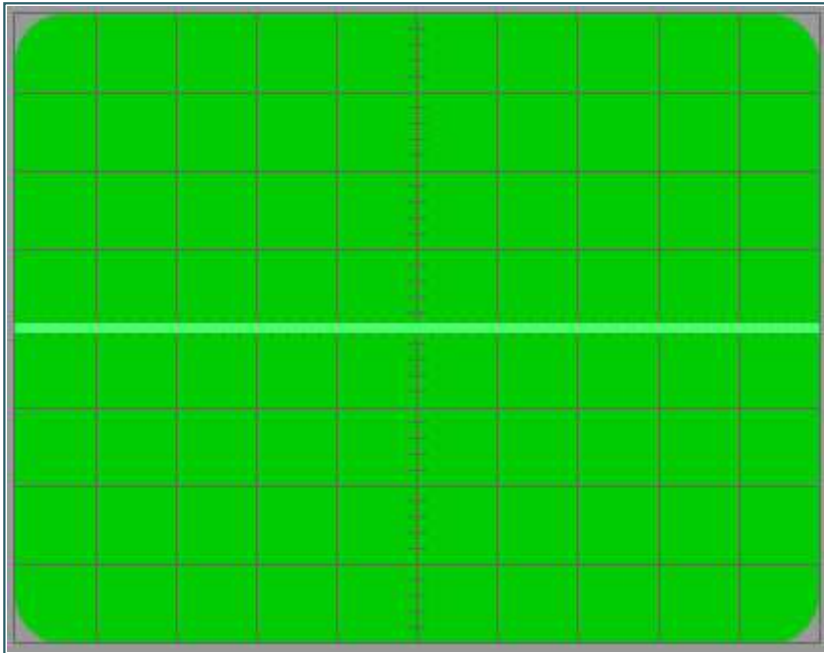
☒ 1.☐ 00.0☐ 00.1☐ 100.☐ 0.00

Answer Guide

The reading shown would be "1.". This is the overload symbol showing the reading is too large for the selected scale.

Measuring with an Oscilloscope

- 1 Oscilloscopes typically display waveforms on a 10×8 grid.
What does the horizontal axis (x-axis) of the display represent?



- ☐ Voltage
- ☒ Time
- ☐ Wavelength
- ☐ Frequency

Answer Guide

The x-axis represents time. It is usually displayed as 10 divisions.

2

Which of the following time measurements is the smallest?



☐ 0.5 s

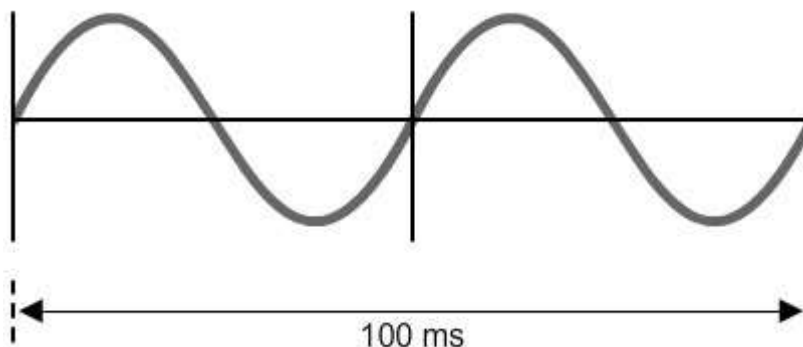
☒ 0.5 ms

☐ 1,000 μ s

Answer Guide

There are one thousand microseconds (μ s) in one millisecond (ms); there are one thousand milliseconds in one second (s). 0.5 milliseconds is smaller than both 0.5 seconds and 1,000 microseconds.

Study this waveform and answer the next two questions.



3

What is the period of the wave?

☒ 50 ms☐ 100 ms☐ 200 ms☐ 500 ms

Answer Guide

The waveform completes two cycles in 100 ms. The period of the waveform is the time taken to complete one cycle; in this case it is 50 ms.

4

What is the frequency of the wave?

☐ 2 Hz☐ 5 Hz☒ 20 Hz☐ 50 Hz

Answer Guide

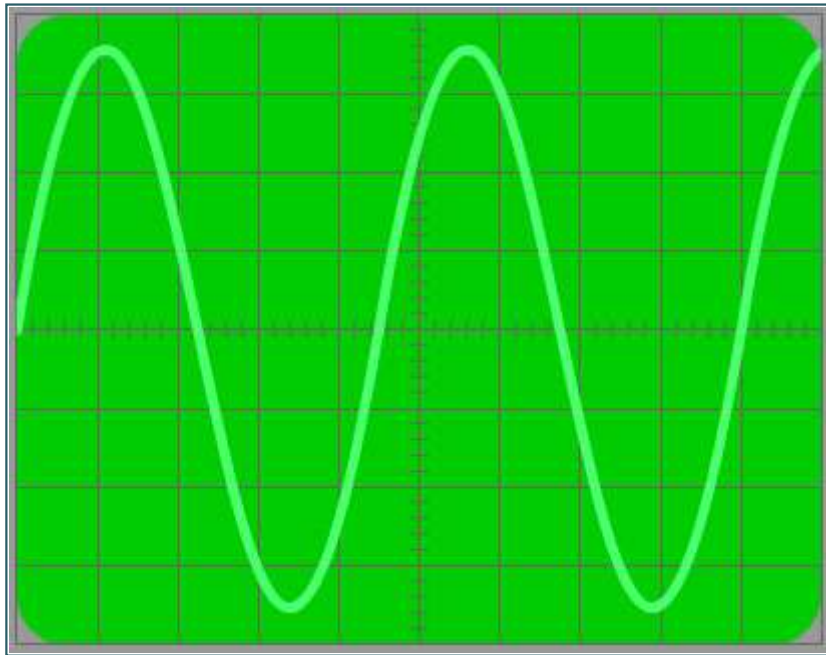
Frequency is expressed in hertz (Hz) and is calculated using this equation:

$$\text{Frequency} = \frac{1}{\text{Period}}$$

In this example the period is 50 ms, which is 0.05 s.

$$\frac{1}{0.05 \text{ s}} = 20\text{Hz}$$

Study this waveform and answer the remaining questions.



5

The waveform is displayed by an oscilloscope with the Time/Div control set to 5 ms per division.



☐ What is the period of the signal?

☐ 90 ms

☐ 45 ms

☒ 22.5 ms

☐ 9 ms

Answer Guide

Two cycles cover nine divisions. With each division equal to 5 ms, these two cycles take 45 ms. Therefore, one cycle takes half this time, or 22.5 ms.

6 What is the frequency of the signal?



☐ 444 Hz

☒ 44.4 Hz

☐ 225 Hz

☐ 22.5 Hz

Answer Guide

Frequency is calculated by dividing one by the period, in this instance:

$$\frac{1}{0.0225 \text{ s}} = 44.4 \text{ Hz}$$

7 The waveform above was displayed with the Volts/Div control set to 50 V. What is the peak-to-peak amplitude of the signal?



