I'm not a robot

Electricity has become an essential part of our everyday life, changing the way we live and work. In the past, people depended on fire for light, warmth, and cooking. Today, we can easily turn on lights, heat our homes, and charge our devices with just a switch or button. This is all possible because of electric current the flow of electrical charge that powers many of the things we use daily. From small devices like toasters and mobile phones to large industries and transportation systems, electric current plays a key role in making everything work. Here, we will explore what electric current is, how it works, and why it is so important to our modern lives.Electric Current DefinitionElectric current is the flow of electric charge through a conductor, such as a wire. The SI Unit of electric current is the Ampere.Electric Current is the movement of electric charge, typically carried by electrons, through a conductor.It occurs when there is a difference in electrical potential (voltage) between two points, causing charges to move.Electric current is measured in amperes (A), which represents the amount of charge passing through a point in a conductor per second.There are two main types of electric current:Direct Current (DC): The flow of electric charge is in one constant direction.Alternating Current (AC): The flow of electric charge periodically reverses direction.Current flows through conductors, such as copper wires, due to the presence of free-moving electrons in the material.Electric current powers devices, appliances, and systems in homes, industries, and technology.The flow of current can be influenced by factors like resistance, temperature, and the material of the conductor.Read More:Alternating CurrentDC CurrentMaterials are classified as conductors and insulators based on their ability to conduct electricity:Conductor:A conductor is a material that allows electric charge to flow through it easily.Conductors have free electrons that can move easily, facilitating the flow of electric current.Common conductors include metals such as copper, aluminum, and silver.Properties of conductors:Low resistance to the flow of electric current.High electrical conductivity.Used in electrical wiring and circuits.Did You Know? The best conductor of electricity is Silver.Insulator:An insulator is a material that resists the flow of electric current.Insulators have very few free electrons, which makes it difficult for electric charges to move through them.Common insulators include rubber, plastic, wood, glass, and ceramics.Properties of insulators:High resistance to electric current.Low electrical conductivity.Used to protect or separate conductors to prevent electric shocks or short circuits.Unit of Electric CurrentAs Electric Charge and Time come under the Fundamental quantities and their units are respectively Coulomb and second. So by the definition of Electric Current, its unit is Coulomb/second.In the SI Unit of Electric Current is Ampere (A).In the CGS system, the unit of Electric Current is Biot or sometimes called an Abaampere.If 6.241 x 10^18 electrons flow through a conductor in one second, the electric current passing through it is defined as one ampere.The ampere (A) is the standard unit of electric current, commonly used in electrical and electronic technologies. To express smaller currents, units like milliampere (mA), which is 0.001 A, and microampere (A), which is 0.000001 A, are frequently used.Electric Current Formula,The electric current can be represented as the rate of flow of electric charge (q) which mathematically can be represented as follows:What Is Electromotive Force or EMF?Normally, in a conductor, Electrons are present, and they are not stationary, they keep on moving in random directions, and due to their randomness, the overall displacement of all electrons becomes zero, and hence, no current is produced. In order to produce current, some external force is required to align electrons in one direction and make them move in that one direction, this external force is known as Electromotive Force and is also famous as EMF. It is nothing but the voltage applied to produce current.Read more : Electromotive ForceConventional Current Flow Vs Electron FlowConventional Current FlowConventional current flow refers to the direction in which positive charge is considered to flow in an electrical circuit. By convention, current is assumed to flow from the positive terminal to the negative terminal of a power source, even though, in reality, electrons (which are negatively charged) flow in the opposite direction, from the negative terminal to the positive terminal.Electron FlowElectron flow refers to the actual movement of electrons in a conductor, which flows from the negative terminal to the positive terminal of a power source. Since electrons carry a negative charge, they are attracted to the positive terminal and repelled by the negative terminal, resulting in this direction of flow. Electron flow is the opposite of conventional current flow, which assumes positive charge flows from the positive to the negative terminal.Let us understand the differences between conventional current flow and electron flow:AspectConventional Current FlowElectron FlowDescriptionFlows from positive terminal to negative terminal.Flows from negative terminal to positive terminalDirection of CurrentAssume positive charge carriers are moving.Involves the movement of negative charged electrons.BasisCommonly used in circuit analysis and electrical engineeringUsed