اسم الطالب: ....

EINS TIN

In Physics

قديما كانت تمثل الفيزياء رعبا للطالب أما الآن

اسلوب جديد لعرض الفيزياء بعيدا عن التعقيد

Electric potential

UNIT 3 Electric potential

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- 3.2 Definition of Electric Potential
- 3.3 Equipotential Surfaces and lines
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Chapter 3

Electric potential

اينشتاين في الفيزياء

2025

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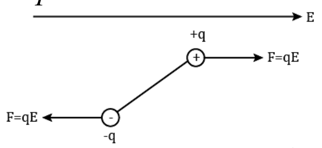
1 Electric Potential energy

When a force, F, acts on a particle, work is done on the particle in moving from point a to point b



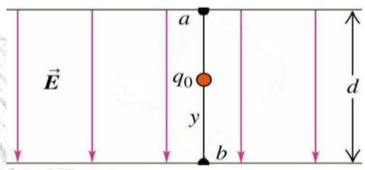
$$W_{a\to b} = \int_a^b \vec{F}\cdot d\vec{L}$$

Work Done by Uniform Electric Field

Force on charge is

$$F = qE$$

Work is done on the charge by field



$$W_{a\to b} = Fd = qEd$$

The work done is independent of path taken from point a to point b . Why?

- *Because The Electric Force is a conservative force*

The energy gained by a charge because of its position in an electric field.”

Change in potential energy of a charge: ΔU

It equals negative the work done by the electric force to transfer the charge from one point to the another point in the electric field

$$W_{a\to b} = -(U_b - U_a) = -\Delta U$$

Change in potential energy of a charge in a uniform electric field:

When a charge is transferred with a constant velocity in a uniform electric field, the change of its potential energy will be given by:

$$U_b - U_a = -\int_a^b F\cdot ds = -qE_{uniform}(y_b - y_a)$$

$$\boldsymbol{\Delta U_{a-b} = Ub - Ua = -\,q\,E\,d}$$

Where:

$\boldsymbol{\Delta U_{a-b}}$ Change in potential energy of a charge

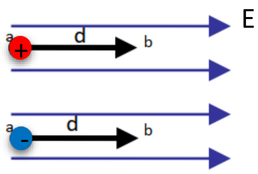
q *The transferred charge*

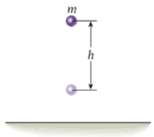
E *The electric field*

d *The displacement parallel to the field*

NOTES

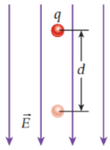
- *The work done only depends upon the change in position*
- *Potential Energy increases if the particle moves in the direction opposite to the force on it Work will have to be done by an external agent for this to occur*
- *Potential Energy decreases if the particle moves in the same direction as the force on it*
- *The potential energy of a positive charge decreases in the direction of the electric field. Decrease of U for +ve charge*
  The potential energy of a negative charge decreases opposite to the direction of the electric field. Increase of U for -ve charge





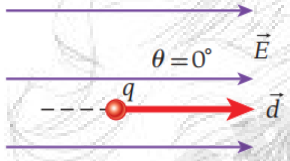
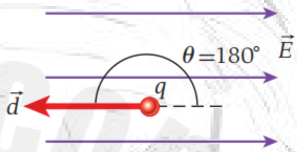
A mass falls in a gravitational field

$$\Delta U = -W = -\vec{F}_g \bullet \vec{d} = -mgh$$



A positive charge moves in the same direction as an electric field.

$$\Delta U = -W = -q\vec{E} \bullet \vec{d} = -qEd$$

Make angle $W = qE \bullet d = qEd\cos\theta$	
parallel	*antiparallel*
When the displacement is parallel to the electric field ($\theta = 0°$) *work done by the field is $W = qEd$.*	*When the displacement is antiparallel to the electric field ($\theta = 180°$),* *The work done by the field is $W = -qEd$.*
	

1. 500 J of work are required to carry a charged particle between two points with a potential difference of 20V, the magnitude of the charge on the particle is:
   ⓐ 0.04 C ⓑ 12.5 C ⓒ 20 C ⓓ none of these

2. A total charge of 7×10^{-8} C is uniformly distributed throughout a non-conducting sphere with a radius of 5 cm. The electric potential at the surface, relative to the potential far away, is about:
   ⓐ -1.3×10^4 V ⓑ 1.3×10^4 V ⓒ 7.0×10^5 V ⓓ -6.3×10^4 V

3. It takes 50 J of energy to move 10 C of charge from point A to point B.
What is the potential difference between points A and B?
   ⓐ 500 V ⓑ 50 V ⓒ 5 V ⓓ 0.5 V

