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Let us now learn about field lines which are a pictorial representation or way to imagine electric fields. The notion of the electrical field was first presented by the 19th-century physicist Michael Faraday. It was Faraday's understanding that the pattern of lines describing the electric field is an invisible reality. For a single positive point charge q, the electric field is given by relation $\vec{F}=\frac{kq{\widehat{r}}}{4\pi \epsilon _{0}r^{2}}$ now to get a feel of this field one can sketch a few representative vectors as shown in fig below Since the electric field varies as the inverse of the square of the distance that points from the charge the vector gets shorter as you go away from the origin and they always point radially outwards. Connecting up these vectors to form a line is a nice way to represent the electric field. An electric field line is an imaginary line drawn in such a way that its direction at any point is the same as the direction of the field at that point. Field-line in general is a curve drawn in such a way that the tangent to it at each point in the direction of the net field at that point. Concept and Definition Definition: An electric field line is an imaginary line or curve drawn over an empty space region such that its tangent at each position, points in the direction of the electric field vector at this position. The relative spacing between lines provides an indication of the electric field strength at that point. So, The magnitude of the field is indicated by the density of the lines. This means that electric field strength due to the charged body is more in the region where the density of field lines is high. In the region where the density of these lines is low, the electric field has lower strength. Magnitude is strong near the center where the electric field lines are close together, and it becomes weak as ve move farther outwards, where they are relatively apart or they have less density. A field line or electric line of force can be considered as the path along which a small positive test charge would move if we let it move freely along the path. Rules for Drawing Electric Field lines Patterns The field line begins at the +ive charge and ends either at the -ive charge or at infinity. So we can draw electric field vectors at each point in space around the charge and join them to form the lines. It must be noted that for each location, the electric field vectors point tangent to the direction of the electric field lines at any given point. (physicsclassroom.com) When the field is stronger, the field lines are closer to each other. The number of field lines depends on the magnitude of the electric charge. The field lines should never cross each other. Field Lines due to some charge configurations For a positive charge Field lines of a single +ive charge point radially outwards For a negative charge For a negative charge, they are radially inwards as shown below in the figure These two figure given above shows how to draw field lines for a single charge (+ive and -ive) Electric Field Lines for Configurations of Two or More Charges Field lines around the system of two +ive charges give a different picture and describe the mutual repulsion between them. Field lines around a system of a positive and -ive charge clearly show the mutual attraction between them as shown below in the figure. Properties Of Electric Field Lines Some important general properties of field lines are Field lines start from a positive charge and end on a negative charge. They are directed away from the positive electric charge and towards the negative electric charge. So, at any point tangent to field lines give the direction of the electric field at that point. These lines leave or enter the charged surface normally. Field lines never cross each other because if they do so then at the point of intersection there will be two directions of the electric field. Electric field lines do not pass through a conductor, this shows that the electric field inside a conductor is always zero. Electric field lines are continuous curves in a charge-free region. Electric field lines have the tendency to contract in length. This explains the existence of the electric force of attraction between two oppositely charged objects. Electric lines of force have a tendency to expand laterally, i.e., they tend to separate from each other in the direction perpendicular to their lengths. This explains the electric force of repulsion between like charges. Questions What does an electric field line represent? When are electric field lines parallel to each other? Where do electric field lines start and end? Other useful Links Written By Anum Last Modified 24-01-2023 Electric Field Lines: An electric field is a region around a charge where other charges can feel its influence. Mathematically, the electric field at a point is equal to the force per unit charge. It is a vector quantity, i.e., it has both magnitude and direction. For a system of charges, the electric field is the region of interaction surrounding them. But how do we visualize it? Charges can sense the field around them, but we can merely detect it with proper equipment. To allow the pictorial representation of the overall intensity of the field, Micheal Faraday, in the \(19^\rm{th}\) century, came up with the idea of Electric Field Lines. Electric Field Lines Electric field lines are a presentation of electric field lines on paper. These are the drawings representing electric fields around charged objects using lines and arrows, making them very useful in visualizing field strength and direction. Like all vectors, the electric field can be represented by an arrow with a length proportional to its magnitude and that points in the direction of the net electric field at that point. In the sense of the arrows on the lines, a tangent at any point to an electric field gives the direction of the electric field at that point.The magnitude of the field is proportional to the number of field lines per unit area passing through a small surface normal to the lines.Thus, field lines determine the magnitude, as well as the direction of the electric field. At points where the field lines are closely spaced, the electric field is considered to be stronger, while the points where the field lines are far apart are the points where the electric field