to describe the real behaviour of charges in the circuit.Charge MovementPositive charges are considered to move in the direction of currentNegatively charged electrons move in the direction of currentAccuracyHistorically used but not reflective of actual charge movementReflects the actual movement of charge in a circuitOhm's LawGerman physicist "Georg Simon Ohm" stated that the current flowing in a wire is directly proportional to the voltage drop across it. According to Ohm's Law, the current flowing through a wire is directly proportional to the voltage applied at the ends of the wire provided that the temperature and conductivity remain the same.V I Upon removing the proportionality sign, a proportionality constant is introduced known as Resistance:The relationship between voltage (V), current (I), and resistance (R) is expressed as:V = I RWhere,V is Voltage at the ends of conductorR is Resistance offered by the conductorI is Current through the wireOhm's Law can be illustrated using the following diagram:Try it now !Connect a resistor, ammeter, and voltmeter in a circuit. Vary the resistance and observe how the current changes, then explain the relationship between current and resistance using Ohms Law.Effects of Electric CurrentThere are different effects that can be noticed due to the flow of electric current in a wire, for example, when current passes through a resistor, the resistor has a property of resisting which does not let the whole current pass but since energy can neither be created nor destroyed, it is converted in heat energy and is released in the form of heat, this effect is called as the heating effect of current. Similarly, we have the magnetic and chemical effects of electric current.1. Chemical Effect of Electric CurrentWhen Electric current is passed through a which is conducting in nature, the solution breaks in its respective ions, and effects are seen visibly. The major effects that are prominent,The color of the solution may change.The deposition of metal at the electrodes may be seen.There can be the formation of gas bubbles at the electrodes.Read More: Chemical Effects of Electric CurrentElectroplating 2. Magnetic Effect of Electric CurrentElectric current is nothing but the motion of electrons, and it is known, when charges are stationary, they create Electric Field but when charges are in motion, they create a Magnetic field. When current is passed through a wire and a metallic sheet is placed there with a needle, the needle will be deflected due to the presence of a magnetic field which is produced by the electric current. One of the biggest applications of the Magnetic effect of electric current is Electromagnets, they are formed with the help of passing current.Read More: Magnetic field on the circular axis current carrying loop3. Heating Effect of Electric CurrentWhen current flows in a conductor, heat energy is produced and released from the conductor and the amount of effect depends upon the resistance offered by the conductor. If the conductor has to offer high resistance, it simply means that it will not allow most of the current to flow but due to the conservation of energy (energy can neither be created nor destroyed), current that could not pass is converted into heat and the phenomenon is known as the Heating effect of current. The formula for heat energy is given by,Where, H is Heat energy releasedI is current flowing in the conductorR is Resistance offered by the conductorT is Time for which the current was flowing in the conductorThe heating effect of electric current depends on several factors:Duration of current flow (time 't'): The longer the current flows through a conductor, the more heat is produced. So, the time the current is allowed to pass through the conductor plays a key role in heat generation.Resistance of the conductor: The higher the resistance of the material, the more heat is generated. This is because the resistance opposes the flow of current, converting electrical energy into heat.Amount of current: The greater the current flowing through the conductor, the more heat is generated. More charge carriers moving through the conductor result in more energy being dissipated as heat.Applications of the heating effect of current involve Electric Irons, Electric Heaters, filament lamps, Electric kettles, etc.Read More: Heating Effect of Electric CurrentSolved Examples of Electric CurrentThere are some solved examples of electric current for better understanding given below :Example 1: In a conductor, 10 Coulombs of charge flow for 5 seconds, determine the current produced.SolutionThe current in a circuit is given by,I = q/t I = 10/5 Amperes I = 2 AmperesTherefore, 2 amperes of current flows in the circuit.Example 2: In the circuit given below, Find the current flowing through the circuit.SolutionIn the figure provided, it is clear that there are two resistances, and they are in series.R = R1 + R2 R = 2+ 2 R = 4 ohmsFrom Ohms Law,V = IR I = V/R I = 20/4 I = 5 AmperesExample 3: What is the Heat energy produced when 2 amperes of current is flowing in a circuit for 5 seconds having an overall resistance in the circuit of 4 ohms?SolutionHeat Energy Produced is given by,H = I R t H = (2)24 5 H = 16 5 H = 80 JoulesTherefore, 80 Joules heat is produced in the circuit.Example 4:What is the heat energy produced when 3 amperes of current is flowing in a circuit for 10 seconds with an overall resistance of 6 ohms?SolutionThe formula to calculate heat energy is given by:H = I R tSubstitute the given values:I = 