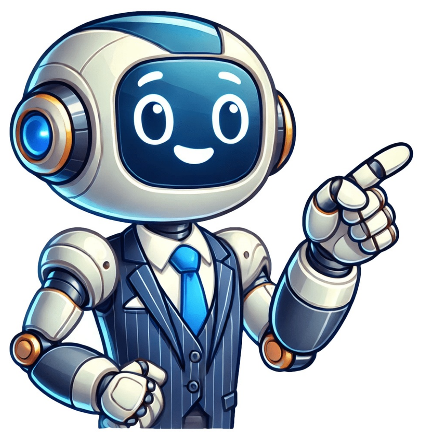

Electricity - What is it?Electricity is a form of energy that is transmitted through copper conductor wire to give power to the operation of electrical machines and devices such as industrial, commercial, institutional and residential lighting, electric motors, electrical transformers, communications networks, home appliances, electronics, etc.When charged particles flow through the conductor, we call it "current electricity". This is because when the charged particles flow through wires, electricity also flows. We know that current means the flow of anything in a particular direction. For example, the flow of water. In the similar way, the flow of electricity in a certain direction is called current electricity or electric current.What is magnetism?Magnetism is a type of attractive or repulsive force that acts up to certain distance at the speed of light. The distance up to which this attractive or repulsive force acts is called a "magnetic field". Magnetism is caused by the moving electric charges (especially electrons). When two magnetic materials are placed close to each other, they experience an attractive or repulsive force.What is the relationship between electricity and magnetism?In the early days scientists believed that, thet weretwo uniquely, separate forces. However, James Clerk Maxwell proved these two separate were actually interrelated forces.In 1820, Hans Christian Orsted observed a surprising thing, when he switched on the battery from which the electric current is flowing, the compass needle moved away from the point north. After this experiment, he concluded that, the electric current flowing through the wire produces a magnetic field.Electricity and magnetism are related closely to each other. The electric current flowing through the wire produces a circular magnetic field outside the wire. The direction (clockwise or counter-clock wise) of this magnetic field is depends on the direction of the electric current.In the similar way, a changing magnetic field produces an electric current in a wire or conductor. The relationship between them is called electromagnetism.Electricity and magnetism is an interesting aspect of electricity sciences. We are familiar with in our everyday lives with the phenomenon of static cling - when two objects, such as a piece of Saran wrap and a wool sweater, are rubbed together, they cling.One feature of this that we don't encounter too often is static "repulsion" - if each piece of Saran wrap is rubbed on the wool sweater, then the pieces of Saran wrap will repel when brought near each other. These phenomena are interpreted in terms of the objects acquiring anelectric charge, which has the following features:There are two types of charge, which by convention are labelledpositiveandnegative.Like charges repel, and unlike charges attract.All objects may have a charge equal to an integral number of a basic unit of charge.Charge is never created or destroyed.Electric FieldsA convenient concept for describing these electric current and magnetic current forces is that ofelectric fieldscurrents. Imagine that we have a fixed distribution of charges, such as on the plate below, and bring in the vicinity of this distribution atest chargeQ.Fig. 1Test charge in the presence of a fixed charge distributionThis charge will experience a force due to the presence of the other charges. One defines the electric field of the charge distribution as:The electric field is a property of this fixed charge distribution; the force on a different chargeQ'at the same point would be given by the product of the chargeQ'and thesameelectric field. Note that the electric field atQis always in the same direction as the electric force.Because the force on a charge depends on the magnitude of the charges involved and on the distances separating the charges, the electric field varies from point to point, both in magnitude and direction.By convention, the direction of the electric field at a point is the direction of the force on apositivetest charge placed at that point. An example of the electric field due to a positive point charge is given below.Fig. 2:Electric field lines of a positive chargePower and Magnetic FieldsA phenomenon apparently unrelated to power are electrical magnetic fields. We are familiar with these forces through the interaction of compasses with the earth's magnetic field, or through fridge magnets or magnets on children's toys. Magnetic forces are explained in terms very similar to those used for electric forces:There are two types ofmagnetic poles, conventionally called North and SouthLike poles repel, and opposite poles attractHowever, this attraction differs from electric power in one important