2018-2019 Term 2

PHYS1001 Essential Physics

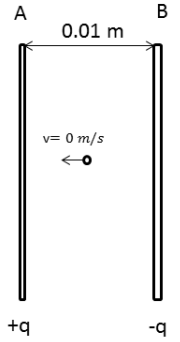
Assignment 7

Due date: 26th March, 2019 by 6:00 pm

(Please leave your homework in the box with the label "PHYS 1001" outside room 213 in Science Centre North Block)

Please answer **all** five questions

1. An electron, originally placed at the mid-point between the two charged planes, starts from rest. It is known that the electric field between the two plates is uniform and has a value of 0.002 N/C. Ignore the effect of gravitation in the calculation. Given that the mass of an electron is 9.11×10^{-31}kg.



(a) Calculate the electric force on the electron.
(b) Calculate the time it takes the electron to reach plate A.

Answer:

(a)
$$F = qE$$
$$F = (1.6 \times 10^{-19})(0.002)$$
$$F = 3.2 \times 10^{-22}\ \text{N}$$

(b)
$$F_{net} = ma$$
$$3.2 \times 10^{-22} = (9.11 \times 10^{-31})a$$
$$a = 0.351 \times 10^{9}\ m/s^2$$
$$s = \frac{0.01}{2}, u = 0, a = 0.351 \times 10^{9}, t = ?$$
$$s = ut + \frac{1}{2}at^2$$
$$\frac{0.01}{2} = \frac{1}{2}(0.351 \times 10^{9})t^2$$
$$t = 5.34 \times 10^{-6}\text{s}$$

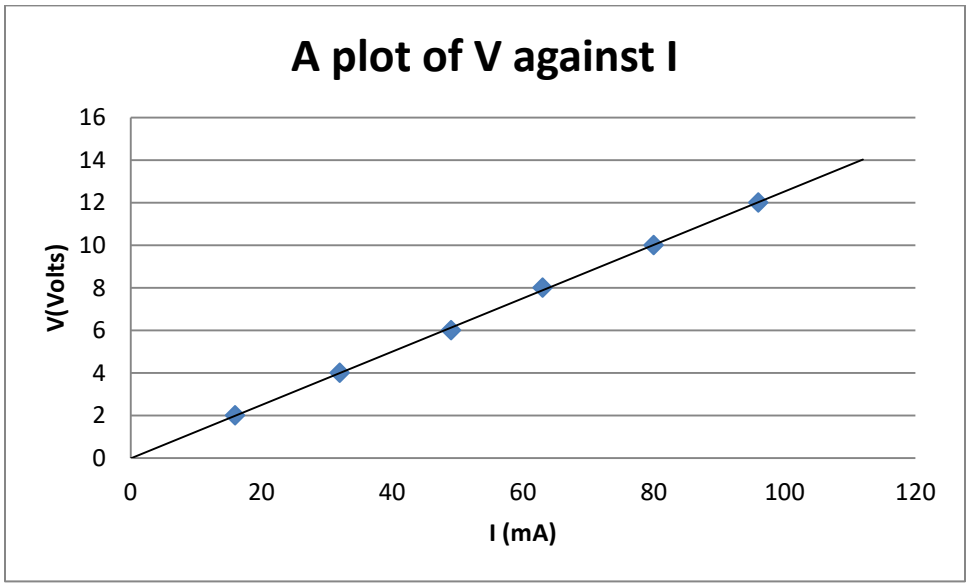
2. A student measures the resistance of an unknown resistor experimentally by collecting the potential difference V across the resistor and the current passing through the resistor.

V/volts	2	4	6	8	10	12
I/mA	16	32	49	63	80	96

(a) Plot a graph of *V* against *I*. Label your graph properly.
(b) What is the meaning of the slope of the graph? Find the value of the slope.

Answer:

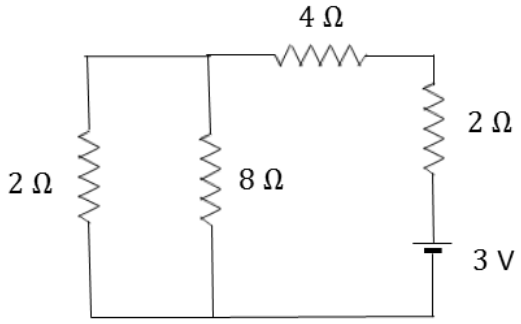
(a)



(b) The slope is the resistance of the resistor.

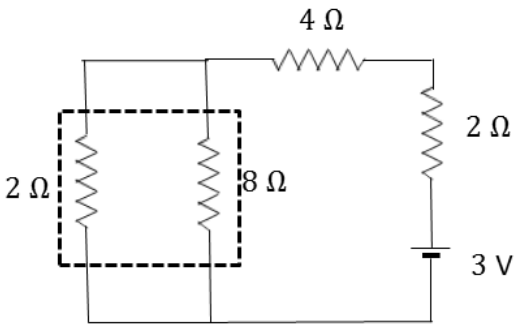
$$R = \frac{12 - 2}{(96 - 16) \times 10^{-3}} = 125\ \Omega$$

3. (a) Calculate the current passing through each resistor.



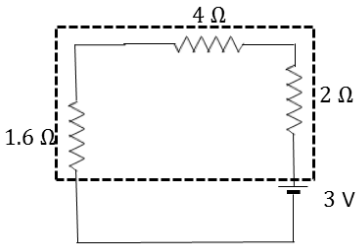
(b) Calculate the power consumed by each resistor.