☐ 35 V

☐ 175 V

☒ 350 V

☐ 400 V

Answer Guide

The waveform covers seven divisions from the positive peaks to the negative peaks. V each division representing 50 V, the peak-to-peak amplitude is:

$$7 \times 50 \text{ V} = 350 \text{ V}$$

8

What is the peak amplitude of the signal?

☐ 35 V☒ 175 V☐ 350 V☐ 400 V

Answer Guide

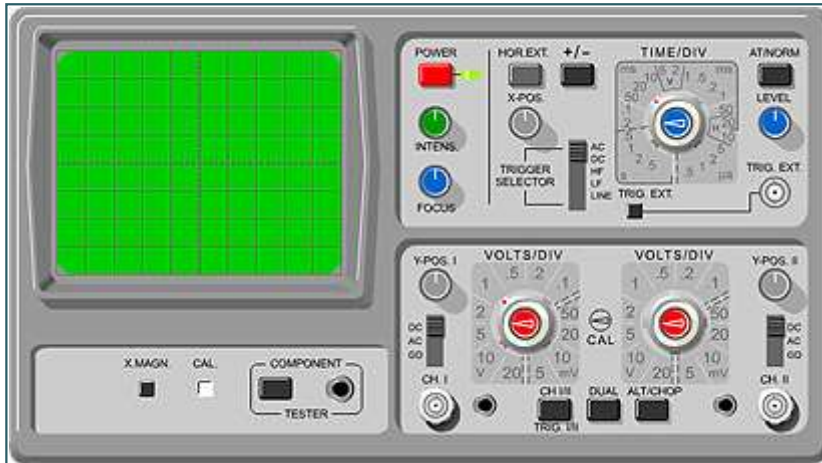
The peak amplitude is half of the peak-to-peak amplitude.

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Amplitude and Timebase Settings of an Oscilloscope

1

Which oscilloscope control allows a technician to display more or fewer cycles of an alternating waveform on the display?



- ☐ Time/Div
- ☐ Volts/Div
- ☒ Time/Volts
- ☐ Div/Time

Answer Guide

The Time/Div control can be used to increase or decrease the length of time represented by each horizontal division of the oscilloscope display.

For any given waveform, the longer the Time/Div value, the more complete cycles will be displayed on the screen.

2

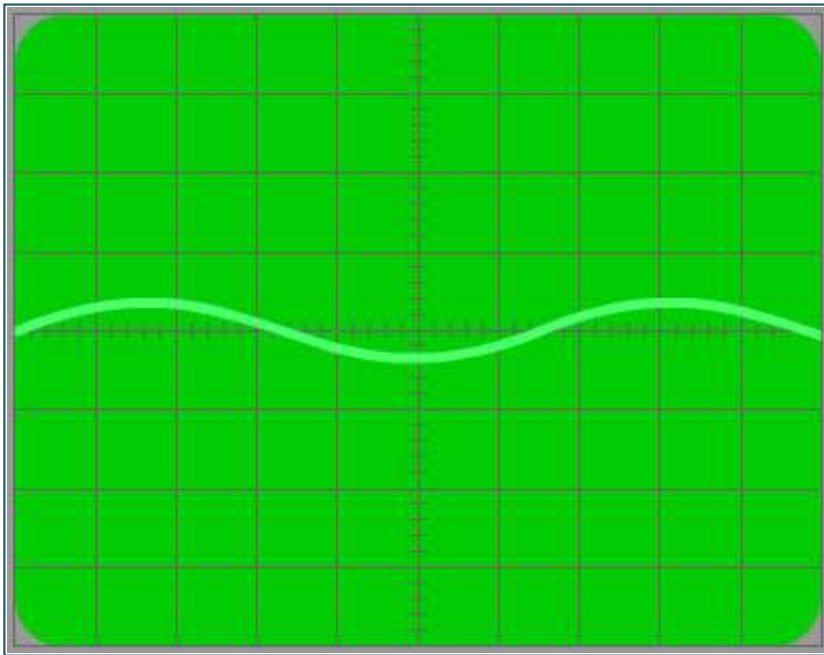
Examine the setting of this Time/Div control. How many divisions of the grid would a waveform with a period of 5 ms cover in one complete cycle?

☐ 0.2☐ 1☒ 5☐ 10

Answer Guide

The Time/Div control is set to 1 ms. Each horizontal division represents 1 ms, so a waveform with a period of 5 ms will cover 5 divisions in one complete cycle.

Use the waveform shown here to answer the next two questions.



3

Which measurement is made more difficult with the waveform displayed in this way?



☐ Period

☒ Amplitude

Answer Guide

Measuring amplitude is difficult when a flat waveform like this is displayed. The more vertical divisions are covered by the waveform, the easier it is to estimate the amplitude.

4

How could the display of the waveform be improved to allow measurements to be taken more easily?



- ☐ Increase the Volts/Div setting
- ☐ Increase the Time/Div setting
- ☒ Decrease the Volts/Div setting
- ☐ Decrease the Time/Div setting

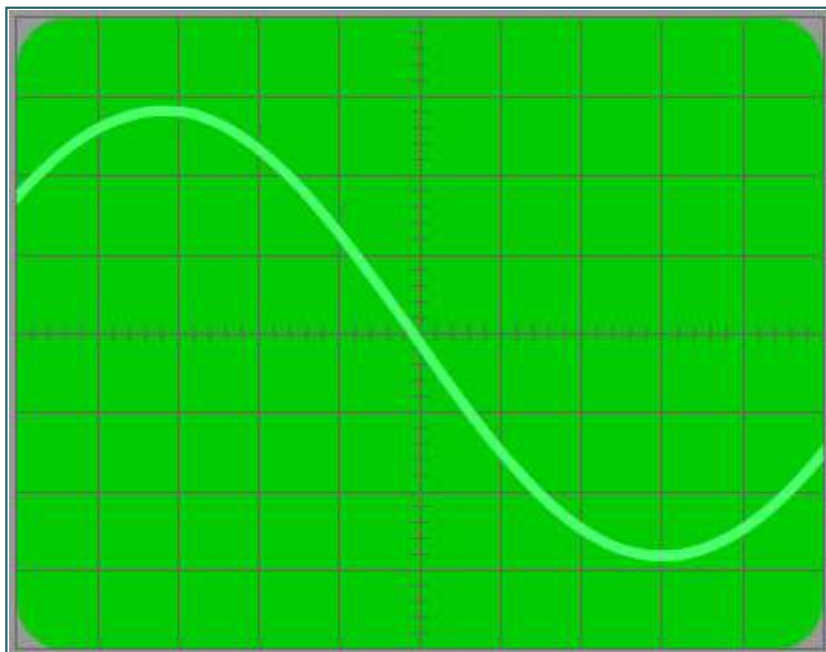
Answer Guide

The Volts/Div control affects the height of the displayed waveform. Decreasing the Volts/Div setting means that the waveform will be increased in height.

