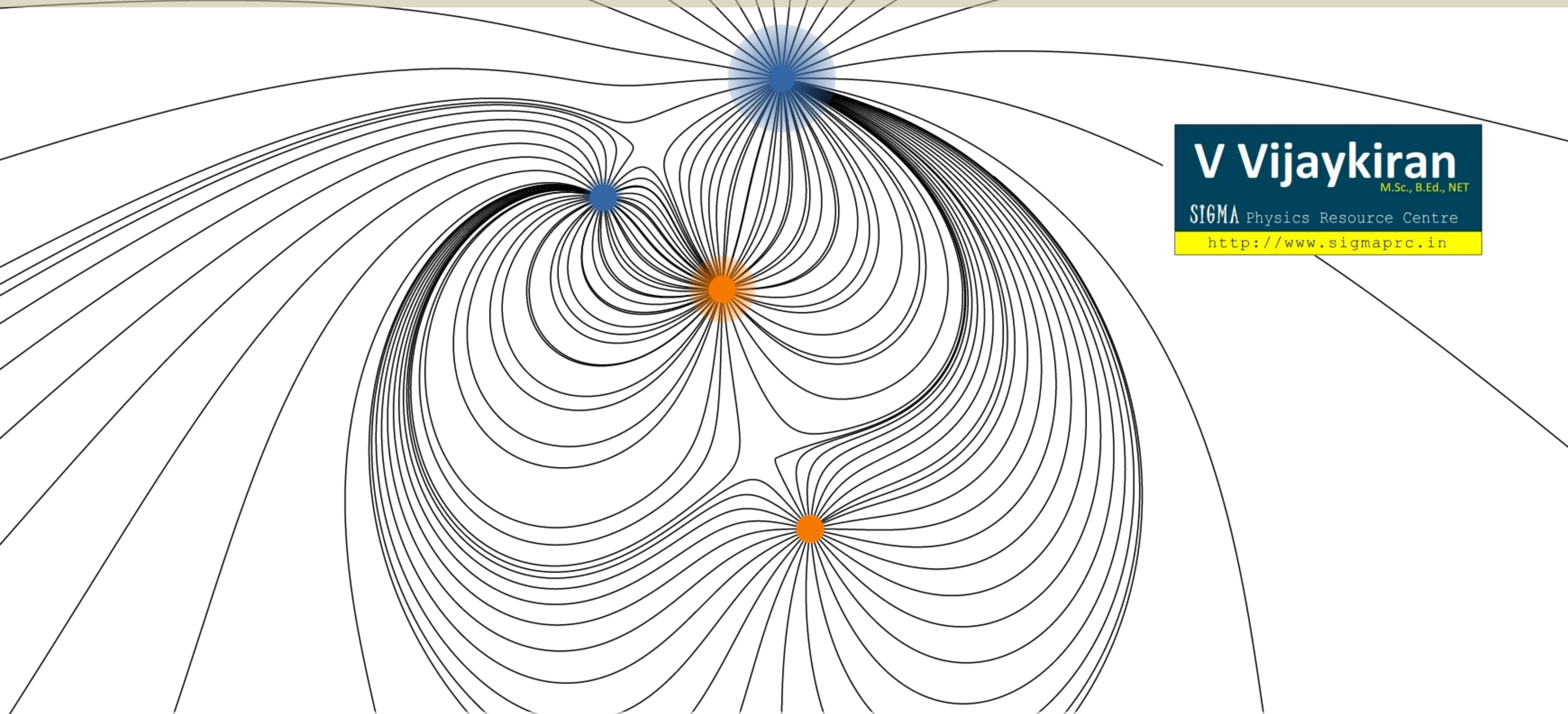
Electric field



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Note : The notes given in this file is no substitute to the much detailed discussion held in the online/contact classes with active participation of students. It , at best, serves the purpose of ready reference for important concepts/derivations covered in the classes.

Electric field

It is the region of space around a charged body within which its influence is felt by other charged bodies.

