General Physics 2 - Module 2

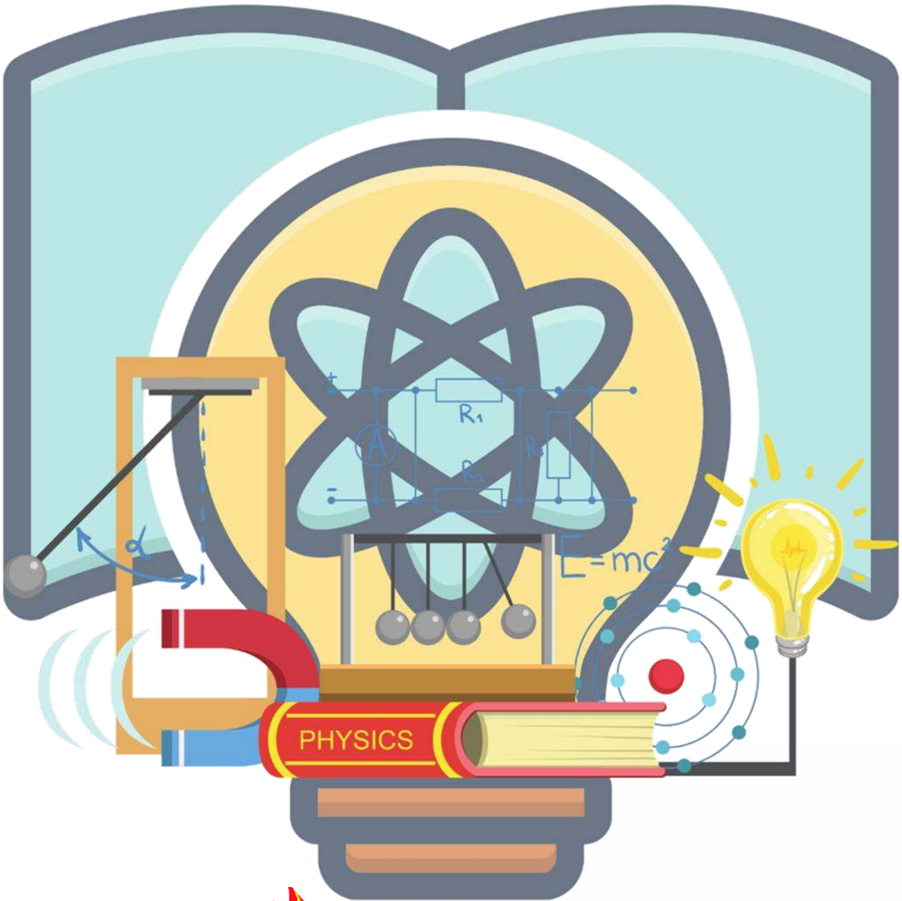
PHYSICS (Polytechnic University of the Philippines)

Senior High

General Physics 2

Quarter 3 - Module 2

Electric Potential



General Physics 2
Alternative Delivery Mode Self-Learning Module
Quarter 3 - Module 2: Electric Potential
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Development Team of the Module

Author: Madeleine J. Ngitngit

Content Evaluator: Noeme S. Lagos

Language Evaluator: Pinky dela Calzada

Illustrator and Layout Artist: Arian S. Edullantes

Management Team
Chairperson: Cherry Mae L. Limbaco, PhD, CESO V
Schools Division Superintendent

Co-Chairpersons: Rowena H. Para-on, PhD.
Assistant Schools Division Superintendent

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Gemma Pajayon, PDO II

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Telefax: (08822)855-0048
E-mail Address: cagayandeoro.city@deped.gov.ph

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This instructional material was collaboratively developed and reviewed by educators from public and private schools, colleges, and or/universities. We encourage teachers and other education stakeholders to email their feedback, comments, and recommendations to the Department of Education at action@ deped.gov.ph.

We value your feedback and recommendations.

Department of Education ● Republic of the Philippines

Table of Contents

What This Module is About

This module is about demonstrates your understanding on the concepts of electric potential and electric potential energy. Electric potential energy is the energy that is needed to move a charge against an electric field. You need more energy to move a charge further in the electric field, but also more energy to move it through a stronger field.

This module will help you explore the key concepts on topics that will help you answer the questions pertaining to electric potential.