If the waveform has a peak-to-peak amplitude of 12 V and each division represents 10 then there will be just over one vertical division between the peaks.

If the Volts/Div setting is decreased to 2 volts, then exactly six vertical divisions will be covered by the waveform.

Examine the waveform shown here and answer the next two questions.



5

Which measurement is made more difficult with the waveform displayed in this way?



☒ Period

☐ Amplitude

Answer Guide

Measuring period is difficult when less than one cycle is displayed. The oscilloscope should display at least one complete cycle so that the horizontal divisions can be counted and the period calculated.

6

How could the display of the waveform be improved to allow measurements to be taken more easily?



☒ Increase the Volts/Div setting

☐ Increase the Time/Div setting

☐ Decrease the Volts/Div setting

☐ Decrease the Time/Div setting

Answer Guide

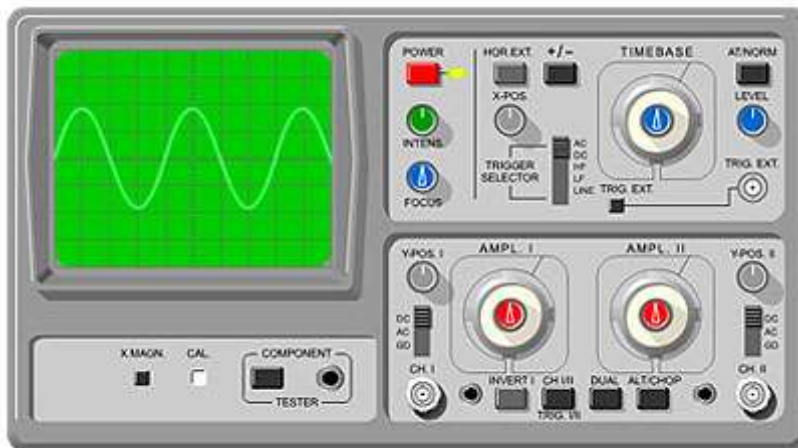
Increasing the Time/Div setting means that the waveform will be compressed horizontally.

If the waveform has a period of 1.4 s and each division represents 0.1 s, then one complete cycle will not be displayed.

If the Time/Div setting is increased to 0.2 s, then exactly seven divisions will be covered by one cycle.

Introduction to Alternating Current

1 What is the wave shape shown on this oscilloscope display?



- ☐ Square wave
- ☐ Triangle wave
- ☒ Sine wave
- ☐ Pulse wave

Answer Guide

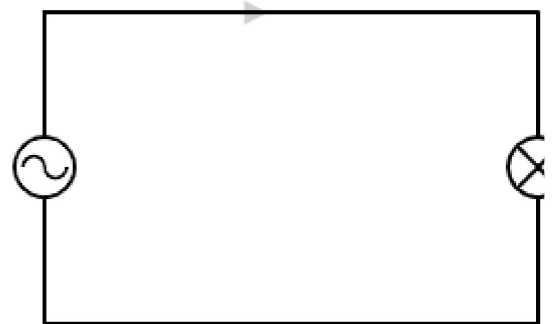
The wave shape is a sine wave, also known as a sinusoidal waveform. An AC supply voltage has this wave shape.

2

Study the two circuit diagrams here. Which animation shows alternating current?



Circuit A



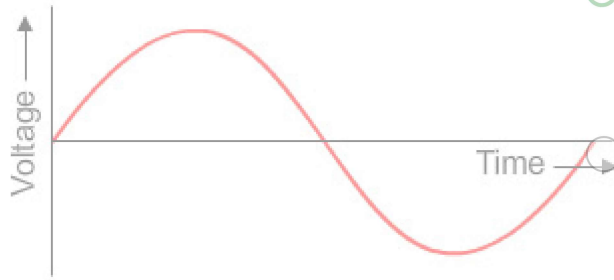
Circuit B

Answer Guide

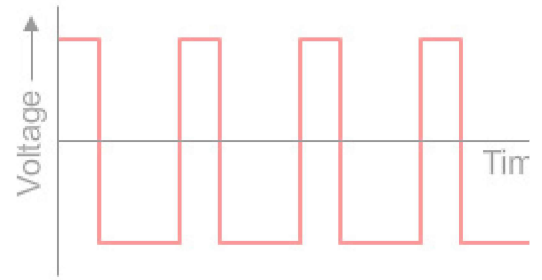
Circuit B shows alternating current flowing in a lamp circuit. AC is supplied to homes and is used in many household appliances. Circuit A shows direct current (DC) supplied by battery.

3

Which of the following voltage-time graphs illustrates the waveform that a charged battery would produce?



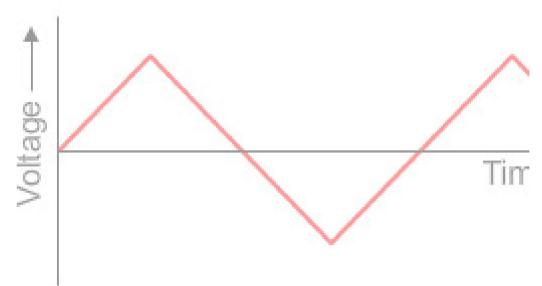
Voltage-time graph A



Voltage-time graph B



Voltage-time graph C



Voltage-time graph D

Answer Guide

A battery supplies direct current (DC). The voltage is constant and can be represented graph as a horizontal line.

4

If the period of a wave is 0.25 seconds, what is its frequency?



☒ 4 Hz

☐ 4 V

☐ 8 Hz

☐ 8 V

☐ 25 Hz

☐ 25 V

Answer Guide

The hertz is the unit of frequency. A wave that has a period of 0.25 seconds will repeat times in one second. It has a frequency of 4 Hz.

$$\text{Frequency} = \frac{1}{\text{period}}$$

$$\text{Frequency} = \frac{1}{0.25 \text{ s}}$$

$$\text{Frequency} = 4 \text{ Hz}$$

5

An AC supply voltage is displayed on an oscilloscope. The display shows that each cycle is completed in 0.02 s. What is the frequency of the wave?

