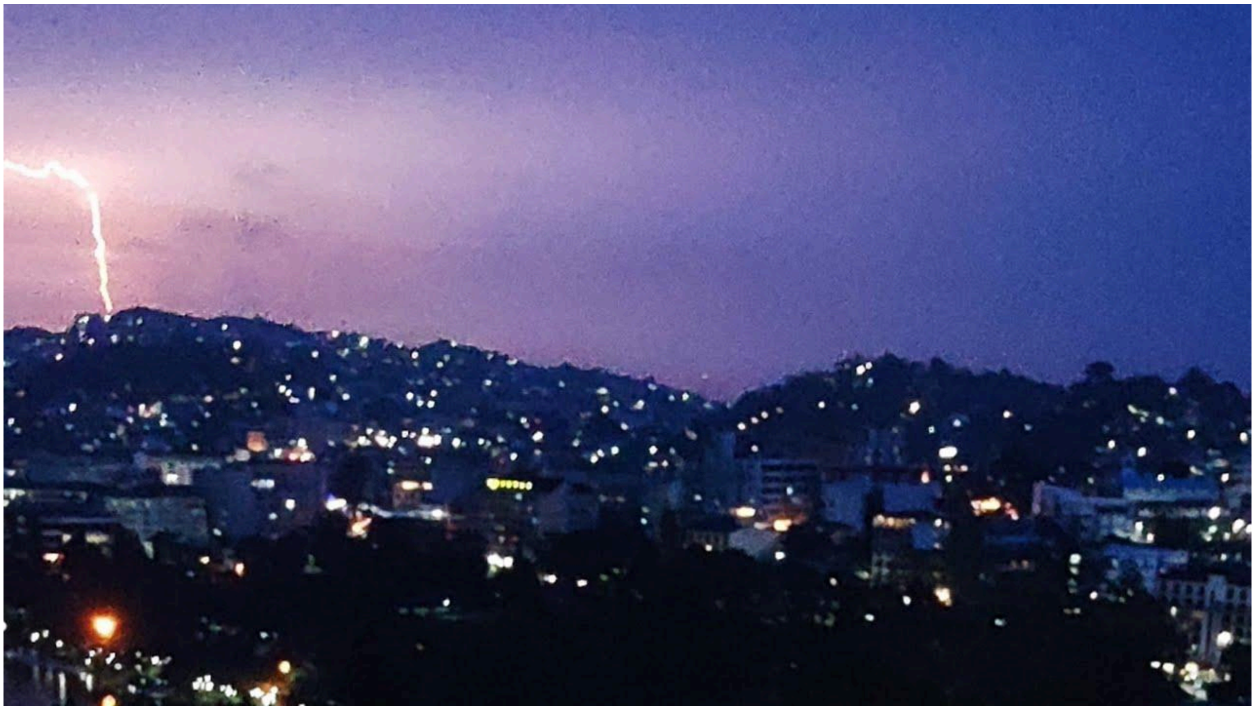
UNIT II: ELECTROMAGNETISM
Module 5: Electricity



Introduction
Electromagnetism is a fundamental branch of physics that studies the interactions between electrically charged particles and the magnetic fields they create. It is a unifying theory that underlies much of modern technology, including electronics, telecommunications, and power generation. From the behavior of lightning to the functioning of a simple electric motor, the principles of electromagnetism are present in countless natural and man-made phenomena. In this module, we will explore the basic concepts of electromagnetism, including electric fields, magnetic fields, electromagnetic waves, and the laws that govern their behavior. By the end of this module, you will have a solid foundation in electromagnetism that will enable you to understand and appreciate the science behind some of the most fascinating technological innovations of our time.

Objectives
After working on this module, you should be able to:
- Define electric charge,
- Understand the law of conservation of charge,
- Differentiate conductors and insulators,
- Understand Coulomb's Law,
- Illustrate electric field,
- Understand how capacitors work, and
- Define electric potential

TOPIC 13:
Electric Charge and Coulomb's Law

Electricity is a broad and fascinating field that deals with the behavior and interactions of electric charges. Here is an outline of the topics that may be covered in a module on electricity:

Electric Charge and Coulomb's Law

Electric charge is a fundamental property of matter that comes in two types: positive and negative. Objects with the same charge repel each other, while objects with opposite charges attract each other. The SI unit for electric charge is the Coulomb (C).

