# NEET

# PHYSICS

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# Class 11 | Physics

# 01 Units and Measurement

## 01. Physical Quantities

All the quantities which are used to describe the laws of physics are known as *physical quantities*.

**Classification :** Physical quantities can be classified on the following bases :

**(A) Based on their directional properties**

**I. Scalars :** The physical quantities which have only magnitude but no direction are called *scalar quantities*.

e.g. mass, density, volume, time, etc.

**II. Vectors :** The physical quantities which both magnitude and direction and obey laws of vector algebra are called *vector quantities*.

e.g. displacement, force, velocity, etc.

**(B) Based on their dependency**

**I. Fundamental or base quantities :** The quantities which do not depend upon other quantities for their complete definition are known as *fundamental or base quantities*.

e.g. length, mass, time, etc.

**II. Derived quantities :** The quantities which can be expressed in terms of the fundamental quantities are known as *derived quantities*.

e.g. Speed (=distance/time), volume, acceleration, force, pressure, etc.

***Example*** Classify the quantities displacement, mass, force, time, speed, velocity, acceleration, pressure and work under the following categories:

(a) base and scalar
(b) base and vector
(c) derived and scalar
(d) derived and vector

***Solution***

(a) mass, time
(b) displacement
(c) speed, pressure, work
(d) force, velocity, acceleration

## 02. Units of Physical Quantities

The chosen reference standard of measurement in multiples of which, a physical quantity is expressed is called the *unit* of that quantity.

**System of Units**

**(i) FPS or British Engineering system :** In this system length, mass and time are taken as fundamental quantities and their base units are foot (ft), pound (lb) and second (s) respectively.

**(ii) CGS or Gaussian system :** In this system the fundamental quantities are length, mass and time and their respective units are centimeter (cm), gram (g) and second (s).

**(iii) MKS system :** In this system also the fundamental quantities are length, mass and time but their fundamental units are metre (m), kilogram (kg) and second (s) respectively.

**(iv) International system (SI) of units :** This system is modification over the MKS system and so it is also known as *Rationalised MKS* system. Besides the three base units of MKS system four fundamental and tow supplementary units are also included in this system.

| SI BASE QUANTITIES AND THEIR UNITS | | | |
|---|---|---|---|
| **S. No.** | **Physical quantity** | **Unit** | **Symbol** |
| 1 | Length | metre | m |
| 2 | Mass | kilogram | kg |
| 3 | Time | second | s |
| 4 | Temperature | kelvin | K |
| 5 | Electric current | ampere | A |
| 6 | Luminous intensity | candela | cd |
| 7 | Amount of substance | mole | mol |

## 03. Classification of Units

The units of physical quantities can be classified as follows :

**(i) Fundamental or base units**

The units of fundamental quantities are called *base units*. In SI there are seven base units.

**(ii) Derived units**

The units of derived quantities or the units that can be expressed in terms of the base units are called *derived units*.

e.g. unit of speed = $\frac{\text{unit of distance}}{\text{unit of time}} = \frac{\text{metre}}{\text{second}} = \text{m/s}$

Some derived units are named in honour of great scientists.

e.g. unit of force – newton (N), unit of frequency – hertz (Hz), etc.

**(iii) Supplementary units**

In International System (SI) of units two *supplementary units* are also defined viz. radian (rad) for plane angle and steradian (sr) for solid angle.

- **radian :** 1 radian is the angle subtended at the centre of a circle by and arc equal in length to the radius of the circle.
- **steradian :** 1 steradian is the solid angle subtended at the centre of a sphere, by the surface of the sphere which is equal in area to the square of the radius of the sphere.

**(iv) Practical units**

Due to the fixed sizes of SI units, some *practical units* are also defined for both fundamental and derived quantities. e.g. light year (ly) is a practical unit of distance (a fundamental quantity) and horse power (hp) is a practical unit of power (a derived quantity).

Practical units may or may not belong to a particular system of units but can be expressed in any system of units.

e.g. 1 mile = 1.6 km = $1.6 \times 10^3$ m = $1.6 \times 10^5$ cm.

**Conversion factors**

To convert a physical quantity from one set of units to the other, the required multiplication factor is called *conversion factor*.

Magnitude of a physical quantity = numeric value (n) × unit (u)

While conversion from one set of units to the other the magnitude of the quantity must remain same. Therefore

$$n_1u_1 = n_2u_2 \quad \text{or} \quad nu = \text{constant} \quad \text{or} \quad n \propto \frac{1}{u}$$

This is the numeric value of a physical quantity is inversely proportional to the base unit.

e.g. 1m = 100 cm = 3.28 ft = 39.4 inch
(SI) (CGS) (FPS)

***Example*** The acceleration due to gravity is 9.8 m $s^{-2}$. Given its value in ft $s^{-2}$

***Solution*** As 1m = 3.2 ft

$\therefore$ $9.8 \text{ m/s}^2 = 9.8 \times 3.28 \text{ ft/s}^2 = 32.14 \text{ ft/s}^2 \approx 32 \text{ ft/s}^2$

## 04. Dimensions

Dimensions of a physical quantity are the powers for exponents to which the base quantities are raised to represent that quantity.

**Dimensional formula**

The dimensional formula of any physical quantity is that expression which represents how and which of the base quantities are included in that quantity.

It is written by enclosing the symbols for base quantities with appropriate powers in square brackets i.e. [ ]

e. g. Dimensional formula of mass in $[M^1L^0\ T^0]$ is the dimensional formula of the force and the dimensions of force are 1 in mass, 1 in length and −2 in time

## 05. Applications of Dimensional Analysis

**(i) To convert a physical quantity from one system of units to the other :**

This is based on a fact that magnitude of a physical quantity remains same whatever system is used for measurement i.e. magnitude = numeric value (n) × unit (u) = constant or $n_1u_1 = n_2u_2$

So if a quantity is represented by $[M^aL^bT^c]$

Then $$n_2 = n_1\left(\frac{u_1}{u_2}\right) = n_1\left(\frac{M_1}{M_2}\right)^a\left(\frac{L_1}{L_2}\right)^b\left(\frac{T_1}{T_2}\right)^c$$

Here $n_2$ = numerical value in II system
$n_1$ = numerical value in I system
$M_1$ = unit of mass in I system
$M_2$ = unit of mass in II system
$L_1$ = unit of length in I system
$L_2$ = unit of length in II system
$T_1$ = unit of time in I system
$T_2$ = unit of time in II system

***Example*** Convert 1 newton (SI unit of force) into dyne (CGS unit of force)

***Solution*** The dimensional equation of force is $[F] = [M^1 L^1 T^{-2}]$

Therefore if $n_1$, $u_1$, and $n_2$, $u_2$, corresponds to SI & CGS units respectively, then

$$n_2 = n\left[\frac{M_1}{M_2}\right]^1\left[\frac{L_1}{L_2}\right]^1\left[\frac{T_1}{T_2}\right]^{-2} = 1\left[\frac{kg}{g}\right]\left[\frac{m}{cm}\right]\left[\frac{s}{s}\right]^{-2} = 1\times 1000\times 100\times 1 = 10^5 \;\therefore$$

1 newton = $10^5$ dyne.

**(ii) To check the dimensional correctness of a given physical relation**

If in a given relation, the terms on both the sides have the same dimensions, then the relation is dimensionally correct. This is known as the principle of homogeneity of dimensions.

***Example*** Check the accuracy of the relation $T = 2\pi\sqrt{\frac{L}{g}}$ for a simple pendulum using

***Solution*** The dimensions of LHS = the dimension of T = $[M^0 L^0 T^1]$

The dimensions of RHS $= \left(\dfrac{\text{dimensions of } \le \text{ngth}}{\text{dimensions of acceleration}}\right)^{1/2}$ ($\because$ $2\pi$ is a dimensionless constant)

$$= \left[\frac{L}{LT^{-2}}\right]^{1/2} = [T^2]^{1/2} = [T] = [M^0 L^0 T^1]$$

Since the dimensions are same on both the sides, the relation is correct.

**(iii) To derive relationship between different physical quantities**

Using the same principle of homogeneity of dimensions new relations among physical quantities can be derived if the dependent quantities are known.