4. The net work done in moving an electron from point A, where the potential is -50 V, to point B, where the potential is +50 V, is
   ⓐ $+1.6\times10^{-17}$ J ⓑ -1.6×10^{-17} J. ⓒ Zero ⓓ none of these

5. A proton, initially at rest, is accelerated through an electric potential difference of 500 V. What is the kinetic energy of the proton?
   ⓐ 500 J ⓑ $+1.6\times10^{-19}$ J. ⓒ $+8.0\times10^{-17}$ J. ⓓ zero

6. A proton, initially at rest, is accelerated through an electric potential difference of 500 V. What is the speed of the proton?
   ⓐ 2.2×10^5 m/s ⓑ 3.1×10^5 m/s ⓒ 9.6×10^{10} m/s ⓓ zero

7. How much work does 9.0 V do in moving 8.5×10^{18} electrons?

   ⓐ 12 J ⓑ 7.7 J ⓒ 1.4 J ⓓ 1.1 J

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4,2 Definition of Electric Potential

Change in electric potential: ΔV

"The change in potential energy of a positive test charge divided by the test charge."

To calculate the change in the potential energy of a charge between two points

$$\Delta V = \frac{\Delta U}{q}$$

$$\Delta U = -W$$

Electric potential: V

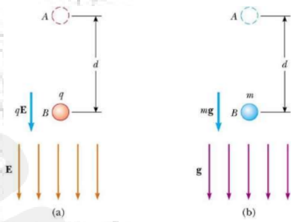
"The potential energy of a positive test charge divided by the test charge."

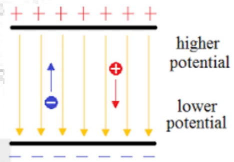
To calculate the potential energy of a charge at a point

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

$$U = -W$$

- *Electric potential is defined as the electric potential energy per unit charge*
- *Scalar quantity with units of volts (1 V = 1 J/C)*
- *Sometimes called simply "potential" or "voltage"*
- *Electric potential is characteristic of the field only, independent of a test charge placed in that field*
- *Potential energy is a characteristic of a charge-field system due to an interaction between the field and a charge placed in the field*
- *When a positive charge is placed in an electric field, it moves from a point of high potential to point of lower potential*
- *When a negative charge is placed in an electric field, it moves from a point of low potential to point of higher potential*





$$\Delta V = V_f - V_i = V_B - V_A$$

Potential Energy of Two Point Charges

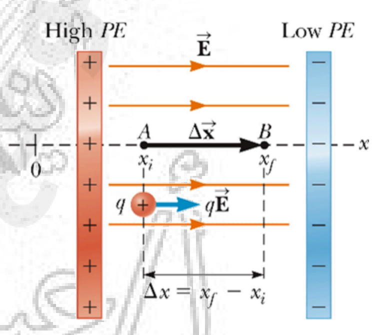
Suppose we have two charges q and q_0 separated by a distance r The force between the two charges is given by Coulomb's Law

$$F = \frac{kq_1q_2}{r^2}$$

$$W_{a\to b} = Fd$$

$$U = W_{a\to b} = \frac{kq_1q_2}{(r_f - r_i)}$$

$$V = \frac{W}{q} \to \frac{kq}{(r_f - r_i)}$$

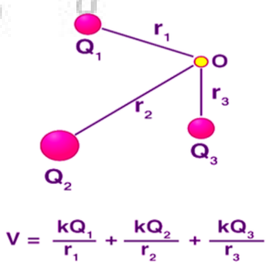


Electric potential created by a point charge: $V = \frac{kq}{r}$

*Depends only on **q** and **r***

Multiple point charges

$$V = K\sum\frac{q}{r} = K\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3}\right)$$



Where $E = \frac{F}{q}$

$$V = \frac{W}{q} \rightarrow \frac{F.d}{q} \rightarrow E.d$$

$$V = E.d$$

$$E = \frac{V}{d}$$

The electric field unit (N/C or V/m)

Notes:

The electric potential and the potential difference both are measured in volt (Jule/Coulomb).

The electric potential, like the electric field is a property independent of the charge at the point.

The electric potential decreases in the direction of the field and increases in a direction opposite to the field.

The electric potential has the same value at all points on any line parallel to the charged planes (perpendicular to the electric field lines)

We see that the electric field points in the direction of decreasing potential

We are often more interested in potential differences as this relates directly to the work done in moving a charge from one point to another

$$W = qV = 1.6 \times 10^{-19} joules = 1\ eV$$

Self-leaning Batteries

Batteries:

"A battery is basically a device that converts chemical energy directly into electrical energy."

The weight of the batteries needs to be as small as possible.

They need to be rapidly rechargeable for hundreds of cycles.

They need to deliver as constant a potential difference as possible.