is comparatively weaker. Faraday invented the picture of field lines to develop an intuitive non-mathematical way of visualizing electric fields around charged configurations. Faraday referred to them as “lines of force.” This term is somewhat misleading, especially in magnetic fields, which is why they were termed as “field lines” (electric or magnetic). To understand how to draw field lines around a point charge, assume a point charge kept at the origin. From this charge, vectors are drawn in the direction of the electric field, with the length of each vector depicting the strength of the electric field at that point.The electric field due to a point charge varies inversely with the square of the distance of that point from the point charge. Thus, the electric field’s vector gets shorter as we move away from the origin in a radially outwards direction. Each small arrow indicates the force experienced by a unit positive charge kept at the end of each arrow; by connecting the arrows in a direction along a line, we get an electric field line. Similarly, many field lines can be drawn, all pointing outwards from the point charge. This gives us the direction of the electric field. The density of field lines represents the magnitude of the electric field at that point. Near a charge, the field is stronger; thus, the density of field lines is more, and the field lines are much closer. But as the field gets weaker away from the charge, the density of field lines is less. An infinite number of lines can be drawn to represent the electric field in any region. In three dimensions, the number of lines per unit cross-sectional area is considered while calculating the density of field lines in a region. As the electric field varies inversely with the square of the distance from a point charge, thus the area enclosing the charge increases as we move away from the charge. The number of field lines crossing the enclosing area remains constant, whatever be the area’s distance from the charge. Properties of Electric Field Lines Properties of electric field lines are as follows: Field lines start from a positive charge and end on a negative charge.Electric field lines move away from the positive electric charge and towards the negative electric charge.A tangent drawn at any point on a field line gives the electric field direction at that point.Electric field lines enter or exit a charged surface normally.Field lines never cross each other because if they do so, then at the point of intersection, there will be two directions of the electric field.In a uniform electric field, the field lines are straight, parallel, and uniformly spaced.Electric field lines can not pass through a conductor; that’s why the electric field inside a conductor is always zero.In a charge-region, electric field lines are continuous curves.Electric field lines tend to contract in length due to the force of attraction between two oppositely charged objects.Electric lines of force tend to expand laterally, i.e., they tend to separate from each other in the direction perpendicular to their lengths because of the force of repulsion between like charges. a. Around a Positive Charge: Electric field lines are radially away from the positive charge. b. Around a Negative Charge: Electric field lines are radially towards the negative charge. c. Around Two Positive Charges: The pattern of electric field lines between two positive charges of equal magnitude can be shown as: d. Around Two Negative Charges: The pattern of electric field lines between two negative charges of equal magnitude can be shown as: e. Around a Positive and Negative Charge: The pattern of electric field due to two equal and opposite charges can be shown as: Electric field lines in a region describe the nature of the electric field in a system of charges. They also reveal the direction of electric field strength at a point in a region of space. If the electric field lines intersect, then there must be distinctly two electric fields with different directions. This is impossible as a single location has only one direction and magnitude of the electric field associated with it. Electric field lines show the pictorial mapping of the electric field around a configuration of charges. An electric field line is, in general, a curve drawn in such a way that the tangent to it at each point is in the direction of the net field at that point. An arrow on the curve is necessary to specify the direction of an electric field from the two possible directions indicated by a tangent to the curve. A field line is a space curve, i.e., a curve in three dimensions. The field lines are denser at places where the field is strong and further apart in the region where the field is weak. Thus, by the closeness or relative density of the field lines at the given points, we can judge the strength of the electric field at that point. To compare the field strength between \(R\) and \(S\), imagine equal and small elements of the area placed at points \(R\) and \(S\) normal to the field lines. The number of field lines in our picture cutting the area elements is proportional to the magnitude of the field at these points. As can be seen from the picture, the field at \(R\) is stronger than at \(S\). Electric field lines are a presentation of electric field lines on paper. These are the drawings representing electric fields around charged objects using lines and arrows, making them very useful in visualizing field strength and direction.Following are the basic properties of electric field lines: Field lines start from a positive charge and end on a negative charge.Electric field lines move away from the positive electric charge and towards the negative electric charge.A tangent drawn at any point on a field line gives the electric field direction at that point.Electric field lines enter or exit a charged surface normally.Field lines never cross each other because if they do so, then at the point of intersection, there will be two directions of the electric field.In a uniform electric field, the field lines are straight, parallel, and uniformly spaced.Electric field lines can not pass through a conductor; that’s why the electric field inside a conductor is always zero.In a charge-region, electric field lines are continuous curves.An infinite number of lines can be drawn to represent the electric field in any region. Q.1. What is an electric