***Example*** It is known that the time of revolution T of a satellite around the earth depends on the universal gravitational constant G, the mass of the earth M, and the radius of the circular orbit R. Obtain an expression for T using dimensional analysis.

We have $[T] = [G]^a [M]^b [R]^c$

***Solution*** $[M]^0 [L]^0 [T]^1 = [M]^{-a} [L]^{3a} [T]^{-2a} \times [M]^b \times [L]^c = [M]^{b-a} [L]^{c+3a} [T]^{-2a}$

Comparing the exponents

For $[T]: 1 = -2a \Rightarrow a = -\frac{1}{2}$ For $[M]: 0 = b - a \Rightarrow b = a = -\frac{1}{2}$

For $[L]: 0 = c + 3a \Rightarrow c = -3a = \frac{3}{2}$

Putting the values we get $T \propto G^{-1/2} M^{-1/2} R^{3/2} \Rightarrow T \propto \sqrt{\frac{R^3}{GM}}$

The actual expression is $T = 2\pi\sqrt{\frac{R^3}{GM}}$

**Dimensions of trigonometric, exponential, logarithmic function etc.**
All trigonometric, exponential and logarithmic functions and their arguments are dimensionless.

***NOTE*** ☞ Trigonometric function $\sin\theta$ and its argument $\theta$ are dimensionless.

## 06. Limitations of this Method

- In Mechanics the formula for a physical quantity depending one more than three physical quantities cannot be derived. It can only be checked.
- This method can be used only if the dependency is of multiplication type. The formulae containing exponential, trigonometrical and logarithmic functions can't be derived using this method. Formulae containing more than one term which are added or subtracted like $s = ut + at^2/2$ also can't be derived.
- The relation derived from this method gives no information about the dimensionless constants.
- If dimensions are given, physical quantity may not be unique as many physical quantities have the same dimensions.
- It gives no information whether a physical quantity is a scalar or a vector.

## 07. Significant Figures or Digits

The significant figure (SF) in a measurement are the figure or digits that are known with certainity plus one that is uncertain.
Significant figures in a measured value of a physical quantity tell the number of digits in which we have confidence. Larger the number of significant figure obtained in a measurement, greater is its accuracy and vice versa.

**Rules to find out the number of significant figures**

**I Rule** : All the non-zero digits are significant e.g. 1984 has 4 SF.

**II Rule** : All the zeros between two non-zero digits are significant. e.g. 10806 has 5 SF

**III Rule** : All the zeros to the left of first non-zero digit are not significant. e.g. 00108 has 3 SF.

**IV Rule** : If the number is less than 1, zeros on the right of the decimal point but to the left of the first non-zero digit are not significant. e.g. 0.002308 has 4 SF.

**V Rule** : The trailing zeros (zeros to the right of the last non-zero digit) in a number with a decimal point are significant. e.g. 01.080 has 4 SF.

**VI Rule** : The trailing zeros in a number without a decimal point are not significant e.g. 010100 has 3 SF. But if the number comes from some actual measurement then the trailing zeros become significant. e.g. m = 100 kg has 3 SF.

**VII Rule** : When the number is expressed in exponential form, the exponential term does not affect the number of S.F. For example in $x = 12.3 = 1.23 \times 10^1 = 0.123 \times 10^2 = 0.0123 \times 10^3 = 123 \times 10^{-1}$ each term has 3 SF only.

**Rules for arithmetical operations with significant figures**

**I Rule** : In addition or subtraction the number of decimal places in the result should be equal to the number of decimal places of that term in the operation which contain lesser number of decimal places. e.g. $12.587 - 12.5 = 0.087 = 0.1$ ($\because$ second term contain lesser i.e. one decimal place)

**II Rule** : In multiplication or division, the number of SF in the product or quotient is same as the smallest number of SF in any of the factors. e.g. $4.0 \times 0.12 = 0.484 = 0.48$

- To avoid the confusion regarding the trailing zeros of the numbers without the decimal point the best way is to report every measurement in scientific notation (in the power of 10). In this notation every number is expressed in the form a × 10b, where a is the base number between 1 and 10 and b is any positive or negative exponent of 10. The base number (a) is written in decimal form with the decimal after the first digit. While counting the number of SF only base number is considered (Rule VII).
- The change in the unit of measurement of a quantity does not effect the number of SF. For example in 2.308 cm = 23.08 mm = 0.02308 m = 23080 μm each term has 4 SF.

***Example*** Write down the number of significant figures in the following.
(a) 165
(b) 2.05
(c) 34.000 m
(d) 0.005
(e) 0.02340 N $m^{-1}$
(f) 26900
(g) 26900 kg

***Solution***

| | |
|---|---|
| (a) 165 | 3 SF (following rule I) |
| (b) 2.05 | 3 SF (following rule I & II) |
| (c) 34.000 m | 5 SF (following rule I & V) |
| (d) 0.005 | 1 SF (following rules I & IV) |
| (e) 0.02340 N $m^{-1}$ | 4 SF (following rule I, IV & V) |
| (f) 26900 | 3 SF (see rule VI) |
| (g) 26900 kg | 5 SF (see rule VI) |

## 08. Rounding Off

To represent the result of any computation containing more than one uncertain digit, it is rounded off to appropriate number of significant figures.

**Rules for rounding off the numbers :**

**I Rule** : If the digit to be rounded off is more than 5, then the preceding digit is increased by one. e.g. $6.87 \approx 6.9$

**II Rule** : If the digit to be rounded off is less than 5, than the preceding digit is unaffected and is left unchanged. e.g. $3.94 \approx 3.9$

**III Rule** : If the digit to be rounded off is 5 than the preceding digit is increased by one if it odd and is left unchanged if it is even. e.g. $14.35 \approx 14.4$ and $14.45 \approx 14.4$

***Example*** The length, breadth and thickness of a metal sheet are 4.234 m, 1.005 m and 2.01 cm respectively. Give the area and volume of the sheet to correct number of significant figures.

***Solution*** length ($l$) = 4.234 m breadth (b) = 1.005 m

thickness (t) = 2.01 cm = $2.01 \times 10^{-2}$ m

Therefore area of the sheet $= 2\,(l \times b + b \times t + t \times l)$

$= 2\,(4.234 \times 1.005 + 1.005 \times 0.0201 + 0.0201 \times 4.234)\ m^2$

$= 2\,(4.3604739)\ m^2 = 8.720978\ m^2$

Since area can contain a max$^m$ of 3 SF (Rule II of article 4.2) therefore, rounding off, we get

Area = 8.72 $m^2$

Like wise volume $= l \times b \times t = 4.234 \times 1.005 \times 0.0201\ m^3 = 0.0855289\ m^3$

Since volume can contain 3 SF, therefore, rounding off, we get

Volume = 0.0855 $m^3$

## 09. Order of Magnitude

Order of magnitude of a quantity is the power of 10 required to represent that quantity. This power is determined after rounding off the value of the quantity properly. For rounding off, the last digit is simply ignored if it is less than 5 and, is increased by one if it is 5 or more than 5.

- When a number is divided by $10^x$ (where x is the order of the number) the result will always lie between 0.5 and 5 i.e. $0.5 \le N/10^x < 5$

*Example* Order of magnitude of the following values can be determined as follows :

(a) 49 $= 4.9 \times 10^1 \approx 10^1$

*Solution* $\therefore$ Order of magnitude = 1

(b) 51 $= 5.1 \times 10^1 \approx 10^2$

*Solution* $\therefore$ Order of magnitude = 2

(c) 0.049 $= 4.9 \times 10^{-2} \approx 10^{-2}$

*Solution* $\therefore$ Order of magnitude = −2

(d) 0.050 $= 5.0 \times 10^{-2} \approx 10^{-1}$

*Solution* $\therefore$ Order of magnitude = −1

(e) 0.051 $= 5.1 \times 10^{-2} \approx 10^{-1}$

*Solution* $\therefore$ Order of magnitude = −1

- **Accuracy, Precision of Instruments and Errors in Measurement**

  **Accuracy and Precision**

  The result of every measurement by any measuring instrument contains some uncertainty. This uncertainty is called error. Every calculated quantity which is based on measured value, also has an error. Every measurement is limited by the reliability of the measuring instrument and skill of the person making the measurement. If we repeat a particular measurement, we usually do not get precisely the same result as each result is subjected to some experimental error. This imperfection in measurement can be described in terms of accuracy and precision. The accuracy of a measurement is a measure of how close the measured value is to the true value of the quantity. Precision tells us to what resolution or limit the quantity is measured, we can illustrate the difference between accuracy and precision with help of a example. Suppose the true value of a certain length is 1.234 cm. In one experiment, using a measuring instrument of resolution 0.1 cm, the measured value is found to be 1.1cm, while in another experiment using a measuring device of greater resolution of 0.01m, the length is determined to be 1.53cm. The first measurement has move accuracy (as it is closer to the true value) but less precision (as resolution is only 0.1 cm), while the second measurement is less accurate but more precise.