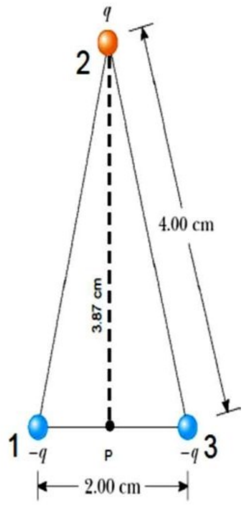
They need to be available at an affordable price.

Lithium-ion batteries:

	Advantages	Disadvantages
1	Has a much higher energy density, than conventional batteries	If a lithium-ion battery is completely discharged, it can no longer be recharged.
2	They can be recharged hundreds of times.	Rising temperature decreases the efficiency of a lithium-ion battery.
3	They have no "memory" effect and thus, do not need to be conditioned to hold their charge.	If the batteries are discharged too quickly, the constituents can catch fire or explode.

Example:

The three charges shown in the figure are at the vertices of an isosceles triangle.
Let $q = 7.00\ nC$*, and calculate the electric potential at the midpoint of the base p.*



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A particle charge of (+2.0 µC) is released from rest at a point on the x- axis, $(x = +6.0\ cm)$*. It begins to move due to the presence of (+8.0 µC) a charge that remains fixed at the origin*$(x = 0.0)$*.*
Calculate the kinetic energy of the particle at the instant it passes the point $(x = +15\ cm)$*.*

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An electron is accelerated from rest between two points, through a potential difference of 20 V, in a uniform electric field 5000 V/m.
1-Calculate the change in kinetic energy of the electron between these two points.
2-Find the distance after which the electron gains this kinetic energy.
3-Find the speed of the electron at the end of this distance.

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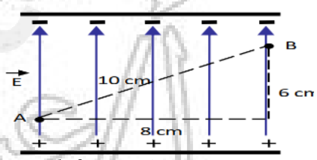
In the figure A, and B, are two pointes in a uniform electric field 4×10^{4} *V/m.*
Using information on the figure, calculate:
1-Calculate the change in electric potential from A to B.
2- Calculate the change in electric potential from B to A.
3- Calculate the change in electric potential energy of a proton when transferred from A to B.
4- Calculate the change in electric potential energy of a proton when transferred from B to A.



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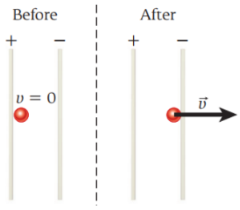
The difference in electric potential between the two plates is 450 V . The proton is released from rest close to the positive plate.



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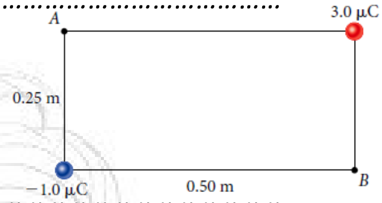
Two point-charges are located at two corners of a rectangle, as shown in the figure.
a) What is the electric potential at point A?
b) What is the potential difference between points A and B?



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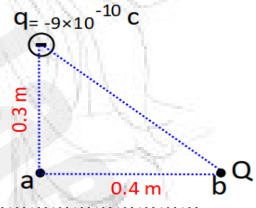
In the figure shown, the electric potential at point "a" equals zero.
1- Find the charge Q.
2- What is the electric potential at point "b"?



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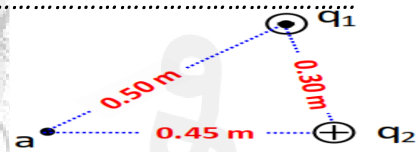
In the figure shown, the point "a" in the electric field of the two charges ($q1= -2.0\times10^{-8}$ C), and ($q2= +2.0\times10^{-8}$ C).
1- Calculate the electric potential at point "a".



2- Find the work exerted by the electric force to transfer the charge q2 from "b" to "a".

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How much work would be done by an electric field in moving a proton from a point at a potential of +180 V to a point at a potential of –60.0 V?

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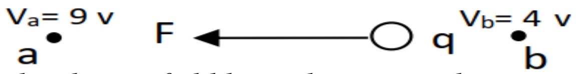
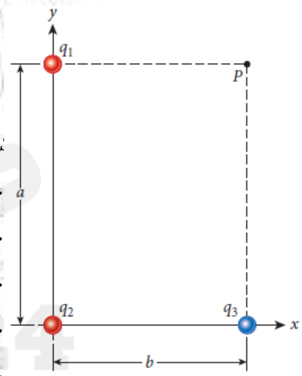
in the figure shown, a charge q is moving from point "b" to point "a" in a uniform electric field.



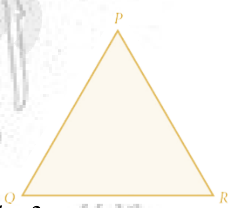
1- Draw on the figure the electric field lines showing its direction.
2- Calculate the change in the electric potential energy of the charge (1.6×10^{-12}C) when transferred from "b" to "a

What potential difference is needed to give an alpha particle (composed of 2 protons and 2 neutrons) 200 keV of kinetic energy?'

