Minisry of Education
Khaled Bin Al Waleed School
Al ain

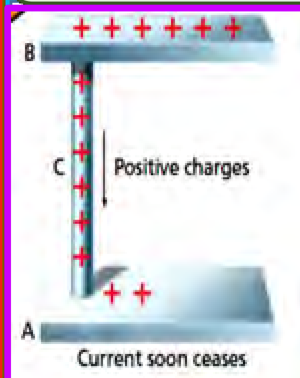
وزارة التربية والتعليم
مدرسة خالد بن الوليد
العين

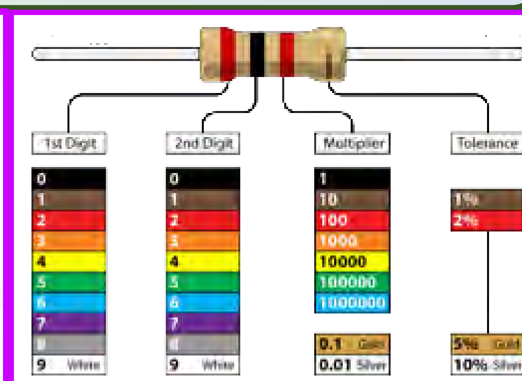
رؤيتنا :إعداد طالب ذي قيم مسلح بالكفايات التي تؤهله لاستكمال التعليم العالي بالمعايير العالمية وقادر على مواجهة التحديات

الاسم : .... الثاني عشر ( ) **Current and resistance** التاريخ : / / 2020

UNIT 5

Current and resistance



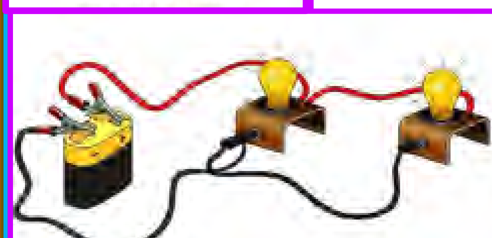


PHYSICE

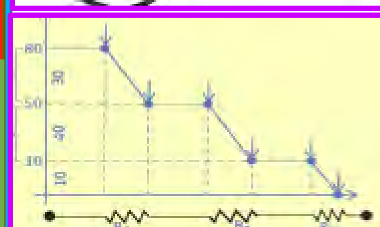
(2019-2020)

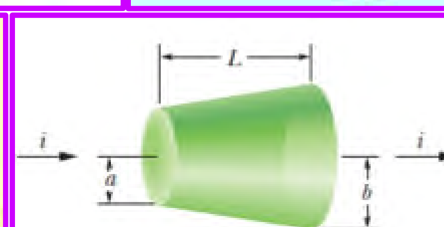
ريادة العالم ....انسانيا وحضاريا

تبدأ عندما نتعلم كيف نتسامح



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





إعداد

المعلم : لؤي بني عطا

الفصل الدراسي الثاني

الصف الثاني عشر المتقدم

اسم الطالب / .... الشعبة / ....

اسم المدرسة / ....

مدرسة خالد بن الوليد --- مدرس المادة : لؤي محمد بني عطا *** 0505369567

الثاني عشر المتقدم ****الفيزيـــــــــــاء**** 2019/2020

5-1 electric Current

- **Electric Current**: The movement of electrical charges through a specific conductor (a flow of charge) In metals, current is the movement of negative charge, i.e. electrons
- **Intensity of Electric Current:** The rate of flow the charge. (Is the net charge passing a given point in a given time, divided by that time)

$$i = \frac{dq}{dt}$$

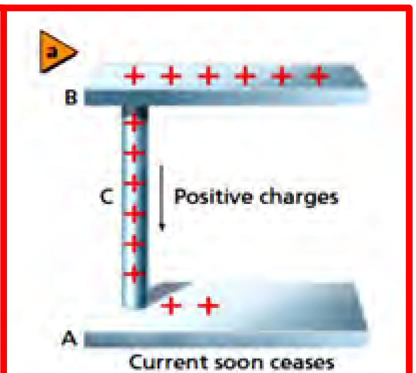
The net amount of charge passing a given point in time *t* is the integral of the current with respect to time

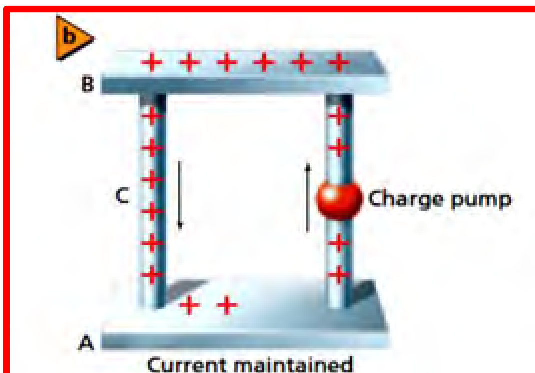
$$q = \int dq = \int idt = it$$

$$I = \frac{Q}{t}$$

Producing Electric Current: In **Figure,** two conductors, A and B, are connected by a wire conductor, C. charges flow from the higher potential difference of B to A through C. This flow of positive charge is called **conventional current.**