field line?Ans: Electric field lines can be defined as a curve representing the direction of the electric field when a tangent is drawn on it at any point. These are used to diagrammatically realize the presence of an electric field in a given region. Q.2. What is an electric field?Ans: An electric field is a region around a charge where similar charges can feel its influence. It is a vector quantity, and it is equal to the force per unit charge acting at the given point around an electric charge. Q.3. Sketch the electric field lines around two opposite charges, with the magnitude of the negative charge being smaller than the magnitude of the positive charge.Ans: When a smaller negative charge is placed across a more significant positive charge, the distribution of the field lines will become: Q.4. Can two electric field lines intersect?Ans: No, two electric field lines do not intersect. If the electric field lines intersect, then this would mean that we can draw two tangents at their point of intersection. Thus, the electric field intensity at the point will have two directions, which is not possible. Q.5. Why aren’t there any electric field lines inside a conductor?Ans: There are no electric field lines within a conductor because the electric field inside a conductor is zero. Q.6. Write a few properties of electric field lines.Ans: Few general properties of field lines are: Electric field lines start from a positive charge and end at a negative charge.Field lines do not form closed curves.The number of electric field lines leaving a positive charge or entering a negative charge is proportional to the magnitude of the charge.Electric field lines never intersect.If the electric field in a given region of space is zero, electric field lines do not exist.In a uniform electric field, the field lines are straight, parallel, and uniformly spaced. We hope this detailed article on Electric Field Lines helps you in your preparation. If you get stuck do let us know in the comments section below and we will get back to you at the earliest. Electricity is an important part of modern day life and electricity infrastructure is built to facilitate this. As a result you may live near an overhead line, pylon or substation and want to find out more about it. This website is designed to give you a balanced, informative view of Electric and Magnetic Fields (EMFs) from overhead lines and substations. 'EMF The Facts' is a comprehensive summary produced by the Energy Networks Association. Download EMF The Facts Everything you need to know about living near, or buying or selling a house near an overhead line. Find out more Everything you need to know about living near, or buying or selling a house near a substation. Find out more Look into the electricity system and learn about overhead lines, pylons and substations. Find out more Current evidence on health effects including information on microshocks, pacemakers and childhood leukaemia. Find out more Up to date information about the UK's stance on EMFs including national policies and exposure limits. Find out more A short guide of everything you need to know about EMFs. Find out more Share — copy and redistribute the material in any medium or format for any purpose, even commercially. Adapt — remix, transform, and build upon the material for any purpose, even commercially. The licensor cannot revoke these freedoms as long as you follow the license terms. Attribution — You must give appropriate credit , provide a link to the license, and indicate if changes were made . You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use. ShareAlike — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original. No additional restrictions — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits. You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation . No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Electric field lines or electric lines of force are imaginary lines drawn to represent the electric field visually. Since the electric field is a vector quantity, it has both magnitude and direction. Suppose one looks at the image below. The arrows indicate the electric field lines, and they point in the direction of the electric field. The significance of electric field lines is that they tell us how space is distorted by the presence of a charge or a distribution of charges. Figure 1: Electric Field Lines English physicist Michael Faraday first developed the concept of electric field lines in the 1830s. For isolated charges, the electric field lines come out of a positive charge and terminate at infinity. On the other hand, they start from infinity and terminate at a negative charge.When a positive charge is placed near a negative charge, the field lines originate in the former and terminate at the latter.The number of field lines leaving a positive charge or entering a negative charge is proportional to the magnitude of the charge.The field lines never cross each other.The strength of the electric field is given by the number of field lines passing through a unit area, and hence, is proportional to the closeness of the field lines. They are close together where the electric field is strong and far apart where the field is weak.The direction of the electric field is the same as the direction of electric field lines in the case of a single isolated charge. If two charges placed next to each other, the electric field direction is given by a tangent drawn at any point on the lines. The electric field lines follow a specific pattern and configuration depending upon the distribution of electric charges. Since the electric field is a vector, it is represented by arrows drawn near the charges. The rules for drawing electric field lines follow the properties mentioned above. For a Single Charge For a single isolated charge, the lines are drawn differently for positive and negative charges, as shown in Figure 1. They are drawn such that they come out of a positive charge and terminate at infinity. On the other hand, the lines start from infinity and terminate at a negative charge. Such a direction is known as the radial direction. In other words, the lines are radially outward for a positive charge and radially inward for a negative charge. The strength of charge also affects how the lines are drawn. A lower charge will have fewer lines surrounding it than a higher charge, as shown in Figure 2. Since the