Conservation of charge: Electric charge is conserved, meaning that the total amount of charge in a closed system remains constant.

Coulomb's Law: Coulomb's law describes the relationship between the magnitude of electric charges and the strength of the electric force between them. The law states that the electric force between two point charges is directly proportional to the product of their charges and inversely proportional to the square of the distance between them. Mathematically, this can be expressed as:

$F_e = k_e \frac{q_1 q_2}{r^2}$ (Eqn 13.1)

q_1 = charge 1 q_2 = charge 2 r = distance between charge 1 and charge 2
k_e = 8.99x109 $(N*m^2)/C^2$

This equation states that the *electric force* exerted by a point charge q_1 on a second charge q_2 is inversely proportional to the square of the distance separating them, r^2. The constant k_e is called the *Coulomb constant* and has a value of k_e = 8.99x109 $(N*m^2)/C^2$.

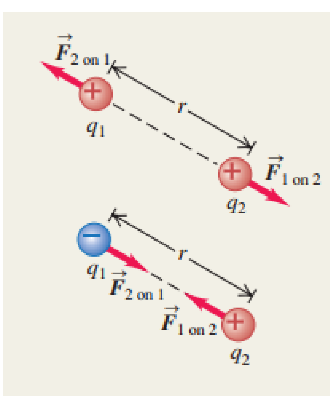


Figure 13.1 The direction of the electric force is along the line that connects the charges. Image retrieved from University Physics with Modern Physics (13th ed.).

The **direction of the force** is along the line that separates the two charges, when both charges have the same sign the force repulsive, and when they have opposite signs the force is attractive.

> *Note:* A positive or negative sign in front of a vector (such as force) indicates the direction of the force. For example, a force of +1N along the x-axis implies that the force is directed towards the positive direction, and a force of -1N means that it is directed towards the negative direction.

Comments on problem solving: A good understanding of geometry/trigonometry is needed when solving problems related to Coulomb's Law since it requires that the solver/student identify the separation between charges. Furthermore, a brief review of Newton's Laws of motion should provide the student with the necessary tools to analyze systems that involve electric force. *Emphasis on Free-body diagrams should be noted*

Solved Problems:

*1. In a thundercloud, there may be electric charges of *+40.0 C* near the top of the cloud and *-40.0 C* near the bottom of the cloud. These charges are separated by *2.00 km*. What is the electric force on the top charge?

Solution:
First, let us list the given quantities:
$q_1 = +40.0\ C$
$q_2 = -40.0\ C$
$r = 2.0\ km$

The problem is asking for the electric force exerted by the bottom cloud on the top cloud. We can treat this problem as purely one-dimensional problem (along the y-axis) and thus, the solution is obtained by substituting the quantities to (Eqn 13.1)

$F_e = k_e \frac{(+40.0\ C)(-40.0\ C)}{(2{,}000\ m)^2}$ (Eqn 11.2)

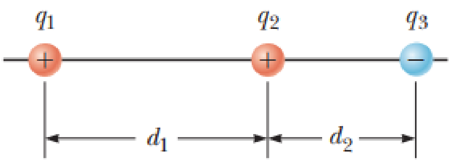
$$F_e = 8.99x109\ (N * m^2)/C^2 \frac{(+40.0\ C)(-40.0\ C)}{(2{,}000\ m)^2}$$

$$F_e = 3.60 \times 10^6 N$$

Since the charges have opposite signs, the force acting on the top charge is attractive and is therefore directed downward.

Thus, the final answer is:

**2. Three point charges lie along a straight line as shown in the figure below, where q_1 = 6.00 µC, q_2 = 1.50 µC, and q_3 = 22.00 µC. The separation distances are d_1 = 3.00 cm and d_2 = 2.00 cm. Calculate the magnitude and direction of the net electric force on (a) q1, (b) q2, and (c) q3.



Solution:
To obtain the net force acting on each charge we add the forces using vector addition, but because the problem is only one dimensional all we have to do is add the forces as they are computed.