aspect:Unlike electric charges, magnetic poles always occur in North-South pairs; there are nomagnetic monopoles.Later on we will see at the atomic level why this is so.As in the case of electric charges, it is convenient to introduce the concept of amagnetic fieldin describing the action of magnetic forces. Magnetic field lines for a bar magnet are pictured below.Fig. 3:Magnetic field lines of a bar magnetOne can interpret these lines as indicating the direction that a compass needle will point if placed at that position.The strength of magnetic fields is measured in units ofTeslas(T). One tesla is actually a relatively strong field - the earth's magnetic field is of the order of 0.0001 T.Magnetic Forces On Moving ChargesOne basic feature is that, in the vicinity of a magnetic field, amovingcharge will experience a force. Interestingly, the force on the charged particle is always perpendicular to the direction it is moving. Thus magnetic forces cause charged particles to change their direction of motion, but they do not change thespeedof the particle.This property is used in high-energy particle accelerators to focus beams of particles which eventually collide with targets to produce new particles in gamma rays and radio waves.Another way to understand these electricity and magnetism forces is to realize that if the force is perpendicular to the motion, then no work is done. Hence these forces do no work on charged particles and cannot increase their kinetic energy.If a charged particle moves through a constant magnetic field, its speed stays the same, but its direction is constantly changing. A device in which this property is used is themass spectrometer, which is used to identify elements. A basic mass spectrometer is pictured below.Figure 4:Mass spectrometerIn this device a beam of charged particles (ions) enter a region of a magnetic field, where they experience a force and are bent in a circular path. The amount of bending depends on the mass (and charge) of the particle, and by measuring this amount one can infer they type of particle that is present by comparing to the bending of known elements.Magnet Power From Electric PowerA connection was discovered (accidentally) by Orsted over 100 years ago, who noticed that a compass needle is deflected when brought into the vicinity of a current carrying wire. Thus, currents induce in their vicinity magnetic fields. Anelectromagnetis simply a coil of wires which, when a current is passed through, generate a magnetic field, as below.Figure 5:ElectromagnetAnother example isin an atom, since an electron is a charge which moves about the nucleus, in effect it forms a current loop, and hence a magnetic field may be associated with an individual atom. It is this basic property which is believed to be the origin of the magnetic properties of various types of materials found in nature.Maxwell equations (otherwise known as maxwell theory) are a set of coupled partial differentialequationsthat, together with the Lorentz force law, form the foundation of classical electromagnetism which deal withelectromagnetic radiation,electromagnetic waves andelectromagnetic force. Physics>> Magnetism >> Relation between electricity and magnetism Electricity is a form of energy that is transmitted through the wires (especially copper wires) for operating the various machines and devices such as lights, fans, refrigerator, computers, television, air conditioner, washing machines, etc. Electricity is the property of charged particles such as electrons and protons. When these particles are at rest, it is called static electricity. Static electricity occurs due to the existence of charged particles. On the other hand, when charged particles flow through the conductor, it is called current electricity. Because, when the charged particles flow through the conductor, electricity also flows. We know that current means the flow of anything in a particular direction. For example, the flow of water in a particular direction is called water current. In the similar way, the flow of electricity or charged particles (especially free electrons) in a particular direction is called current electricity or electric current. What is magnetism? Magnetism is a type of attractive or repulsive force that acts up to certain distance. The distance up to which this attractive or repulsive force acts is called magnetic field. Magnetism is caused by the moving electric charges (especially electrons). When two magnetic materials are placed close to each other, they experience an attractive or repulsive force. We know that all the objects in the universe are made of small particles called atoms. The atoms consist of sub atomic particles such as electrons, protons, and neutrons. The