Charges flowing from the positive plate to the negative plate





Agenerator pumps the positive charges back to the positive plate and maintains the current

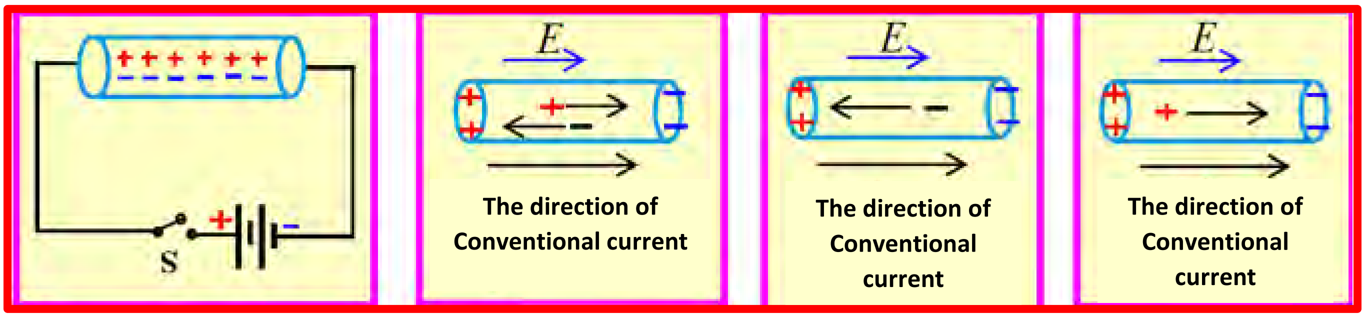
Conventional current: is the direction in which a positive test charge moves

Conservation of charge: Charges cannot be created or destroyed, but they can be separated

Electric circuit: Any closed loop or conducting path allowing electric charges to flow

The unit of current, **coulombs per second**, was given the name **ampere**

$$1A = \frac{1C}{1s}$$



Types of electric currents:

1- **Direct currentIt (D.C)** is the current that flows in one direction only and does not change with time
2- **Alternating current (A.C)** : It is the current that flows in one direction and then flows in the opposite direction

Electric charge carriers: They are electrical charges moving in conducting materials

There are several types of charge carriers :

1- In solid conductors **(electrons)**
2- In conductive liquids (electrolytic solutions) **negative and positive ions**.

Q: Battery written on it (9mAh). **How much time** is required for this battery by providing us with a constant current of intensity (0.4mA)?

....

....22.5h

Q: Car battery written on it (60Ah) **How much constant current** that battery can provide us if it works continuously for (24h) until the battery is discharged?

....

....**2.5A**

Q: **How much charge** is flowing through a conductive section which its current is passed 10A Within two hours?

....

.... $7.2 \times 10^4 C$

Q) A nurse wants to administer 80 μg of dexamethasone to the heel of an injured soccer player. If she uses an iontophoresis device that applies a current of 0.14 mA, as shown in Figure, **How long does the administration of the dose take**? Assume that the instrument has an application rate of 650 μg/C and that the current flows at a constant rate

....

....

....

....

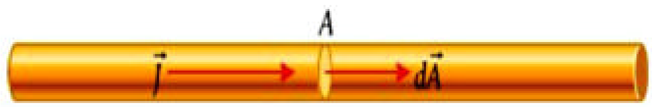
....

....**880 s**

5-2 Current Density

Current density ($\vec{J}$) it is vector quantity (the current per unit area flowing through the conductor at the point)

The direction of *J* is defined as the direction of the velocity of the positive charges (or opposite to the direction of negative charges) crossing the plane.



$$i = \int j dA \quad \Rightarrow \quad i = j\,A$$

$$j = \frac{i}{A}$$

The unit of current density is ampere per square meter $\frac{A}{m^2}$ As for its direction, it is the direction of flow of current

Q) Section radius wire **(2mm)** and the intensity of the current flow through it **($2 \times 10^5\ \frac{A}{m^2}$)**

How much current is in the wire

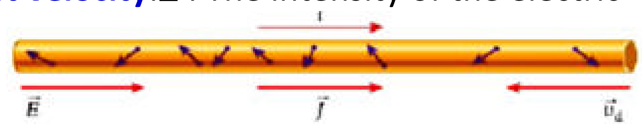
....