Let us compute for the magnitude of all of the forces of interaction among all the charges:

$$F_{2\ on\ 1} = k_e \frac{q_1 q_2}{d_1^2} = 8.99x109 \left(\frac{Nm^2}{C^2}\right) \frac{(6.00\ \mu C)(1.50\ \mu C)}{(3.0\ cm)^2} = 89.9\ N \text{ (Eqn 13.3.1)}$$

$$F_{3\ on\ 1} = k_e \frac{|q_1 q_3|}{(d_1 + d_2)^2} = 8.99x109 \left(\frac{Nm^2}{C^2}\right) \frac{|(6.00\ \mu C)(-2.00\ \mu C)|}{(2.0cm + 3.0\ cm)^2} = 43.2\ N \text{ (Eqn 13.3.2)}$$

$$F_{3\ on\ 2} = k_e \frac{|q_2 q_3|}{(d_2)^2} = 8.99x109 \left(\frac{Nm^2}{C^2}\right) \frac{|(1.50\ \mu C)(-2.00\ \mu C)|}{(2.0\ cm)^2} = 67.4\ N \text{ (Eqn 13.3.3)}$$

Now, to determine the net force acting on each charge we have to identify the direction of each force. In addition to this, to identify the magnitude of the force of q_1 on q_2 we have to apply Newton's third law on $F_{2\ on\ 1}$.

For q_1: The force due to q_2 is toward the negative direction (to the left) since it is repulsive and the force due to q3 is toward the positive direction (to the right) since it is attractive. Therefore,

$$F_1 = - F_{2\ on\ 1} + F_{3\ on\ 1} = -89.9\ N + 43.2\ N = -46.7\ N\ or\ (46.7\ N\ to\ the\ left)$$

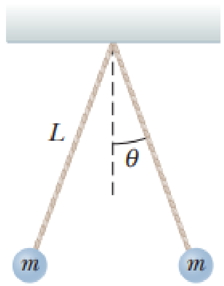
For q_2:

$$F_2 = F_{1\ on\ 2} + F_{3\ on\ 2} = 89.9\ N + 67.4\ N = 157\ N\ or\ (157\ N\ to\ the\ right)$$

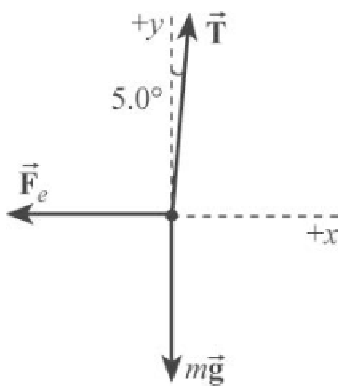
Finally, for q_3:

$$F_3 = -F_{1\ on\ 3} - F_{2\ on\ 3} = -43.2\ N - 67.4\ N = 111\ N\ or\ (111\ N\ to\ the\ left)$$

***3. Two small metallic spheres, each of mass *m = 0.200 g*, are suspended as pendulums by light strings of length *L* as shown in the figure. The spheres are given the same electric charge of *7.2 nC*, and they come to equilibrium when each string is at an angle of $\theta = 5.00^o$ with the vertical. How long are the strings?



Solution:
First, draw the free-body diagram of one of the spheres:



Here, we identify the forces acting on the sphere and their directions. Because the system is in equilibrium the net force acting on each sphere is zero.

For the forces along the y-axis: This includes y-component of tension and the gravitational force

$\sum F_y = 0$ (Eqn 5.4)

$\sum F_y = Tcos(5.0^o) - mg$

$0 = Tcos(5.0^o) - mg \rightarrow T \cos cos\, 5.0^o = mg \rightarrow T = \frac{mg}{coscos\, 5.0^o}$ (Eqn 13.4.1)

Now, for the forces along the x-axis: This includes the x-component of the tension and the electric force.

$\sum F_x = 0$ (Eqn 13.5)

$\sum F_x = T \sin sin\, 5.0^o - F_e$

From Eqn 5.4.1 we obtain the expression for the tension and substitute it in the above equation
$0 = T \sin sin\, 5.0^o - F_e \rightarrow F_e = \frac{mg}{coscos\, 5.0^o} \sin sin\, 5.0^o = mg \tan tan\, 5.0^o$ (Eqn 13.5.1)

In equilibrium, the separation distance between the two spheres is $r = 2L \sin sin\, 5.0^o$ which can be obtained by applying trigonometric identities to the given figure for the problem.