strong nuclear force between the protons and neutrons makes them stick together to form nucleus. The electrons present in the atom revolve around the nucleus because of the electrostatic force of attraction between the electrons and nucleus. The electrons revolving around the nucleus also rotates or spins around its own axis. Because of this spinning of electrons, magnetic field is produced. If the majority number of electrons in the atom spins in the same direction, a strong magnetic field is produced. The direction of the electrons spin determines the direction of magnetic field. On the other hand, if the equal number of electrons in the atom spins in the opposite direction, the spinning speed of the electrons cancels out. Thus, the magnetism also cancels out. Relationship between electricity and magnetism In the early days scientists believed that, electricity and magnetism are two separate forces. However, after the publication of James Clerk Maxwell, these forces are treated as interrelated forces. In 1820, Hans Christian Orsted observed a surprising thing, when he switched on the battery from which the electric current is flowing, the compass needle moved away from the point north. After this experiment, he concluded that, the electric current flowing through the wire produces a magnetic field. Electricity and magnetism are closely related to each other. The electric current flowing through the wire produces a circular magnetic field outside the wire. The direction (clockwise or counter-clock wise) of this magnetic field is depends on the direction of the electric current. In the similar way, a changing magnetic field produces an electric current in a wire or conductor. The relationship between electricity and magnetism is called electromagnetism. Magnetism and electricity involve the attraction and repulsion between charged particles and the forces exerted by these charges. The interaction between magnetism and electricity is called electromagnetism. The movement of a magnet can generate electricity. The flow of electricity can generate a magnetic field. Magnetism causes a compass needle to point north, unless it is in the presence of a different magnetic field. In 1820, Hans Christian Oersted observed that a compass needle did not point north when he held it near an electric current flowing through a wire. After further experimentation, he concluded that the electric current in the wire produced a magnetic field. Electric current flowing through a single loop of wire does not generate a very powerful magnetic field. A coil of wire looped many times makes a stronger magnetic field. Placing an iron bar inside the coil of wire makes an electromagnet which is hundreds of times stronger than the coil alone. When an electric current flows through a loop or coil of wire, placed between the two poles of an electromagnet, the electromagnet exerts a magnetic force on the wire and causes it to rotate. The rotation of the wire starts the motor. As the wire rotates, the electric current changes directions. The continuous change in direction of the current keeps the motor running. Together, magnetic fields and electric current make waves called electromagnetic radiation. One part of a wave carries a strong electric field, while a magnetic field is in another part of the wave. When an electric current weakens it generates a magnetic field. As the magnetic field weakens it generates an electric field. Visible light, radio waves and X-rays are examples of electromagnetic radiation. Mentzer, Alissa Pond. "Relationship Between Electricity & Magnetism" sciencing.com, . 24 April 2017. APA Mentzer, Alissa Pond. (2017, April 24). Relationship Between Electricity & Magnetism. sciencing.com. Retrieved from Chicago Mentzer, Alissa Pond. Relationship Between Electricity & Magnetism last modified March 24, 2022. By the end of this section, you will be able to: Define electricity and magnetism. Recognize that electricity and magnetism are different aspects of electromagnetism. Electricity is a branch of physics concerned with the effects "associated with the presence and motion of matter possessing an electric charge" [1]. As we will see, an electric charge is associated with an electric field that can affect other electric charges around it. Common natural phenomena that involve electricity, including lightning and static electricity (Fig. \(\PageIndex{1}\)). Electricity also plays a central role in many modern technologies that are pervasive through everyday life, including electric heating, electric lighting, and electric circuits in cellular phones, computers, appliances, automobiles, and other devices that use electrical power. Indeed, it is hard to wake up in the morning, get through your