....

....**2.512A**

Drift velocity: (v_d): It is the velocity vector of the random motion of electrons and Its direction is opposite to the electric field direction The magnitude of the velocity of random motion is on the order of 10^6 m/s, while the magnitude of the drift velocity is on the order of 10^{-4} m/s or even less

The relationship between current density and drift velocity: $\boldsymbol{E}$: The intensity of the electric field created by the circuit



$\boldsymbol{l}$: The Length of the wire driven by electrons

$\boldsymbol{A}$: The area of the conductor section

$\boldsymbol{V}$: The volume in which the electrons move through the conductr $\quad \boldsymbol{V = Al}$

v_d: drift velocity $\quad \boldsymbol{v_d = \frac{l}{dt}}$

$\boldsymbol{i}$: Electric current $\quad \boldsymbol{i = \frac{dq}{dt}}$

$\boldsymbol{n}$: The number of electrons per unit volume

$\Delta\boldsymbol{N}$: The sum of free electrons contained in a part of the wire $\quad \boldsymbol{\Delta N = nlA}$

$\boldsymbol{dq}$: The total charge that the conductor carries through $\boldsymbol{l}$ and cross area $\boldsymbol{A}$

$$dq = e\Delta N$$

$$dq = nelA$$

Each electron moves its net distance $\quad l = v_d \Delta t$

$$dq = nev_d \Delta tA$$

Each electron is charged with a negative charge

$$dq = -nev_d \Delta tA$$

$$\boldsymbol{i = \frac{dq}{dt} = \frac{-nev_d \Delta tA}{dt} == -nev_d A}$$

The resulting current density is

$$\boldsymbol{j = \frac{i}{A} = -nev_d}$$

$$\boldsymbol{\vec{j} = -(ne)\vec{v}_d}$$

- The direction of the conventional current, electric field, and current density in the same direction
- The drift velocity of the electrons flow exactly opposite to them
- The drift velocity of positive charges in their direction (all them)

Q) The opposite figure shows a conductor in which the electrons are moving to the left

Determine the direction of each:

1- **Current:** ....
2- **Current density** : ....
3- **Electric field** : ....
4- **Drift velocity** : ....

Q: You are playing 'Galactic Destroyer" on your video game console. Your game controller operates at 12 V and is connected to the main box with an 18-gauge copper wire of length 1.5 m. As you fly your spaceship into battle, you hold the joystick in the forward position for 5.3 s, sending a current of 0.78 mA to the console. **How far have the electrons** in the wire moved during those few seconds, while on the screen your spaceship crossed half of a star system?

....

....

....

....

....

.... $x = 3.7\times10^{-7}$ m = 0.37 µm

Q) The 12-gauge copper wire in a typical residential building has a cross-sectional area of 3.31×10^{-6} m^2. If it carries a current of 10.0 A, **What is the drift speed of the electrons**? Assume that each copper atom contributes one free electron to the current. The density of copper is 8.95 g/cm^3.

....

....

....

....

.... **2.22×10^{-4} m/s**

5-3 Resistivity ρ and Resistance R

1- **The resistivity, ρ :** is a measure of how strongly a material opposes the flow of electric current.

2- **The resistance, R**, is a material's opposition to the flow of electric current.

The resistance of that conductor is given by:

$$R = \frac{\Delta V}{i}$$

Unit of resistance is : $R = \frac{\Delta V}{i} = \frac{\text{v}}{\text{A}} = \Omega$

Ohm's Law: The intensity of the current passing through the conductor is directly proportional to the difference in voltage between its ends it can be written in several pictures

Sometimes devices are described in terms of the **conductance,** G, defined as

$$G = \frac{I}{\Delta V} = \frac{1}{R}$$

Conductance has the SI derived unit of siemens (S): $1S = \frac{1A}{1v} = \frac{1}{\Omega}$

Conductivity (σ) *Is* the ability of materials to conduct $\rho = \frac{1}{\sigma} \rightarrow \sigma = \frac{1}{\rho}$

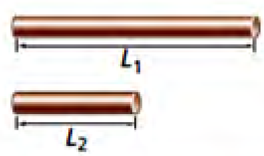
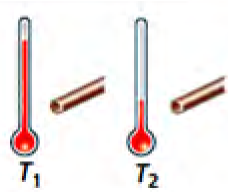
The resistivity is defined in terms of the magnitude of the applied electric field, ***E***, and the magnitude of the resulting current density, ***J*** :

$$\rho = \frac{E}{j}$$

The units of resistivity are

$$[\rho] = \frac{[E]}{[j]} = \frac{V/m}{A/m^2} = \frac{Vm}{A} = \Omega$$

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

Changing Resistance		
Factor	**How resistance changes**	**Example**
Length	Resistance increases as length increases.	 $R_{L1} > R_{L2}$
Cross-sectional area	Resistance increases as cross-sectional area decreases.	 $R_{A1} > R_{A2}$
Temperature	Resistance increases as temperature increases.	 $R_{T1} > R_{T2}$
Material	Keeping length, cross-sectional area, and temperature constant, resistance varies with the material used.	R increases ↑: Platinum, Iron, Aluminum, Gold, Copper, Silver