Thus, $F_e = k_e \frac{q^2}{(2L\, sinsin\, 5.0^o)^2}$ which we can equate with Eqn 13.5.1

$k_e \frac{q^2}{\left(2L \text{ sin}sin\ 5.0^o\right)^2} = mg \text{ tan } tan\ 5.0^o$, solving for L

$$L = \sqrt{\frac{k_e q^2}{mg\text{tan}tan\ 5.0^o \left(2\text{sin}sin\ 5.0^o\right)^2}}$$

$$L = \sqrt{\frac{8.99x109\left(\frac{Nm^2}{C^2}\right)(7.2\ nC)^2}{0.20g\left(9.8\frac{m}{s^2}\right)\text{tan}tan\ 5.0^o\left(2\text{sin}sin\ 5.0^o\right)^2}} = 0.299\ m$$

Here are some problem-solving tips about electric charge and Coulomb's law:

1. Start by identifying the charges involved: When solving problems related to electric charges and Coulomb's law, the first step is to identify the type and magnitude of the charges involved. This will help you determine the direction and strength of the electric force between them.
2. Understand the principle of superposition: Coulomb's law states that the electric force between two charged objects is proportional to the product of their charges and inversely proportional to the square of the distance between them. When dealing with more than two charges, it is important to understand the principle of superposition, which states that the total force on a charge is the vector sum of the forces due to each individual charge.
3. Use vector analysis: The electric force between two charged objects is a vector quantity, meaning it has both magnitude and direction. To solve problems involving Coulomb's law, it is important to use vector analysis, including vector addition and subtraction, to determine the net force on a charge.
4. Pay attention to units: When using Coulomb's law to calculate the electric force between two charged objects, it is important to pay attention to the units of charge and distance. The standard SI units for charge and distance are coulombs and meters, respectively.
5. Check your work: As with any type of problem-solving, it is important to check your work to ensure that your calculations are correct and that your final answer makes sense in the context of the problem.

By following these problem-solving tips, you can effectively apply the principles of electric charge and Coulomb's law to solve a wide range of problems.

Here are some great YouTube videos that explain electric charge and Coulomb's law:

- "Electric Charge and Coulomb's Law" by Khan Academy,
  Link: https://www.youtube.com/watch?v=YGjyt6vS-2I

- "Coulomb's Law and Electric Fields" by The Organic Chemistry Tutor,
  Link: https://www.youtube.com/watch?v=WIo-BGTTXJM

- "Electric Charge and Coulomb's Law" by Michel van Biezen,
  Link: https://www.youtube.com/watch?v=9XKMfOI0ji8

- "Coulomb's Law and Electric Forces" by Flipping Physics,
  Link: https://www.youtube.com/watch?v=bCZBcZEZ7fA

- "Electric Fields and Coulomb's Law" by Doc Schuster,
  Link: https://www.youtube.com/watch?v=XFwZPaIcL_I

These videos provide clear explanations of electric charge and Coulomb's law, as well as examples of how to apply them to solve problems. They are great resources for anyone who wants to understand these fundamental concepts of electromagnetism. I hope you find them helpful!

If you prefer to have a more detailed discussion on this topic, you can read the following chapters in textbooks:

- Chapter 18 of College Physics by Paul Peter Urone & Roger Hinrichs (pp. 691-702)
- Chapter 5 of University Physics Vol. 2 by Samuel J. Ling, Jeff Sanny & William Moebs (pp. 181-197)
- Chapter 16 of Physics for Dummies by Steven Holzner (pp. 253-257)

Applications of Coulomb's law: Coulomb's law has many practical applications, such as calculating the electric forces between charged particles in a particle accelerator, designing capacitors for electronic circuits, and understanding the behavior of electrically charged particles in the atmosphere.

Overall, a module on electric charge and Coulomb's law will provide students with a foundational understanding of the properties and behavior of electric charges, as well as the mathematical tools needed to analyze and calculate electric forces and fields.