Let's calculate the electric potential at a given point due to a system of point charges. Figure shows three point charges: $q1 = +1.50\ \mu c$ located at (0,8) m, $q2 = +2.50\ \mu c$ located at (0,0) m, and $q3 = -3.50\ \mu c$ located at (6,0)m.
The electric potential at point P is the sum of the potentials due to the three charges



Three charges, q1, q2, q3, are located at the corners of an equilateral triangle with side length of 1.20 m.
Find the work done in each of the following cases:
a. to bring the first particle, $q1 = 1.00\ \mu C$, to P from infinity.
b. to bring the second particle, $q2 = 2.00\ \mu C$, to Q from infinity.
c. to bring the last particle, $q3 = 3.00\ \mu C$, to R from infinity.
d. Find the total potential energy stored in the final configuration of q1, q2, and q3.



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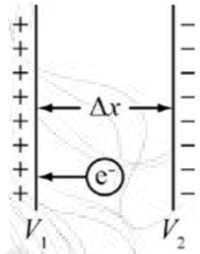
A 10.0 V battery is connected to two parallel metal plates placed in a vacuum. An electron is accelerated from rest from the negative plate toward the positive plate.
a. What kinetic energy does the electron have just as it reaches the positive plate?
b. What is the speed of the electron just as it reaches the positive plate?

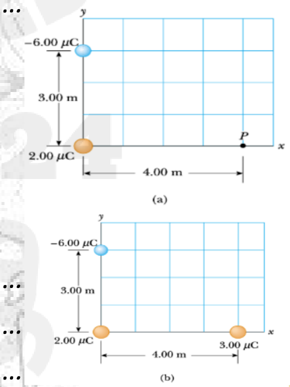
☐

Two parallel plates are held at potentials of +200.0 V and –100.0 V. The plates are separated by 1.00 cm.



a. Find the electric field between the plates.
An electron is initially placed halfway between the plates.
b. Find its kinetic energy when it hits the positive plate.

A charge $q1 = 2.00\mu C$ *is located at the origin, and a charge* $q2 = -6.00\mu C$ *is located at* $(0, 3.00)$ *m, as shown in Figure*
(A) Find the total electric potential due to these charges at point P, whose coordinates are (4.00, 0) m.
(B) Find the change in potential energy of the system of two charges plus a charge $q3 = 3.00\mu C$ *as the latter charge moves to point P*



Choose the correct answer:

1. *Which of the following is not a vector?*

ⓐ *electric force* ⓑ *electric field* ⓒ *electric potential* ⓓ *electric line of force*

2. *One joule per coulomb is a*

ⓐ newton ⓑ *volt* ⓒ *electron-volt* ⓓ *farad*

3. *Two identical aluminum objects are insulated from their surroundings. Object A has a net charge of excess electrons. Object B is grounded.*
Which object is at a higher potential?

ⓐ *A* ⓒ *Both are at the same potential.*
ⓑ *B* ⓓ *cannot be determined without more information*

4. *For a proton moving in the direction of the electric field*

ⓐ *its potential energy increases and its electric potential decreases.*
ⓑ *its potential energy decreases and its electric potential decreases.*
ⓒ *its potential energy increases and its electric potential increases.*
ⓓ *its potential energy decreases and its electric potential increases.*

5. *For an electron moving in a direction opposite to the electric field*

ⓐ *its potential energy increases and its electric potential decreases.*
ⓑ *its potential energy decreases and its electric potential decreases*
ⓒ *its potential energy increases and its electric potential increases.*
ⓓ *its potential energy decreases and its electric potential increases.*

6. *Several electrons are placed on a hollow conducting sphere. They*

ⓐ *clump together on the sphere's outer surface.*
ⓑ *clump together on the sphere's inner surface.*
ⓒ *become uniformly distributed on the sphere's inner surface*
ⓓ *become uniformly distributed on the sphere's outer surface.*

7. *A small, charged ball is accelerated from rest to a speed v by a 500 V potential difference. If the potential difference is changed to 2000 V, what will the new speed of the ball be?*

ⓐ *1v* ⓑ *2v* ⓒ *4v* ⓓ *16*

8. *The energy acquired by a particle carrying a charge equal to that on the electron as a result of moving through a potential difference of one volt is referred to as*

ⓐ *a coulomb.* ⓑ *a proton-volt.* ⓒ *an electron-volt* ⓓ *a joule.*

9. *The absolute potential at a distance of 2.0 m from a positive point charge is 100 V. What is the absolute potential 4.0 m away from the same point charge?*