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الاسم : .... الثاني عشر ( ) **Current and resistance** التاريخ : / / 2020

Q) Standard wires that electricians put into residential housing have fairly low resistance **What is the resistance** of the 100.0-m standard 12-gauge copper wire that is typically used in wiring household electrical outlets?

....

....

.... 0 520 Ω

Q) What is the resistance of a copper wire that has length $L = 70.0$ m and diameter $d = 2.60$ mm?

a) 0.119 Ω b) 0.139 Ω c) 0.163 Ω d) 0.190 Ω e) 0.227Ω

Q) If the diameter of the wire doubles, **then its resistance**:

a) Increase by a factor of 4 b) Increase by a factor of 2 c) Remain the same

d) Decrease by a factor of 4 e) decrease by a factor of 2

Q) Nickel wire length (9m) and its radius (4mm) and a voltage difference between two ends equal (2v) If you know that the specific resistance of nichrome is at room temperature is (108×10^{-8} Ωm

How much is the electric current passing through it?

....

....

الاسم : .... الثاني عشر (   ) **Current and resistance** التاريخ :   /   / 2020

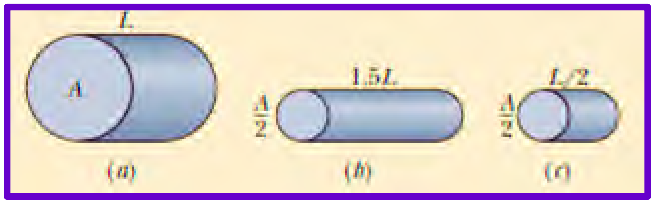
Q) The following figures represent three cylindrical wires. All copper and the same temperature. Connect between Both ends have the same potential difference.

Which of these wires passes the greatest current strength value? Explain your answer???

....

....

....



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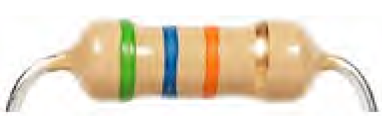
Resistor Codes

- Resistors are commonly made of carbon enclosed in a plastic cover that looks like a medicine capsule, with wires sticking out at the ends for electrical connection
- The value of the resistance is indicated by three or four color bands on the plastic covering
- The first two bands indicate numbers for the mantissa,
- The third represents a power of 10
- The fourth indicates a tolerance for the range of values
- No band at all means 20%.

Q) Using the opposite table. **How much resistance** each of the following resistors



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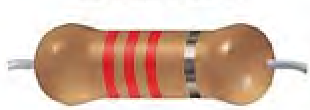

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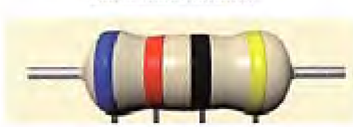

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Standard EIA Color Code Table 4 Band: ±2%, ±5%, and ±10%

Color	1st Band (1st figure)	2nd Band (2nd figure)	3rd Band (multiplier)	4th Band (tolerance)
Black	0	0	10^0	
Brown	1	1	10^1	
Red	2	2	10^2	±2%
Orange	3	3	10^3	
Yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
Violet	7	7	10^7	
Gray	8	8	10^8	
White	9	9	10^9	
Gold			10^{-1}	±5%
Silver			10^{-2}	±10%

Temperature Dependence and Superconductivity

$$\rho - \rho_0 = \rho_0 \alpha (T - T_0)$$

ρ Specific resistance to temperature T

ρ_0 Specific resistance to temperature T_0

α is the temperature coefficient of electric resistivity for the particular conductor

$$R - R_0 = R_0 \alpha (T - T_0)$$

O) If the temperature of the copper wire its resistance 100 Ω increase by 25 K then the resistance is:

a) Increase by 10 Ω
b) Increase by 4mΩ
c) decrease by 4mΩ
d) decrease by 10Ω
e) Nothing

Q) A copper wire has radius r = 0.0250 cm, is 3.00 m long, has resistivity $\rho = 1.72 \times 10^{-8}$ Ω m, and carries a current of 0.400 A. The wire has density of charge carriers of 8.50×10^{28} e/m^3.

a) **What is the resistance**, R, of the wire?

....

