PHYS 2212

Look Over
Chapter 24 sections 1-7, 9-12
Examples 1, 2, 3, 4, 5, 6, 7

PHYS 1112

Read Over
Chapter 17 sections 1-5
Examples 2, 3, 4, 5, 6

Things to Know

1) How to Calculate the Electrical Potential Energy.
2) How to find the Work done due to Electrical Potential Energy.
3) The difference between Electrical Potential Energy and the Electric Potential.
4) What a Volt is.
5) The relationship between Equipotential Surfaces and the Electric field.

Potential Energy Again

If we compare Newton's law of gravity to Coulomb's Law we see that they are very similar.

$$F_G = G\frac{m_1 m_2}{r^2}$$

$$G = 6.67\times10^{-11}\ \frac{N\cdot m^2}{kg^2}$$

$$F_C = k\frac{q_1 q_2}{r^2}$$

$$k = 9.0\times10^{9}\ \frac{N\cdot m^2}{C^2}$$

So like we did for gravity we want to look at the potential energy associated with the electric force.

Electric Potential Energy U

When the electric static force acts between two or more charged particles we can assign an **Electric Potential Energy *(U)*** to the system.

Work and Electrical Potential Energy

$$U_f - U_i = \Delta U = -W$$

The negative sign is there since we are looking at the work done on the system by the electrostatic force.

We will define the electric potential energy of a system of the particle to be zero when the particles are an infinite distance apart.

Electric Potential

Mechanical Energy | Electrical Energy

$W = \Delta PE = \vec{F} \bullet \vec{d}$
$W = mgh$

$W = \Delta PE = \vec{F} \bullet \vec{d}$
$W = \pm qEy$

So mass and charge plays the same role, but charge can be negative or positive which would make the change in potential energy positive or negative.

Work and Electric Potential

We define the electric potential V as the potential energy per unit charge as:

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

$$\Delta V = V_f - V_i = \frac{U_f}{q} - \frac{U_i}{q} = \frac{\Delta U}{q} = \frac{-W}{q}$$

Potential difference can be positive, negative or zero depending on the signs and magnitude of *q* and *W*.

So the work done on a charged particle can be found as:

$$W = \Delta V q$$

Units of Electric Potential

The SI unit for potential is the joule per Coulomb. Which is given a special unit, the Volt (*V*) where:

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

This new unit allows us to adopt a more conventional unit for the electric field *E* as:

$$1\frac{N}{C} = 1\frac{V}{m}$$

eV

A convenient unit for energy in atomic and nuclear physics is the Electron-Volt (eV). One electron Volt is the energy equal to the work required to move a single electron or proton though a potential difference of exactly one Volt.

$$1eV = e(1V) = (1.6\times10^{-19}C)(1\frac{J}{C}) = 1.6\times10^{-19}J$$

Example 1

1)Through what potential difference would an electron need to be accelerated for it to achieve a speed of 40% of the speed of light, starting from rest?

Equipotential Surfaces

Gravity acts only in a direction perpendicular to a contour line.

Equipotential Surfaces

Adjacent points that have the same electric potential form **Equipotential Surface**

No net work W is done on a charged particle by an electric field when the particle moves between to points *i* and *f* on the same equipotenial surface.

Equipotential Surfaces and Electric Fields

Equipotential Surfaces are always perpendicular to electric field lines and thus to ***E***.

Calculating The Potential from E

If we look at the work done on a charge q_0 we see that the work done in moving the charge a small distance Δs is given by:

$$\Delta W = \vec{F} \bullet \Delta\vec{s} \text{ or}$$
$$\Delta W = q\vec{E} \bullet \Delta\vec{s}$$

V and E

The total work done is then the sum of the work along the path that the charge q_0 take as:

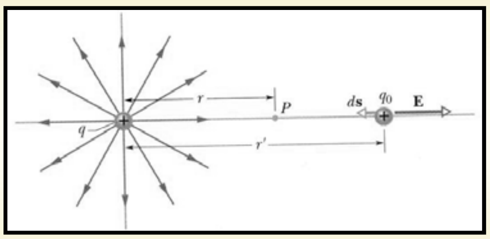
$$W = q \lim_{\Delta s \Rightarrow 0} \sum_{j=i}^{f} \vec{E} \bullet \Delta\vec{s} = -q(V_f - V_i)$$

$$W = q\int_i^f \vec{E} \bullet d\vec{s} = -q(V_f - V_i)$$

If we let $V_i=0$ and set $V=V_f$ then

$$V = -\int_i^f \vec{E} \bullet d\vec{s}$$

Example 2



2)What is the electric potential a distance r from a point charge q?

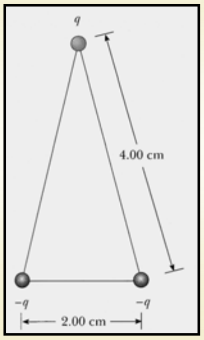
Potential due to a Group of point Charges

Using the superposition principle we simply have to add up the potential from each point charge in a collection of charge to find the total potential.

$$V = \sum_{i=1}^{n} V_i = \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \frac{q_i}{r_i}$$

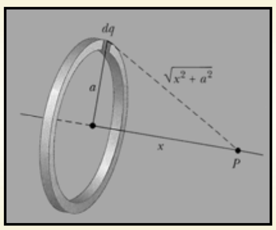
The electric potential energy of a system of fixed point charges is equal to the work that must be done by an external agent to assemble the system, bringing each charge in form an infinite distance.

Example 3



3) The three charges shown are at the vertices of an isosceles triangle. Calculate the electric potential at a point midpoint of the base. ($q=7.00\ \mu C$)

Example 4

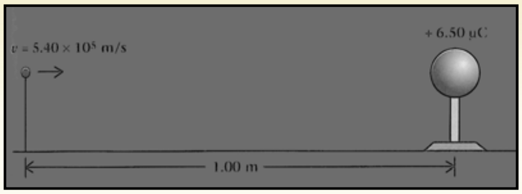


4) Find an expression for the electric potential at a point P located on the perpendicular central axis of a uniformly charged ring of radius a and charge Q?

Potential of a Charged Isolated Conductor

An excess charge placed on an isolated conductor will distribute itself on the surface of that conductor so that all points of the conductor --whether on the surface or inside-- come to the same potential.

Example 5



4) A small metal sphere, carrying a net positive charge is held fixed on an insulating stand. An alpha particle is projected along a radial path toward the sphere. How close to the sphere does the particle get?