Answer:

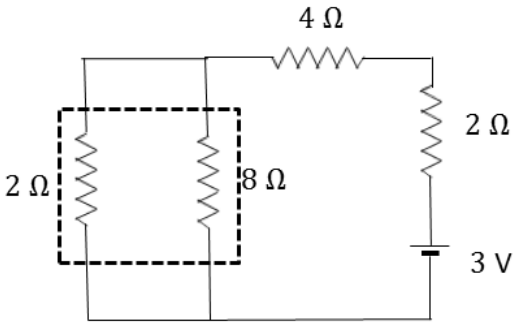


$$\frac{1}{\text{Equivalent resistance}} = \frac{1}{2} + \frac{1}{8}$$

$$\text{Equivalent resistance} = 1.6\ \Omega$$



$$\text{Equivalent resistance} = 1.6 + 4 + 2 = 7.6\ \Omega$$



Current passing through the 2 Ω and 4 Ω resistor$= \frac{3}{7.6} = 0.395$ A

Potential difference across the 8 Ω resistor$= 3 - 2 \times 0.395 - 4 \times 0.395 = 0.63$ V

Current passing through the 2 Ω resistor=0.316 A

Current passing through the 8 Ω resistor=0.080 A

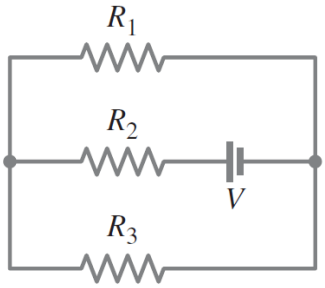
(b) Power of the 2 Ω resistor (the 2 Ω resistor in parallel with the 8 Ω resistor)$= I^2R = (0.316)^2(2) = 0.2$ W

Power of the 8 Ω resistor)$= I^2R = (0.08)^2(8) = 0.05$ W

Power of the 4 Ω resistor)$= I^2R = (0.395)^2(4) = 0.62$W

Power of the 2 Ω resistor (the 2 Ω resistor in the rightmost branch))$= I^2R = (0.395)^2(2) = 0.31$ W

4. In the circuit below, the resistance of resistors 1, 2 and 3 are 10 Ω, 5Ω and 10 Ω respectively. The EMF of the battery is 5V.



(a) Calculate the current passing through R_2.
(b) Calculate the voltage across R_1 and R_3

Answer:
(a) R_1 and R_3 are connected in parallel

$$\frac{1}{R_1}+\frac{1}{R_3}=\frac{1}{R_{eq}}$$

$$R_{eq,A}=5\ \Omega$$

$R_{eq,A}$ and R_2 are connected in series

$$R_{eq,total}=5+5=10\ \Omega$$

The current passing through $R_{eq,total}$ is:

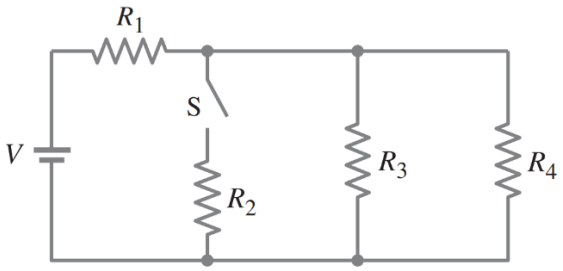
$$V=IR_{eq,total}$$
$$I=\frac{V}{R_{eq,total}}$$
$$I=\frac{5}{10}$$
$$I=0.5\ \text{A}$$

(b) The potential difference across R_2 is $V=IR_2=(0.5)(5)=2.5$ V
The potential difference across R_1:

$$V_1=-V_2+\text{E. M. F.}$$
$$V_1=5-2.5$$
$$V_1=2.5\ \text{V}$$

Similarly, the potential difference across R_3 is also 2.5 V.

5. Consider the following circuit:



The resistance of each resistor is 10 Ω and $V = 100$ V.

(a) Before the switch is closed, calculate the currents through each resistor.
(b) After the switch is closed, calculate the currents through each resistor.

Answer:

(a) Before the switch is closed, R_3 and R_4 are connected in parallel.

$$\frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{R_{eq,A}}$$
$$R_{eq,A} = 5\ \Omega$$

$R_{eq,A}$ is connected in series with R_1.

$$R_{eq,total} = 5 + 10 = 15\ \Omega$$

The current through the battery:

$$V = IR_{eq,total}$$
$$100 = I(15)$$
$$I = 6.67\ \text{A}$$

The current through R_1 is 6.67 A. The current passing through R_3 is $\frac{6.67}{2} = 3.33$ A. Similarly, the current passing through R_4 is $\frac{6.67}{2} = 3.33$ A.

(b) After the switch is closed, R_2, R_3 and R_4 are connected in parallel.

$$\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{R_{eq,A}}$$
$$R_{eq,A} = 3.33\ \Omega$$

$R_{eq,A}$ is connected in series with R_1.

$$R_{eq,total} = 3.33 + 10 = 13.33\ \Omega$$

The current through the battery:

$$V = IR_{eq,total}$$
$$100 = I(13.33)$$

$$I = 7.5 \text{ A}$$

The current through R_1 is 7.5 A. The current passing through R_2 is $\frac{7.5}{3} = 2.5$ A. Similarly, the current through each resistor R_3 and R_4 is $\frac{7.5}{3} = 2.5$ A