day, and get back to bed at night without encountering multiple electric devices or phenomena! Figure \(\PageIndex{1}\): Lightning [2] and static electricity [3] are examples of a natural electrical phenomenon. Magnetism is a branch of physics concerned with the effects associated with a magnetic field. In contrast to electric charges, magnetic fields do not arise from separate "magnetic charges." Instead, we will see that they are caused by the motion of electric charges or their intrinsic magnetic properties. While magnetic fields are perhaps most commonly associated with permanent iron magnets (Fig. \(\PageIndex{2}\)), a temporary magnetic field can be created by electric charges moving through a coil of wire. Like electricity, magnetism also plays a critical role in modern technologies, including motors, generators, relays, solenoids, loudspeakers, hard drives, and many other examples [4]. Figure \(\PageIndex{2}\): Iron filings are attracted to an permanent bar magnet. [5] While we will start our study of electricity and magnetism by examining them separately for simplicity, it turns out that it will eventually be better to think about the two phenomena as different aspects of one phenomenon called electromagnetism [6]. Oscillating charges will generate electromagnetic waves, which are oscillations in the electromagnetic field that travel from one location to another. The frequency of the wave is its number of oscillations per second. Radio waves, infrared light, visible light, ultraviolet light, x-rays, gamma rays are all examples of electromagnetic waves with different frequency ranges in the electromagnetic spectrum [7]. Given the wide range of electromagnetic technologies, it is not possible to include them all in an introductory textbook. In this book, we will be focusing on wireless technology and Amateur Radio as a means to show how the principles of electricity and magnetism can be used in practice. References Electromagnetism, a macroscopic theory, is a branch of science that is composed of two different aspects, namely, electricity and magnetism. Electromagnetism deals with the magnetic forces (interactive forces) that exist between two electrically charged particles. These interactive forces contain both components (electricity and magnetism) and are therefore known as electromagnetic forces, also known as the Lorentz force. These forces may be either attractive or repulsive in nature. The structure of an atom is the best example of an electromagnetic force, as the interactive forces/electromagnetic forces between the positively charged nucleus and the orbital electrons binds the charged particles together and maintain the stability of an atom.Electromagnetic forces are one of the four fundamental forces of nature. The electromagnetic force is defined as the interactive force (magnetic lines) that occurs when a current is allowed to pass through a conductor. These electromagnetic forces are carried by electromagnetic fields, composed of electric and magnetic fields, that are responsible for the generation of electromagnetic radiation. Radio Waves, TV waves, Radar waves, Heat (infrared radiation), Light, Ultraviolet Light, X-rays, and Short waves are some examples of electromagnetic radiation.Electromagnetic induction, on the other hand, is defined as the electricity generated, because of the electromotive force, due to changing magnetic fields. Changing magnetic fields move electric charges. This either happens when a conductor is placed in a moving magnetic field or when a conductor is constantly moving in a stationary magnetic field. Electric generators, Electromagnetic forming, Graphics tablets, Hall effect sensors, Induction cooking, Induction motors, and Induction sealing are a few examples of electromagnetic induction. Examples of ElectromagnetismElectromagnetism holds significant importance in a wide variety of fields including, industrial, transportation, and medical fields. Apart from this, we cannot deny the fact that we also rely on electromagnetic appliances on a daily basis to some extent. Some of the daily life examples of electromagnetism are explicated as follows-1. Kitchen Microwave OvensMicrowave ovens, also known as electric ovens, are widely used to heat or cook the food by high-frequency electromagnetic waves. Ovens use electromagnetic oscillators which produce electromagnetic waves in the wavelength range of 1m to 1mm. These electromagnetic waves are called microwaves and are produced only when the oven is operating. The food absorbs these microwaves and generates heat, which is responsible for cooking. The commonly used wave frequency for microwave ovens is roughly 2,450 megahertz (2.45 gigahertz). Other than microwaves, other home