....

b) **What is the electric potential difference**, ΔV, across the wire?

....

....

c) **What is the electric field**, E, in the wire?

....

....

Q) A 34-gauge copper wire, with a constant potential difference of 0.10 V applied across its 1.0 m length at room temperature (20. °C), is cooled to liquid nitrogen temperature (77 K = −196 °C).

a) **Determine the percentage change** in the wire's resistance during the drop in temperature.

....

....

b) **Determine the percentage change** in current flowing in the wire.

....

....

c) **Compare the drift speeds** of the electrons at the two temperatures

....

....

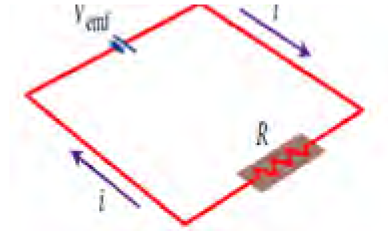
5-4 Electromotive Force and Ohm's

- The potential difference, supplied by a battery or other device, is termed an electromotive force (**emf)**
- (Electromotive force is not a force at all, but rather a potential difference.
- Charges are inside the conducting material and do not come from the battery (source)
- The ***emf*** device is assumed to maintain a constant potential difference, V_{emf}, between these terminals.
- ***mAh*** it is another unit of electric charge, for example.

How much total electric charge is stored in a battery written on it (50*mAh*)

Ohm's Law can be written in terms of the external *emf* as

$$V_{emf} = i\,R$$

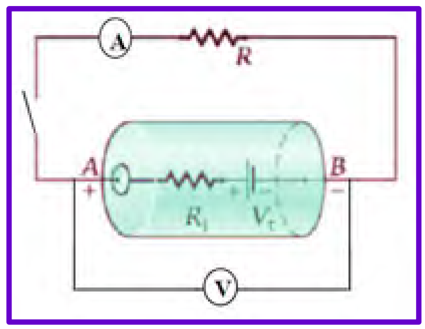


The change in potential of the current must occur in the resistor, according to Ohm's Law.

This change is referred to as the **potential drop** across the resistor.

The internal resistance of the battery

In the circle shown in the opposite figure



- When the circuit is open (no current passes) the voltmeter reading is (V_t)
- When the switch is closed and the battery is connected in siers with external resistance, the voltmeter reading will be (V_{emf})
- Note that when the switch is closed the reading of the voltmeter will decrease, i.e.

$$V_{emf} < V_t$$

$$V_t = iR_{eq} = i\,(R + R_i)$$

$$V_t = iR + iR_i$$

$$V_t = V_{emf} + V_i$$

When the internal resistance of the battery neglecting, then

$$V_t = V_{emf}$$

Q) In the previous figure if the reading voltmeter when the circuit is open (12v) and when the circle was closed a voltmeter reading became (11.5v) and reading of ameter (2A)

Calculate the amount

1- **The internal resistance** of the battery

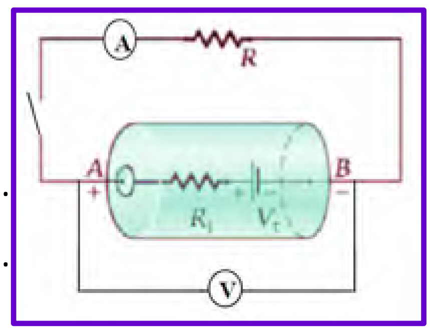
.... $R_i = 0.25\Omega$

2- **External resistance**

.... $R= 5.75\Omega$

Q) Consider a battery that has V_t = 12.0 V when it is not connected to a circuit, When a 10.0Ω resistor is connected with the battery, the potential difference across the battery's terminals drops to 10.9 V.

What is the internal resistance of the battery?



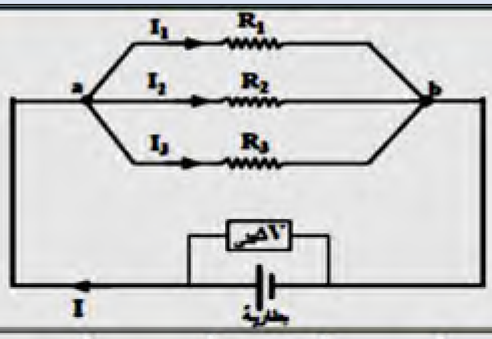
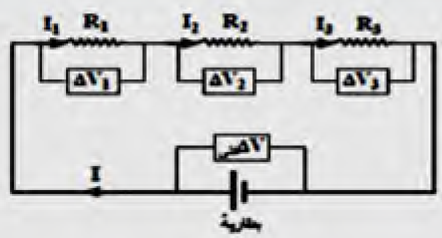
....

....

....