## 10. Errors

The difference between the true value and the measured value of a quantity is known as the error of measurement.

Errors may arise from different sources and are usually classified as follows

**Systematic or Controllable Errors**

Systematic errors are the errors whose causes are known. They can be either positive or negative. Due to the known causes these errors can be minimised. Systematic errors can further be classified into three categories

**(i)** **Instrumental errors :-** These errors are due to imperfect design or erroneous manufacture or misuse of the measuring instrument. These can be reduced by using more accurate instruments.

**(ii)** **Environmental errors :-** These are due to the changes in external environmental conditions such as temperature, pressure, humidity, dust vibrations or magnetic and electrostatic fields.

**(iii) Observational errors :-** These errors arise due to improper setting of the apparatus or carelessness in taking observations.

**Random Errors**

These errors are due to unknown causes. Therefore they occur irregularly and are variable in magnitude and sign. Since the causes of these errors are not known precisely they can not be eliminated completely. For example, when the same person repeats the same observation in the same conditions, he may get different readings different times.

Random errors can be reduced by repeating the observation a large number of times and taking the arithmetic mean of all the observations. This mean value would be very close to the most accurate reading.

*NOTE* ☞ If the number of observations is made $n$ times then the random error reduces to $\left(\frac{1}{n}\right)$ times.

**Gross Errors :** Gross errors arise due to human carelessness and mistakes in reading the instruments or calculating and recording the measurement results.

For example :-

(i) Reading instrument without proper initial settings.
(ii) Taking the observations wrongly without taking necessary precautions.
(iii) Exhibiting mistakes in recording the observations.
(iv) Putting improper values of the observations in calculations.

These errors can be minimised by increasing the sincerity and alertness of the observer.

## 11. Representation of Errors

Errors can be expressed in the following ways

**Absolute Error (Δa) :** The difference between the true value and the individual measured value of the quantity is called the absolute error of the measurement.

Suppose a physical quantity is measured $n$ times and the measured values are $a_1$, $a_2$, $a_3$ ............$a_n$. The arithmetic mean ($a_m$) of these values is

$$a_m = \frac{a_1 + a_2 + a_3 + \text{..........}a_n}{n} = \frac{1}{n}\sum_{i=1}^{n} a_i \qquad \text{...(i)}$$

If the true value of the quantity is not given then mean value ($a_m$) can be taken as the true value. Then the absolute errors in the individual measured values are

$$\Delta a_1 = a_m - a_1$$
$$\Delta a_2 = a_m - a_2$$
$$\text{.........................}$$
$$\text{.........................}$$
$$\Delta a_n = a_m - a_n$$

The arithmetic mean of all the absolute errors is defined as the final or mean absolute error $(\Delta a)_m$ or Δa of the value of the physical quantity a

$$(\Delta a_m) = \frac{|\Delta a_1| + |\Delta a_2| + \text{..........} + |\Delta a_n|}{n} = \frac{1}{n}\sum_{i=1}^{n} |\Delta a_i| \qquad \text{...(ii)}$$

So if the measured value of a quantity be 'a' and the error in measurement be Δa, then the true value ($a_t$) can be written as

$a_t = a \pm \Delta a$ ...(iii)

**Relative or Fractional Error :** It is defined as the ratio of the mean absolute error ($(\Delta a)_m$ or $\overline{\Delta a}$) to the true value or the mean value ($a_m$ or $\bar{a}$) of the quantity measured.

$$\text{Relative or fractional error} = \frac{\text{Mean absolute error}}{\text{Mean value}} = \frac{(\Delta a)_m}{a_m} \text{ or } \frac{\overline{\Delta a}}{\bar{a}} \quad \text{...(iv)}$$

When the relative error is expressed in percentage, it is known as percentage error, percentage error = relative error × 100

$$\text{or} \quad \text{percentage error} = \frac{\text{mean absolute error}}{\text{true value}} \times 100\% = \frac{\overline{\Delta a}}{a} \times 100\% \quad \text{...(v)}$$

## 12. Propagation of Errors in Mathematical Operations

**Rule I :** The maximum absolute error in the sum or difference of the two quantities is equal to the sum of the absolute errors in the individual quantities.

If $X=A+B$ or $X=A-B$ and if $\pm\ \Delta A$ and $\pm\ \Delta B$ represent the absolute errors in A and B respectively, then the maximum absolute error in $X = \Delta X = \Delta A + \Delta B$ and

$$\text{Maximum percentage error} = \frac{\Delta X}{X} \times 100 \quad \text{...(i)}$$

The result will be written as $X \pm \Delta X$ (in terms of absolute error)

or $X \pm \frac{\Delta X}{X} \times 100\%$ (in terms of percentage error)

**Rule II :** The maximum fractional or relative error in the product or division of quantities is equal to the sum of the fractional or relative errors in the individual quantities.

If $X = A \times B$ or $X = A/B$

$$\text{then} \quad \frac{\Delta X}{X} = \pm\left(\frac{\Delta A}{A} + \frac{\Delta B}{B}\right) \quad \text{...(ii)}$$

**Rule III :** The maximum fractional error in a quantity raised to a power (n) is n times the fractional error in the quantity itself, i.e.

$$\text{If} \quad X = A^n \quad \text{then} \quad \frac{\Delta X}{X} = n\left(\frac{\Delta A}{A}\right) \quad \text{...(viii)}$$

$$\text{If} \quad X = A^p B^q C^r \quad \text{then} \quad \frac{\Delta X}{X} = \left[p\left(\frac{\Delta A}{A}\right) + q\left(\frac{\Delta B}{B}\right) + r\left(\frac{\Delta C}{C}\right)\right]$$

$$\text{If} \quad X = \frac{A^p B^q}{C^r} \quad \text{then} \quad \frac{\Delta X}{X} = \left[p\left(\frac{\Delta A}{A}\right) + q\left(\frac{\Delta B}{B}\right) + r\left(\frac{\Delta C}{C}\right)\right]$$

**IMPORTANT POINTS**

- Systematic errors are repeated consistently with the repetition of the experiment and are produced due to improper conditions or procedures that are consistent in action whereas random errors are accidental and their magnitude and sign cannot be predicated from the knowledge of the measuring system and conditions of measurement.
  Systematic errors can therefore be minimised by improving experimental techniques, selecting better instruments and improving personal skills whereas random errors can be minimised by repeating the observation several times.
- Mean absolute error has the units and dimensions of the quantity itself whereas fractional or relative error is unitless and dimensionless.
- Absolute errors may be positive in certain cases and negative in other cases.

***Example*** The initial and final temperatures of water as recorded by an observer are $(40.6 \pm 0.2)^{\circ}C$ and $(78.3 \pm 0.3)^{\circ}C$. Calculate the rise in temperature with proper error limits.