line density at any point indicates the strength of the electric field in that region, the closer the lines, the stronger is the field. The density is high near the charge and decreases as one moves further. Figure 2 : Density of Electric Field Lines For Two Isolated Point Charges The presence of other charges will alter the path of electric field lines. In this case, the electric field will follow the principle of superposition. The magnitude and direction of the electric field at each location is simply the vector sum of the electric field vectors for each charge. Let us take the simple case of two opposite charges of the same magnitude placed next to each other, as shown in Figure 3. The electric fields at point A due to charges +q and -q are E1 and E2, respectively. Therefore, the net electric field at A due to the charges is E = E1 + E2. Similarly, suppose other points in the region are chosen (not shown in the image for simplicity). The electric field at those points can be determined by this vectorial addition method. Electric Field Due to Two Point Charges Once we know the electric field at different points, we can proceed to draw the field lines. Keep in mind that the electric field’s direction is tangential to the electric field line at that point (refer to property #6). The following image shows the field lines between (a) two equal and opposite charges and (b) two equal and like charges. It is evident from Figure 4 that opposite charges attract and like charges repel. Figure 4 : How to Draw Electric Field Lines For a Conductor In the case of a conductor, the charges lie on the surface. The electric field vector can be resolved into perpendicular and parallel components. The parallel components cancel each other; otherwise, there will be a surface current on the conductor. The perpendicular components will add and contribute to the total electric field. Therefore, the electric field lines are drawn perpendicular to the conductor’s surface. For a symmetrical surface like a sphere or cylinder, the perpendicular components are radial. The lines are drawn such that they radially come out (outward) of a positively charged conductor, as shown in Figure 5. If a conductor has a negative charge on its surface, then the lines will be radially inward as mentioned in the properties (#1). Figure 5 : Electric Field Lines Spherical Cylindrical Conductor Q.1. Why do electric field lines not pass through a conductor? Ans. The free electrons in a conductor arrange to cancel any electric field line inside and make the electric field zero. In this way, they are at the lowest potential. Q.2. Why do electric field lines curve near the edges of a parallel plate capacitor? Ans. The electric field lines in a parallel plate capacitor are represented by parallel lines between two conducting sheets – positive and negative. At the edges, the lines curve because the charges behave like point charges. This phenomenon is known as the fringe effect. Q.3. Why can electric field lines not be discontinuous? Ans. If the electric field lines are discontinuous, the electric field will not exert any force on a charge at the points of discontinuity. It is not possible because a charge experiences a continuous force when traced in an electric field. Q.4. What is the main difference between magnetic and electric lines of force? Ans. Magnetic lines of force are closed. They travel inside a magnet and magnetized object. On the other hand, electric lines of force are continuous loops that are not closed. They are not present inside a conductor. Q.5. Can electric field lines cross each other? Ans. The electric field is given by drawing a tangent at any point on the electric field lines. If the lines intersect, that will mean that there are two electric fields at the point of intersection, which is impossible. Article was last reviewed on Thursday, February 2, 2023 The electric field is defined as the force per unit charge exerted on a small positive test charge placed at that point. The rules for drawing electric field lines for any static configuration of charges are The lines begin on positive charges and terminate on negative charges. The number of lines drawn emerging from or terminating on a charge is proportional to the magnitude of the charge. No two field-lines ever cross in a charge-free region. (Because the tangent to the field line represents the direction of the resultant force, only one line can be at every point.) The line approaches the conducting surface perpendicularly. Electric field lines may be considered as a visual representation of the electric field existing between or for a charge itself. It was introduced by Michael Faraday in the year (1791-1867) who named them lines of force. A field basically is a function that specifies a particular quantity everywhere in a region. When we say electric field lines, it gives us means of representing the electric field pictorially. By looking into the electric field lines, its magnitude, orientation, and other properties can be evaluated. As shown in the below figure electric field lines exist between positive and negative charges. The lines of forces are directed outwards for positive charge and inwards for a negative charge. The arrow represents the direction of the force. The magnitude can also be considered based on a number of arrows and density around the charge. In other words, a number of lines or arrows is proportional to the magnitude of the electric field in a particular region. As shown above, the electric field is vector E is tangent to an electric field line at each point. The line has the same direction as the direction of the electric field.The number of lines of force leaving the positive charge is equal to a number of lines terminating on a negative charge. If the charge is equal and opposite, the same number of lines leave and terminate at respective charges. In the case of a single charge present, the lines of force radiate outwards in case of positive charge and tend to infinity.What is Electric Field Lines?The electric field may be defined as “Electric field lines are imaginary lines in a region of space-time along which a free charge would move if allowed to do so”. This means that electric field lines or lines of force are a visual representation of the electric field in a region, which exists between two charges. Just like a magnetic field that exists between two poles. The