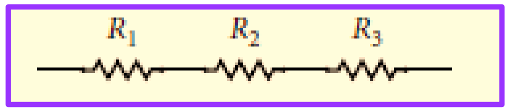
....1.0Ω

5-5 Resistors in Series and Prallel

Resistors in Prallel	Resistors in Series	$R = \frac{V}{I}$
		**Electrical circuit**
$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$ The equivalent resistance is smaller than the smallest	مكافئة $R_{eq} = R_1 + R_2 + R_3$ The total resistance of a circuit is called the equivalent resistance and is equal to the sum of the resistors (The equivalent resistance is greater than largest	**Equivalent Resistor**
(بطارية) $I = I_1 + I_2 + I_3$ Current is distributed over resistors and The total Current is equal to the sum of the Currents	(بطارية) كلي $I = I_1 = I_2 = I_3$ All resistors have the same Current and equal to the battery current	**Current strength in resistors**
(بطارية) $\Delta V = \Delta V_1 = \Delta V_2 = \Delta V_3$ All resistors have the same voltage and equal to the source voltage	$\Delta V = \Delta V_1 + \Delta V_2 + \Delta V_3$ Voltage is distributed over resistors	**Voltage difference**
$R_{eq} = \frac{R}{n}$ Equivalent Resistor is the product of one of them is divide by its number	مكافئة $R_{eq} = n R$ Equivalent Resistor is the product of one of them is multiplied by its number	**For equal resistors**
$\Delta V = I_1 R_1 = I_2 R_2 = I_3 R_3$ $I_1 = \frac{\Delta V}{R_1}$ $I_2 = \frac{\Delta V}{R_2}$ $I_3 = \frac{\Delta V}{R_3}$ $I = \frac{\Delta V}{R_{eq}}$	$I = \frac{\Delta V_1}{R_1} = \frac{\Delta V_2}{R_2} = \frac{\Delta V_3}{R_3} = \frac{\Delta V}{R_{eq}}$	

- ✓ In the case of consecutive bulbs: the lamp whose resistance is greater is its greater brightness
- ✓ In the case of parallel lamps in parallel: the lamp whose resistance is greater is its lower brightness

Q) Three identical resistors, R_1, R_2, and R_3, are wired together as shown in the figure. An electric current is flowing through the three resistors. **The current through R_2**



a) Is the same as the current through R_1 and R_3.

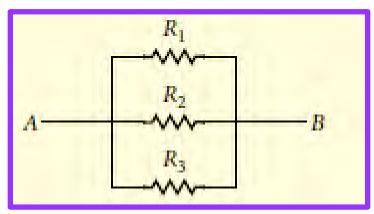
b) Is a third of the current through R_1 and R_3.

c) Is twice the sum of the current through R_1 and R_3.

d) Is three times the current through R_1 and R_3.

e) Cannot be determined.

Q) Three identical resistors, R_1, R_2, and R_3, are wired together as shown in the figure. An electric current is flowing from point A to point B. **The current flowing through R_2**



a) Is the same as the current through R_1 and R_3.

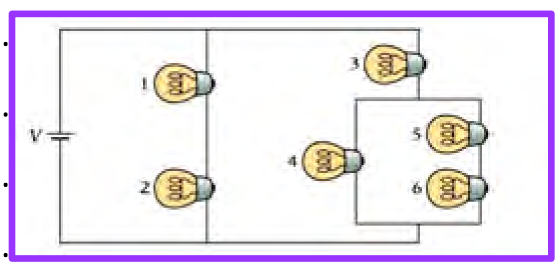
b) Is a third of the current through R_1 and R_3.

c) Is twice the sum of the current through R_1 and R_3.

d) Is three times the current through R_1 and R_3.

e) cannot be determined.

Q) Arrange the brightness of the lamps shown in the opposite circuit



....

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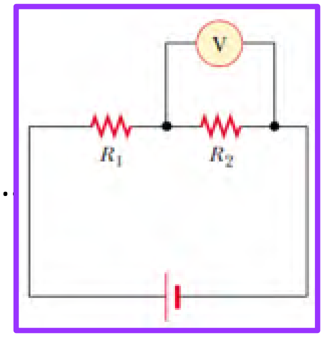
....

....

Q) In the opposite circuit (R_1 =6Ω) (R_2 = 4Ω). And the reading of voltmeter (3v)



Find the following:

1- **The amount of voltage drop in the resistance**

....

....4.5*V*

2- **Electromotive force of battery V_{emf}**

....