☐ 5 Hz☐ 20 Hz☒ 50 Hz☐ 200 Hz

Answer Guide

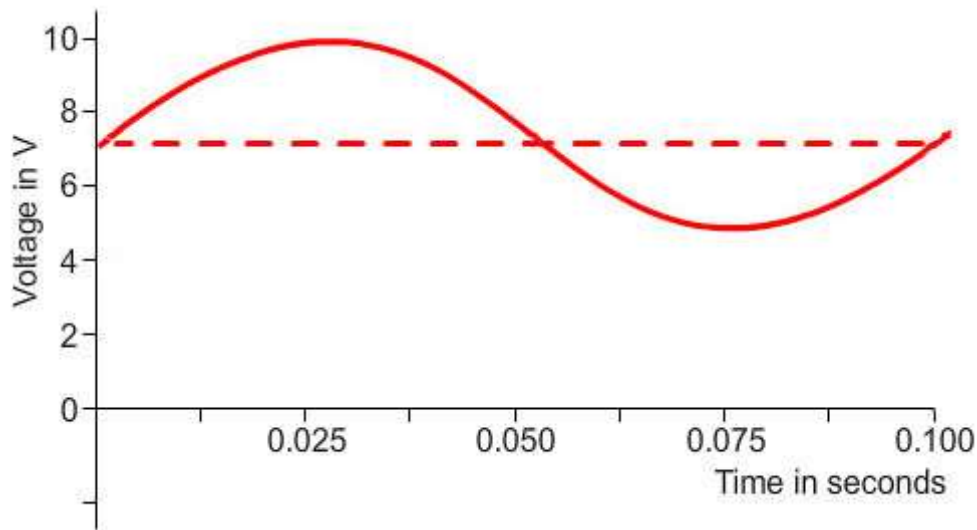
$$\text{Frequency} = \frac{1}{\text{period}}$$

$$\text{Frequency} = \frac{1}{0.02 \text{ s}}$$

$$\text{Frequency} = 50 \text{ Hz}$$

6

This diagram illustrates how a pulsating DC voltage changes over time. What is its frequency, and what is its voltage?



☒ Frequency 10 Hz, maximum voltage = 10 V

☐ Frequency 20 Hz, minimum voltage = 5 V

☐ Frequency 10 Hz, maximum voltage = 5 V

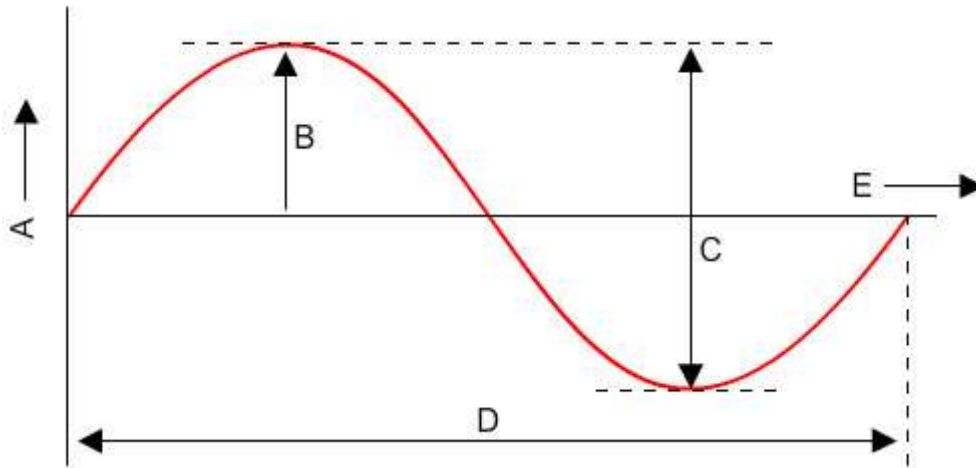
☐ Frequency 20 Hz, minimum voltage = 10 V

Answer Guide

One cycle of the waveform is completed in 0.100 seconds. Ten cycles will be completed in one second, so the frequency is 10 Hz. The voltage changes between a maximum of 10 volts and a minimum of 5 volts.

Effective Values of Alternating Voltages and Currents

Study the sine wave shown here, which is a representation of an AC voltage, and then answer the next two questions.



1

Which letter represents the peak-to-peak value?



☐ A

☐ B

☒ C

☐ D

☐ E

Answer Guide

The peak-to-peak value is the voltage difference between the positive and negative peaks of the wave.

2

Which letter represents the value that is multiplied by 0.707 to calculate the RMS voltage?

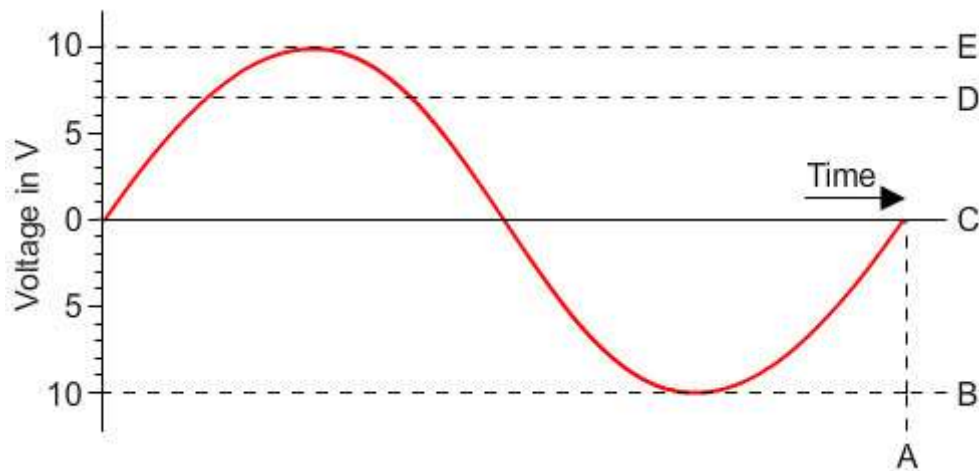
☐ A☒ B☐ C☐ D☐ E

Answer Guide

The peak value is the maximum instantaneous voltage. It is used in the calculation of RMS value. RMS is approximately 70 % of this peak value.

3

Study this sine wave that represents AC current. Which letter identifies the RMS value?

☐ A☐ B☐ C☒ D☐ E

Answer Guide

The magnitude of current indicated by D is the RMS value. RMS is approximately 70 % the peak value of the sine wave.

4

A wash room is fitted with an electric shower. The alternating voltage supplied to the unit is measured by a multimeter as 230 V. What is the approximate value of the peak voltage supplied to the unit?

☐ 163 V☐ 230 V☐ 300 V☒ 325 V

Answer Guide

A multimeter used to measure AC voltage will display the RMS value. The RMS is approximately 70 % of the peak value. The RMS value must be multiplied by $\sqrt{2}$, (1.414 find the peak voltage.

$$V_{\text{peak}} = 1.414 \times V_{\text{RMS}}$$

$$V_{\text{peak}} = 1.414 \times 230 \text{ V}$$

$$V_{\text{peak}} = 325 \text{ V}$$

5

“Oscilloscopes and multimeters can both be used to measure AC voltage.”



Is this statement true or false?

☒ True

☐ False

Answer Guide

Both types of test instruments can be used to measure AC voltage. Oscilloscopes usually only allow you to measure peak and peak-to-peak values; a simple calculation must be performed to convert these to RMS.