Electric field intensity

Electric field intensity at any point is the force acting on a unit positive charge placed at that point.

$$\boxed{\boldsymbol{E} = \lim_{q \to 0} \frac{\boldsymbol{F}}{q}}$$

- SI unit : NC^{-1}, Vm^{-1}
- Electric field intensity is a vector quantity
- Null point : A point where the net electric field intensity is zero
- Force on any charge placed at the null point is zero

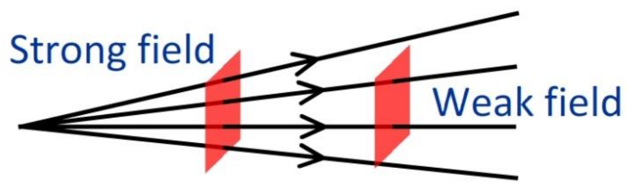
Force acting on a point charge q placed in a region of electric field of intensity E is given by

$$\boxed{\boldsymbol{F} = q\boldsymbol{E}}$$

Electric charges & Fields

Electric field lines and their properties

- ❑ Electric field line is an imaginary line drawn along the path followed by a unit positive charge.
- ❑ Electric field lines originate at positive charge and terminate at negative charge
- ❑ Electric field lines do not form closed loops
- ❑ Number of field lines crossing a unit area is an indication of strength of electric field in that region



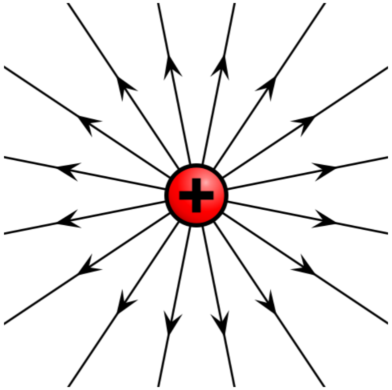
- ❑ Tangent drawn to field line at any point gives direction of electric field at that point

- ❑ Two electric field lines do not intersect each other

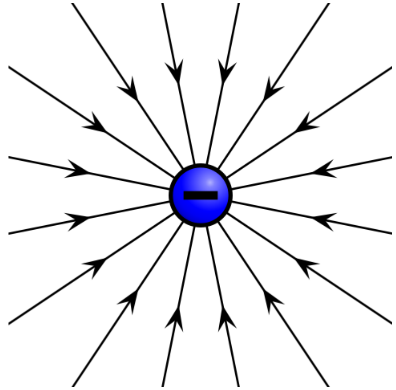
If they were to intersect then it would mean that the electric field at that point has two directions simultaneously.
That is not possible !

Electric charges & Fields

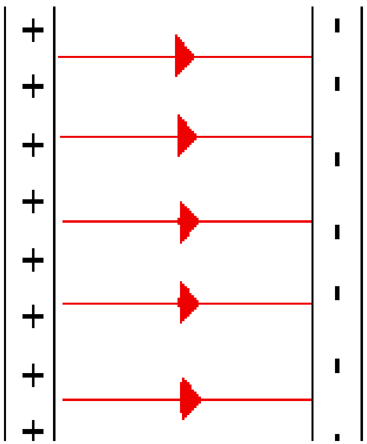
Examples of electric field lines due to some charge combinations