This module covers the following lesson:

Electric Potential and Electric Potential Energy

What I Need to Know

At the end of this module, you should be able to:

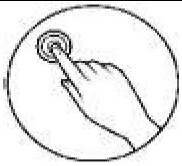
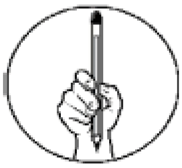
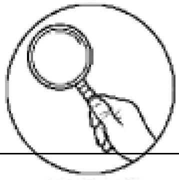
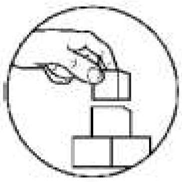
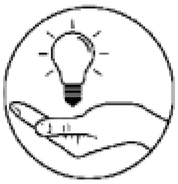
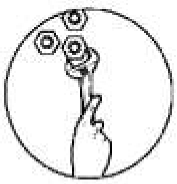
1. Relate the electric potential with work, potential energy, and electric field. (**STEM_GP12EM-IIIb-15)**
2. Determine the electric potential function at any point due to highly symmetric continuous-charge distributions (**STEM_GP12EM-IIIc-17)**
3. Infer the direction and strength of electric field vector, nature of the electric field sources, and electrostatic potential surfaces given the equipotential lines Define the work done by the electric force. (**STEM_GP12EM-IIIc-18)**
4. Calculate the electric field in the region given a mathematical function describing its potential in a region of space **(STEM_GP12EM-IIIc-20)**
5. Solve problems involving electric potential energy and electric potentials **(STEM_GP12EM-IIIc-22)**

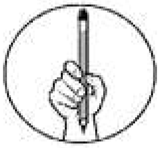
How to Learn from this Module

To achieve the objectives cited above, you are to do the following:

1. Carefully read and follow instructions.
2. Write your answer/s on a separate sheet of paper**,** notebook, workbook or whichever is specified by your subject teacher.
4. Take the pretest.
5. Read all lessons included in this module.
6. Perform all the activities diligently, as these will help you have a better understanding of the topic. When you need help, tap your parent/guardian, facilitator or contact your subject teacher
7. Eventually, take the posttest at the end of this module.

Icons of this Module

	**What I Need To Know**	This part contains learning objectives that Know are set for you to learn as you go along the module.
	**What I Know**	This is an assessment as to you level of knowledge to the subject matter at hand, meant specifically to gauge prior relate knowledge.
	**What's In**	This part connects previous lesson with that What's In of the current one.
	**What's New**	An introduction of the new lesso through various activities, before it will be presented to you
	**What is It**	These are discussions of the activities as a way to deepen your discovery and understanding of the concept
	**What's More**	These are follow - up activities that are in - What's More tended for you to practice furthe in order to master the competencies.
	**What I Have Learned**	Activities designed to process what you have learned from the lesson
	**What I Can Do**	These are tasks that are designed to show- case your skills and knowledge gained, an applied into real-life concerns and situations.



What I Know

Multiple Choice. Select the letter of the best answer from among the given choices.

1. What is the energy per unit charge?
   A. current
   B. frequency
   C. power
   D. voltage

2. The magnitude of electric potential is ______ at an infinite distance.
   A. negative infinity
   B. one hundred
   C. positive infinity
   D. zero

3. Which statements must be true about the surface of a charged conductor in which no charge is moving?
   A. The electric field is zero at the surface.
   B. The electric potential of the surface is zero.
   C. The electric potential is constant over the surface.
   D. The electric field is constant at the surface.

4. Of the following quantities, which is vector in character?
   A. charge
   B. electric field
   C. energy
   D. potential difference

5. A system of two charges has a positive potential energy. This closely indicates that
   A. both charges are positive
   B. both charges are negative
   C. both charges are positive or both are negative
   D. one charge is positive & the other is negative

6. An electron & a proton are accelerated through the same potential difference
   A. the electron has greater KE
   B. the proton has greater KE
   C. the electron has greater speed
   D. the proton has greater speed.

7. The electric potential due to several point charges is given by the equation: $V = k\Sigma q_i / r_i$. The r indicates:
   A. the distance from the point charge to the point at which the potential is evaluated
   B. the radius of the two pair of charges.
   C. the radius from the center of the charge
   D. none of these

8. A positive charge is located at the origin. As a test charge moves away from the charge, what will happen to the electric potential electric potential due to this charge?
   A. increases
   B. decreases
   C. remains the same
   D. undetermined

9. Which of the following statements are TRUE?
   I. When a positive charge moves in the direction of an electric field, the field does negative work and the potential energy increases.
   II. When a negative charge moves in the direction of an electric field, the field does negative work and the potential energy increases.
   III. When a negative charge moves in the direction of an electric field, the field does positive work and the potential energy decreases.