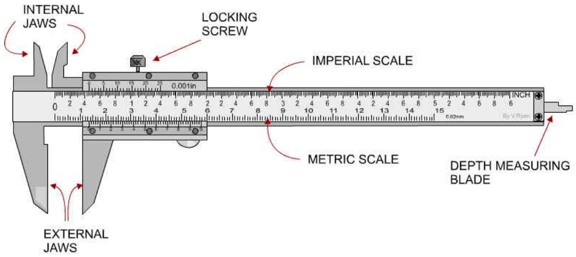
***Solution*** Given $\theta_1 = (40.6 \pm 0.2)^{\circ}C$ and $\theta_2 = (78.3 \pm 0.3)^{\circ}C$
Rise in temp. $\theta = \theta_2 - \theta_1 = 78.3 - 40.6 = 37.7^{\circ}C$.
$\Delta\theta = \pm(\Delta\theta_1 + \Delta\theta_2) = \pm (0.2 + 0.3) = \pm 0.5^{\circ}C$ $\therefore$ rise in temperature = $(37.7 \pm 0.5)^{\circ}C$

## 13. Least Count

The smallest value of a physical quantity which can be measured accurately with and instrument is called the least count (L. C.) of the measuring instrument.

**Least Count of Vernier Callipers**

Suppose the size of one main scale division (M.S.D.) is M units and that of one vernier scale division (V. S. D.) is V units. Also let the length of 'a' main scale divisions is equal to the length of 'b' vernier scale divisions.



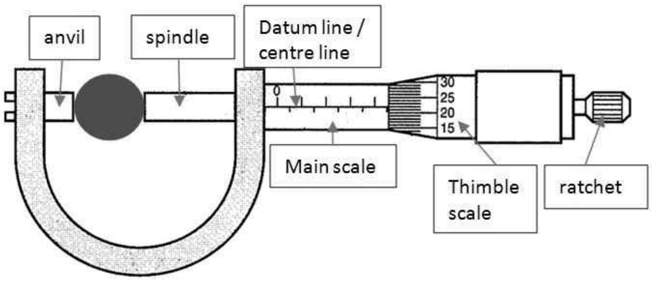

$$aM = bV \Rightarrow V = \frac{a}{b}M$$

$$\therefore \quad M - V = M - \frac{a}{b}M \text{ or } \quad M - V = \left(\frac{b-a}{b}\right)M$$

The quantity (M− V) is called vernier constant (V. C.) or least count (L. C.) of the vernier callipers.

$$L.C. = M - V = \left(\frac{b-a}{b}\right)M$$

**Least Count of screw gauge or spherometer**




$$\text{Least Count} = \frac{\text{Pitch}}{\text{Total number of divisions on the circul scale}}$$

where pitch is defined as the distance moved by the screw head when the circular scale is given one complete rotation. i.e.

$$\text{Pitch} = \frac{\text{Distance moved by the screw on the linear scale}}{\text{No. of full rotations given}}$$

***NOTE*** ☞ With the decrease in the least count of the measuring instrument, the accuracy of the measurement increases and the error in the measurement decreases.

***Example*** One cm on the main scale of vernier callipers is divided into ten equal parts. If 20 divisions of vernier scale coincide with 8 small divisions of the main scale. What will be the least count of callipers ?

***Solution*** 20 div. of vernier scale = 8 div. of main scale $\Rightarrow 1\,V.S.D. = (\frac{8}{20})$ M. S. D. = $(\frac{2}{5})$M. S. D.

Least count = 1 M. S. D. − 1 V. S. D. = 1 M. S. D. − $(\frac{2}{5})$M. S. D. = $(1-\frac{2}{5})$ M. S. D.

$$= \frac{3}{5}\,M.S.D. = \frac{3}{5} \times 0.1\,cm = 0.06\,cm$$

$$(\because 1\,M.S.D. = \frac{1}{10}\,cm = 0.1\,cm)$$

***NOTE*** ☞ The final absolute error in this type of questions is taken to be equal to the least count of the measuring instrument.

# NEET
## Exercise (1)

1. A physical quantity of the dimension of length that can be formed out of $c$, $G$ and $\frac{e^2}{4\pi\varepsilon_0}$ is [c is velocity of light, $G$ is universal constant of gravitation and $e$ is charge]
   (a) $\frac{1}{c^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$
   (b) $c^2\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$
   (c) $\frac{1}{c^2}\left[\frac{e^2}{G4\pi\varepsilon_0}\right]^{1/2}$
   (d) $\frac{1}{c}G\frac{e^2}{4\pi\varepsilon_0}$

2. If dimensions of critical velocity $v_c$ of a liquid flowing through a tube are expressed as $[\eta^x \rho^y r^z]$, where η, ρ and r are the coefficient of viscosity of liquid, density of liquid and radius of the tube respectively, then the values of x, y and z are given by
   (a) 1, −1, −1
   (b) −1, −1, 1
   (c) −1, −1, −1
   (d) 1, 1, 1

3. In an experiment, four quantities $a$, $b$, $c$ and $d$ are measured with percentage error 1%, 2%, 3% and 4% respectively. Quantity $P$ is calculated $P = \frac{a^3b^2}{cd}$%. Error in $P$ is
   (a) 14%
   (b) 10%
   (c) 7%
   (d) 4%

4. If energy ($E$), velocity (v) and time ($T$) are chosen as the fundamental quantities, the dimensional formula of surface tension will be
   (a) $[Ev^{-2}T^{-1}]$
   (b) $[Ev^{-1}T^{-2}]$
   (c) $[Ev^{-2}T^{-2}]$
   (d) $[E^{-2}v^{-1}T^{-3}]$

5. Dimensions of resistance in an electrical circuit, in terms of dimension of mass $M$, of length $L$, of time $T$ and of current $I$, would be
   (a) $[ML^2T^{-3}I^{-1}]$
   (b) $[ML^2T^{-2}]$
   (c) $[ML^2T^{-1}I^{-1}]$
   (d) $[ML^2T^{-3}I^{-2}]$

6. Which two of following five physical parameters have the same dimensions?
   (i) Energy density
   (ii) Refractive index
   (iii) Dielectric constant
   (iv) Young's modulus
   (v) Magnetic field

   (a) (ii) and (iv)
   (b) (iii) and (v)
   (c) (i) and (iv)
   (d) (i) and (v)

7. In a vernier callipers $N$ divisions of vernier scale coincide with $N-1$ divisions of main scale (in which length of one division is 1 mm). The least count of the instrument should be
   (a) $N$
   (b) $N-1$
   (c) $\frac{1}{10N}$
   (d) $\frac{1}{(N-1)}$