ⓐ *25 v* ⓑ *50 v* ⓒ *200 v* ⓓ *400 v*

10. *The absolute potential at a distance of 2.0 m from a positive point charge is -100 V. What is the absolute potential 4 .0 m away from the same point charge?*

ⓐ -25 v ⓑ -200 v ⓒ -50 v ⓓ -400 v

11. *The absolute potential at the exact center of a square is 3.0 V when a charge of +Q is located at one of the square's corners. What is the absolute potential at the square's center when each of the other corners is also filled with a charge of +Q?*

ⓐ zero ⓑ 12 v ⓒ 3 v ⓓ 9 v

12. *The absolute potential at the center of a square is 3.0 V when a charge of +Q is located at one of the square's corners. What is the absolute potential at the square's center when a second charge of -Q is placed at one of the remaining corners?*

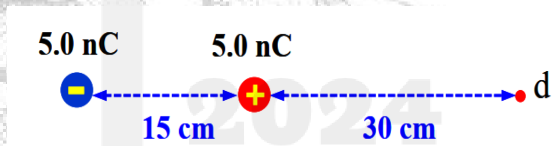
ⓐ zero ⓑ 12 v ⓒ 3 v ⓓ 9 v

13. *A proton is placed midway between points A and B. The potential at point A is –20 V, and the potential at point B is +20 V. The potential at the midpoint is 0 V. The proton will:*

ⓐ remain at rest.
ⓑ accelerate toward point B
ⓒ move toward point B with constant velocity.
ⓓ accelerate toward point A.

14. *in the system shown in the opposite figure. Which of the following is true about both the voltage and the electric field at point (d)?*

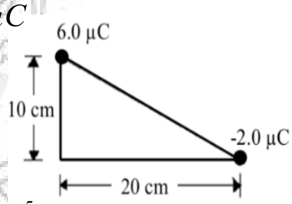
	electric potential	electric field
ⓐ	negative	to the right
ⓑ	positive	to the right
ⓒ	positive	to the left
ⓓ	negative	to the left



15. *The potential energy of a system of three equal charges arranged in an equilateral triangle is 0.54 J If the length of one side of this triangle is 33 cm, What is the charge of one of the three charges?*

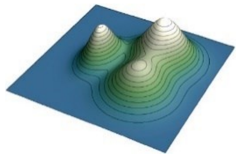
ⓐ 1.7 μC ⓑ 4.3 μC ⓒ 2.6 μC ⓓ 2.0 μC

16. *Two-point charges are located at two corners of a triangle as shown. What is the electric potential at the right corner of the triangle?*



ⓐ 2.1×10^5 V ⓑ 4.5×10^5 V ⓒ 6.3×10^5 V ⓓ 7.2×10^5 V

2 Definition of Electric Potential

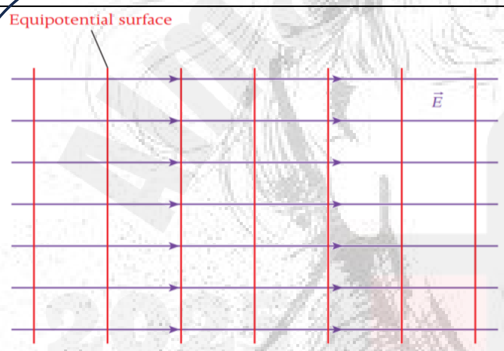


- *surfaces each of which contain all points that have the same electric potential.*
- *The surface of any conductor forms an equipotential surface.*
- *Equipotential surfaces are always perpendicular to the electric field lines at any point in space.*
- *Similar to topographic map, which shows lines of constant elevation.*

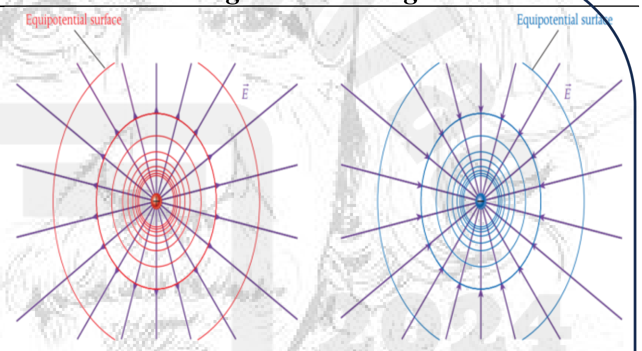
Since $\Delta V = 0$ for each surface, $W = 0$ along the surface.