appliances such as washing machines, vacuum cleaners, food blenders, ovens, microwaves, dishwashers, hairdryers, tumble dryers, etc., contain electric motors, which also work on the basic principle of electromagnetism.2. Entertainment gadgetsEntertainment gadgets, such as television, mobile phones, and radios, use radiowaves to broadcast or communicate their signals. Radiowaves hold the longest wavelength in the EM spectrum with a frequency range of 104to 1012 Hertz. These waves can be easily transmitted through the air, and they do not cause any harm to the human body. These devices use radiowaves and convert them into mechanical vibrations for the production of sound waves. Television waves have a wavelength range of 50 centimeters to about 10 meters, which is shorter than the wavelength used in radios, therefore TV waves diffract less. Mobile phones, also known as low-powered radiofrequency transmitters, have approximately 10-1000 m wavelength and operates between the frequency range of 450 and 2700 MHz.3. Maglev Trains/Magnetic suspension trainsMaglev trains, also known as magnetic levitation trains, is a land transportation vehicle that is supported by either attraction or repulsion. This magnetic suspension train uses two sets of magnets, one set is used to repel and push the train up off the track up to 10 cm, and another one moves the train ahead. This magnetic field setup is used to suspend, guide, and propel the train onto the track. These magnetic fields interact with simple metallic loops present in the concrete walls of the Maglev guideway. These metallic loops are composed of conductive materials, like aluminum, and when a magnetic field crosses these loops, an electric current is produced which generates another magnetic field. One vital advantage of using these trains is that they are eco-friendly, as no fuel is being used and thus no air pollution.4. TransformersTransformers are cylindrical voltage-controlling (increase or decrease) devices used to control the voltage of alternating current. Transformers work on the principle of electromagnetic induction to transfer energy from one circuit to another. The core of the transformer directs the path of the magnetic fields between primary and secondary coils. Once the magnetic field reaches the secondary coil, it forces electrons to move and an electromotive force is generated which produces an electric current.5. MicrophonesMicrophones, the most commonly used device nowadays, works on the principle of electromagnetic induction. It converts mechanical energy (sound waves) into electrical energy (audio signals). Sound waves hit the diaphragm present in the microphone which vibrates and converts is converted into electrical energy through magnetic coils.6. Electric FanElectric fans work on the basic principle of electromagnetic induction with the help of an electric motor. An electric motor contains a coil of wire around a metallic core. When current is passed through this coil, a magnetic field is created which further helps in the clockwise rotation of the fan blades.7. Electric Door BellElectric doorbell works the electromagnetism mechanism. It contains an electromagnet, an artificial magnet, in which the flow of current produces magnetic fields. In this device, the wire wound around a coil acts as the electromagnet. These generated magnetic fields last as long as they have access to the flow of current. When the electric power supply is stopped, it will stop behaving like a magnet.8. Magnetic Card ReaderWhen the magnetic stripe is swiped through the scanner, an electromotive force is induced due to the change in magnetic flux (in one direction). Therefore, electric car readers, such as ATM cards, and credit cards are applications of electromagnetic induction.9. Storage and recording DevicesTape recorders, video cassette recorders, magnetic tapes, and video cassette players employ the content of electromagnetism to record data. Iron oxide and chromium dioxide are usually used for coating magnetic materials in cassette tape recorders. As the tape passes the five magnetic heads of a tape recorder, the sound is recorded, replayed, or erased according to the heads that are activated.Hard disks also use the electromagnetism phenomenon to store data to a large extent. They consist of a platter and an actuator. A platter, a hard ferromagnetic material, is a place where all the files and data are stored, whereas an actuator arm is a piece that writes the data and magnetizes certain parts of the platter, giving it a value of 0 or 1.10. Digital CameraInfrared radiations are usually used in cameras for clicking pictures. A digital camera is an application of electromagnetic induction and is highly preferred over conventional