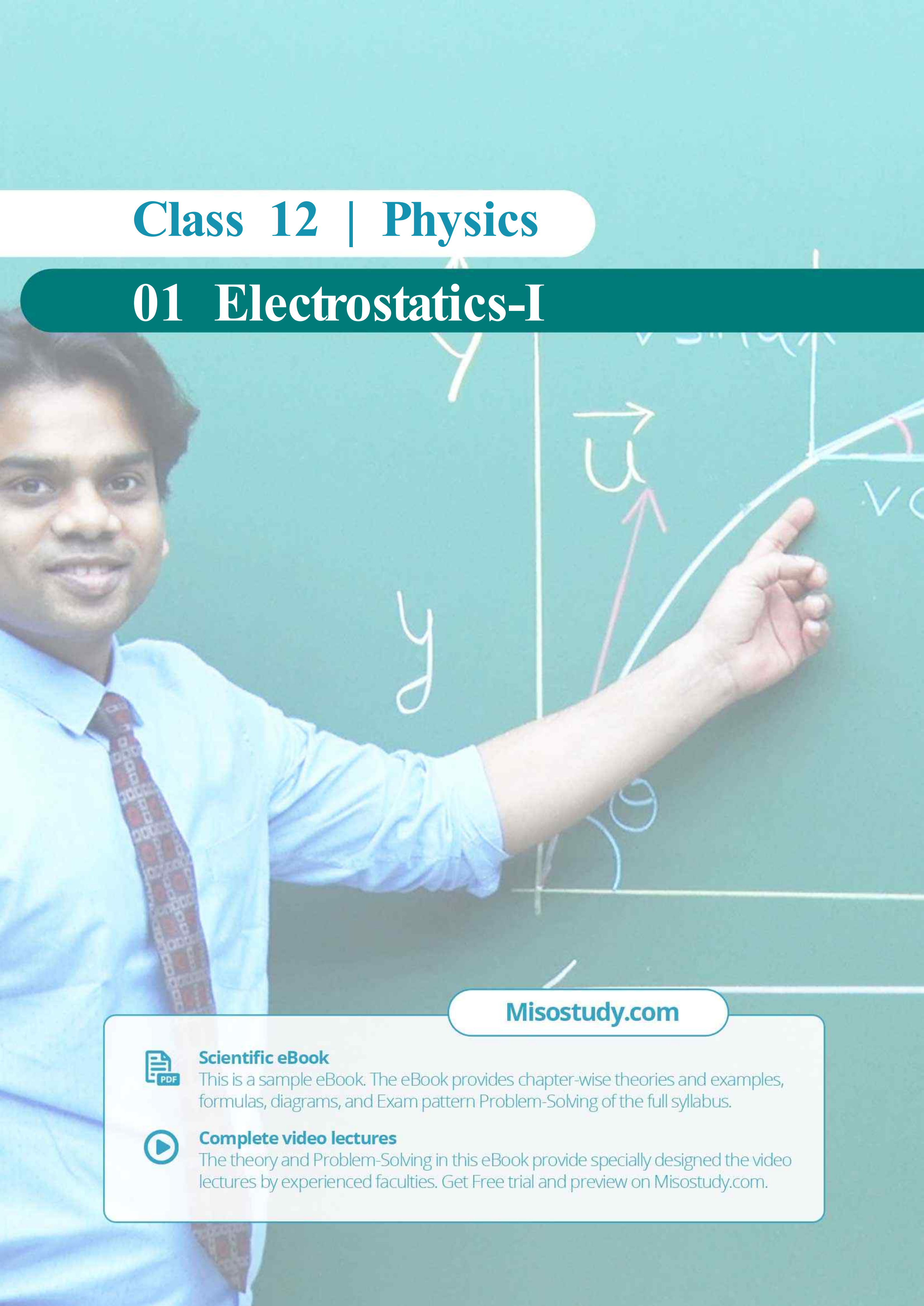
8. The dimensional formula for permeability of free space, $\mu_0$ is
   (a) $[MLT^{-2}A^{-2}]$
   (b) $[ML^{-1}T^{2}A^{-2}]$
   (c) $[ML^{-1}T^{-2}A^{2}]$
   (d) $[MLT^{-2}A^{-1}]$

9. If $p$ represents radiation pressure, $c$ represents speed of light and $S$ represent radiation energy striking unit area per sec. The non-zero integers x, y, z such that $p^x S^y c^z$ is dimensionless are
   (a) x = 1, y = 1, z = 1
   (b) x = −1, y = 1, z = 1
   (c) x = 1, y = −1, z = 1
   (d) x = 1, y = 1, z = −1

10. A certain body weighs 22.42 g and has a measured volume of 4.7 cc. The possible error in the measurement of mass and volume are 0.01 g and 0.1 cc. Then, maximum error in the density will be
   (a) 22%
   (b) 2%
   (c) 0.2%
   (d) 0.02%

# Class 12 | Physics

# 01 Electrostatics-I



## 01. Introduction

Electrostatics, deals with the study of charges in rest. These stationary charges occurs due to friction of two insulting bodies, therefore it is often called frictional electricity.

**Important points**

(i) Gravitational force is the weakest while nuclear force is the strongest force of the nature

(ii) Nuclear force does not depend upon charge, it acts equally between proton-proton, proton neutron and neutron-neutron.

(iii) There are weak forces acting in β-degradiation in radio-activity.

(iv) A stationary charge produces electric filed while a moving charge produce electric as well as magnetic field.

(v) Moving charge produce electric field as well as magnetic field but does not radiate energy while uniform acceleration.

(vi) Accelerated charge produce electric field as well as magnetic field and radiate energy.

## 02. Charge

Property of a substance by virtue of which it can repel or attract another charged substance.

**Charges are of two types**

**(a) Positive charge :** Lesser number of electrons than number of protons.

**(b) Negative charge :** More number of electrons than number of protons

**Importants Points : Only, electron is responsible for a substance to be charged and not the proton.**

**Properties of Charge**

(i) Like charges repel while unlike charges attract each other.

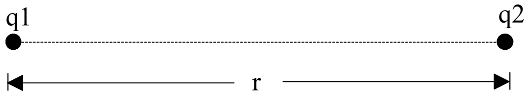
(ii) Charge is quantized in nature i.e. The magnitude of charge possessed by different objects is always and integral multiple of charge of electron (or proton) i.e. $q = \pm ne$ where $n = 1, 2, 3$ ..........

(iii) The minimum possible charge that can exist in nature is the charge of electron which has a magnitude of $e = 1.60207 \times 10^{-19}$ coulomb. This is also known as quantum of charge or fundamental charge.

(iv) In an isolated system the algebraic sum of total charge remains constant. This is the law of 'Conservation of charge'.

## 03. Coulomb's Las

The force of attraction or repulsion between two stationary point charges is directly proportional to the product of charges and inversely proportional to the square of distance between them. This force acts along the line joining the two. If $q_1$ & $q_2$ are charges in consideration r, the distance between them and F, the force acting between them




Then, $F \propto q_1 q_2$

$F \propto 1/r^2$

$\therefore \quad F \propto \dfrac{q_1 q_2}{r^2}$

$\Rightarrow \quad F = K\dfrac{q_1 q_2}{r^2}$, where k = constant.

$$K = \frac{1}{4\pi\varepsilon_0\varepsilon_r} = \frac{9 \times 10^9}{\varepsilon_r} \mathrm{N\,m^2C^{-2}}$$

where,

$\varepsilon_0 =$ Electric permittivity of vacuum or air

$= 8.85 \times 10^{-12} C^2N^{-1}m^{-2}$ and

K or $\varepsilon_r =$ Relative permittivity or Dielectric constant or Specific inductive capacity

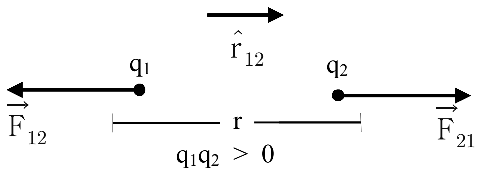
$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0} \Rightarrow \varepsilon = \varepsilon_0\varepsilon_r$$

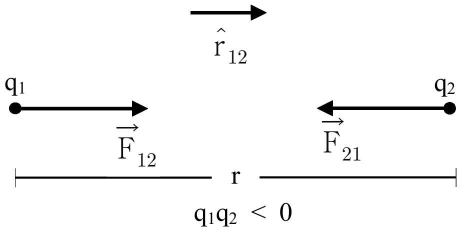
**[Newton's law for particles is analogous to coulomb's law for rest charge. The difference is that Newton's law gives attraction force while coulomb's law gives attraction as well as repulsion force]**

***NOTE*** ☞
(i) Coulomb's law is applicable to point charges only. But it can be applied for distributed charges also
(ii) This law is valid only for stationary charges and cannot be applied for moving charges.
(iii) This law is valid only if the distance between two charges is not less than $10^{-15}$ m

### Direction

Direction of the force acting between two charges depends upon their nature and it is along the line joining two charges.



$\vec{F}_{21}$ = force on $q_2$ due to $q_1$

$$\vec{F}_{21} = \frac{q_1 q_2}{4\pi\varepsilon_0\varepsilon_r r_{12}^2}\hat{r}_{12} \qquad \text{........(A)}$$

(where $\hat{r}_{12}$ is a unit vector pointing from $q_1$ to $q_2$)

$\vec{F}_{12}$ = Force on $q_1$ due to $q_2$

$$\vec{F}_{12} = \frac{q_1 q_2}{4\pi\varepsilon_0\varepsilon_r r_{12}^2}\hat{r}_{21} \qquad \text{........(B)}$$

(where $\hat{r}_{21}$ is a unit vector pointing from $q_2$ to $q_1$)

⇒ Electric force between two charges not depends on neighbouring charges.

⇒ If a dielectric slab $(\in_r)$ of thickness 't' is placed between two charges (distance d), force decreases.

$$F = \frac{Q_1 Q_2}{4\pi\in_0 r^2} \qquad \text{where } r = d - t + t\sqrt{\in_r}$$

## 04. Electric Field

A charge produces something called and electric field in the space around it and this electric field exerts a force on any charge placed in it.