   A. I&IV　　B. II&III
   D. I&III　　D. II&IV

10. How much work is done in moving a charge between two points on the same equipotential surface?

    A. zero　　B. maximum
    B. depends on the charge　　D. undetermined

11. A negative charge moves in the direction of a uniform electric field. What does this entail?

    A. The charge moves to a position of higher potential.
    B. The charge moves to a position of lower potential
    C. The charge moves to a position with the same potential
    D. The potential cannot be determined.

12. The unit Volt, V is the same as.

    A. J/C　　B. C/J
    B. JC　　D. CJ

13. As a proton moves in the direction the electric field lines...

    A. it is moving from low potential to high potential and gaining electric potential energy.
    B. it is moving from low potential to high potential and losing electric potential energy.
    C. it is moving from high potential to low potential and gaining electric potential energy.
    D. it is moving from high potential to low potential and losing electric potential energy.

14. A charge of 31μC moves from the positive to the negative terminal of a 9.0-V battery. How much energy does the battery impart to the charge?

    A. -9.72×10^{-4} J　　B. -2.79×10^{-4} J
    C. 2.79×10^{-4} J　　D. 9.72×10^{-4} J

15. Electric potential ____________ as distance increases.

    A. increases　　B. decreases
    C. remains constant　　D. 0

Lesson 1

ELECTRIC POTENTIAL AND ELECTRIC POTENTIAL ENERGY

What's In

We just scratched the surface (or at least rubbed it) of electrical phenomena. In quarter 1 Module 6, we introduced the concepts of work and energy in the context of mechanics, this time we'll combine this concept with what we have learned about electric charge, electric force and electric field. Two terms commonly used to describe electricity are energy and voltage. The energy and voltage are not the same thing.

Potential energy is the energy stored by an object because of its position relative to other objects, its electric charge, or other factors. A common type of potential energy includes the electric potential energy.

What I Need to Know

In this lesson, you will be able to relate the electric potential with work, potential energy, and electric field. You will also solve problems involving electric potential for point charge and continuous charge distribution.

What's New

Activity 2.1 Finding You. Discover the words which relate to electric potential energy.

E	E	C	A	M	E	R	A	S	E	L	O	W	S
N	L	O	J	E	C	T	I	L	L	M	S	S	R
O	W	E	T	H	C	A	V	O	E	Y	B	R	E
P	O	T	E	N	T	I	A	L	C	E	S	T	H
F	R	D	N	F	L	C	L	F	T	C	A	U	G
S	K	U	E	H	A	E	V	S	R	F	R	I	I
T	U	H	R	U	T	L	E	T	I	I	Y	O	C
B	I	O	G	E	L	E	L	B	C	E	O	M	R
G	O	N	Y	D	E	R	O	G	J	O	U	L	E
W	M	E	V	O	L	T	G	H	G	N	J	D	V
R	O	S	Q	S	F	T	I	N	J	R	T	I	O
E	R	R	O	S	T	I	T	E	C	V	S	C	L
G	F	Y	K	E	N	O	Y	G	R	F	C	N	V
S	W	E	M	I	N	G	T	T	Y	E	B	E	R

What Is It

In an electric field, a charge has potential energy relative to its position. When a positive charge q is accelerated in an electric field, the charge has electric potential energy (see Figure 2.1). It is like an object being accelerated in a gravitational field, as if the charge were going down an electrical hill, although the sources of the forces are very different.

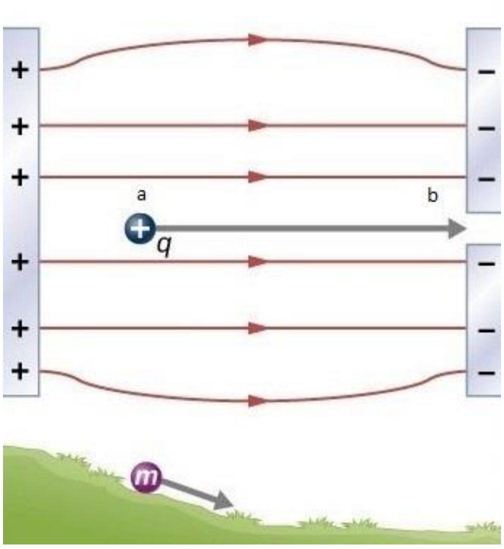


Figure 2.1 Analogy of a charge accelerated by an electric field and a mass going down a hill. Work is done by a force, but since this force is conservative, W= –ΔU.