- *Thus, electric field lines are perpendicular to the equipotential surfaces at all points*
- *E points in the direction of the maximum decrease in ΔV (E points from high to low potential)*
- *Similar to a topographic contour map (slope is steepest perpendicular to lines of constant elevation)*
- *Electric field is thus sometimes called the potential gradient (meaning grade or slope)*
- *On a contour map a hill is steepest where the lines of constant elevation are close together If equipotential surfaces are drawn such that the potential difference between adjacent surfaces is constant, then the surfaces are closer together where the field is stronger*

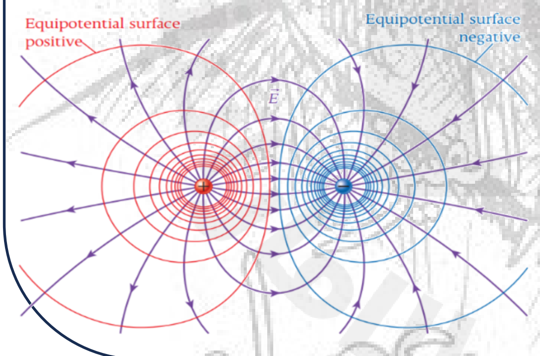
Constant electric Field:



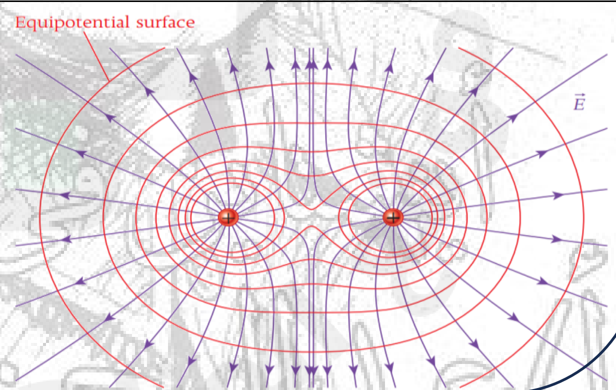
Single Point Charge:

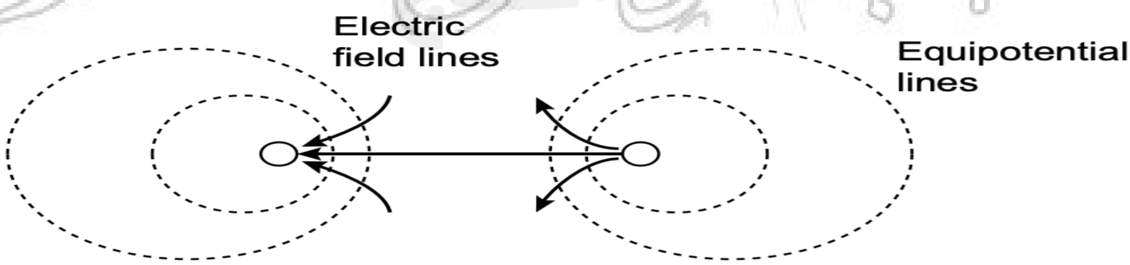


Two oppositely Charged Point Charges:



Two identical Point Charges:



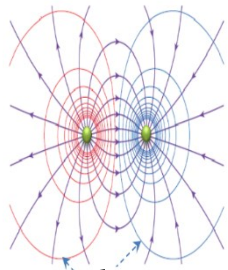


1. why the surface of the conductor considers ***equipotential surface****?*
Because free electrons on the surface of the conductor do not accelerate.
2. why the charged conductor is ***equipotential surface****?*
Because the field equals zero everywhere within the conductor, the total size of the conductor should be at the same electric potential.
3- Lines of ***equipotential*** *always perpendicular to the direction of the electric field . Explain ?*
Because charges can move perpendicular to the electric field without any field being occupied, since according to $W = qEd\cos\theta$ *the product of the standard multiplication of the field vector and the displacement is zero where* $\theta = 90°$ *and the electric potential will remain the same as where the work done is zero.*

• *Since the lines of the electric field are straight and parallel and away from each other Equal spacing*
• ***equipotential*** *lines are parallel and perpendicular to the electric field lines They are evenly spaced.*

Field lines move away from positive charge , And end in infinity.
The electric field lines start at infinity, And ends at the negative charge.
Circles represent the lines at which they intersect Page level with spherical objects And be equal in potential.
The potential difference between lines is equal to adjacent potential.
equipotential *lines are close to each other near the charge and diverge from each other as we move away from the charge.*
equipotential *lines are always perpendicular to the electric field lines.*
equipotential *surfaces do not contain arrows because electric potential is scalar.*

1. *The figure shows the electric field lines and equipotential surfaces of two-point charges. Which of the following is correct?*



J lins

	point charges	J lines
ⓐ	same magnitude and opposite sin	electric field lines
ⓑ	Equipotential surfaces	same magnitude and opposite sin
ⓒ	identical and positive	electric field lines
ⓓ	Equipotential surfaces	identical and negative