***NOTE*** ☞ The electric field does not exert force on source charge.

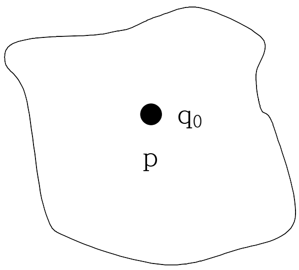
### Electric field Intensity

Force experienced by a unit positive charge placed in and electric field at a point is called electric field intensity at that point. It is also known as electric field simply. Let $q_0$ be the positive test charge placed in an electric field. If $\vec{F}$ is the force experienced by this charge, then

$$\vec{E} = \lim_{q_0 \to 0}\frac{\vec{F}}{q_0}$$

(i) Unit : N/C or volt/metre

(ii) This is a vector quantity and its direction is the same as force on the positive test charge.



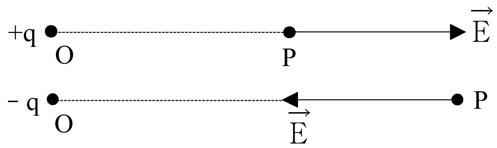

(iii) Since $\vec{E}$ is the force on unit charge, force on charge q is. $\vec{F} = q\vec{E}$.

(iv) Dimension is $[M^1L^1T^{-3}A^{-1}]$

(v) Electric field due to a point charge is

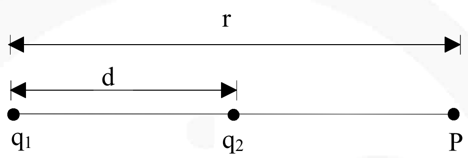
$$\vec{E} = \frac{kq}{r^2}.\hat{r}$$

(vi) Direction of electric field due to positive charge is away from charge while direction of electric field due to negative charge is towards the charge.



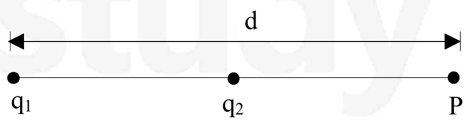

**Special point**

(a) If $q_1$ and $q_2$ are at a distance r and both have the same type of charge, then the distance 'd' of the point from $q_1$ where electric field is zero is given by $d = \frac{\sqrt{q_1}\,r}{\left(\sqrt{q_1}+\sqrt{q_2}\right)}$. This point will lie between line joining $q_1$ & $q_2$.




(b) If $q_1$ and $q_2$ have opposite charges then distance 'd' of the point 'p' from $q_1$ where electric field is zero is given by

$$d = \frac{\sqrt{q_1}\,r}{\sqrt{q_1}-\sqrt{q_2}}, \qquad [|q_1| > |q_2|]$$




(c) There charges $+Q_1$, $+Q_2$ and q are placed on a straight line. If this system of charges is in equillibrium, charge q should be a given

$$q = \frac{Q_1Q_2}{\left(\sqrt{Q_1}+\sqrt{Q_2}\right)^2}$$

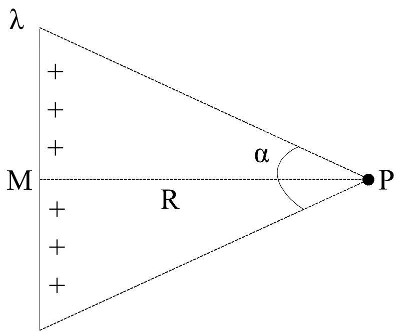
⇒ For measuring $\vec{E}$ practically a test charge (+ve) of magnitude much less than the source charge should be used.

⇒ Electric force on a charge in uniform E is constant and hence acceleration is constant, so equations of motion can be used

(acceleration $a = \frac{qE}{m}$)

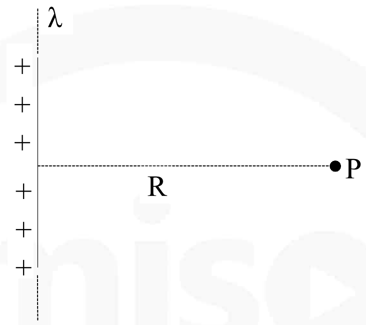
⇒ Electric field due to linear charge distribution (a) Finite wire

(d) Finite wire



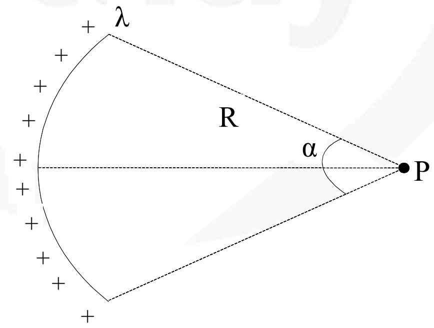

$$E_p = \frac{2k\lambda}{R}\sin\frac{\alpha}{2}$$

(e) Infinite wire (α = 180º)



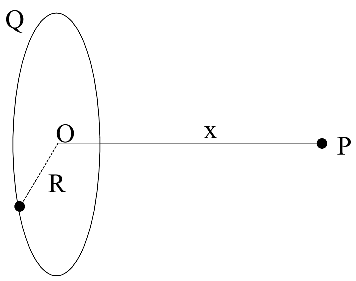

$$E_P = \frac{2k\lambda}{R}$$

(f) Charged arc




$$E_P = \frac{2k\lambda}{R}\sin\left(\frac{\alpha}{2}\right)$$

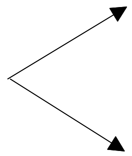
(g) Charged ring of radius R



at and axial point $E_P = \dfrac{kQx}{(R^2+x^2)^{3/2}}$;

$$x >> R \Rightarrow E_P = \frac{kQ}{x^2}$$

If



$$x \ll R \Rightarrow E_P = \frac{kqx}{R^2}$$

As x is increases: $\vec{E}$ due to ring first ↑ then ↓ and at $X = \dfrac{R}{\sqrt{2}}$ it is maximum.

**Electric lines of forces : (ELF)**

The electric field in a region can be represented by drawing certain curves known as electric lines of force.

An electric line of force is that imaginary smooth curve drawn in an electric field along which a free isolated unit positive charge moves.

**Properties**

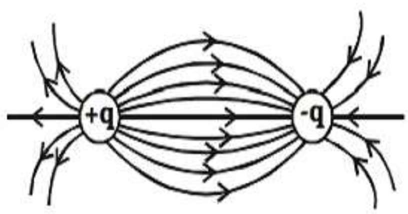
(i) Imaginary

(ii) Can never cross each other

(iii) Can nerver be closed loops

(iv) The number of lines originating or terminating on a charge is proportional to the magnitude of charge. In rationalised MKS $\left(\dfrac{1}{\varepsilon_0}\right)$ system electric lines are associated with unit charge, so if a body encloses q, total lines of force associated with it (called flux) will be $q/\varepsilon_0$.

(v) Total lines of force may be fractional as lines of force are imaginary.




(vi) Lines of force ends or starts normally at the surface of a conductor.

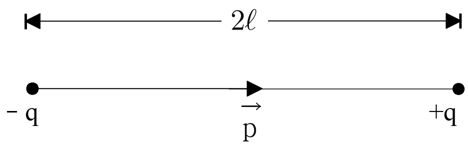
(vii) If there is no electric field there will be no lines of force.

(viii) Lines of force per unit area normal to the area at a point represents magnitude of intensity, crowded lines represent strong field while distant weak field.

(ix) Tangent to the line of force at a point in an electric field gives the direction of intensity. So a positive charge free to move follow the line of force.

## 05. Electric Dipole

(i) An system consisting of two equal and opposite charges separated by a small distance is termed and electric dipole.




**Example :** $Na^+Cl^-$, $H^+$ $Cl^-$ etc.

(ii) An isolated atom is not a dipole because centre of positive charge coincides with centre of negative centres. But if atom is placed in an electric field, then the positive and negative centres are displaced relative to each other and atom become a dipole.

(iii) DIPOLE MOMENT: The product of the magnitude of charges and distance between them is called the dipole moment.