3 A, R = 6 , t = 10 s H = (3) 6 10 H = 9 6 10 H = 540 joulesThe heat energy produced is 540 joules.ConclusionElectric current refers to the movement of electric charge through an electrical circuit, representing the amount of electricity flowing. It is measured in amperes (A), and a higher value in amperes indicates a greater flow of electricity. The flow of current is essential for powering devices and systems. The direction of the current is typically considered from the positive to the negative terminal, although electrons move in the opposite direction. Electric current is defined as the rate of flow of negative charges of the conductor. For an electric current to occur, it has to be conducted through a material. When the flow of electrons provided by electricity finds a resistance, it results in a dissipation of energy in the form of heat. If there is an excessive amount of heat generated, the tissue may be burnt. Physiologically, the difference between a normal burn and a burn caused by electricity is that electricity has the ability to burn tissue beneath the skin, even burning internal organs without apparent external evidence of itThe contact with electric current can have various effects on the human body such as pain, burns or even death. There are many factors which affect the way the body interacts with current, such as the skin resistance, the voltage, the lenght of time of contact,theamount of electric current and its intensity. The body is extremely sensitive to the effects of electric current, thats why this scenario can lead to a variety of outcomes. Firstly it disrupts normal operation of our nervous and muscular systems. The other reason when current passes through your body, it is transformed into thermal energy. This can cause serious burns, both inside your body and on your skin.Currents of about 10 mA can cause a very painful shock. The longer the current continues to pass through you, the worse it gets. More heat is generated and the damage to your body increases, so the inability to let go can cause some serious problems. Currents above about 100 mA are almost always fatal unless immediate medical attention is provided.The amount of current passing through a human body depends on two things:the voltage supplied by the sourceandthe electrical resistance of your body. The amount of electric current that flows through the body determines various effects of an electric shock. Most current-related effects result from heating of tissues and stimulation of muscles and nerves. Electrocution[edit | edit source]Electrocution or so called electric shock occurs when current passes through the human body. The real measure of electrocution intensity is directly related to the amount of current (Ohms law),in amperes, that passes through the body, and not to the voltage. Resistance also plays a very important role on the amount of energy that passes through the body. Depending on the body resistance, wet (500)or dry (1000) and point of contacts we have very different effects for the same current. Voltage and electroporation[edit | edit source]Voltage, also known as electric tension si defined as the force that pushes electric current through the body. The curren flows for any given voltage depending on the resistace. It is the current that determines physiological effects.Electroporation (cell membrane damage) is due to the application of a large voltage across a length of tissue. The major problem with electroporation is substantial cell death caused by high voltage pulses and only limited membrane repair. It is the reason why even atiny contact with curent can lead to deep tissue injuries.General effects of electric current[edit | edit source]The general effects of electric current differ for man, woman and child. For the same amount of current, women generally have worse symptoms then men. In the case of child or babies normally there is a distinct dark mark, similar to a burn on the lips, once that in the first years of life babies use the mouth to discover the world around them.Electric current (contact for 1s)EffectBelow 1 mANot perceptible1 mAThreshold of feeling, tingling5 mASlight shock. Not painful. Average individual can let go. Involuntary reaction can lead to indirect injuries6-25 mA (women)Painful shocks. Loss of muscle control9 to 30 mA (men)Freezing current, "can't let go". The person may be thrown away from the power source. Individual cannot let go. Strong involuntary reaction can lead to involuntary injuries50 to 150 mAExtreme pain. Respiratory arrest. Muscles reactions. Possible Death.1 to 4.3 AFibrillation of the heart. Muscular contraction and nerve damage occur. Likely death.10 ACardiac arrest, severe burns. Death is probableElectricity in the Nervous System[edit | edit source]One of the most significant physiological effects of electricity regards the nervous system. Electricity can affect all the network of nerve cells and neurons which process and conduct the signals responsible for the regulation of our body functions. The sensory and motor organs of our body such as the brain and the spinal cord work together to allow it to move, answer, think, sense and remember.Nerve cells communicate by creating electrical signals with very small voltages. If electric current of sufficient magnitude passes through the living tissues, its effect will be override the natural impulses of the neurons, overloading the nervous system and blocking the passage of voluntary impulses that activate in the muscles. The muscles will then involuntarily