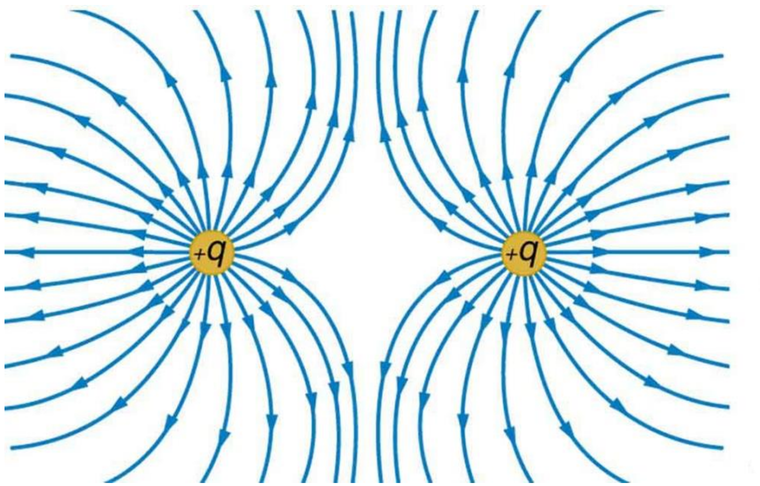
Positive charge



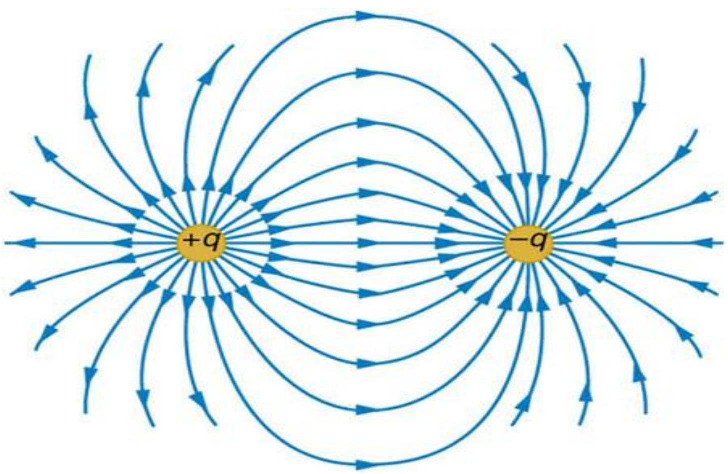
Negative charge



Uniform electric field



Two positive charges



Dipole

Electric field intensity due to a single charge

Consider a charge Q (called source charge) fixed at a point in space. Let P be a point at which electric field intensity is to be determined. Let r be the distance of P from the source charge. Consider a small charge q (called test charge) located at point P.

Force acting on the test charge at that point is given by Coulomb's inverse square law

$$\boldsymbol{F} = \frac{1}{4\pi\varepsilon_o}\frac{Qq}{r^2}\hat{r} \qquad \text{i}$$

Electric field at a point is defined by the relation

$$\boldsymbol{E} = \frac{\boldsymbol{F}}{q} \qquad \text{ii}$$

Substituting (i) in relation (ii) we get

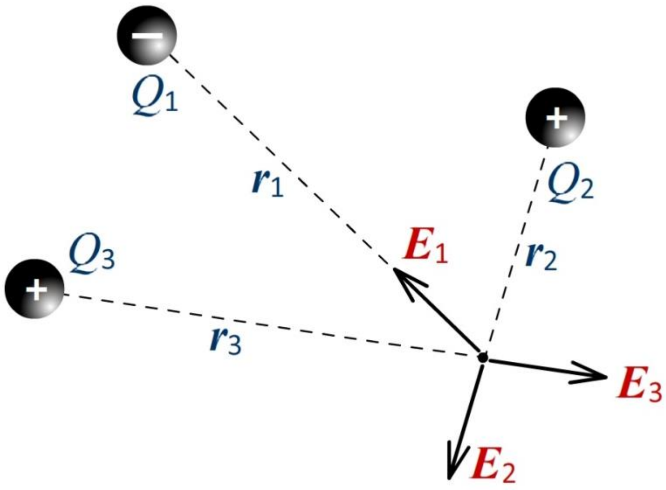
$$\boldsymbol{E} = \frac{1}{4\pi\varepsilon_o}\frac{Qq}{r^2}\hat{r} \times \frac{1}{q}$$

$$\boxed{\boldsymbol{E} = \frac{1}{4\pi\varepsilon_o}\frac{Q}{r^2}\hat{r}}$$

Principle of superposition

Net electric field at any point , due to a system of charges, is the vector sum of electric field intensity due to each charge at that point individually.

$$\boldsymbol{E} = \boldsymbol{E}_1 + \boldsymbol{E}_2 + \boldsymbol{E}_3 \ldots$$



Note : For continuous charge distribution, method of integration should be used to obtain net electric field intensity at any point