It is denoted by $\vec{p}$ and $|\vec{p}| = q \times 2\ell$

(a) This is a vector quantity which is directed from negative to positive charge.
(b) Unit : C-m
(c) Dimension : $[M^0L^1T^1A^1]$

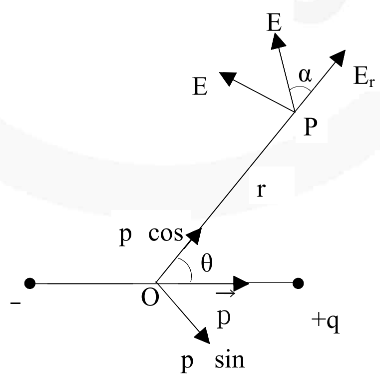
### Electric field due to a dipole

(i) There are two components of electric field at any point

(a) $E_r \rightarrow$ in the direction of $\vec{r}$
(b) $E_\theta \rightarrow$ in the direction perpendicular to $\vec{r}$

$$E_r = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2p\cos\theta}{r^3}$$

$$E_\theta = \frac{1}{4\pi\varepsilon_0} \cdot \left(\frac{p\sin\theta}{r^3}\right)$$




(i) Resultant

$$E = \sqrt{E_r^2 + E_\theta^2} = \frac{p}{4\pi\varepsilon_0 r^3}\sqrt{1+3\cos^2\theta}$$

(ii) Angle between the resultant $\vec{E}$ and $\vec{r}$, $\alpha$ given

by $\alpha = \tan^{-1}\left(\frac{E_\theta}{E_r}\right) = \tan^{-1}\left(\frac{1}{2}\tan\theta\right)$

(iii) If θ = 0, i.e point is on the axis -

$$E_{axis} = \frac{2kp}{r^3} \qquad (r \gg \ell)$$

(iv) If θ = 90º , i.e. point is on the line bisecting the dipole perpendicularly

$$E_{equatorial} = \frac{kp}{r^3} \qquad (r \gg \ell)$$

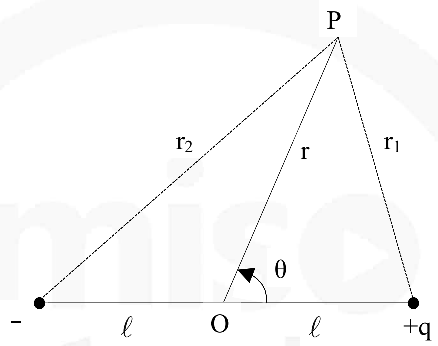
(v) So, $E_{axis} = 2E_{equatorial}$ (for same r)

(vi) $$E_{axis} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{2pr}{\left(r^2 - \ell^2\right)^2}$$

$$E_{equatorial} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p}{\left(r^2 + \ell^2\right)^{3/2}}$$

where $p = q \cdot (2\ell)$

(vii)




potential at a general point.

$$V = \frac{1}{4\pi\varepsilon_0} \frac{p\cos\theta}{r^2}$$

(viii) If θ = 0º, $V_{axis} = \frac{kp}{r^2}$

(ix) If θ = 90º, $V_{equator} = 0$

(x) Here we see that V = 0 but E ≠ 0 for points at equatorial position.

(xi) Again, if r >> d is not true and d = 2ℓ,

$$V_{axis} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{p}{\left(r^2 - \ell^2\right)}$$

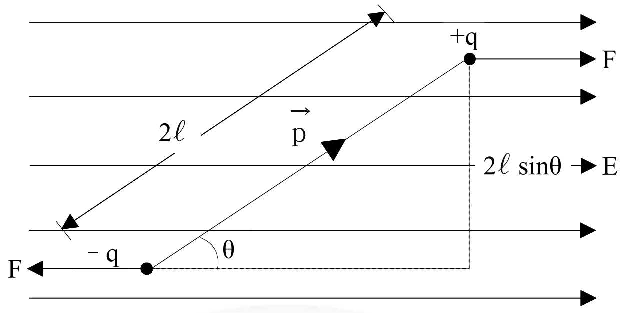
$$V_{equator} = 0$$

*NOTE* ☞
**(i) This is not essential that at a point, where E = 0, V will also be zero there eg. inside a uniformly charged sphere, E = 0 but V ≠ 0**
**(ii) Also if V = 0, it if not essential for E to be zero eg. in equatorial position of dipole V = 0, but E ≠ 0**

**Electric Dipole In an Electric Field – Uniform Electric Field**

(i) When an electric dipole is placed in a uniform electric dipole, A torque acts on it which subjects the dipole to rotatory motion. This τ is given by τ = pE sinθ or $\vec{\tau}=\vec{p}\times\vec{E}$

(ii) Potential energy of the dipole
$U=-pE\cos\theta=-\vec{p}.\vec{E}$




**Cases**

(a) If θ = 0º, i.e. $\vec{p}\parallel\vec{E},\tau=0$ and U = –pE, dipole is in the minimum potential energy state and no torque acting on it and hence it is in the stable equilibium state.

(b) For θ = 180º, i.e. $\vec{p}$ and $\vec{E}$ are in opposite direction, then τ = 0 but U = pE which is maximum potential energy state. Although it is in equilibium but it is not a stable state and a slight perturbation can disturb it.

(c) $\theta=90^\circ$, i.e. $\vec{p}\perp\vec{E}$, then
τ = pE (maximum) and U = 0

**Work done in rotating an electric dipole in and electric field**

(i) To rotate the dipole by an angle θ from the state of stable equilibrium W = PE (1 – cosθ).

(ii) Work done in rotating the dipole from $\theta_1$ to $\theta_2$ in an uniform electric filed
$$W = pE(\cos\theta_1 - \cos\theta_2)$$

(iii) Work done in rotating the dipole through 180º from stable equilibrium state
$$W = 2pE = 2\text{ (potential energy)}$$

## 06. Electric Flux

(i) It is denoted by '$\phi$'.

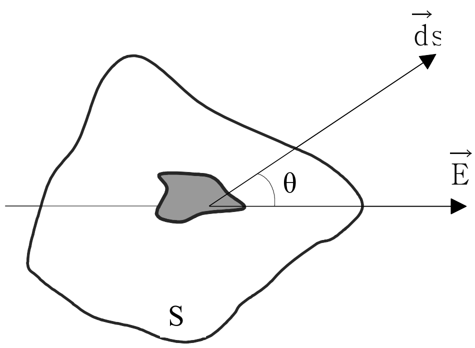
(ii) It is a scalar quantity.

(iii) It is defined as the total number of lines of force passing normally through a curved surface placed in the field.

(iv) It is given by the dot product of $\vec{E}$ and normal infinitesimal $\overrightarrow{ds}$ area integrated over a closed surface.

$$d\phi=\vec{E}.\overrightarrow{ds}$$
$$\phi=\oint\vec{E}.\vec{ds}=\oint Eds\cos\theta$$

where θ = angle between electric field and normal to the area




(v) Unit : (a) N-m$^2$/C (b) volt – meter
(vi) Dimension : $[ML^3T^{-3}A^{-1}]$
(vii) Flux due to a positive charge goes out of the surface while that due to negative charge comes into the surface.
(viii) Value of electric flux is independent of shape and size of the surface.
(ix) If only a dipole is present in the surface then net flux is zero.
(x) Net flux from a surface is zero does not imply that intensity of electric field is also zero.