Source: https://openstax.org/books/university-physics-volume-2/pages/7-1-electric-potential-energy

If the electric force is conservative, then the work done by this force on a charged particle moving from point *a* to point a can be expressed in terms of the electric potential energy $\boldsymbol{U}$,

$$W_{ab} = W_{a\rightarrow b} = \int_b^a \vec{F}\cdot d\vec{l} = \int_a^b q_o\vec{E}\cdot d\vec{l} = -\Delta U = U_a - U_b$$

The work done is equal to the negative of the change in electric potential energy.

Whether the test charge is positive or negative, the following general rules apply:

1. **U increases** if a test charge moves in the direction **opposite** to the electric force acting on it.

2. **U decreases** if a test charge moves in the **same** direction as the electric force acting on it.

Electric Potential Energy of Point Charges

The electric potential energy for two point charges, q_1 and q_0, separated by a distance r (see Figure 2.2) is given as

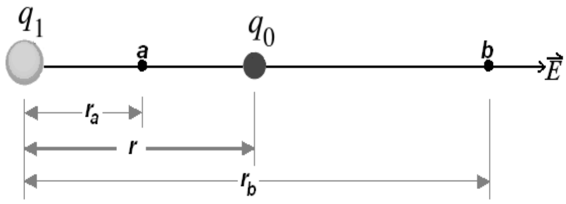


Figure 2.2 Two Point Charges

$$U = \frac{1}{4\pi\varepsilon_o}\frac{q_1 q_0}{r}$$

The electric potential energy for a test charge q_o in the electric field produced by a collection of charges (see Figure 2.3) is given by

$$U = \frac{q_0}{4\pi\varepsilon_0}\sum_{i}^{n}\frac{q_i}{r_i} = \frac{q_0}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1}+\frac{q_2}{r_2}+\frac{q_3}{r_3}+\ldots+\frac{q_n}{r_n}\right)$$

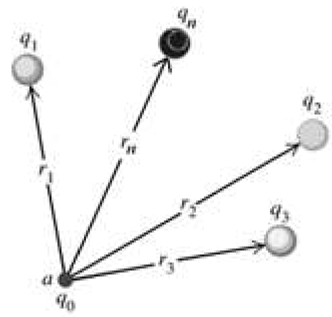


Figure 2.3 A Test Charge in a Collection of Charges

A more general equation to determine the total electric potential energy of the system:

$$U = \frac{1}{4\pi\varepsilon_o}\sum_{i<j}^{n}\frac{q_i q_j}{r_{ij}}$$

Electric Potential

Electric Potential, V, is defined as the potential energy per unit charge. The electric potential energy is shown by two elements, the charge possessed by the object itself and the position relative to an object with respect to electrically charged objects. The **magnitude of electric potential** is dependent on the amount of work done in moving the object from one point to another against the electric field.

When an object is moved against the electric field it gains amount of energy which is the **electric potential energy**. In a given charge the electric potential energy is the total work done by an external agent in bringing the system of charges from continuity to the present without any acceleration. It is obtained by dividing potential energy to the quantity of charge. Electric potential energy is a scalar quantity. It is measured in terms of Joules.

$$V = \frac{U}{q_o}$$

Unit of Electric Potential: I Volt, V = 1 J/C

Given the sizes of each charge and the distance between them, the electric potential energy they have relative to each other can be calculated. This is assuming the two charges can be treated as point charges, which are where all the charge is concentrated at an exact point in space.

1. The potential of infinity is defined to be zero.
2. If a point charge is positive, the electric potential of the charge is positive. When moving a charge from infinity to this point, the electric potential increases above a zero level.
3. If a point charge is negative, the electric potential of the charge negative. When moving a charge from infinity to this point, the electric energy decreases below a zero level.

Moving along the direction of the electric field, $\vec{E}$, in both positive and negative point charges, the electric potential V decreases. Otherwise, the potential V increases (see Figure 2.4).