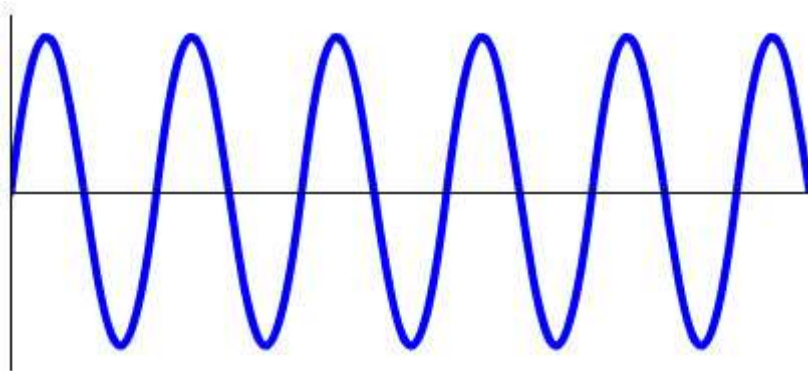
Multimeters measure RMS values directly.

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Alternating Current Equations

1

What is the name of the term used to describe the number of times that an alternating wave repeats its pattern in a unit of time?



- ☐ Period
- ☐ Amplitude
- ☒ Frequency
- ☐ Oscillation

Answer Guide

The number of times that an alternating wave repeats its pattern (called its cycle) in a unit of time, is its frequency.

2

What unit of measurement is used for the number of times that an alternating wave repeats its cycle in a unit of time?



☐ degree

☒ hertz

☐ meter

☐ second

Answer Guide

The number of times that an alternating wave repeats its cycle in a unit of time (one second) is measured in hertz.

3

Calculate the frequency of a waveform that has a known period of 0.02 s. Give your answer in Hz.



Hz (Enter your answer as a number and press return)

Answer Guide

$$\text{Frequency in hertz (Hz)} = \frac{1}{\text{Period in seconds (s)}}$$

$$\text{Frequency in Hz} = \frac{1}{0.02}$$

$$\text{Frequency in Hz} = 50$$

4

Calculate the frequency of a waveform that has a known period of 2.5 μs .
Give your answer in kHz.



kHz (Enter your answer as a number and press return)

Answer Guide

$$\text{Frequency in hertz (Hz)} = \frac{1}{\text{Period in seconds (s)}}$$

$$\text{Period in s} = \frac{2.5 \mu\text{s}}{1,000,000}$$

$$\text{Period in s} = 0.0000025$$

$$\text{Frequency in Hz} = \frac{1}{0.0000025}$$

$$\text{Frequency in Hz} = 400,000$$

$$\text{Frequency in kHz} = \frac{400,000}{1,000}$$

$$\text{Frequency in kHz} = 400$$

5

Calculate the period of a waveform that has a known frequency of 250 kHz.
Give your answer in μs .



μs (Enter your answer as a number and press return)

Answer Guide

$$\text{Period in seconds (s)} = \frac{1}{\text{Frequency in hertz (Hz)}}$$

$$\text{Frequency in Hz} = 250 \times 1,000$$

$$\text{Frequency in Hz} = 250,000$$

$$\text{Period in seconds (s)} = \frac{1}{250,000}$$

$$\text{Period in s} = 0.000004$$

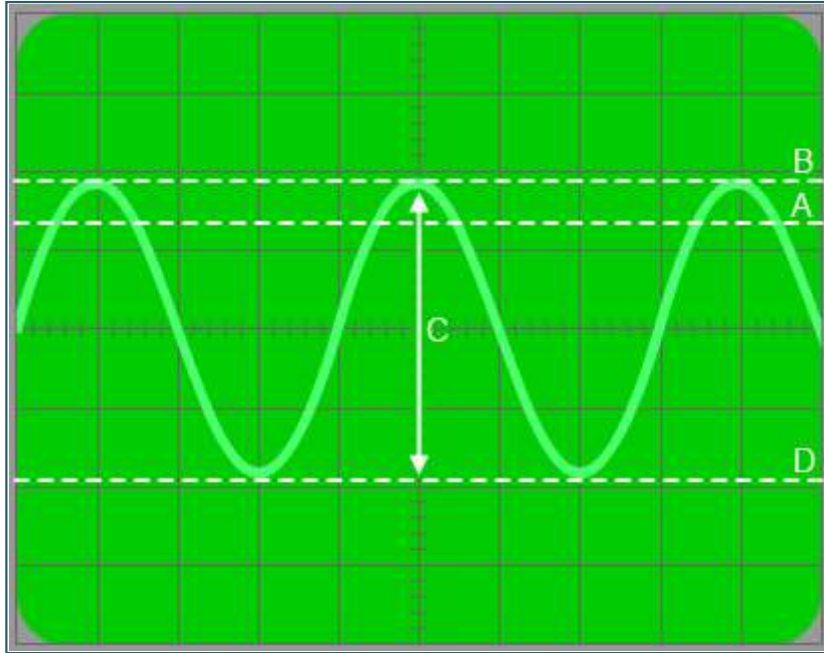
$$\text{Period in } \mu\text{s} = 0.000004 \times 1,000,000$$

$$\text{Period in } \mu\text{s} = 4$$

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Calculating the Effective Values of Alternating Voltages and Currents

Study this diagram and answer the following three questions:



1 Which label represents the peak-to-peak value?

☐ A

☐ B

☒ C

☐ D



Answer Guide

The distance between the lowest and the highest point of the alternating waveform is known as its peak-to-peak value.

2

The dotted line labelled A represents the RMS value. What is its approximate value?



☒ 50 % of C

☐ 50 % of B

☐ 70 % of C

☐ 70 % of B

Answer Guide

The RMS (root mean square) value is calculated as approximately 70 % of the peak value (B).

3

If the RMS value of the waveform is 14 V, what is the approximate peak value?



☐ 10 V

☐ 14 V

☒ 20 V

☐ 28 V

Answer Guide

RMS (root mean square) voltage is approximately 70 % of the peak voltage. The peak value can, therefore, be estimated by multiplying the RMS voltage by 100 and dividing by 70.

$$V_{PEAK} = 14 \text{ V} \times \frac{100}{70}$$

$$V_{PEAK} = 20 \text{ V}$$

4

RMS voltage is calculated using the following equation:



$$V_{RMS} = \frac{1}{\sqrt{2}} \times V_{PEAK}$$

What is the mathematical value of $\frac{1}{\sqrt{2}}$?

Enter your answer to 3 d.p.

(Enter your answer as a number and press return)

Answer Guide

The $\sqrt{}$ symbol means 'square root'.

A calculator can be used to find the square root of a number.

The square root of 2 is 1.414 (to 3 d.p.).