contract (tetany).Different effects of AC and DC[edit | edit source]The effects of AC (alternating current) depends largely on frequency, low frequency tends to be much more dangerous than high frequency. AC with the same amperage and voltage as DC is more dangerous and provoke worse effects on the human body. Low frequency AC provokes muscle contraction (tetany) which can induce the "cannot let go" effect by freezing the muscles of the hand. This happens because the flexors of the hand are stronger than the extensors, so when an external electrical stimulation is applied, the flexors outdo the extensors. AC has a more of a tendency to induce heart fibrillation while DC makes the heart stop. That is why defibrillation equipment is DC, which stops the heart and gives a chance to recover.Skin resistance[edit | edit source]Resistance is measured in ohms.The human body has is own resistance to electric current, 99% os this resistance is at the skin. As referred anteriorly dry and wet skin have much different values of resistance but are not the only aspect to have in account in electrocution. Cuts and deep abrasions of the skin contribute to a significant decrease on the skin resistance. Skin act as a capacitor and permits more current to flow if a voltage is changing rapidly. The internal body resistance is about 300 , being related to the wet, relatively salty tissues beneath the skin. Skin breaks down from 500 V onwards which results has a decrease of the body's resistance that can mean a bigger amount of current entering the body, damaging the nerves and muscles. This is one of the reasons why sometimes there isn't significant damage of the skin but a significant deep tissue injury.Injuries caused by electricity[edit | edit source]Electric shock is aphysical effect and aviolent response to the electrical current, that enters the body.After an encounter with the electric current, there are primary electrical injuries, which indicate tissue damage. Electric current is able to create severe burns in the body. The reason is hidden in the power dissipation across the bodys electrical resistance.Shock can cause: cardiac arrest, burns to tissues and organs, muscle spasms, serious effects to the nervous system and other unexpected consequenses. Other disorders can appear in the weeks or months following the shock, depending on which organs the current passed through.Another note to pay attention to, is diffents effects of alternating current and direct one. As to the alternating current, it depends mainly on the frequency, in fact the low frequency alternating current is more dangerous than the high-frequency alternating and direct current of the same voltage.The low frequency alternating current produces extended muscle contraction-tetanus. Tetanusis the condition where muscles involuntarily contract due to the passage of external electric current through the body. When involuntary contraction of muscles controlling the fingers causes a victim to be unable to let go of an energized conductor, the victim is said to befrozen on the circuit..Direct current is most likely to cause a single convulsive contraction, which often forces the victim away from the currents source.Direct current (DC) is more likely to cause muscle tetanus than alternating current (AC), making DC more likely to freeze a victim in a shock scenario. However, AC is more likely to cause a victims heart to fibrillate, which is a more dangerous condition for the victim after the shocking current has been halted. Internal organs are mainly affected by electrical burns. The burns of this kind may appear slightly or they doesnt show on the skin at all. They are caused by the heat generated from the bodys resistance to the current passing through it. These cases are more dangerous than external injuries.Internal burns are devastating and often have serious consequences: scarring, amputation, loss of function, loss of sensation and even death. For example, if a lot of tissue is destroyed, the large amount of waste generated can cause serious kidney or blood circulation disorders.Cardiac effects are among the most serious and among the most common electrical injuries. The issue is that the heart's central anatomical location in the chest and it is more commonly affected than other internal organs because the electric current usually follows the path of least resistance in the body along blood vessels and nerves, directing the current towards the heart. Arrhytmias: Exposure to high voltage current is more likely to cause cardiac asystole, but even low voltage alternating current ca cause cardiac arrest by ventricular fibrilation.The mechanism behind induced cardiac arrhytmias is predicted to be initial damage to heart muscle and subsequent scar formation leading to abnormal elecrical activation of the heart.Bradycardia: Injuries can result from interference with the normal conduction system The sino-atrial and atrio-ventricular nodes responsible for impulse generation and propagation within the heart may be more susceptible to damage by electrical injury than other cardiac cells.Heart muscle injury: Chest pain may be absent and injury may manifest only as non-specific electrocardiograpjic changes, increased levels of myocardial proteins in the blood-troponin from damaged tissue. Occasionaly, mostly after high voltage accidents, myocardial infarction can be caused by occlusion of coronary arteries by blood clots or spasm.The Blood Vessels: The walls of blood vessels through which a current has passed long