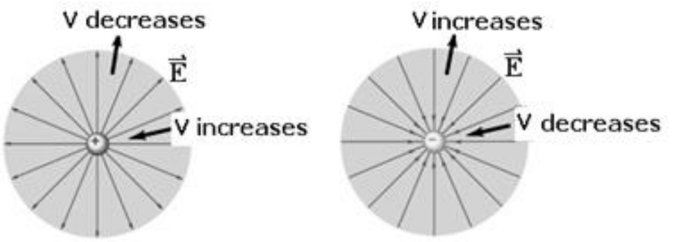


Figure 2.4 Electric Field and Electric Potential of a (A) Positive Charge (B) Negative Charge

Equations for Calculating Electric Potential

Working Equation	Description
$V = k\frac{q}{r} = \frac{1}{4\pi\varepsilon_o}\frac{q}{r}$	for single point charge
$V = k\sum_i \frac{q_i}{r_i} = \frac{1}{4\pi\varepsilon_o}\sum_i \frac{q_i}{r_i}$	for several point charges
$V = k\int \frac{dq}{r} = \frac{1}{4\pi\varepsilon_o}\int \frac{dq}{r}$	for continuous charge distribution $dq = \lambda dl \rightarrow$ linear charge distribution $dq = \sigma dA \rightarrow$ surface charge distribution $dq = \rho dV \rightarrow$ volume charge distribution

The **potential difference** between two points can be expressed as a line integral given by

$$V_{ab} = V_a - V_b = \frac{W_{a\to b}}{q_o} = \int_a^b \vec{E}\cdot\vec{dl} = \int_a^b E\cos\emptyset\, dl$$

Electron Volt

One electron volt (1 eV) is the kinetic energy gained by an electron moving through a potential difference of one volt (1 V).

$$1\text{ eV} = 1.602 \times 10^{-19}\text{ J}$$

Equipotential Line

An equipotential is a line surface over which the electric potential (V) is constant at every point. Electric field lines are perpendicular to equipotentials.

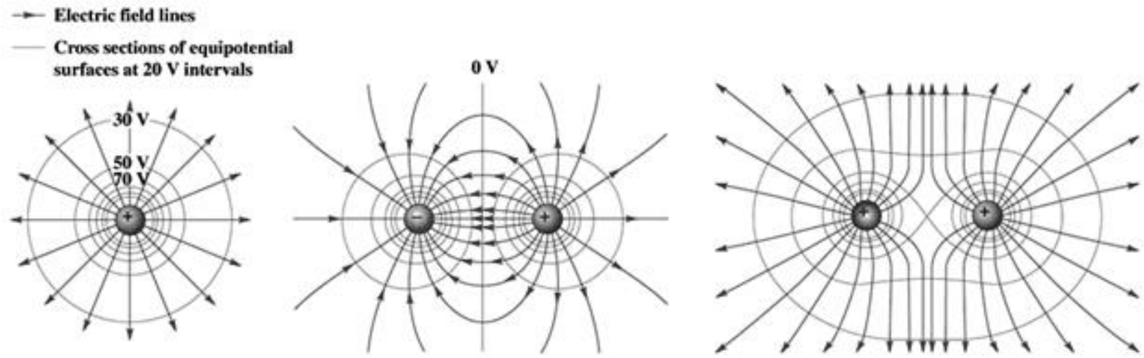


Figure 2.5 Equipotential lines of a positive point charge, a dipole and a pair of positive charges
Source: https://openstax.org/books/university-physics-volume-2/pages/7-5-equipotential-surfaces-and-conductors

Equipotential Surface

An equipotential surface is one on which all points are at the same potential. The potential difference between any two points on an equipotential surface is zero; there is no work done to move a charge between two points.

Characteristics of Equipotential Surfaces

1. No work is done to move a charge between two points on the same equipotential surface.
2. Electric filed lines are perpendicular to equipotential surface.
3. The surface of a conductor is an equipotential surface.

Solving Problems Involving Electric Potential Energy and Electric Potential

1. Two point charges q_1=-e and q_2=+e are located on the x-axis at x=0 and x=a respectively.
   a) Find the work that must be done in bringing a third charge q_3=+e from infinity to x=2a
   b) Find the total potential energy of these three point charges.

