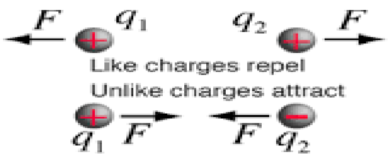
CLASS XII PHYSICS CHAPTER 1. ELECTROSTATICS

SUMMARY

1.The branch of physics which deals with the study of electric force, electric field, electric potential, and electric energy due to charges at rest is known as **ELECTROSTATICS.**

COULOMB'S LAW- According to this, the magnitude of force of attraction or repulsion between any two-point charges at rest is directly proportional to the product of the magnitude of charges and inversely proportional to the square of distance between them. Mathematically,



$$F = \frac{kq_1q_2}{r^2} = \frac{q_1q_2}{4\pi\varepsilon_0 r^2}$$ *Coulomb's Law*

3.If there are several charges in the vicinity of the test charge, then the total force is given by the algebraic sum of the individual forces acting on the test charge due to all other charges. This is superposition principle.

4.Continuous charge distribution is the case when we have a system of charges closely spaced .If the continuous charge is along a line -its line charge density, on the surface- its surface charge density and if its on a volume – its volume charge density.

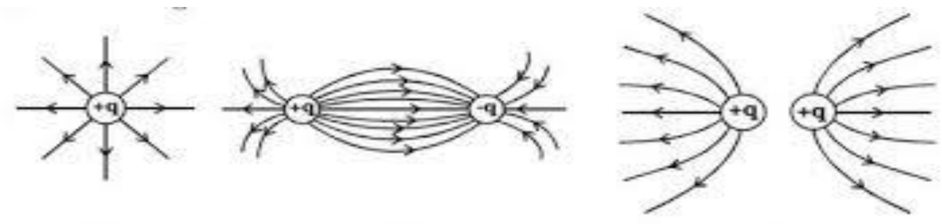
5. Electric field intensity due to a source charge at any point in in its electric field is defined by the force experienced by a unit positive charge i.e. the test charge placed at that point. Mathematically**,**

Coulomb's Law: $\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q\,q_i}{r^2}\hat{r}_i$ newtons

Electric field: $\vec{E} = \frac{\vec{F}}{q} = \frac{1}{4\pi\epsilon_0}\frac{q_i}{r^2}\hat{r}_i$ newtons/coulomb

Where $\hat{r}_i$ are unit vectors indicating the line between each q_i and q.

6.Electric field lines are imaginary lines to represent the presence of electric field and they are such that the tangent at any point on the field lines give the direction of the field at that point in the region.



(a) Isolated charge (b) Unlike charges (c) Like charges

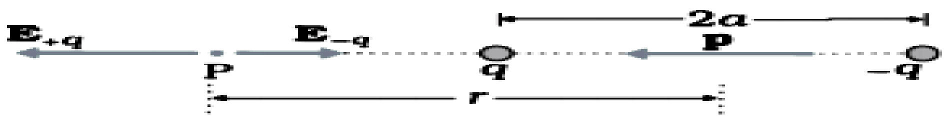
7.ELECTRIC DIPOLE: Electric dipole is a pair of two equal, but opposite charges separated by certain small distance generally denoted by 2l or 2r.

8.Electric dipole moment is defined as the product of the magnitude of either charge of the dipole and the dipole length. Electric field thus produced by a dipole is called the dipole field.

CALCULATION OF ELECTRIC FIELD AT A POINT IN THE EQUATORIAL PLANE OF A DIPOLE

The derivation can be seen here :
https://www.youtube.com/watch?v=XwkzudZmmG0

ELECTRIC FIELD INTENSITY AT A POINT ON THE AXIAL LINE OF AN ELECTRIC DIPOLE (END ON POSITION)



(a)

Then

$$\mathbf{E}_{-q} = -\frac{q}{4\pi\varepsilon_0 (r+a)^2}\hat{\mathbf{p}}$$

where ˆp is the unit vector along the dipole axis (from −q to q). Also

$$\mathbf{E}_{+q} = \frac{q}{4\pi\varepsilon_0 (r-a)^2}\hat{\mathbf{p}}$$

The total field at P is

$$\mathbf{E} = \mathbf{E}_{+q} + \mathbf{E}_{-q} = \frac{q}{4\pi\varepsilon_0}\left[\frac{1}{(r-a)^2} - \frac{1}{(r+a)^2}\right]\hat{\mathbf{p}}$$

$$= \frac{q}{4\pi\varepsilon_o}\frac{4ar}{(r^2-a^2)^2}\hat{\mathbf{p}}$$

For $r >> a$

$$\mathbf{E} = \frac{4qa}{4\pi\varepsilon_0 r^3}\hat{\mathbf{p}} \qquad (r >> a)$$

According to GAUSS'S THEOREM the surface integral over any closed surface S enclosing a volume Vin vacuum i.e. total electric flux over the closed surface S in vacuum is $1/\varepsilon_o$ times the total charge Q enclosed by the surface.