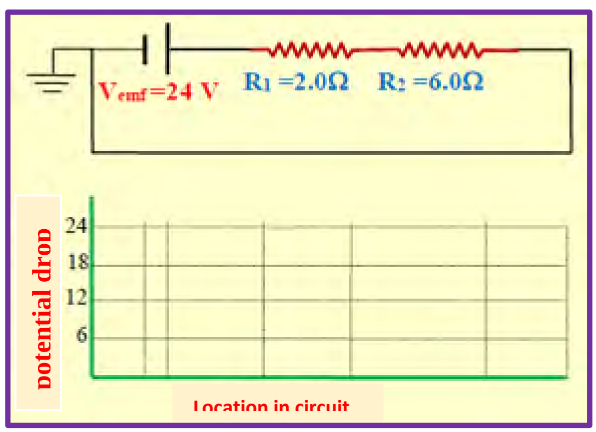
....7.5*V*

3- **The amount of total voltage V_t** . If you know that the internal resistance of the battery (1.5Ω)

....

....8.625V

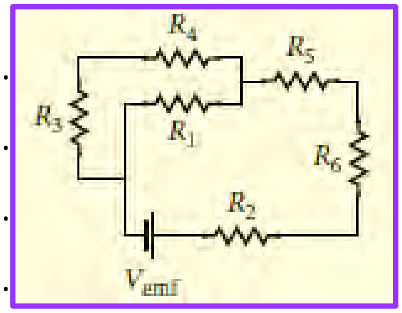
Q) From the circuit diagram shown in Figure . **Draw** on the diagram **the potential drop** with **the location** for each part of the department



Resistor with a non-Constant Cross Section

$$R = \frac{\rho L}{\pi r_1 r_2}$$

O) **Calculate the equivalent** resistance in the next circuit



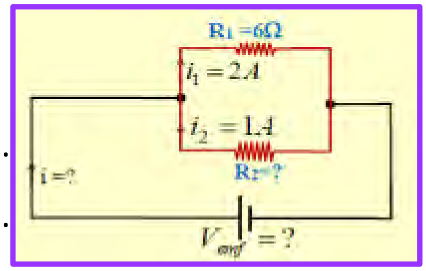
....

....

....

....

Q) Based on the data shown on the adjacent circuit, **calculate**



1- **The amount of resistance (R_2)**

....

....

....

....*12Ω*

2-**The intensity of the current** passing through the battery (i)

....

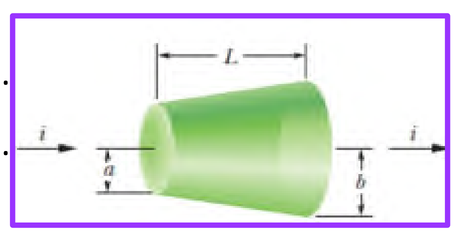
....*3 A*

3- **Electromotive force of battery V_{emf}**

....

....*12 V*

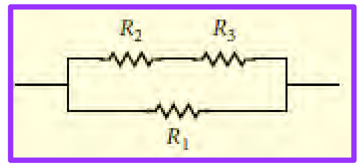
Q) Through the opposite shape to its specific resistance conductor 731Ωm and its radius increases from right to left Where the small radius (a=2mm) ,Large radius (b =2.3mm) with a long amount (L = 1.94cm) **What** is the electrical resistance of the conductor?



....

....

Q) In the figure, R_1 = 1.90, R_2 = 0.980, and R_3 = 1.70.

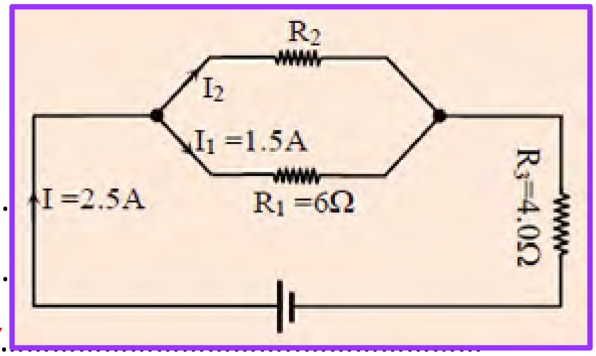


What is the equivalent resistance of this combination of resistors?

a) 0.984 Ω b) 1.11 Ω c) 1.26 Ω d) 1.42 Ω e) 1.60Ω

Q) Depending on the electrical circuit shown in the opposite circuit and the data on it.

Calculate :



1- **Battery voltage difference**

....

....

.... *19V*..........

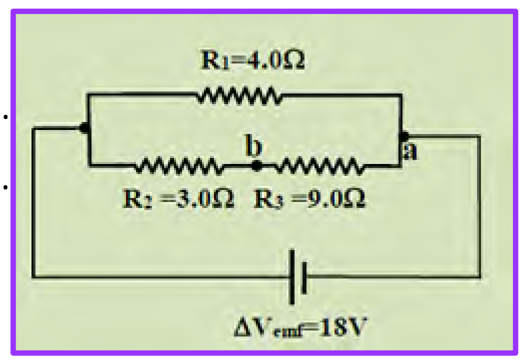
2- **The amount of resistance (R2)**

....