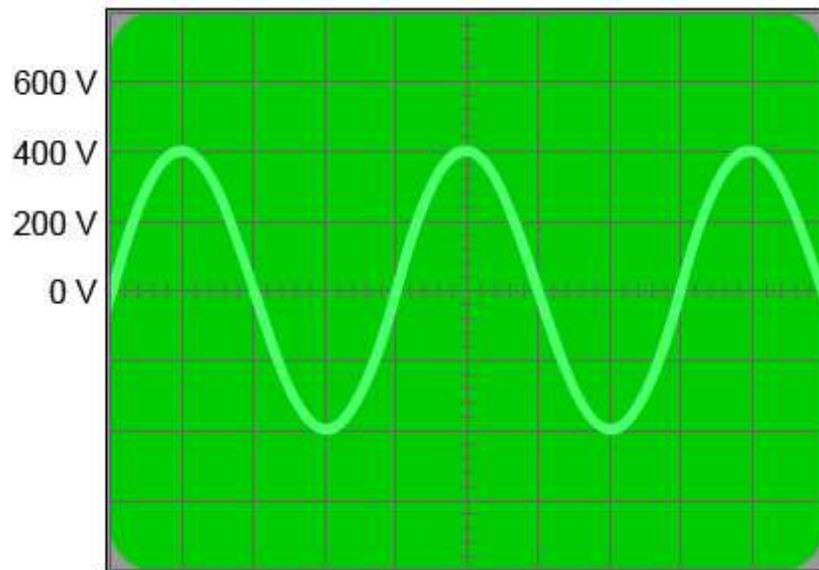
1 divided by 1.414 equals 0.707.

5

Each vertical division of this oscilloscope display represents 200 V. What is the RMS voltage?



Give your answer to the nearest whole number.



V (Enter your answer as a number and press return)

Answer Guide

V_{RMS} can be calculated when V_{PEAK} is known. V_{PEAK} can be measured in this example counting the vertical divisions covered by the top (or bottom) half of the wave in one cycle and multiplying by the value of each division.

Two divisions are covered and each division is 200 V, so:

$$V_{PEAK} = 200 \text{ V} \times 2$$

$$V_{PEAK} = 400 \text{ V}$$

V_{RMS} can then be calculated, using this formula:

$$V_{RMS} = 400 \text{ V} \times 0.707$$

$$V_{RMS} = 283 \text{ V}$$

Inductors - Graphs and Equations

The following formulae may be useful in answering the questions that follow:

$$\tau = \frac{L}{R}$$

$$I = \frac{V_b}{R} \left(1 - e^{\left(\frac{-tR}{L} \right)} \right)$$

$$V_L = V_b \times e^{\left(\frac{-tR}{L} \right)}$$

where:

τ = time constant in s

L = inductance in H

R = resistance in Ω

I = current in A

V_b = supply voltage in V

V_L = voltage across inductor in V

t = time in s

1

In which of the following situations does an inductor affect the current in a circuit?



☐ A constant current flowing through the inductor

☐ No current flowing through the inductor

☒ A changing current flowing through the inductor

Answer Guide

A changing magnetic field is produced in an inductor when the current flowing through inductor is changing. This changing magnetic field induces a voltage, which resists the build up of current in the inductor.

2

An LR circuit contains an inductor with an inductance of 2.35 H and a resistor with a resistance of 4.7 Ω .



What is the time constant for this circuit?

s (Enter your answer as a number and press return)

Answer Guide

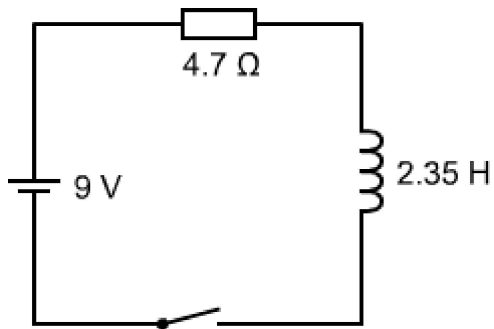
$$\tau = \frac{L}{R}$$

$$\tau = \frac{2.35 \text{ H}}{4.7 \Omega}$$

$$\tau = 0.5 \text{ s}$$

3

Study the LR circuit. How many seconds after the switch, S1, is closed will the current through the inductor reach its maximum value?



s (Enter your answer as a number and press return)

Answer Guide

$$\tau = \frac{L}{R}$$

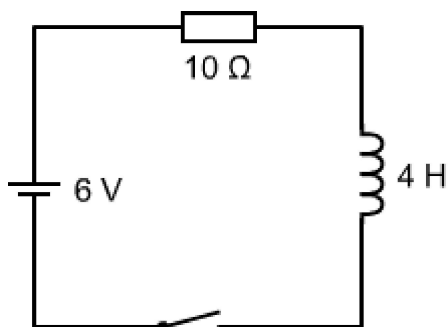
$$\tau = \frac{2.35 \text{ H}}{4.7 \Omega}$$

$$\tau = 0.5 \text{ s}$$

The current will reach the maximum value after 5 time constants.

$$\text{Time} = 5 \times 0.5 = 2.5 \text{ s}$$

Use the following LR circuit to answer the next two questions.



4

Calculate the current through the inductor 1 second after the switch is closed.



A (Enter your answer as a number and press return)

Answer Guide

$$I = \frac{V_b}{R} \left(1 - e^{\left(\frac{-tR}{L} \right)} \right)$$

$$I = \frac{6}{10} \left(1 - e^{\left(\frac{-1 \times 10}{4} \right)} \right)$$

$$I = 0.6 \times (1 - 0.0821)$$

$$I = 0.55 \text{ A}$$

5

Calculate the voltage across the inductor 1 second after the switch is closed.



V (Enter your answer as a number and press return)

Answer Guide

$$V_L = V_b \times e^{\left(\frac{-1 \times 10}{4} \right)}$$

$$V_L = 6 \times e^{\left(\frac{-1 \times 10}{4} \right)}$$

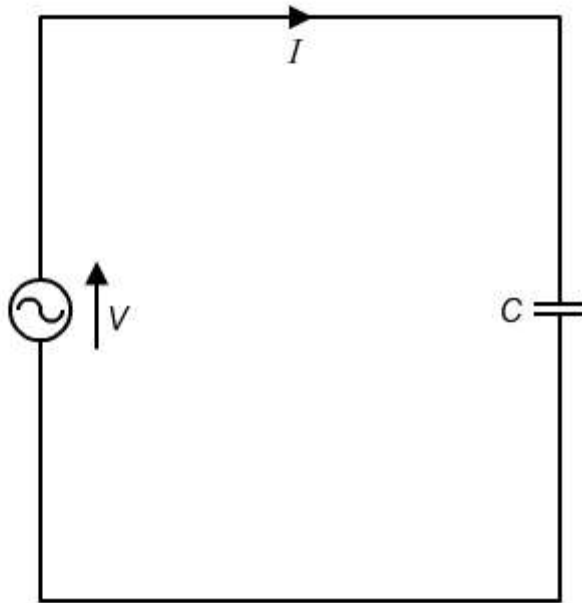
$$V_L = 6 \times 0.0821$$

$$V_L = 0.49 \text{ V}$$

Capacitors in AC Circuits

1

Which statement describes the waveforms in this circuit for the current to lead the voltage?