force existing between two charges is directly proportional to the product of charges and inversely proportional to the square of the distance between them as per Coulomb’s Force Law.electric-field-linesProperties of Electric Field LinesSome important properties of electric field lines are given below:The electric field lines or lines of force originate from the positive charge and terminate at a negative charge. Same as magnetic lines of force which orient from the north pole to south poleThe lines of force that exist between two charges never form any closed path. Which means that the lines originating from positive charge terminate at a negative charge, and do not come back to the positive charge.lines-of-forceAs shown in the above figure, the lines of force originate from positive charge but do not come back and hence do not form any closed loop. It may be noticed that the magnetic lines of force form a closed path i.e. starting from north pole move towards the south pole and come back to the north pole.The lines of force that originate from positive charge, in case of absence of negative charge i.e. single charge case, never terminate in space. They tend to exist up to infinity. Magnitude decreases as the distance are increases, but they never terminate at the origin.The lines of force originating or terminating at a charge is subjective, but whereas the density of lines of force is objective. This means that a number of lines originating from a charge may vary for different charges, but the density of these lines around the charge must be uniformly decreasing as they move away.The lines of force originating for terminating at charge are directly proportional to the magnitude of charge.charge-magnitudeAs shown in the above figure, if a number of lines originating from +Q are 4, then the number of lines originating from +2Q would be 8.The lines of force originating or terminating at a particular charge are symmetrical to the line joining two charges.line-joining-chargesAs shown in the figure, the lines of force are symmetrical over line joining charges. This means that the same number of lines exist above and below the line joining charges.The density of lines originating or terminating for the respective charge gives the magnitude of the charge.The lines of force are perpendicular to the surface of the charge.The direction of this is given by the tangent drawn at lines of force. The direction of the tangent gives the direction of the electric field.The lines of force originating or terminating at a particular charge, never intersect each other. If we draw a tangent at the point of intersection, then it will give two directions at the same point. Hence, the lines of force never intersect with each other.If field lines are originating from positive charge, then in presence of one more positive charge, the field line will repel. That means field lines repel to positive charge and similarly attract towards negative charge.A uniform electric field is represented by parallel, straight and equally spaced lines of force.If a conductor is under electrostatic condition then there would be no electric field existing in the conductor. If these lines exist, then it would impose a force on the electrons, which will move the electrons and hence produce current. Then the electrostatic condition is not valid. Hence it is said that, under electrostatic conditions, the electric field existing is zero.These are always perpendicular to the surface of the conductor.Electric Field lines Attraction and RepulsionThe electric field lines get attracted to the negative charge and there exists a repulsion for the positive charge. If there are two positive charges nearby, then the line of force originating from the positive charges would repel and bend towards infinity. They never intersect with each other.Rules for DrawingTo draw electric field lines, the following rules need to be followed.These lines originate from positive charge and terminate at a negative charge.The field lines originating are always perpendicular to the surface of the charge.Two field lines never intersect each other.The field lines are attracted to negative charges and repel from the positive charge.These are symmetrical about the line of joining the charges.These are proportional to the magnitude of charge.FAQs1). Do electric field lines ever end?No, if there is a single positive charge, then field lines originate from it and tend towards the infinity. They never end. However, if we have positive and negative charges, then lines of force terminate at a negative charge.2). Where are the electric field lines strongest?The field lines are strongest near the charge and become weak as they move away from the charge.3). What are the three properties of electric field lines?The three properties are:The field lines originate from positive charge and terminate at a negative chargeThe field lines are perpendicular at the surface of the chargeThe field lines never intersect with each other.4). How is the electric field defined?The electric field is a particular function that specifies lines of force everywhere in a region5). What is the SI unit of electric field?The SI unit of electric field strength is newtons per coulomb (N/C) or volts per meter (V/m)Hence we have seen how the electric field is defined and we have seen the properties of the electric field. This helps to understand the characteristics of electric field strength based on which we can evaluate electric field strength and electric field density. These characteristics and properties of the electric field help us to understand Gauss Law and Maxwell Rules. We have also seen the rules to draw the electric field and some frequently asked questions. Here is a question for you, how do electric field lines are different from magnetic field lines? When electricity flows through a wire, we can compare it to water flowing through a hosepipe; the current would be the volume of water, and the voltage would be the pressure pushing the water through the hosepipe. To transfer electricity, we always have a voltage and a current. Electric fields are produced by voltage and are independent of the current (load) in an overhead line. Electric field strengths are measured in : volts per metre (V/m) kilovolts per metre (kV/m) 1 kV/m = 1000 V/m The atmospheric electric field at ground level is approximately 100 V/m in fine weather and may