2. *Which one of the following statements is not true?*

ⓐ *Equipotential lines are parallel to the electric field lines.*
ⓑ *When a charge moves on an equipotential surface, the work done on the charge is zero.*
ⓒ *Equipotential surfaces exist for any charge distribution.*
ⓓ *Equipotential lines for a point charge are circular.*

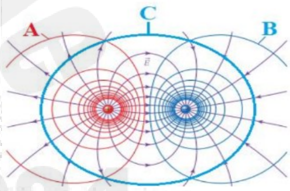
3. *If a positive charge moves in the direction of an electric field, its potential energy*

ⓐ *increases* ⓑ *decreases* ⓒ *remains the same* ⓓ *increases rabidly then decreases.*

4. *If a negative charge moves in the direction of an electric field, its potential energy*

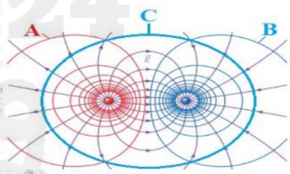
ⓐ *increases* ⓑ *decreases* ⓒ *remains the same* ⓓ *increases rabidly then decreases.*

5. *Which of the following is/are equipotential surface/s?*



ⓐ *A* ⓑ *B* ⓒ *C* ⓓ *A&B*

6. *Which of the following is not an equipotential surface?*



ⓐ *A* ⓑ *B* ⓒ *C* ⓓ *A&B*

7. *Which of the following statements is correct?*

ⓐ *The change in electric potential energy due to some spatial rearrangement of a system is equal to the negative of the work done by the conservative force during this spatial rearrangement*
ⓑ *The change in electric potential energy due to some spatial rearrangement of a system is equal to the positive of the work done by the conservative force during this spatial rearrangement*
ⓒ *The change in electric potential energy due to some spatial rearrangement of a system is equal to the positive of the work done by the unconservative force during this spatial rearrangement*
ⓓ *The change in electric potential energy due to some spatial rearrangement of a system is equal to the negative of the work done by the unconservative force during this spatial rearrangement.*

8. *Determine the wrong statement in the following.*

ⓐ *we need to do work on a charge to move it on an equipotential surface,*
ⓑ *Electric field lines are perpendicular to equipotential surfaces at any point.*
ⓒ *The surface of any conductor is an equipotential surface.*
ⓓ *In a uniform electric field, the electric field lines are always parallel.*

5 the Electric Field from the Electric Potential

*The electric field, **E**, points in the direction of decreasing potential*
Since points A and B are in the same relative horizontal location in the electric field there is on potential difference between them
The work done by the electric force in moving a test charge from point a to point b is given by

$$W_{a\to b} = \int_a^b \vec{F}\cdot d\vec{s} = \int_a^b q\vec{E}\cdot d\vec{s}$$

*Dividing through by the test charge **q** we have*

$$V_a - V_b = -\int_a^b \vec{E}\cdot d\vec{s}$$

$$dV = -\vec{E}\cdot d\vec{s}$$

$$\vec{E} = \frac{dV}{d\vec{s}}$$

$$\vec{E} = -\vec{\nabla} V$$

The electric field can be calculated from the electric potential:

$$\vec{E} = -\left(\frac{\partial V}{\partial x}\hat{x} + \frac{\partial V\partial}{y}\hat{y} + \frac{\partial V}{\partial z}\hat{z}\right)$$

In a certain region of space, the electric potential is given by $V = +Ax^2y - Bxy^2$ *, where A = 5.00 V/m*^{3} *and B = 8.00 V/m*^{3}*.*
Calculate the magnitude and direction of the electric field at the point in the region that has coordinates x = 2.00 m, y = 0.400 m, and z = 0.

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The electric potential V in a region of space is given by $V_{(x,y,z)} = A(x^2 - 3y^2 + z^2)$ *where A is a constant.*

(a) Derive an expression for the electric field $\vec{E}$ *at any point in this region.*
(b) The work done by the field when a 1.50 µC test charge moves from the point (x, y, z) = (0, 0, 0.250 m) to the origin is measured to be 6.00×10^{-5} *J. Determine A.*
(c) Determine the electric field at the point (0, 0, 0.250 m)

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A 2.50 μg dust particle with a charge of 1.00 μC falls at a point $x = 2.00\ m$ in a region where the electric potential varies according to:

$$V(x) = (2.00\ V/m^2)x^2 - (3.00\ V/m^3)x^3$$

a. What is the electric field at $x = 2.00\ m$?

b. what acceleration will the particle start moving after it touches down?

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9. Suppose that the voltage at a point is given by the equation $(V_{(x,y,z)} = 8x^2 - 9y^2 + 5z^2)$ in volts.

Which of the dimensions (x,y,z) determines the magnitude of the electric field at this point?