enough to cause necrotic change become brittle and friable. The inner endothelial lining of the vessel undergoes changes and parietal thrombi are attached to the intima. Neurological: Damage to nerve tissue may cause loss of consciousness, impaired recall, spinal cord injury, paralysis, or loss of sensationes in limbs. Deep burns of skin, muscle and bone tissue caused by high voltage.Electricity may pass through the spinal cord transversely, obliquely or longitudinally, resulting in many different cord syndromes. Permanent defects may remain, of which syndromes from loss of anterior horn cells are common. Peripheral nerves likewise may be transiently paralyzed or more perrmanently damaged by heat-effects from passage of current or by outright burns. Neurophsychological problems are often underappreciated, but post-traumatic stress disorder, depression and chronic neuropathic pain have been reported.The eye: The changes observed on the eyes are usually late complications of electrical injuries. Musculoskeletal system:In some cases the electric arc burns a deep hole in the bone, and the meninges and the brain, too, may be affected, in other cases of less severe types of accidents, the bone is often exposed by the destruction of the soft tissues. Bone fractures and luxations. Direct muscle damage and also compartment syndrome.Links[edit | edit source]Related articles[edit | edit source]External links[edit | edit source] | edit source] DSA to Development: A Complete GuideBeginner to AdvanceJAVA Backend Development - LiveIntermediate and AdvanceTech Interview 101 - From DSA to System Design for Working ProfessionalsBeginner to AdvanceFull Stack Development with React & Node JS - LiveBeginner to AdvanceJava Programming Online Course [Complete Beginner to Advanced]Beginner to AdvanceC++ Programming Course Online - Complete Beginner to AdvancedBeginner to AdvancePage 2Our website uses cookiesWe use cookies to ensure you have the best browsing experience on our website. By using our site, you acknowledge that you have read and understood our Cookie Policy & Privacy Policy Additional Information about Current Electricity for NEET Preparation Importance of Current Electricity NEET: Understanding Current Electricity is crucial for NEET exam success. 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Boost your preparation with paper analysis and best books recommended by toppers. Access study material, notes, and sample papers for thorough revision. Stay updated with the exam date and official website for important announcements. Practice with mock tests and videos to enhance your understanding. Achieve success in NEET with this reliable study resource, brought to you exclusively by EduRev. Electric current is defined as the amount of charge flowing through a specific area per unit time.It is the rate at which electric charges flow.When a net charge Q, flows across any cross-section of a conductor in time t, then the current I, through the cross-section is - I = \[\frac{Q}{t} \] .We know that, The SI unit of electric charge is the coulomb (c), which is equivalent to the charge contained in nearly: 6 x 1018 electronsAn ampere is a unit of measurement for electric current (A).One ampere is the flow of one coulomb of charge per second that is, 1A = 1C/1s.Types of Electric Current:Direct Current (DC): In DC, all the electrons move in the same direction, in all the time that the electricity flows. Example: Current produced by the batteries in torches.Alternating Current (AC): In AC, the direction of the motion of electron changes with time. Example: Power supply in house.Electric Potential and Potential DifferenceThe amount of work required to move a unit charge from a reference point to a specific point in an electric field is known as electric potential. The reference point is usually Earth, but any point outside of the electric field charge's influence can be used.The work done to move a unit charge from one point to the other is the electric potential difference between two points in an electric circuit carrying some current. Potential difference (V) between two points = \[\frac{Work \ done (W) }{Charge} \] $\text{V} = \frac{W}{Q}$We know that, The SI unit of electric potential difference is volt (V), named after Alessandro Volta (17451827), an Italian physicist.A volt is the potential difference between two points in a current-carrying conductor when one joule of work is performed to move a charge of one coulomb from one point to the other.The potential difference is measured using a device known as a voltmeter.The voltmeter is always connected in parallel across the points to be measured for potential difference.Electric Currents in ConductorsSome electrons in other materials, particularly metals, are practically free to move within the bulk material.When an electric field is applied to these materials, which are commonly referred to as conductors, they generate electric currents.In Solid Conductors:In the absence of an electric field, the number of electrons travelling in any direction is equal to the number of electrons travelling in the opposite direction. As a result, there will be no net electrical current.When an electric field is applied, an electric field is created that is directed from the positive to the negative charge.As long as the electrons are moving, they will form an electric current.Current Density:Current density is a vector quantity defined as the current per unit area through an infinitesimal area normal to the direction of current flow.Drift Velocity:When