$\Phi = \int E.\,ds = Q/\varepsilon_o$

Electric potential https://www.youtube.com/watch?v=wBJvbww6EiY

DIELECTRICS

The non- conducting materials which do not have free electrons are called dielectrics. Example: Air, glass, etc.

Dielectrics are of two types: polar molecules like water, ammonia etc. and non-polar molecules.

CAPACITANCE refer https://www.youtube.com/watch?v=-rZ89h6Xx5U

WORKSHEET

VERY SHORT ANSWER TYPE QUESTIONS

1. CHOOSE THE CORRECT OPTION:

i) Electric flux Φ through a closed surface enclosing charge Q is Q/ε_o. What will be the electric flux through the closed surface if its size is doubled?

a) $2Q/\varepsilon_o$ b) $Q/2\varepsilon_o$ c) Q/ε_o d) zero

ii) Electric field E and electric potential V are related as

a) E = -dr/dv b) E = -dv/dr c) E = dv/dr d) E = dr/dv

iii) When air is replaced by a dielectric medium of dielectric constant K, the maximum force of attraction between two charges separated by a distance

a) Decreases K times c) increases K times

a) Decreases K^2 times d) remain unchanged

iv) A charge q is placed at the centre of the line joining two exactly equal positive charges Q. The system of three charges will be equal to

a) -Q/4 b) Q c) -Q d) Q/2

SHORT ANSWER TYPE QUESTIONS FOR 1 & 2 MARKS

2. An electric dipole of moment p is lying along a uniform electric field E. Find the work done in rotating the dipole by 90°.

3.How does the permittivity of a medium is related to the relative permittivity?

4. Does Coulomb's law follow Newton's third law of motion?

5. Force of attraction between two-point charges placed at a distance d is F. What distance apart should they be kept in the same medium so that the force between them is F/3?

6.Electric field is zero at a point. Can electric potential be zero at this point?

7. Two-point charges 4 µC and -2 µC are separated by a distance of 1 m in air. Calculate at what point on the line joining the two charged, the electric potential is zero.

8. An electric dipole with dipole moment 4×10^{-9} Cm is aligned at an angle 30° with the direction of a uniform electric field of magnitude 5×10^4 NC. Calculate the magnitude of the torque acting on the electric dipole.

9. A point charge 5 µC is at a distance 2 cm directly above the centre of a square of side 4 cm. What is the magnitude of the electric flux through the square?

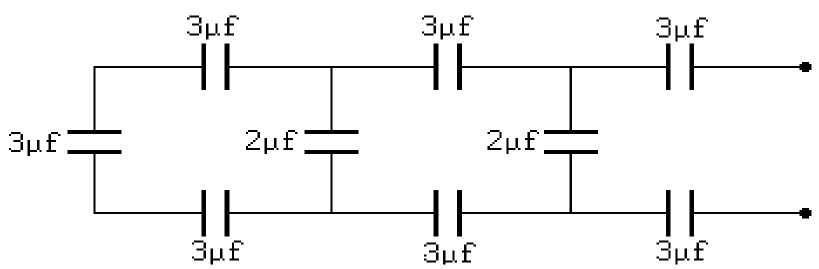
LONG ANSWER TYPE QUESTIONS FOR 3 & 5 MARKS

10. Derive the electric potential energy of an electric dipole placed in a uniform field.

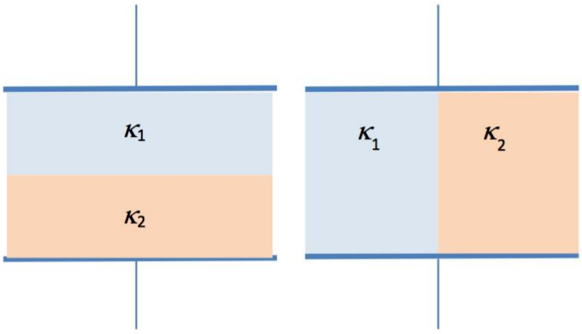
11. Derive an expression for electric field intensity at a point on the equatorial plane of a short electric dipole.

12. Deduce an expression for energy density in the case of a parallel plate capacitor.

13. Find the equivalent capacitance of the following:



14. Solve the following:



7. A parallel plate capacitor has the space between plates filled with two slabs of dielectric (same size) with constants κ_1 and κ_2. Show that the capacitances are $C = \frac{2\varepsilon_0 A}{d}\frac{\kappa_1\kappa_2}{\kappa_1+\kappa_2}$ for the left one and $C = \frac{\varepsilon_0 A}{d}\frac{\kappa_1+\kappa_2}{2}$ for the right one, where *d* is the total spacing between plates.