TOPIC 14:
Electric Field

Electric fields are a fundamental concept in electromagnetism and are central to our understanding of the behavior of charged particles and the operation of many electrical devices. An electric field is a force field that exists in the space around a charged object. This field exerts a force on other charged objects placed within it.

Electric field: An electric field is a region of space where a charged object experiences an electric force. Electric fields are created by electric charges and can be measured in volts per meter (V/m).
The electric field $\vec{E}$ at some point in space is defined as the electric force that acts on a small positive test charge placed at that point divided by the magnitude of the test charge:

$\vec{E} = \frac{\vec{F}_e}{q_o}$ (Eqn 14.1)

E = is the electric field at some point P
q_o = is the charge of the test charge
F_e = is the force experience by the test charge at point P

The direction of the electric field is the same as the direction of the force experienced by a positive test charge.

Electric field due to a point charge: The electric field due to a point charge is proportional to the magnitude of the charge and inversely proportional to the square of the distance from the charge.

Electric field due to multiple point charges: The electric field due to multiple point charges can be found by summing the electric fields due to each individual charge.

Electric field lines: Electric field lines are a visual representation of the electric field in a region of space. They show the direction and strength of the electric field at every point.

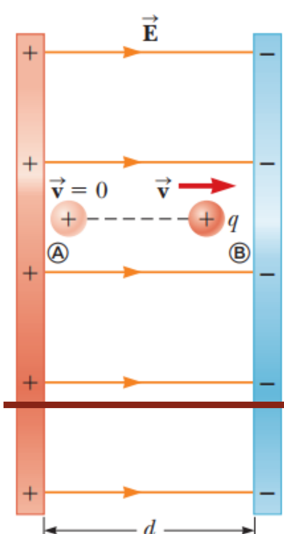
Electric dipole: An electric dipole is a pair of equal and opposite charges separated by a small distance. The electric field due to a dipole varies with distance and orientation.

Electric field due to continuous charge distributions: The electric field due to a continuous charge distribution can be found by integrating the contributions from infinitesimal charge elements.

Comments on problem solving: Similar to Coulomb's law-related problems, a good understanding of geometry, trigonometry, and Newton's laws of motion will make analysis of problems and systems easier for the student. For motion in an electric field, a short review of the kinematic equations is necessary.

Solved Problems:

1. A uniform electric field **E is directed along the x-axis between parallel plates of charge separated by a distance *d* as shown on the figure below. A positive point charge *q* of mass *m* is released from rest at a point *A* next to the positive plate and accelerates to a point *B* next to the negative plate. Find the speed of the particle at point B by modeling it as a particle under constant acceleration.



Solution:
The given quantities are as follows:

- The electric field, **E,** since it is uniform the magnitude and direction at any point is the same.
- The separation distance between the plates: *d*.
- The charge: q.
- The mass of the charge: m

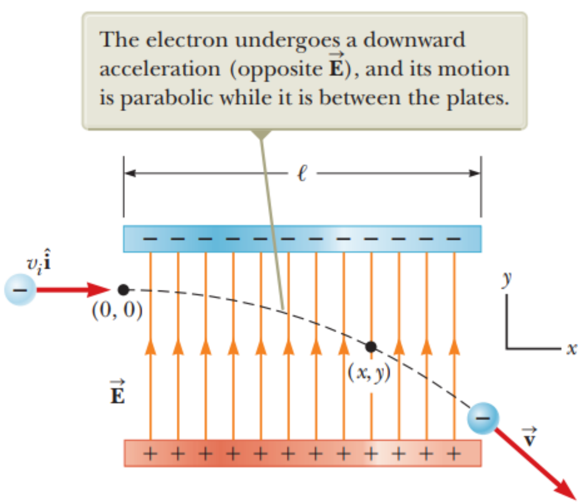
First we need to determine the acceleration of the particle we use Newton's second law of motion.
$F = ma \rightarrow a = \frac{F}{m}$ (Eqn 14.2.1)

From equation 14.1 and 14.2.1 we have
$a = \frac{qE}{m}$ (Eqn 14.2.2)
Now, we use kinematic equations to solve for the speed, we will assume that the particle starts from rest and thus the initial speed is zero.