an electric field is applied in a conductor, a force acts on each electron in the direction opposite to that of the field. The electrons start random motion. As a result, the electrons drift slowly in that direction.Drift velocity, $v = \dfrac{{Ee\tau }}{{2m}}$: average time interval between two successive collisionsE : electric fielde : charge on an electronm : the mass of an electron.Therefore,Current, $i = nAve$Current density, $j = \dfrac{i}{A} = nve$Ohms Law:If the physical conditions of conductor (temperature, length etc.) remain constant, then the current in the conductor is directly proportional to the potential difference across the conductor.Consider a conductor through which current I flow, and let V be the potential difference between the conductor's ends. According to Ohm's law : \[V\propto I\]Or, \[V\text{ }=\text{ }R\text{ }I;\]Here the constant of proportionality R is called the resistance of the conductor. The SI units of resistance is ohm, and is denoted by the symbol .The Resistance of the Conductor Depends-The resistance of the conductor depends upon the temperature of the conductor.The resistance of the conductor depends upon the cross-sectional area of the conductor.The resistance of the conductor depends upon the length of the conductor.The resistance of the conductor depends upon the nature of the material of the conductor.We know that, Electrical resistance is directly proportional to the length (L) of the conductor and inversely proportional to the cross-sectional area (A).$\text{R}=\rho l/\text{A}$, Here $\rho $ is the resistivity of the material (measured in Ωm, ohm meter)Resistivity is a qualitative measurement of a material's ability to resist flowing electric current. Obviously, insulators will have a higher value of resistivity than of conductors.Limitations of Ohms LawOhm's law does not apply to unilateral electrical elements such as diodes and transistors because they only allow current to flow in one direction.Voltage and current will not be constant with respect to time for non-linear electrical elements with parameters such as capacitance, resistance, and so on, making Ohm's law difficult to apply.Ohmic and non-ohmic Conductor:When the current or voltage is reversed, the magnitude of the current remains constant. The voltage determines the current. Current and resistance are affected by temperature.When the current or voltage is reversed, the magnitude of the current remains change. The voltage has no effect on the current. Light and temperature are two of the many factors that influence it. Ohmic and Non-Ohmic ConductorThe Electrical Resistivity of a Material:Electrical resistivity is a feature that is unique to each material and must be understood before developing and building electrical and electronic systems. Understanding how materials differ in resistivity allows for the selection of acceptable materials for motors, electrical circuits, dielectrics, resistive heating, and superconducting applications.The resistance of a uniform metallic conductor is proportional to its length (l) and inversely proportional to its cross-sectional area (A).That is,$R\propto l$ and$\text{R}\propto \dfrac{1}{A}$Combining both, we get$\text{R}\propto \dfrac{l}{A}$$\text{or, R}=\rho \dfrac{l}{A}$.Here (rho) is a constant of proportionality and is called the electrical resistivity of the material of the conductor.The SI unit of resistivity is m.It is a distinguishing feature of the material.Variation of Resistance with Temperature:The resistance of any material is proportional to its resistivity, which varies with temperature. Therefore, resistance also varies with temperature.A material's resistivity is discovered to be temperature dependent.An alloy's resistivity is generally greater than that of its constituent metals. At high temperatures, alloys do not oxidise (burn).As a result, they are commonly used in electrical heating devices such as electric irons and toasters.Tungsten is almost exclusively used for electric bulb filaments, whereas copper and aluminium are commonly used for electrical transmission lines.Some materials, such as Chrome (a nickel, iron, and chromium alloy), have a very weak temperature dependence of resistivity.${R_t} = {R_0}(1 + \alpha t + \beta {t^2})$, where t is the temperatureFor small temperature, ${R_t} = {R_0}(1 + \alpha t)$Combination of Resistances:Series Combination: $R = {R_1} + {R_2}$Parallel Combination: $\dfrac{1}{R} = \dfrac{1}{{{R_1}}} + \dfrac{1}{{{R_2}}}$Two Major Types of Resistors:Wire bound resistors: These are created by winding wires of an alloy, such as manganic, constantan, chrome, or a similar alloy.The selection of these materials is primarily influenced by the fact that their resistivity are relatively insensitive to temperature.These resistances are typically in the range of a few hundred ohms to a fraction of an ohm.Carbon Resistors:The majority of resistors in the higher range are made of carbon. Carbon resistors are small and inexpensive, so they are widely used in electronic circuits.Because carbon resistors are small in size, their values are represented by a color code.Resistors Colour Code:Many years ago, an international and globally acknowledged resistor colour code scheme was devised as a simple and rapid manner of identifying a resistor's ohmic value regardless of size or condition. It is made up of a series of distinct coloured rings or bands that are arranged in spectral order to represent each digit of the resistor's value.The resistor colour code marks are always