cameras.11. Induction CookersAn induction cooker, a kitchen appliance, works on the basic principle of electromagnetic induction and is widely used in homes nowadays. It is used to transfer electrical energy by induction from a coil of wire into a metal vessel. The coil is placed under the cooking surface and a high-frequency alternating current is passed through it. The current in the coil produces a magnetic field which in turn induces heat and the food is cooked.12. Electric GeneratorsAn electric generator, also known as a dynamo, is a device used to convert mechanical or chemical energy into electrical energy. These works on the principle of electromagnetic induction. The internal structure of a generator constitutes a conductor coil and a magnet. The conductor coil is wound on the surface of a metal core and is rotated between the poles of the magnet. The arrangement of the conductor coil and core is known as an armature. Horse-shoe-shaped magnets are used in electric generators. Due to alterations in magnetic fields, caused by the movement of the coil, an interference takes place in the electrons. This interference results in the conversion of mechanical energy into electrical energy. An electric generator acts as an uninterrupted power supply device and serves to be helpful in case of power cuts or power outages.13. Electric motorsElectric motors also work on the principle of electromagnetism, which converts electrical energy into mechanical energy. Motors are usually employed in devices that require circular or rotatory movements as mechanical energy. Motors are an example of electromagnetism and are also the most commonly used in day-to-day life. When a current is allowed to pass through the coil, present in electric motors, a magnetic field is generated. This magnetic field induces interaction forces (attractive or repulsive), thus resulting in the spilling or rotation of the motor blades.Electricity and Magnetism are two key areas of physics that study electric charges, electric and magnetic fields, and how they interact. Electricity focuses on how electric charges behave, how current flows, the role of voltage, and how circuits work. Magnetism, on the other hand, looks at magnetic fields and how they affect moving charges. Together, these two topics form the core of electromagnetism, which helps us understand everything from how electrical circuits work to the nature of electromagnetic waves.1.0Coulombs LawThe electrostatic force between two point charges is directly proportional to the product of their magnitudes and inversely proportional to the square of the distance separating them. This force always acts along the line joining the two charges.F=Kr2q1q2k=401=9109Nm2C2=Electrostatic constant or Coulombs Constant2.0Electric Field, Electric Potential and Electric Potential EnergyElectric Field: An electric field is the region around a charge or charge distribution where another charge experiences an electric force.E=q0F SI unit : N/C or V/mElectric potential: It is defined as the work done by an external force in moving a unit positive charge from a reference point to a specific location without changing its kinetic energy.Vp=q(Wp)ext (K=0)Electric Potential Energy: It is the work done to move a charge from infinity to its current position without altering its kinetic energy.U=rkQq3.0Electric Field Lines and FluxElectric Field Lines: Electric field lines are imaginary lines, straight or curved, that represent the direction and strength of an electric field. The tangent at any point on a field line shows the direction of the field at that point.Electric Flux: This physical quantity is used to measure strength of electric field and it is defined as the total number of electric field lines passing through an area.=E.A=EACos4.0Gausss LawAccording to this law the total electric flux () through any closed surface (S) in free space is equal to 01 times the total electric charge (q) enclosed by the surface.=E.dS=0QenclosedApplications of Gauss Law(1).Electric field Intensity due to infinitely long wire, E=20r=r2K(2).Electric Field due to Uniformly Charged Infinite Sheet(A).Non Conducting Sheet E=20 (B) Conducting sheet or Metal Plate E=0(3).Electric field due to uniformly charged long cylindrical pipe/cylindrical shellCase 1.Electric field at any point outside the cylinder(r>R)E=0rRCase 2.For the point lying on the surface(rR)E=0Case 3.For the point inside the surface(rR)E=40r2q=r2kq(b). For any point lying on the surface of sphere (r=R)Es=R2kq=40R2q=0 (=4R2q(c). Electric Field at any point Inside the sphere(rR): E=r2kq(b). Electric field at any point lying on the surface of sphere(r=R) ES=30R (is volume charge density)(c). Electric field at any point inside the sphere(r