....9Ω

Q) Depending on the circuit shown in the oppoosit figure, **calculate**

1- **Equivalent resistance of the circuit**



....

....

.... 3Ω

2-**The voltage difference between the two points (a , b)**

....

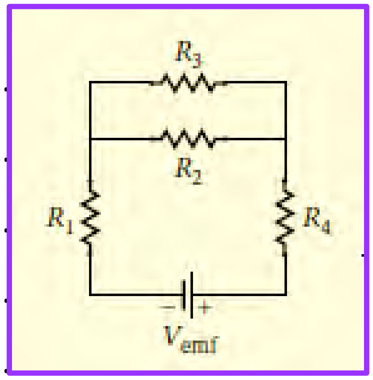
....

....*13.5V*

الاسم : .... الثاني عشر ( ) **Current and resistance** التاريخ : / / 2020

Q) The circuit shown in Figure has four resistors and a battery with V_{emf} = 149 V. the values of the four resistors are R_1 = 17.0 Ω, R_2 = 51.0 Ω, R_3 = 114.0 Ω, and R_4 = 55.0 Ω.

What is the magnitude of the potential drop across R_2?



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....

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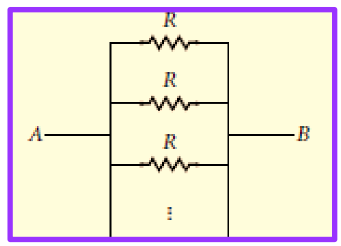
....

....**V =49.0 V.**

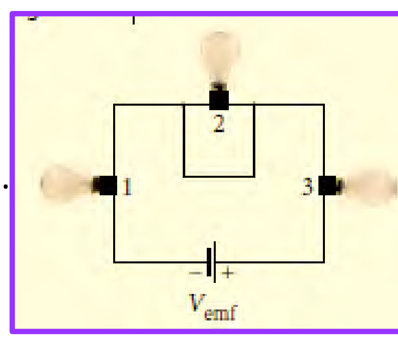
Q) As more identical resistors, R, are added to the circuit shown in the figure, the resistance between points A and B will



a) Increase. b) Stay the same.

c) Decrease. d) Change in an unpredictable manner.

Q) Three light bulbs are connected in series with a battery that delivers a constant potential difference, V_{emf}. When a wire is connected across light bulb 2 as shown in the figure, light bulbs 1 and 3



a) Burn just as brightly as they did before the wire was connected.

b) Burn more brightly than they did before the wire was connected.

c) Burn less brightly than they did before the wire was connected.

d) Go out.

5-6 Energy and Power in electric Circuits

In any closed circuit

1- a source of emf with potential difference ΔV causes acurrent i

2- The work required from the emf device to move a differential amount of charge, dq, from the negative terminal to the positive terminal (within the emf device) is equal to the increase in electric potential energy of that charge, dU

3- From $dU = dq\Delta V$ and $i = dq/dt$ The relationship can be written $dU = idt\Delta V$

4- Using the definition of power, $P = dU/dt$, and substituting into it the expression for the differential potential energy, we obtain

$$P = \frac{dU}{dt} = \frac{idt\Delta V}{dt} = i\Delta V$$

$$P = i\Delta V = i^2R = \frac{(\Delta V)^2}{dt}$$

The unit of power is the watt (W). and the energy is measured in kilowatt-hours (kW h).

5- The energy converted to thermal energy will be $E = Pt$. Because $P = I^2R$ and $P = V^2/R$,

6- The total energy to be converted to thermal energy can be written in the following ways.

Thermal Energy:

$E = P\,t$ $\qquad$ $E = I^2R\,t$ $\qquad$ $E = (\frac{V^2}{R})\,t$

Q) A 100-W light bulb is connected in series to a source of emf with V_{emf} = 100 V. When the light bulb is lit, the temperature of its tungsten filament is 2520 °C.

What is the resistance of the light bulb's tungsten filament at room temperature (20 °C)?

....

....

....

....

....**8.2Ω**

Q) A 39Ω resistor is connected across a 45V battery.

a. What is the current in the circuit?

....

....

b. How much energy is used by the resistor in 5.0 min?

....

....

Q) A 100.0W light bulb is 22 percent efficient. This means that 22 percent of the electric energy is converted to light energy.

a. How many joules does the light bulb convert into light each minute it is in operation?

....

....

b. How many joules of thermal energy does the light bulb produce each minute?

....