read one band at a time, from left to right, with the bigger width tolerance band oriented to the right side to indicate its tolerance. The first digit of the resistance value is recognised by matching the colour of the first band with its associated number in the digit column of the colour chart below.Again, we get the second digit of the resistance value by matching the colour of the second band with its related number in the digit column of the colour chart, and so on. The resistor colour coding is then read from left to right, as seen below: Color CodeThe Resistor Colour Code Table:ColourDigitMultiplierToleranceBlack01Brown110$\pm 1 \%$Red2100$\pm 2 \%$Orange31000Yellow410,000Green5100,000$\pm 0.5 \%$Blue61,000,000$\pm 0.25 \%$Violet710,000,000$\pm 0.1 \%$Grey8$\pm 0.05 \%$White9Gold0.1$\pm 5 \%$Silver0.01$\pm 10 \%$None$\pm 20 \%$Relation of Current and Drift VelocityWhen an electric field is applied, the path of an electron inside a conductor becomes curved (parabolic) instead of straight lines due to electric force, and electrons drift opposite to the field.As a result of this drift, electrons' random motion is altered, and there is a net transfer of electrons across a cross-section, resulting in current.Drift velocity is the average uniform velocity attained by free electrons inside a metal as a result of the application of an electric field that drives current through it.Electrical Energy and PowerElectric power is the rate at which electric energy is dissipated or consumed in an electric circuit. P's power is given by$P=VI$Or $P={{I}^{2}}R={{V}^{2}}/R$The watt is the SI unit of electric power (W).It is the amount of power consumed by a device carrying 1 A of current when operated at a potential difference of 1 V. Thus,$1~\text{W}=1$ Volt $\times 1$ ampere $=1\text{VA}$The commercial unit of electric energy is kilowatt-hour (kW h), commonly known as unitCells In Series and In ParallelCell: A cell is a device that generates electricity by utilizing chemical energy.A cell consists of two electrodes, known as the positive (P) and negative (N), which is immersed in an electrolytic solution where the electrodes exchange charges with the electrolyte.Current flows from cathode to anode via an external circuit;Current flows from anode to cathode via the electrolyte.EMF (Electromotive force):It is defined as the potential difference between electrodes when there is no current in the cell.Emf of the cell initiates the flow of current in the cell.Internal Resistance:It is the resistance provided by the electrolyte and electrodes as current flows. It is represented by the letter 'r.'Cells in SeriesA series combination occurs when multiple cells are arranged in such a way that the positive terminal of one cell is connected to the negative terminal of the next cell, and so on.For two cells of emf's \[{{E}_{1}}\text{ }and\text{ }{{E}_{2}}\] connected in series with \[{{r}_{1}},\text{ }{{r}_{2}}\] as their internal resistances, E equivalent $={{E}_{1}}+{{E}_{2}}$Equivalent $={{r}_{1}} + {{r}_{2}}$The equivalent emf of a series combination of n cells is simply the sum of their individual emf's, and the equivalent internal resistance of a series combination of n cells is simply the sum of their internal resistances.Cells in ParallelParallel combination occurs when cells are arranged in such a way that the positive terminals of all cells are connected together and the negative terminals of all cells are connected together.For two cells of emf's \[{{E}_{1}}\text{ }and\text{ }{{E}_{2}}\] connected in parallel with \[{{r}_{1}},\text{ }{{r}_{2}}\] as their internal resistances, the formula is given as:\[\frac{1}{r} \] equivalent = \[\frac{1}{{r}_{1}} + \frac{1}{{r}_{2}} \]E equivalent/req = \[\frac{{E}_{1}}{{r}_{1}} + \frac{{E}_{2}}{{r}_{2}} \]Important Note:-Cells are connected in series to increase voltage;Cells are connected in parallel to increase current.PotentiometerIt is essentially a long piece of uniform wire, sometimes several metres long, across which a standard cell is connected.A variable resistance (rheostat, R) in the circuit controls the current I that flows through the wire.Because the wire is uniform, the potential difference between A and any point l from A is$E(1)=\Phi l$Here $\Phi $ is the potential drop per unit length.An application of the potentiometer is to compare the emf of two cells of emf ${{\varepsilon }_{1}}$ and ${{\varepsilon }_{2}}$ which is given by the equation:$\dfrac{{{\text{E}}_{1}}}{{{\text{E}}_{2}}}=\dfrac{{{l}_{1}}}{{{l}_{2}}}$The potentiometer has the advantage of drawing no current from the voltage source under test.A potentiometer is also used to measure a cell's internal resistance.Kirchhoff's Law:First Law: The algebraic sum of currents at any junction is equal to zero.Second Law: The algebraic sum of potential drop across all circuit elements in a closed loop is equal to zero.Wheatstone Bridge:It is a special type of network of resistances, commonly used for comparing resistances. It is used to find unknown resistance in terms of three known resistances. It consists of five resistances, of which four resistances are connected in the form of a bridge. Wheatstone BridgeFor balanced bridge, no current flows through the galvanometer.PS = RQIf the positions of battery and the galvanometer are interchanged, then there will still be no deflection in the galvanometer.Heating Effect of Current:When an electric current is passed through a conductor, the conductor becomes hot after some time and produce heat. This happens due to the