rise to many thousands of volts per metre during thunderstorms. Electricity is supplied to UK homes at a voltage of 230 V but outside homes it is distributed at higher voltages - from 11,000 V (usually written 11 kV) up to 400,000 V (400 kV). Generally, the higher the voltage, the higher the electric field. Anything which uses or carries electricity is potentially a source of power-frequency electric fields. They affect the Earth's steady natural fields. The strength of the electric field effect depends on the voltage of the equipment, which remains broadly constant when the equipment is energised. Electric fields are readily screened by most materials including bricks, trees and hedges (unlike magnetic fields). Electric field lines are a representation used to visualize the electric field surrounding charged objects. They provide a way to understand the direction and strength of the electric field at different points in space. It helps analyze electric fields in various situations, such as around point charges, between parallel plates, or within complex arrangements of charges. In this article, we will learn in detail about electric field lines, their properties, and the rules to draw electric field lines for different charges. What is Electric Field Line?The concept of an electric field line is used to define an electric field near charged particles. They were first used by Michael Faraday to define an electric field due to an electron and a proton. Electric field lines are imaginary lines that are used to visualize electric field around a charge in real life. They are also called electric lines of force. The tangent drawn at any point on electric field lines shows the direction of electric field at that particular point. They are regular lines without any break and are curved in nature. They are curved in nature and not linearly straight. In case of the positive charge the direction of electric field lines is radially outwards and in case of negative charge the direction of electric field line is radially inwards. Also, the density of the electric field lines shows the strength of the electric field i.e. the more electric field lines in an area the more the strength of the electric field there. Properties of Electric Field LinesThe electric field lines have the following properties: Electric field lines never intersect each other.Electric field lines are always perpendicular to the surface of the charge.For a single charge, the field lines go from the surface of the charge to up to infinity.The magnitude of the electric field and the number of field lines, both are proportional to each other.In a uniform electric field, field lines are evenly spaced and parallel to each other. In a non-uniform electric field, the field lines are closer together where the field is stronger and farther apart where it is weaker.Electric field lines originate from positive charges and terminate on negative charges.Rules for Drawing Electric Field LinesThe rules used for drawing electric field lines are discussed below: For positive charge, electric field lines always start at their surface and go up to infinity, for negative charge it starts from infinity and ends at its surface.The more field lines in an area the more the strength of the electric field.Electric field lines never intersect each other.Electric field and electric field lines are always tangent at the point where they pass through.Electric Field Lines for Different ChargesUsing the above rules we can draw electric field lines for different configuration of electric charges Electric Field Lines for Individual ChargesIn case of individual positive charge, the direction of electric field line is radially outwards and in case of individual negative charge the direction of the electric field line is radially inwards. Electric Field Lines for Two Equal and Unlike ChargeFor two equal and unlike charge the electric field will originate from positive charge and enter into negative charge forming a close loop Electric Field Lines for Two Equal and Like ChargeIn case of two equal and like charge both will exert repulsive force on each other and the arrangement of electric field lines will be either side of each charge. Related Articles Solved Examples on Electric Field LinesExample 1: At any time, a force of 10 N is operating on the charge of 18 μC. Determine the intensity of the electric field at that location. Solution: Given: F = 10 N, q = 18 μC E = F/qE = 10 / 18 × 10-6E = 5.5 × 105 N/C Example 2: Calculate the strength of the electric field at a distance of 12 cm with a voltage of 68 V. Solution: Given:V = 68 V, r = 12 cm E = V/r E = 68/12E = 5.66 V/cm Example 3: A force of 12 N is acting on the charge of 27 μC. Find Electric Field. Solution: Given: F = 12 N, q = 27 μC E = F/q E = 12 / 27 × 10-6E = 4.44 × 105 N/C Example 4: The electric field is 6.4 N/C at a distance of 6 cm then find the voltage. Solution: Given: E = 6.4 N/C, r = 6 cm V = E × r V = 6.4 × 6V = 38.4 V By the end of this section, you will be able to do the following: Calculate the strength of an electric field Create and interpret drawings of electric fields The learning objectives in this section will help your students master the following standards: (5) The student knows the nature of forces in the physical world. The student is expected to: (C) describe and calculate how the magnitude of the electrical force between two objects depends on their charges and the distance between them. electric field test charge Ask students whether they have seen movies that use the concept of fields as in force fields. Have them describe how such fields work. Describe how gravity can be thought of as a field that surrounds a mass and with which other masses interact. Explain that electric fields are very similar to gravitational fields. You may have heard of a force field in science fiction movies, where such fields apply forces at particular positions in space to keep a villain trapped or to protect a spaceship from enemy fire. The concept of a field is very useful in physics, although it differs somewhat from what you see in movies. A field is a way of conceptualizing and mapping the force that surrounds any object and acts on another object at a distance without apparent physical connection. For example, the gravitational field surrounding Earth and all other masses represents the gravitational force that would be experienced if