Our choice of kinematic equation depends on the quantities that we know, which are: the acceleration, *a*; the distance between two points, *d*; and the initial velocity, v_i. Therefore, we will use:

$v_f^2 = v_i^2 + 2a\Delta x$
Substituting the quantities:
$v_f^2 = 0 + 2\frac{qE}{m}(d - 0)$
$v_f = \sqrt{2\frac{qEd}{m}}$

**2. An electron enters the region of a uniform electric field as shown in the figure below, with an initial x velocity of $v_x = 3.00 \times 10^6\ m/s$ and $E = 200\ N/C$. The horizontal length of the plate is $l = 0.100m$. Assuming the vertical position of the electron as it enters the field is $y_i=0$, what is its vertical position when it leaves the field?



Solution:

Before we can determine the location of the charge when it leaves the field we need to identify the acceleration of the charge within the field, and the time for the charge to leave the field.
The acceleration is fairly simple to calculate since the technique needed is the same as that of the previous question. From equation 12.2.2

$$a = \frac{qE}{m}$$

for an electron q = e = -1.6×10^{-19} C and m = 9.11×10^{-31}kg; substituting these quantities to the equation above.

$$a = \frac{(-1.6x10^{-19}C)(200\frac{N}{C})}{9.11x10^{-31}kg} = -3.51 \times 10^{13} m/s^2 \quad \text{(Eqn 14.3.1)}$$

The time for the electron to leave the field is obtained by analyzing the x-motion of the particle, to do this we use

$$\Delta x = v_x t$$

The value of Δx is just the length of the field which is l and v_x is given in the problem.

$$t = \frac{0.100m}{3\times10^{6} m/s} = 3.3\times10^{-8} s \quad \text{(Eqn 14.3.2)}$$

The vertical position at which is the electron leaves the field may now be computed by using the equation

$$\Delta y = v_y t + \frac{1}{2} a_y t^2$$

Since there is no initial y-velocity the equation simplifies to:

$$\Delta y = \frac{1}{2} a_y t^2$$

Substituting the values

$$\Delta y = \frac{1}{2}\left(-3.51\times\frac{10^{13} m}{s^2}\right)(3.3\times10^{-8} s)^2 = -1.95\, cm$$

If you prefer to have a more detailed discussion on this topic, you can read the following chapters on textbooks from OpenStax:

- Chapter 18 of College Physics by Paul Peter Urone & Roger Hinrichs (pp. 703-777)
- Chapter 16 of Physics for Dummies by Steven Holzner (pp. 258-261)

Here are some great YouTube videos that explain the concept of electric field:

- "Electric Fields" by Physics Girl
  Link: https://www.youtube.com/watch?v=VdmbpMaTn6w
- "Electric Field Explained" by The Organic Chemistry Tutor
  Link: https://www.youtube.com/watch?v=zcqZHYo7ONs
- "Electric Fields and Conductors" by Flipping Physics
  Link: https://www.youtube.com/watch?v=ccV-sKuZq4A
- "Electric Field Lines and Electric Flux" by Doc Physics
  Link: https://www.youtube.com/watch?v=7JhCJS-8WpM
- "Electric Fields: Crash Course Physics #26" by Crash Course
  Link: https://www.youtube.com/watch?v=KuUMU_xjoTY

Here are some tips for solving problems involving electric fields:

When solving problems related to electric field, it is important to understand the concept of electric field strength, which is defined as the force per unit charge experienced by a test charge at a given point in space. To calculate the electric field strength at a point in space, you can use the equation:

$$E = F/q$$

Where E is the electric field strength, F is the electric force acting on the test charge, and q is the magnitude of the test charge.

To apply this equation to a problem, you need to first identify the charges involved and the distance between them. Then, you can calculate the electric force between the charges using Coulomb's law and divide that force by the magnitude of the test charge to obtain the electric field strength.

It is important to pay attention to the direction of the electric field, which is determined by the direction of the electric force acting on a positive test charge. Electric field lines are used to visualize the direction and strength of the electric field at different points in space.

By understanding the concept of electric field strength and how to calculate it, you can effectively solve problems related to electric field and gain a deeper understanding of this fundamental concept in electromagnetism.