   Solution:

   a. $W_{ab} = -\Delta U = U_a - U_b$ (The initial potential energy, U_a, is zero at infinity)

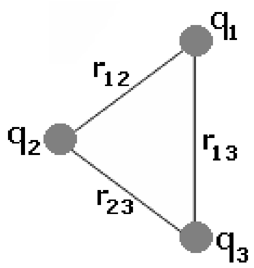
$$W_{ab} = 0 - U_b = -\left[\left(\frac{+e}{4\pi\varepsilon_0}\right)\left(\frac{-e}{2a} + \frac{e}{a}\right)\right] = \frac{-e^2}{8\pi\varepsilon_0 a} = \boxed{\frac{-ke^2}{2a}}$$

b. $U = \frac{1}{4\pi\varepsilon_0}\sum \frac{q_i q_j}{r_{ij}} = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}\right) = \frac{1}{4\pi\varepsilon_0}\left(\frac{(-e)(e)}{a} + \frac{(-e)(e)}{2a} + \frac{(e)(e)}{a}\right)$

$$U = \frac{-e^2}{8\pi\varepsilon_0 a} = \boxed{\frac{-ke^2}{2a}}$$

2. In the figure shown, assume that $r_{12} = r_{13} = r_{23} = 12\ cm$, and that q_1=+q, q_2=-4q and q_3=+2q where q=150nC. What is the potential energy of the system?

Solution:



$$U = k\sum \frac{q_i q_j}{r_{ij}} = k\left[\frac{q_1q_2}{r_{12}} + \frac{q_1q_3}{r_{13}} + \frac{q_2q_3}{r_{23}}\right]$$

where q_1=+q=+150nC

q_2=-4q=-4(150nC)=-600nC

q_3=+2q=+2(150nC)=300nC

$$U = 9x10^9\frac{Nm^2}{C^2}\left[\frac{(150x10^{-9}C)(-600x10^{-9}C)}{0.12m} + \frac{(150x10^{-9}C)(300x10^{-9}C)}{0.12m} + \frac{(-600x10^{-9}C)(300x10^{-9}C)}{0.12m}\right]$$

$$U = \boxed{-0.017J}$$

3. A proton (+q = +1.602 x 10^{-19}C) moves along a straight line from point *a* to point *b* with a separation distance d = 0.50m. Considering the electric field along this line is uniform with magnitude of 1.50 x 10^7V/m and directed from point a to point b. Determine:
a) the force on the proton

b) the work done on it by the field (in Joules & eV units)

c) the potential difference (V_{ab})

Solution:

a) Since the charge is positive, then the electric force is in the same direction of the electric field. Its magnitude is

$$F = qE = (1.602x10^{-19}C)(1.50x10^7\frac{V}{m}) = \boxed{2.4x10^{-12}N}$$

b) The force is constant since the electric field is uniform along the proton's displacement. Hence, the work done by the field is

$$W_{a\to b} = \int_a^b \vec{F}\cdot\vec{dl} = -Fd = -(2.4x10^{-12}N)(0.50m) = \boxed{1.2x10^{-12}J}$$

Converting this value in eV,

$$W_{a\to b} = 1.2x10^{-12}J\left(\frac{1eV}{1.602x10^{-19}J}\right) = 7.5x10^{6}eV = \boxed{7.5MeV}$$

c) From the work done expression, the potential difference (V_{ab}) is then

$$V_{ab} = \frac{W_{a\to b}}{q} = \frac{1.2x10^{-12}J}{1.602x10^{-19}C} = 7.5x10^{6}V = \boxed{7.5MV}$$

4. Electron in TV tube. Suppose an electron in the picture tube of a television set is accelerated from rest through a potential difference V_{ba} = +5000V. What is the change in potential energy of the electron?
   (e = -1.602 x 10^{-19} C)

   Solution:

$$\Delta U = qV_{ba} = (-1.602x10^{-19}C)(+5000V) = \boxed{-8.0x10^{-16}J}$$

   The negative sign indicates that the potential energy decreases.

5. Potential due to charged disk. A thin flat disk of radius R carries a uniformly distributed charge Q. Determine the potential at a point P on the axis of the disk, a distance *x* from its center. ($A_{disk} = \pi R^2$).