another mass were placed at a given point within the field. Michael Faraday, an English physicist of the nineteenth century, proposed the concept of an electric field. If you know the electric field, then you can easily calculate the force (magnitude and direction) applied to any electric charge that you place in the field. An electric field is generated by electric charge and tells us the force per unit charge at all locations in space around a charge distribution. The charge distribution could be a single point charge; a distribution of charge over, say, a flat plate; or a more complex distribution of charge. The electric field extends into space around the charge distribution. Now consider placing a test charge in the field. A test charge is a positive electric charge whose charge is so small that it does not significantly disturb the charges that create the electric field. The electric field exerts a force on the test charge in a given direction. The force exerted is proportional to the charge of the test charge. For example, if we double the charge of the test charge, the force exerted on it doubles. Mathematically, saying that electric field is the force per unit charge is written as E → = F → q test E → = F → q test 18.15 where we are considering only electric forces. Note that the electric field is a vector field that points in the same direction as the force on the positive test charge. The units of electric field are N/C. If the electric field is created by a point charge or a sphere of uniform charge, then the magnitude of the force between this point charge Q and the test charge is given by Coulomb’s law F= k| Q q test | r 2 F= k| Q q test | r 2 where the absolute value is used, because we only consider the magnitude of the force. The magnitude of the electric field is then E= F q test = k| Q | r 2 . E= F q test = k| Q | r 2 . 18.16 This equation gives the magnitude of the electric field created by a point charge Q. The distance r in the denominator is the distance from the point charge, Q, or from the center of a spherical charge, to the point of interest. If the test charge is removed from the electric field, the electric field still exists. To create a three-dimensional map of the electric field, imagine placing the test charge in various locations in the field. At each location, measure the force on the charge, and use the vector equation E → = F → / q test E → = F → / q test to calculate the electric field. Draw an arrow at each point where you place the test charge to represent the strength and the direction of the electric field. The length of the arrows should be proportional to the strength of the electric field. If you join together these arrows, you obtain lines. Figure 18.17 shows an image of the three-dimensional electric field created by a positive charge. Figure 18.17 Three-dimensional representation of the electric field generated by a positive charge. [BL][OL]Point out that all electric field lines originate from the charge. [AL]Point out that the number of lines crossing an imaginary sphere surrounding the charge is the same no matter what size sphere you choose. Ask whether students can use this to show that the number of field lines crossing a surface per unit area shows that the electric field strength decreases as the inverse square of the distance. Just drawing the electric field lines in a plane that slices through the charge gives the two-dimensional electric-field maps shown in Figure 18.18. On the left is the electric field created by a positive charge, and on the right is the electric field created by a negative charge. Notice that the electric field lines point away from the positive charge and toward the negative charge. Thus, a positive test charge placed in the electric field of the positive charge will be repelled. This is consistent with Coulomb’s law, which says that like charges repel each other. If we place the positive charge in the electric field of the negative charge, the positive charge is attracted to the negative charge. The opposite is true for negative test charges. Thus, the direction of the electric field lines is consistent with what we find by using Coulomb’s law. The equation E= k| Q |/ r 2 E= k| Q |/ r 2 says that the electric field gets stronger as we approach the charge that generates it. For example, at 2 cm from the charge Q (r = 2 cm), the electric field is four times stronger than at 4 cm from the charge (r = 4 cm). Looking at Figure 18.17 and Figure 18.18 again, we see that the electric field lines become denser as we approach the charge that generates it. In fact, the density of the electric field lines is proportional to the strength of the electric field! Figure 18.18 Electric field lines from two point charges. The red point on the left carries a charge of +1 nC, and the blue point on the right carries a charge of –1 nC. The arrows point in the direction that a positive test charge would move. The field lines are denser as you approach the point charge. Electric-field maps can be made for several charges or for more complicated charge distributions. The electric field due to multiple charges may be found by adding together the electric field from each individual charge. Because this sum can only be a single number, we know that only a single electric-field line can go through any given point. In other words, electric-field lines cannot cross each other. Figure 18.19(a) shows a two-dimensional map of the electric field generated by a charge of +q and a nearby charge of −q. The three-dimensional version of this map is obtained by rotating this map about the axis that goes through both charges. A positive test charge placed in this field would experience a force in the direction of the field lines at its location. It would thus be repelled from the positive charge and attracted to the negative charge. Figure 18.19(b) shows the electric field generated by two charges of −q. Note how the field lines tend to repel each other and do not overlap. A positive test charge placed in this field would be attracted to both charges. If you are far from these two charges, where far means much farther than the distance between the charges, the electric field looks like the electric field from a single charge of −2q. Figure 18.19 (a) The electric field generated by a positive point charge (left) and a negative point charge of the same magnitude (right). (b) The electric