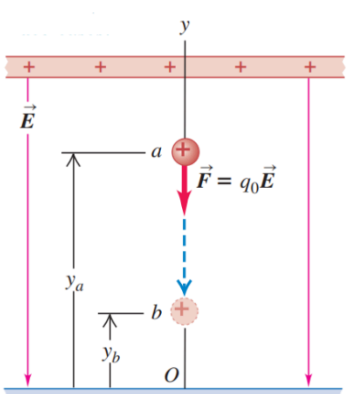
TOPIC 15:
Electric Potential

Before learning about electric potential the student must be familiar with electric potential energy. For two point charges, the electric potential energy is:

$$U = k_e \frac{q_1 q_2}{r} \quad \text{(Eqn 13.1)}$$

k_e is Coulomb's constant, r is the distance of separation between the charges q_1 and q_2.

For charge in an electric field, the electric potential energy is:



$$U = q_o E y \quad \text{(Eqn 13.2)}$$

q_o is the charge, y is the distance measured from the reference point (where the potential energy is zero), on the figure on the left the reference point is along the negative charge distribution; E is the magnitude of the electric field, on the figure the direction is downward.

To better understand the electric potential energy for a charge in an electric field you can make an analogy with gravitational potential energy ($U = mgh$).

Electric potential: Electric potential is a measure of the potential energy per unit charge in an electric field. It is measured in volts (V) and is related to the work done in moving a charge through an electric field.

$$V = \frac{U}{q_o} \quad \text{(Eqn 13.3)}$$

The SI unit for electric potential is volt (1V) which equals 1 joule per coulomb:

$$1V = 1volt = 1\frac{J}{C}$$

For example, the electric potential due to a point charge is:

$$V = k_e\frac{q}{r} \quad \text{(Eqn 13.4)}$$

Note: V_{ab} is the potential of *a* with respect to *b*, equals the work must be done to move a UNIT charge slowly from *b* to *a* against the electric force.

$$V_{ab} = V_a - V_b \quad \text{(Eqn 13.5)}$$

The potential energy of a charge-field system in terms of the electric potential:

$$\Delta U = q\Delta V = - qEy \quad \text{(Eqn 13.6)}$$

Comments on problem solving: Problems involving electric potential and electric potential energy often require knowledge of the work-energy theorem or conservation of energy. A review/refresher on these topics should be given to the students before proceeding with the problem solving.

Solved Problems:

*1. A battery has a specified potential difference ΔV between its terminals and establishes that potential difference between conductors attached to the terminals. A 12-V battery is connected between two parallel plates as shown in Figure 25.5. The separation between the plates is
d = 0.30 cm, and we assume the electric field between the plates to be uniform. (This assumption is reasonable if the plate separation is small relative to the plate dimensions and we do not consider locations near the plate edges.) Find the magnitude of the electric field between the plates.

Solution:

From equation 13.6 we can determine the relation between the potential difference ΔV, and the electric field *E* which is

$-\ qEy\ =\ q\Delta V$ (Eqn 13.7.1)

Here the value of *y* is the plate separation provided in the problem.
Simplifying equation 13.7.1, we get

$Ey\ =\ \Delta V$ (En 13.7.2)

Since we only need the magnitude of the electric field, we can solve for it using equation 13.7.2

$E\ =\frac{|\Delta V|}{y}$

$E\ =\frac{12V}{0.30\times10^{-2}m}=\ 4.0\times10^{3}\ V/m$

The value above implies that as we move along the plates the value of the potential increases, for example if we move along a distance of 0.1cm the value of the potential is 4V. If we move another 0.1cm the potential increases to 8V, and so on.

**2. An electron is to be accelerated from 3.00×10^{6} m/s to 8.00×10^{6} m/s. Through what potential difference must the electro pass to accomplish this?