   Solution:

   The potential (V) for charge distribution is:

$$V = k\int\frac{dq}{r} = \frac{1}{4\pi\varepsilon_o}\int\frac{dq}{r}$$

   from surface charge density, σ:

$$\sigma = \frac{Q}{A} = \frac{Q}{\pi R^2} = \frac{dq}{dA} = \frac{dq}{2\pi r dr}$$

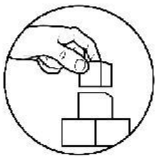
   Therefore, $dq = \sigma dA = \dfrac{2Qrdr}{R^2}$

   The potential, V, is then equal to:

$$V = k\int\frac{dq}{r} = \frac{1}{4\pi\varepsilon_o}\int\frac{\sigma dA}{\left(x^2+r^2\right)^{1/2}} = \frac{2Q}{4\pi\varepsilon_o R^2}\int_0^R\frac{rdr}{\left(x^2+r^2\right)^{1/2}}$$

$$V = \frac{2Q}{4\pi\varepsilon_o R^2}\left(x^2+r^2\right)^{1/2}\Big|_{r=0}^{r=R}$$

$$\boxed{V = \frac{Q}{2\pi\varepsilon_o R^2}\left[\left(x^2+R^2\right)^{1/2} - x\right]}$$ (*V due to a charged disk*)



What's More

Activity 2.2 Problem Solving. Answer the following questions. Write your solution and answer on a separate sheet of paper.

1. How much work is required to move a charge of 4 nC from a point 2m away to a point 0.5 m away from a point charge of 60 nC? What is the potential difference between these points?

2. A point charge q_1=4.00 nC is placed at the origin, and a second point charge q_2=-3.00 nC is placed on the x-axis at x=+20.0 cm. A third point charge q_3=2.00 nC is to be placed on the x-axis between q_1 and q_2. Let the potential energy of the three charges be zero when they are infinitely far apart.
   a) what is the potential energy of the system of the three charges if q_3 is placed at x=+10.0 cm?
   b) where should q_3 be placed to make the potential energy of the system equal to zero?

3. A solid conducting sphere of radius 30 cm has a charge of 4 µC. If the potential is zero at infinity. Find the value of the potential at the following distances from the center of the sphere:
   a) 45 cm b) 30 cm c) 15 cm

What I have Learned

Activity 2.3 Study Log. Answer accordingly.

Keywords	What have learned?	What did I find most interesting?	What questions do I still have?
Electric Potential Energy			
Electric Potential			
Equipotential Lines			

What Can I Do

Activity 2.4. Searching Time. Explore online the answers of the following questions associated with electric potential applications.

1. A *Van de Graff Generator* is a laboratory device with a large hollow metal sphere supported by a cylindrical insulating stand. It is for building up high voltages. Why does your hair stand out when you are charged by such device?

2. An *electron gun* is a device that is the heart of most TVs and computer monitors. How does it work inside the device?

Summary

- A charged object has electric potential energy by virtue of its location in an electric field.

- Electric potential energy is a form of mechanical energy. It is expressed in electron volts (eV).

- The electric potential, or voltage, at any point in an electric field is the electric potential energy per unit charge for a charged object at that point.

- The work done by the electric force on a charged particle moving in an electric field is equal to the negative of the change in electric potential energy.

- Electric Potential can be calculated by summing or integrating over the charges.

- Electron volt (1 eV) is the kinetic energy gained by an electron moving through a potential difference of one volt (1 V),

- An equipotential surface is one on which all points are at the same potential.

Assessment: (Posttest)

Multiple Choice. Answer the question that follows. Choose the best answer from among the given choices.

1. Of the following quantities, the one that is not a scalar in character is
   A. charge　B. electric field
   C. energy　D. potential difference

2. A system of two charges has a negative potential energy. This signifies that
   A. both charges are positive
   B. both charges are negative
   C. both charges are positive or both are negative
   D. one charge is positive & the other is negative

3. An electron & a proton are accelerated through the same potential difference
   A. the electron has lower KE　B. the proton has lower KE
   C. the electron has lower speed　D. the proton has lower speed.