conversion of some electric energy passing through the conductor into heat energy. This effect of electric current is called heating effect of current.The heating effect of current was studied experimentally by Joule (called Joules law) According to the law, the heat produced (H) in a conductor is directly proportional to the product of square of current (i), resistance of the conductor (R) and the time (t) for which current is passed. Thus,$H = {i^2}Rt$Electrical Energy and Power: The work done in pushing a charge round an electrical circuit is given by work done = VitSo that power, $P = Vi$Conductor:A conductor is a substance that easily allows electric charges to pass through it.A conductor has a very low resistance to the flow of current, such as copper, silver, or aluminum.InsulatorAn infinitely high resistance substance that does not allow electric current to flow through it.It is referred to as an insulator.For example, rubber, glass, plastic, Ebonite, and so on.Coulombs Law:Coulomb's law states that the attraction or repulsion force between two charged bodies is proportional to the product of their charges and inversely proportional to the square of their distance. It has an effect along the line that connects the two point charges.Coulomb's Law Formula:$F=\dfrac{1}{4\pi {{\varepsilon }_{0}}}{{\varepsilon }_{r}}}\cdot \dfrac{{{\text{q}}_{1}}{{q}_{2}}}{{{d}^{2}}}=\dfrac{1}{4\pi {{\varepsilon }_{0}}K}\cdot \dfrac{{{\text{q}}_{1}}{{q}_{2}}}{{{d}^{2}}}$$F=\dfrac{1}{4\pi \varepsilon }\cdot \dfrac{{{\text{q}}_{1}}{{q}_{2}}}{{{d}^{2}}}$Here,$\varepsilon $ is absolute permittivity, K or ${{\varepsilon }_{\text{r}}}$ is the relative permittivity or specific inductive capacity, ${{\varepsilon }_{0}}$ is the permittivity of free space, K or ${{\varepsilon }_{r}}$ is also called a dielectric constant of the medium in which the two charges are placed.Important Formulae:Current I\[\text{I} = \frac{Q}{t}\]Q = Charge$\text{t}=$ time takenVoltage VV = \[\frac{E}{Q}\]orV = \[\frac{W}{Q}\]E = Energy, W = Work doneResistance R$\text{R}=\rho l/\text{A}$$\rho =$ Resistivity,I = length,A = Areaor,R = \[\frac{V}{I}\]Power P$P=VI$Conductivity $\sigma $$\sigma = \dfrac{1}{\rho }$Drift velocity$v = \dfrac{{Ee\tau }}{{2m}}$Current density$j = \dfrac{i}{A} = nve$Series Combination of Resistance$R = {R_1} + {R_2}$Parallel Combination of Resistances$\dfrac{1}{R} = \dfrac{1}{{{R_1}}} + \dfrac{1}{{{R_2}}}$ExamplesExample 1:Two identical non-conducting solid spheres of same mass and charge are suspended in air from a common point by two non-conducting, massless strings of same length. At equilibrium, the angle between the strings is α. The spheres are now immersed in a dielectric liquid of density $800 \mathrm{~kg} \mathrm{~m}$ and dielectric constant $21 .$ If the angle between the strings remains the same after the immersion, then(A) electric force between the spheres remains unchanged(B) electric force between the spheres reduces(C) mass density of the spheres is $840 \mathrm{~kg} \mathrm{~m}^{3}$(D) the tension in the strings holding the spheres remains unchangedAnswer: A, BHint: The attractive attraction between electrons and the nucleus is known as electric force. Now, a positive or negative charge forms a field in the empty space around it, which we call an electric field.Complete solution: In air, During air$\mathrm{T} \cos \theta=\mathrm{mg} \ldots . \text { (i) }$$\mathrm{T} \sin \theta=\mathrm{qE} \ldots .$ (ii)$\mathrm{qE}=\mathrm{mg} \tan \theta \ldots . (\text { iii) }$In liquid, During Liquid$\mathrm{T}^{\prime} \cos \theta=\mathrm{mg}-\mathrm{U}$$\mathrm{T}^{\prime} \cos \theta=\mathrm{mg}-\rho \mathrm{vg} \ldots . . \text { (iv) }$$\mathrm{T}^{\prime} \sin \theta=\dfrac{q E}{K} \ldots \ldots(\mathrm{v})$Dividing Eq. (v) by Eq. (ii), we get$\dfrac{T^{\prime}}{T}=\dfrac{1}{K} \Rightarrow T^{\prime}=\dfrac{T}{K}=\dfrac{T}{21} \ldots \ldots$Dividing Eq. (iv) by Eq. (v), we get$\dfrac{q E}{K}=(\mathrm{mg}-\rho \mathrm{vg}) \tan \theta$$q E=\mathrm{K}(\mathrm{mg}-\rho \mathrm{vg}) \tan \theta \ldots . . \text { (vii) }$From Eqs. (vii) and (iii), we get$\mathrm{mg} \tan \theta=\mathrm{K}(\mathrm{mg}-\rho \mathrm{vg}) \tan \theta$$\Rightarrow \mathrm{m}=\mathrm{K}(\mathrm{m}-\rho \mathrm{v})$$\Rightarrow d v=K(d v-\rho v)$$\Rightarrow \mathrm{d}=\mathrm{Kd}-\mathrm{K} \rho$$\Rightarrow d=21 d-21 \rho[\because K=21]$$\Rightarrow 20 \mathrm{~d}=21 \rho$$\Rightarrow 20 \mathrm{~d}=21 \times 800$$\Rightarrow d=840 \mathrm{~kg} / \mathrm{m}^{3}$Example 2:A capacitor is connected to a $20 \mathrm{~V}$ battery through a resistance of 10Ω. It is found that the potential difference across the capacitor rises to $2 \mathrm{~V}$ in 1μ s. The capacitance of the capacitor is _____$\mu \mathrm{F}$. Given : $\ln \left(\dfrac{10}{9}\right)=0.105$(A) 9.52(B) 0.95(c) 0.105(D) 1.85Answer: BHint: A capacitor is a device used in electrical circuits to store charges. A capacitor operates on the idea that when an earthed conductor is moved close to a conductor, its capacitance increases noticeably. As a result, a capacitor has two plates with equal and opposite charges separated by a distance.Complete solution: Given, the peak voltage of the battery, $V_{0}=20 \mathrm{~V}$The voltage of the battery, $V=2 \mathrm{~V}$Time, $\mathrm{t}=1 \mu \mathrm{s}=1 \times 10^{-6} \mathrm{~s}$Resistance of the capacitor, $R=10 \Omega$As we know that,$V=V_{0}\left(1-e^{-t / R C}\right)$Substituting the values in the above equation, we get$2=20\left(1-\mathrm{e}^{-\mathrm{t} / \mathrm{RC}}\right)$$\Rightarrow \dfrac{t}{R