Solution:

The solution to this may be obtained by conservation of energy which means

$\Delta K\ +\ \Delta U\ =\ 0$

Expanding the equation

$\left(\frac{1}{2}mv_2^2-\ \frac{1}{2}mv_1^2\right)+\ q\Delta V\ =\ 0$ (Eqn 13.8.1)

Before anything else, recall the following values for an electron:
Mass: 9.11×10^{-31} kg
Charge: -1.6×10^{-19} C

Computing for the initial kinetic energy

$\frac{1}{2}mv_1^2=\frac{1}{2}\left(9.11\times10^{-31}kg\right)\left(3\times10^{6}\frac{m}{s}\right)^2\ =\ 4.099\times10^{-18}J$

For the final kinetic energy:

$\frac{1}{2}mv_1^2=\frac{1}{2}\left(9.11\times10^{-31}kg\right)\left(8\times10^{6}\frac{m}{s}\right)^2\ =\ 2.915\times10^{-17}J$

Using these results to solve for the potential difference in equation 13.8.1

$$\Delta V = \frac{K_1 - K_2}{q}$$

$$\Delta V = \frac{4.099\times10^{-18} J - 2.915\times10^{-17} J}{-1.6\times10^{-19} C} = 156\ V$$

Capacitance: Capacitance is the ability of a system to store electrical charge. It is measured in Farads, and is related to the electric field and geometry of the system.

Applications of electric potential: Electric potential is used in many practical applications, such as in batteries, circuits, and electric motors.

Overall, a module on electric potential will provide students with a deeper understanding of the behavior of electric charges in the presence of electric potential, as well as the mathematical tools needed to calculate and analyze electric potential in various contexts.

If you prefer to have a more detailed discussion on this topic, you can read the following chapters on textbooks from OpenStax:

- Chapter 19 of College Physics by Paul Peter Urone & Roger Hinrichs (pp. 731-756)
- Chapter 16 of Physics for Dummies by Steven Holzner (pp. 262-270)

Here are some great YouTube videos about electric potential that you might find helpful:

- ***"Electric Potential Energy and Voltage" by Khan Academy*** *- This video provides a clear and concise introduction to electric potential and how it relates to electric potential energy and voltage.*
- ***"Electric Potential and Electric Potential Energy" by Michel van Biezen*** *- This video goes into more detail about electric potential and electric potential energy, including how to calculate them and their relationship to work.*
- ***"Electric Potential Difference" by Physics Online*** *- This video explains what electric potential difference is, how it is measured, and how it relates to electric current.*
- ***"Electric Potential due to a Point Charge" by Doc Physics*** *- This video provides an example of how to calculate electric potential due to a point charge and explains the concept in a fun and engaging way.*
- ***"Electric Field, Potential and Voltage" by The Organic Chemistry Tutor*** *- This video covers the basics of electric fields, electric potential, and voltage, with plenty of examples and practice problems.*

Here are some tips for solving problems related to electric potential:

1. Draw a diagram: Drawing a diagram of the situation can help you visualize the problem and identify key variables. Make sure to label all the relevant quantities, such as the distances between charges and the direction of the electric field.
2. Understand the formula: Be sure you understand the formula for electric potential ($V = kQ/r$), where V is the electric potential, k is Coulomb's constant, Q is the charge, and r is the distance. Also, know how to calculate electric potential energy ($U = QV$) and the potential difference (ΔV).
3. Identify known and unknown variables: Once you understand the formula, identify the variables you know and the ones you need to solve for. Make a list of the known and unknown variables and any relevant equations.
4. Substitute values: Substitute the known variables into the formula and solve for the unknown variable. Be sure to use consistent units throughout your calculation.
5. Check your answer: Double-check your answer to ensure that it makes sense in the context of the problem. Does it have the correct units? Is it reasonable? If not, recheck your calculations and make sure you didn't make any mistakes.
6. Practice, practice, practice: The more problems you solve, the more familiar you'll become with the concepts and formulas involved in electric potential problems. Try to solve problems from different sources and of varying difficulty levels to challenge yourself.

References

- Walker, Halliday and Resnick (2014). Fundamental of Physics, 10th Ed. (Extended), John Wiley & Sons, USA.
- Giancoli, Douglas C. Physics: Principles with Applications 7th Edition
- Nolan, Peter J. Fundamentals of College Physics
- Tipler, Paul A. Physics for Scientists and Engineers 6th Edition
- Young, Hugh D & Freedman, Roger A. University Physics 15th Edition
- Serway, Raymond A & Jewett Jr., John W. Physics for Scientists and Engineers with Modern Physics 9th Edition