ⓐ x ⓑ y ⓒ z ⓓ x&y&z

10. Suppose that the voltage at a point is given by the equation $(V_{(x,y,z)} = 8x - 9y + 5z^2)$ in volts.

Which of the dimensions (x, y, z) determines the magnitude of the electric field at this point?

ⓐ x ⓑ y ⓒ z ⓓ x&y&z

11. Suppose an electric potential has the equation $V_{(x,y,z)} = 3x - 6y + 2z$ in volts.

What is the magnitude of associated electric field, in units of volts per meter at P (0,0,0)?

ⓐ 0 ⓑ 7 ⓒ 1 ⓓ 6

12. The electric potential in some region is given by $V_{(x,y)} = 3x - 2y^2$.

Find the x component of the electric field associated with this potential at point (1,2)

ⓐ 5 V/m ⓑ -6 V/m ⓒ -4 V/m ⓓ 8 V/m

13. The electric potential in some region is given by $V_{(x,y)} = 3x - 2y^2$.

Find the Y component of the electric field associated with this potential at point (1,2)

ⓐ 5 V/m ⓑ -6 V/m ⓒ -4 V/m ⓓ 8 V/m

14. An electric potential is described in volts by $V(x, y, z) = 3x^2 + 8y - 6z$.

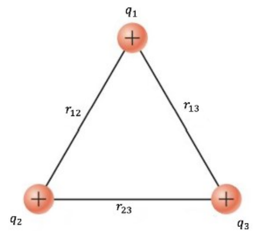
What is the magnitude of an electric field at the point $(+2.0\ m, -2.0\ m, -1.0\ m)$?

ⓐ $6\ V/m$ ⓑ $31.0\ V/m$ ⓒ $27.6\ V/m$ ⓓ $14.0\ V/m$

The total potential energy of an arrangement of more than two charges is the scalar sum of all of the electrostatic potential energy interactions between each pair of charges, for three charges, the sum will be:

$$U = k\frac{q_1 q_2}{r}$$

$$U = k\left(\frac{q_1 q_2}{r_{12}} + \frac{q_1 q_3}{r_{13}} + \frac{q_2 q_3}{r_{23}}\right)$$



1. *What happens to the magnitude of electric potential energy of a system of two-point charges when the distance between them decreases?*

ⓐ increases ⓑ decreases ⓒ remains the same ⓓ increases rabidly then decreases.

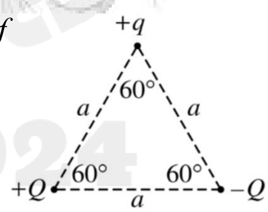
2. *When two charges are separated by a distance d, their electric potential energy is equal to U. What would be their electric potential energy if the separation distance was $\frac{d}{2}$?*

ⓐ U/4 ⓑ U/2 ⓒ 2U ⓓ 4U

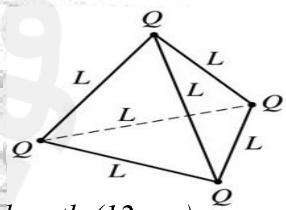
3. *Consider two identical charges of $q = 50\mu C$ each, placed 5.0 m apart. Find the electrostatic potential energy stored in the configuration.*

ⓐ 4.5J ⓑ 0.9J ⓒ 0.2J ⓓ 2.5J

Three particles having charges of +q, +Q, and -Q are placed at the corners of an equilateral triangle of side a, as shown below. The potential energy of the particle with charge +q due to the other two charges is-----------



Four identical charged particles, each with charge Q , are fixed in place in the shape of an equilateral pyramid with sides of length L as shown above. What is the electrical potential energy of this arrangement of charges ?



*Two (+ **4. 0 μC**) point charges arranged at the corners of a square with side length (12 cm) as shown in the figure. What is the potential energy of a system of two charges?*

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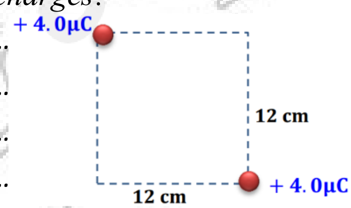
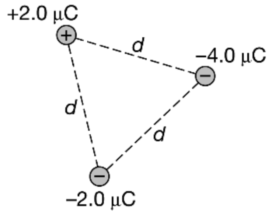


Three spheres are arranged at the corners of an equilateral triangle, as shown in the figure. If the length of each side is d=15cm. The work done by an external force in bringing the charges together from a large distance away is most nearly



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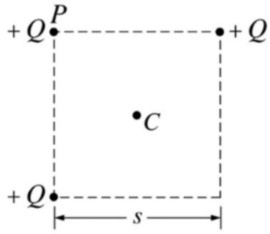
The particle at corner P is allowed to move while the other two particles are held in place. What is the work done by the electric field as the particle at corner P moves away?



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