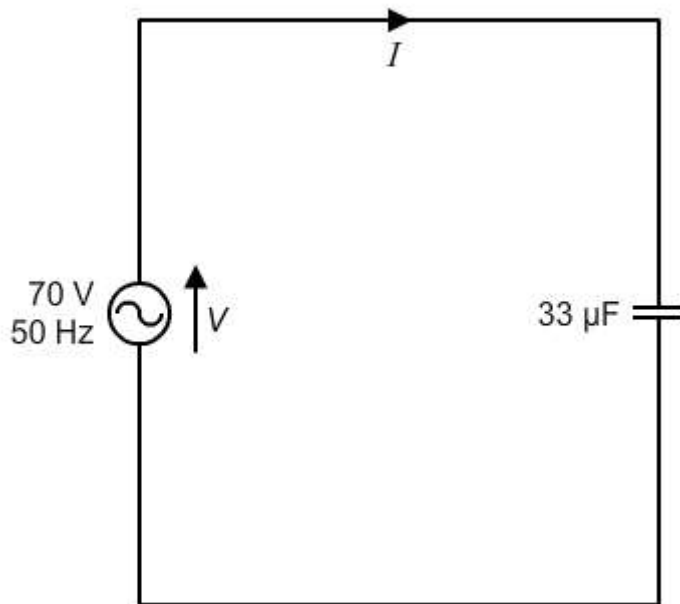
- ☐ When the voltage waveform is crossing zero, the current is at zero.
- ☒ When the voltage waveform is crossing zero, the current is at a peak.
- ☐ When the voltage waveform is crossing zero, the current is changing most rapidly.
- ☐ When the voltage waveform is crossing zero, the current is constant.

Answer Guide

The current leads the voltage because when the voltage waveform is crossing zero, the current is at a peak value.

2

What is the capacitive reactance of this circuit? Give your answer in Ω to 1 d.p.



Ω (Enter your answer as a number and press return)

Answer Guide

$$X_C = \frac{1}{2\pi fC}$$

$$X_C = \frac{1}{2\pi \times 50 \text{ Hz} \times 33 \mu\text{F}}$$

$$X_C = \frac{1}{6.284 \times 50 \times 33 \times 10^{-6}} \Omega$$

$$X_C = 96.45 \Omega$$

3

What value of capacitive reactance will cause a current of 0.58 A to flow through a capacitor when connected to a 30 V AC supply? Give your answer in Ω to 1 d.p.



Ω (Enter your answer as a number and press return)

Answer Guide

$$X_C = \frac{V}{I}$$

$$X_C = \frac{30 \text{ V}}{0.58 \text{ A}}$$

$$X_C = 51.72 \Omega$$

4

What effect does capacitive reactance have on the AC voltage and current applied to it?



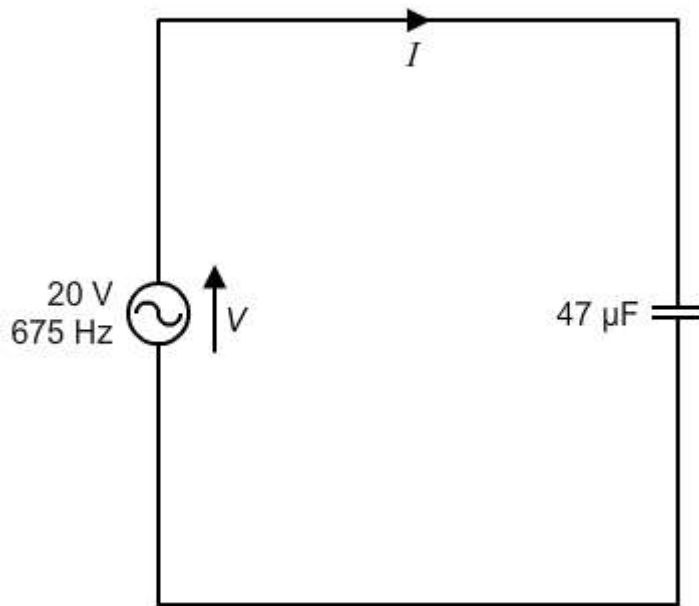
- ☐ The capacitive reactance has no effect.
- ☐ The capacitive reactance increases the supply voltage.
- ☐ The capacitive reactance increases the supply current.
- ☒ The capacitive reactance opposes the changing supply voltage.

Answer Guide

The capacitive reactance opposes the changing supply voltage.

5

What will happen in this circuit if the $47\ \mu\text{F}$ capacitor is replaced by a $5\ \Omega$ resistor?



- ☐ There will be no change to the values of voltage, or current, or their phase relationships.
- ☒ The current will be approximately the same and will be in phase with the supply voltage.
- ☐ The current will be approximately the same and will be leading the supply voltage.
- ☐ The voltage will double and the current will halve but their phase relationship will be unchanged.

Answer Guide

In this circuit, the current will be approximately the same and will be in phase with the supply voltage. The resistor value is approximately equal to the reactance of the capacitor for this frequency of the supply voltage.

Capacitors in AC Circuits

1 Complete the sentence with the correct words.



Capacitance values are stated in . The reactance of a capacitor is measured in .

Answer Guide

Capacitance values are stated in farads. The reactance of a capacitor is measured in ohms.

2 What happens to the reactance of a capacitor as the frequency of the voltage applied to it increases?



☐ The reactance remains constant.

☐ The reactance increases.

☒ The reactance decreases.

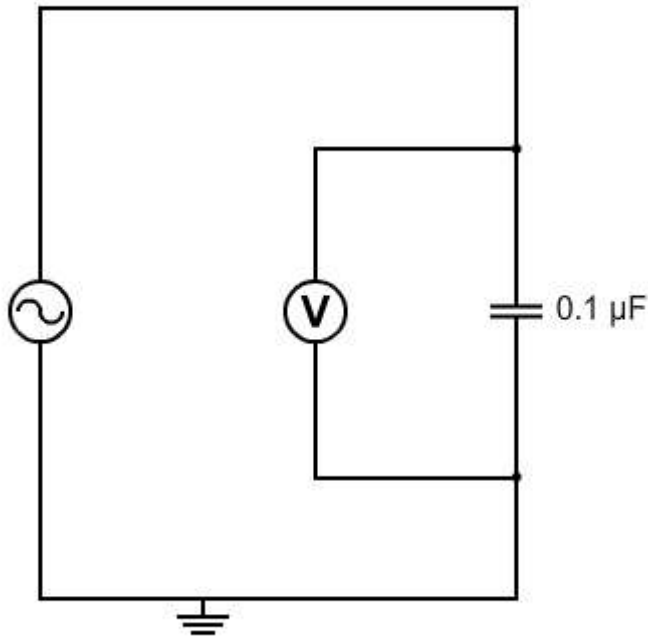
Answer Guide

As the frequency increases, the reactance of the capacitor decreases.