4. The electric potential energy due to several point charges is given by the equation: $U = k \Sigma q_i / r^2_i$. The r indicates:
   A. the distance from the point charge to the point at which the potential energy is evaluated.
   B. the radius of the two pair of charges.
   C. the radius from the center of the charge
   D. none of the above

5. Which of the following statements are TRUE?
   I. When a positive charge moves in the direction of an electric field, the potential energy decreases and the field does positive work
   II. When a positive charge moves in the direction of an electric field, the potential energy increases and the field does negative work
   III. When a negative charge moves in the direction of an electric field, the potential energy increases and the field does negative work
   IV. When a negative charge moves in the direction of an electric field, the potential energy decreases and the field does positive work
   A. I&IV　B. I &III
   C. II&III　D. II&IV

6. In terms of energy unit, which does not belong?
   A. eV　B. J
   C. Nm　D. V

7. How is the direction of the electric field lines related to the equipotential surface?
   A. parallel　B. perpendicular
   C. depends on the sign of the charge　D. undetermined

8. When moving from infinity to towards a negative point charge, the electric potential.
   A. increases
   B. decreases
   C. remains the same
   D. undetermined

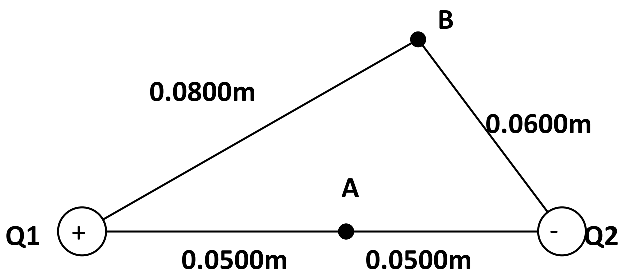
9. A point charge $q = 2.00\mu C$ is located at the origin. Find the electric potential due to this charge at point $x = 4.0$ m.
   A. 1500 V
   B. 2500 V
   C. 3500 V
   D. 4500 V

10. Two protons in the nucleus of a ^{238}U atom are 6.0 fm ($6.0x10^{-15}$m) apart. What is the potential energy (in joules) associated with the electric force that acts between these two particles?
   A. $3.8x10^{-14}$
   B. $4.5x10^{-15}$
   C. $5.0x10^{-9}$
   D. $5.0x10^{-8}$

11. Two point charges are arranged along the x-axis; q1=2.0 µC is at x=0.80m, and q2=2.0 µC at x=0.80m . The net electrical potential measured at the origin due to these point charges is
   A. zero
   B. 4500V
   B. 22500V
   D. 45kV

12. Two like charges of charge +10 nC are placed at the two corners of an equilateral triangle of side 3 cm. What is the magnitude of the total potential at the third corner?
   A. 0
   B. 6 V
   B. 600 V
   D. 6000 V

For numbers 13-15, refer to the figure below where Q_1=+2.0µC, Q2 = -3.0µC.



13. What is the potential at point A?
   A. -180,000 V
   B. -225,000 V
   B. 225,000 V
   D. 180,000 V

14. What is the potential at point B?
   C. -180,000 V
   B. -225,000 V
   D. 225,000 V
   D. 180,000 V

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15. What is the potential difference V_A-V_B?
   A. -90, 000 V
   B. -45,000 V
   C. 45,000 V
   D. 90, 000 V

Key to Answers

What I Know

1 D	6 B	11.D
2 D	7 A	12.A
3 C	8 B	13.D
4 B	9 A	14.C
5 A	10 A	15.B

Lesson 1

Activity 2.1

Across	Down
POTENTIAL	WORK
JOULE	ENERGY
VOLT	

Activity 2.2 1) 3240nJ; 810 V

2a) -3.60×10^{-7}J b) 0.075 m or 0.358 m

3a) 80,000 V b) 120,000 V c) 120,000 V

Activity 2.3 Answers may vary

Activity 2.4 1. When the Van de Graaff generator starts charging, it transfers the charge to the person touching it. The person's hair follicles are then getting charged to the same potential, they try to repel each other so the hair stands up.

2. An electron gun accelerates electrons to a potential difference changing the its electric potential energy. In a cathode ray tube (CRT) -- the big glass tube used in most televisions and computer monitors -- the electrons get aimed at the screen, where they light up the phosphor on the screen to create the image.

Posttest

1 B	6 C	11.D
2 B	7 B	12.D
3 A	8 B	13.A
4.A	9 D	14.B
5 A	10 A	15.C

References

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For inquiries and feedback, please write or call:

Department of Education – Bureau of Learning Resources (DepEd-BLR)

DepEd Division of Cagayan de Oro City
Fr. William F. Masterson Ave Upper Balulang Cagayan de Oro
Telefax: ((08822)855-0048
E-mail Address: cagayandeoro.city@deped.gov.ph