field generated by two equal negative charges. Ask students to interpret the electric field maps. Where is the field strongest? Where is the field weakest? In which direction is the field increasing or decreasing? Where is the field the most uniform? Can they verify that the magnitude of the charges is the same in a given panel? How does the field for the two negative charges differ from that of the positive and negative charges? This simulation shows you the electric field due to charges that you place on the screen. Start by clicking the top checkbox in the options panel on the right-hand side to show the electric field. Drag charges from the buckets onto the screen, move them around, and observe the electric field that they form. To see more precisely the magnitude and direction of the electric field, drag an electric-field sensor, or E-field sensor from the bottom bucket, and move it around the screen. PhET Explorations: Charges and Fields. Move point charges around on the playing field and then view the electric field, voltages, equipotential lines, and more. Access multimedia content Two positive charges are placed on a screen. Which statement describes the electric field produced by the charges? It is constant everywhere. It is zero near each charge. It is zero halfway between the charges. It is strongest halfway between the charges. This video explains how to calculate the electric field of a point charge and how to interpret electric-field maps in general. Note that the lecturer uses d for the distance between particles instead of r. Note that the point charges are infinitesimally small, so all their charges are focused at a point. When larger charged objects are considered, the distance between the objects must be measured between the center of the objects. True or false—If a point charge has electric field lines that point into it, the charge must be positive. Look at the drawing of the electric field in Figure 18.20. What is the relative strength and sign of the three charges? Figure 18.20 Map of electric field due to three charged particles. We know the electric field extends out from positive charge and terminates on negative charge. We also know that the number of electric field lines that touch a charge is proportional to the charge. Charge 1 has 12 fields coming out of it. Charge 2 has six field lines going into it. Charge 3 has 12 field lines going into it. The electric-field lines come out of charge 1, so it is a positive charge. The electric-field lines go into charges 2 and 3, so they are negative charges. The ratio of the charges is q 1 : q 2 : q 3 =+12:−6:−12 q 1 : q 2 : q 3 =+12:−6:−12 . Thus, magnitude of charges 1 and 3 is twice that of charge 2. Although we cannot determine the precise charge on each particle, we can get a lot of information from the electric field regarding the magnitude and sign of the charges and where the force on a test charge would be greatest (or least). A doorknob, which can be taken to be a spherical metal conductor, acquires a static electricity charge of q=−1.5nC. q=−1.5nC. What is the electric field 1.0 cm in front of the doorknob? The diameter of the doorknob is 5.0 cm. Because the doorknob is a conductor, the entire charge is distributed on the outside surface of the metal. In addition, because the doorknob is assumed to be perfectly spherical, the charge on the surface is uniformly distributed, so we can treat the doorknob as if all the charge were located at the center of the doorknob. The validity of this simplification will be proved in a later physics course. Now sketch the doorknob, and define your coordinate system. Use +x +x to indicate the outward direction perpendicular to the door, with x=0 x=0 at the center of the doorknob (as shown in the figure below). If the diameter of the doorknob is 5.0 cm, its radius is 2.5 cm. We want to know the electric field 1.0 cm from the surface of the doorknob, which is a distance r=2.5cm+1.0cm=3.5cm r=2.5cm+1.0cm=3.5cm from the center of the doorknob. We can use the equation E= k| Q | r 2 E= k| Q | r 2 to find the magnitude of the electric field. The direction of the electric field is determined by the sign of the charge, which is negative in this case. Inserting the charge Q=−1.5nC=−1.5× 10 −9 C Q=−1.5nC=−1.5× 10 −9 C and the distance r=3.5cm=0.035m r=3.5cm=0.035m into the equation E= k| Q | r 2 E= k| Q | r 2 gives E = k| Q | r 2 = (8.99× 10 9 N· m 2 /C 2)| −1.5× 10 −9 C | (0.035m) 2 = 1.1× 10 4 N/C. E = k| Q | r 2 = (8.99× 10 9 N· m 2 /C 2)| −1.5× 10 −9 C | (0.035m) 2 = 1.1× 10 4 N/C. Because the charge is negative, the electric-field lines point toward the center of the doorknob. Thus, the electric field at x=3.5cm x=3.5cm is (−1.1× 10 4 N/C) x ^ (−1.1× 10 4 N/C) x ^ . This seems like an enormous electric field. Luckily, it takes an electric field roughly 100 times stronger (3× 10 6 N/C 3× 10 6 N/C) to cause air to break down and conduct electricity. Also, the weight of an adult is about 70kg×9.8 m/s 2 ≈700N 70kg×9.8 m/s 2 ≈700N, so why don’t you feel a force on the protons in your hand as you reach for the doorknob? The reason is that your hand contains an equal amount of negative charge, which repels the negative charge in the doorknob. A very small force might develop from polarization in your hand, but you would never notice it. 15. What is the magnitude of the electric field from 20 cm from a point charge of q = 33 nC? 7.4 × 103 N/C 1.48 × 103 N / C 7.4 × 1012 N / C 0 16. A −10 nC charge is at the origin. In which direction does the electric field from the charge point at x + 10 cm ? The electric field points away from negative charges. The electric field points toward negative charges. The electric field points toward positive charges. The electric field points away from positive charges. 17. When electric field lines get closer together, what does that tell you about the electric field? The electric field is inversely proportional to the density of electric field lines. The electric field is directly proportional to the density of electric field lines. The electric field is not related to the density of electric field lines. The electric field is inversely proportional to the square root of density of electric field lines. 18. If five electric-field lines come out of a +5 nC charge, how many electric-field lines should come out of a +20 nC charge? five field lines 10 field lines 15 field lines 20 field lines