The equation to calculate capacitive reactance is:

$$X_C = \frac{1}{2\pi fC}$$

Use this equation and the circuit diagram to answer the next three questions. Assume that π equals 3.142.



3

What is the reactance of the capacitor if the signal generator is producing a sine wave of frequency 500 Hz? Give your answer to the nearest ohm.



Ω (Enter your answer as a number and press return)

Answer Guide

$$X_C = \frac{1}{2 \times \pi \times 500 \times 0.1 \times 10^{-6}}$$

$$X_C = 3182.7 \, \Omega$$

$$X_C = 3183 \, \Omega \text{ to the nearest ohm}$$

4

If the sine wave from the signal generator is set to 4 V AC at 10 kHz, what current will flow in the circuit? Give your answer to the nearest mA.



mA (Enter your answer as a number and press return)

Answer Guide

$$X_C = \frac{1}{2 \times \pi \times 10 \times 10^3 \times 0.1 \times 10^{-6}} = 159 \, \Omega$$

$$I = \frac{V}{X_C}$$

$$I = \frac{4}{159} = 25 \, \text{mA}$$

5

The current in the existing circuit is to be increased by a factor of 10 without changing the signal generator settings. What value of capacitor must replace the existing one?



☐ 0.01 μF

☒ 0.1 μF

☐ 1.0 μF

☐ 10.0 μF

Answer Guide

To increase the current in the circuit by a factor of 10, the capacitive reactance must be decreased by a factor of 10.

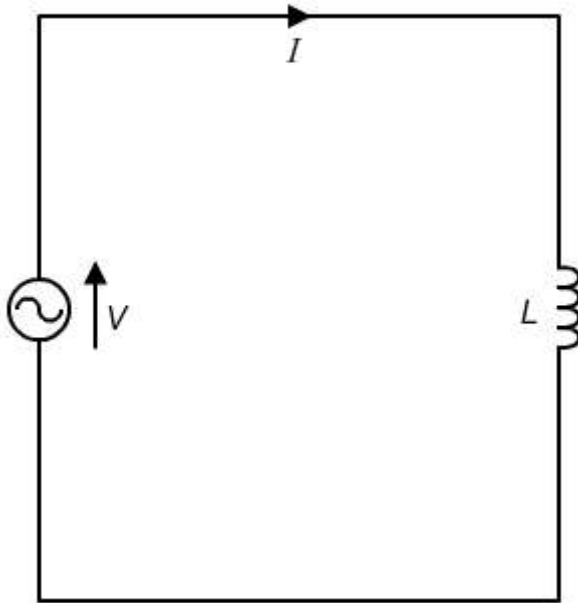
Since:

$$X_C = \frac{1}{2\pi fC}$$

The capacitor value would need to be increased by a factor of 10 to 1.0 μF .

Inductors in AC Circuits

Use this circuit to answer the next four questions.



1

What will be happening to the voltage in the circuit as the current waveform crosses zero?



- ☒ The voltage will be zero
- ☐ The voltage will be at a peak
- ☐ The voltage will be changing most rapidly
- ☐ The voltage will be in phase with the current
- ☐ The voltage will remain constant

Answer Guide

In an inductor circuit, the voltage will be at a peak when the current waveform crosses zero.

2

What will happen to the inductive reactance of the circuit when the frequency of the supply is increased?



- ☐ The inductive reactance will decrease
- ☐ The inductive reactance will not change
- ☒ The inductive reactance will increase
- ☐ The inductive reactance will be zero

Answer Guide

The inductive reactance will increase when the supply frequency is increased.

3

What value of inductive reactance will cause a current of 0.3 A to flow in the inductor when 40 V is applied across it? Give your answer as a whole number in Ω .



Ω (Enter your answer as a number and press return)

Answer Guide

$$X_L = \frac{V}{I}$$

$$X_L = \frac{40 \text{ V}}{0.3 \text{ A}}$$

$$X_L = 133.33 \Omega$$

4

What will the inductive reactance be in the circuit when the supply frequency is 50 Hz and the inductance is 2.2 H? Give your answer as a whole number in Ω .



Ω (Enter your answer as a number and press return)

Answer Guide

$$X_L = 2\pi fL$$

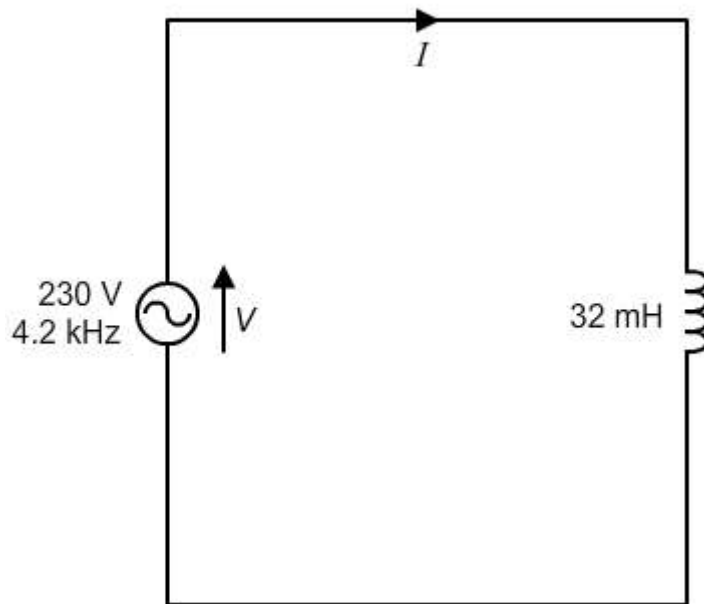
$$X_L = 2\pi \times 50 \text{ Hz} \times 2.2 \text{ H}$$

$$X_L = 6.284 \times 50 \times 2.2 \Omega$$

$$X_L = 691.24 \Omega$$

5

What will the value of the current be in this circuit? Give your answer in A to 2 d.p.



A (Enter your answer as a number and press return)

Answer Guide

Inductive reactance:

$$X_L = 2\pi fL$$

$$X_L = 2\pi \times 4.2 \text{ kHz} \times 32 \text{ mH}$$

$$X_L = 2\pi \times 4.2 \times 10^3 \times 32 \times 10^{-3} \Omega$$

$$X_L = 844.46 \Omega$$

Supply current:

$$I = \frac{V}{X_L}$$

$$I = \frac{230 \text{ V}}{844.46 \Omega}$$

$$I = 0.27 \text{ A}$$