## 07. Gauss's Law

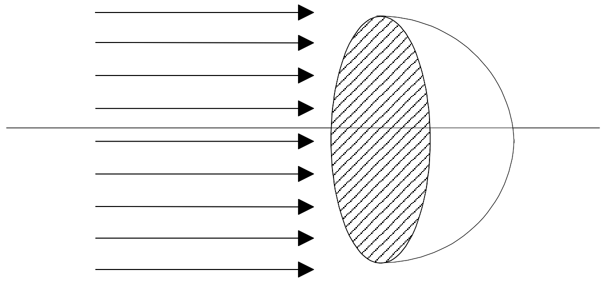
This law states that electric flux $\phi_E$ through any closed surface is equal to $1/\varepsilon_0$ times the net charge 'q' enclosed by the surface i.e

$$\phi_E = \oint \vec{E}.\vec{ds} = \frac{q}{\varepsilon_0}$$

**Important point about flux**

(i) Independent of distances between charges inside the surface and their distribution.
(ii) Independent of shape, size and nature of surface.
(iii) Net flux due to a charge outside the surface will be zero.
(iv) Gauss law is valid only for the vector fields which obey inverse square law

***Example*** A hemispherical surface of radius R is kept in a uniform electric field E such that E is parallel to the axis of hemi-sphere, Net flux from the surface will be



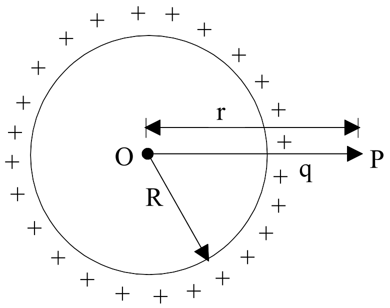
***Solution*** $\phi = \oint \vec{E}.\vec{ds} = E.\pi R^2.$

$= (E)$ (Area of surface perpendicular to E)

$= E.\ \pi R^2.$

## 08. Application of Gauss's Law

### Electric field due to a solid conducting sphere/Hollow conducting sphere.




(i) **Case: 1** r > R $\quad \vec{E} = \frac{kq}{r^2}\hat{r} = \frac{1}{\varepsilon_0}\frac{\sigma R^2}{r^2}\hat{r}$

**Case: 2** r = R $\quad \vec{E} = \frac{\sigma}{\varepsilon_0}\hat{r}$

**Case: 3** r < R $\quad \vec{E} = 0$

i.e. At point interior to a conducting or a hollow sphere, electric field intensity is zero.

(ii) For points outside the sphere, it behaves like all the charge is present at the centre.

(iii) Intensity of electric field is maximum at the surface

**Imp.**

(iv) Electric field at the surface is always perpendicular to the surface.

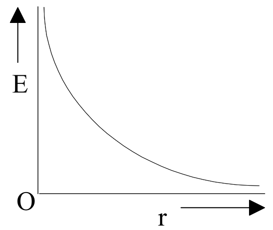
(v) For points, near the surface of the conductor, $E = \frac{\sigma}{\varepsilon_0}$ perpendicular to the surface

### Electric field due to infinitely long charge

(i) A long wire is given a line charge density λ. If wire is positively charged, direction of $\vec{E}$ will be away from the wire (outward ⊥) while fro a negatively charged wire, direction of $\vec{E}$ will be (inward ⊥) towards the wirde.

(ii) E at point p

$$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}\hat{r} \quad \text{or} \quad E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

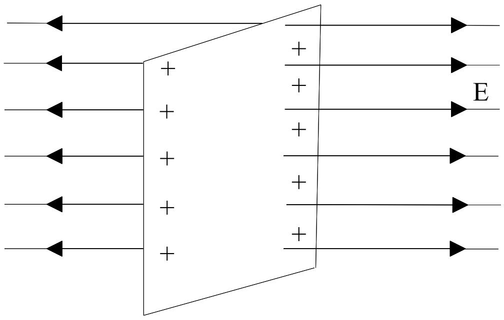



(iii) Potential difference between points A ($r_1$) & $B(r_2) = V_2 - V_B = \frac{\lambda}{2\pi\varepsilon_0}\ell n\left(\frac{r_2}{r_1}\right)$

(iv) Potential difference between points A ($r_1$) & $B(r_2) = V_2 - V_B = \frac{\lambda}{2\pi\varepsilon_0}\ell n\left(\frac{r_2}{r_1}\right)$

**Electric field at a point due to an infinite sheet of charge**

(i) If σ = surface charge density. Intensity at points near to the sheet $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{r}$




(ii) Direction of electric field is perpendicular to the sheet of charge.

(iii) Intensity of electric field does not depend upon the distance of points from the sheet for the points in front of sheet i.e. There is an equipotential region near the charged sheet.

(iv) Potential difference between two points A & B at distances $r_1$ & $r_2$ respectively is

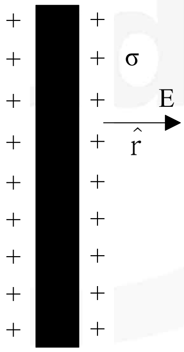
$$V_A - V_B = \frac{\sigma}{2\varepsilon_0}(r_2 - r_1)$$

**Electric field due to infinite charged metal plate**

(i) Intensity at points near the plate $\vec{E} = \frac{\sigma}{\varepsilon_0}\hat{r}$

where σ = surface charge density

(ii) $\vec{E}$ is independent of distance of the point from the plate and also of the area of sheet i.e. There is an equipotential region near the plate.




(iii) Direction of electric field is perpendicular to the palate.

(iv) Potential difference between two point A ($r_1$) and B ($r_2$) ($r_1 < r_2$) near the plate is

$$\Delta V = V_A - V_B = \frac{\sigma}{\varepsilon_0}(r_2 - r_1)$$

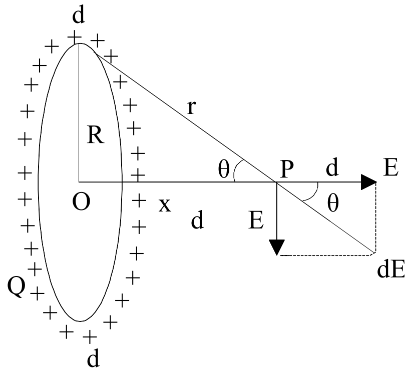
**Electric field due to charged ring : Q charge is distributed over a ring of radius R.**

(i) Intensity of electric field at a distance x from the centre of ring along it's axis-

$$E = \frac{1}{4\pi\varepsilon_0}\frac{Q\cos\theta}{r^2} = \frac{Qx}{4\pi\varepsilon_0 r^3} \quad (\because \cos\theta = x/r)$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{Qx}{(R^2+x^2)^{3/2}} \quad [\because r = \sqrt{R^2+x^2}]$$

and it's direction will be along the axis of the ring.




(ii) Intensity will be zero at the centre of the ring.

(iii) Intensity will be maximum at a distance $R/\sqrt{2}$ from the centre and

$$E_{max} = \frac{2}{3\sqrt{3}} \cdot \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q}{R^2}$$

(iv) Electric potential at a distance x from centre,

$$V = \frac{1}{4\pi\varepsilon_0} \frac{Q}{\sqrt{(x^2 + R^2)}}$$

# NEET
## Exercise (1)

1. The force between two charges situated in air is $F$, The force between the same charges if the distance between them is reduced to half and they are situated in a medium having dielectric constant 4 is
   (a) $F/4$
   (b) 4 $F$
   (c) 16 $F$
   (d) $F$

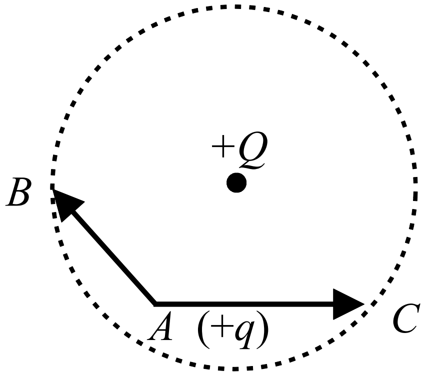
2. If charge $q$ is placed at the centre of the line joining two equal charges $Q$, the system of three charges will be in equilibrium if $q$ is
   (a) $-Q/2$
   (b) $-Q/4$
   (c) $-4Q$
   (d) $+Q/2$

3. Two equally charged identical metal spheres $A$ and $B$ repel each other with a force $3 \times 10^{-5}$ N. Another identical unchanged sphere $C$ is touched with $A$ and then placed at the mid-point between $A$ and $B$. Net force on $C$ is
   (a) $1 \times 10^{-5}$ N
   (b) $2 \times 10^{-5}$ N
   (c) $1.5 \times 10^{-5}$ N
   (d) $3 \times 10^{-5}$ N

4. The electric strength of air is $2 \times 10^7$ N/C. The maximum charge that a metallic sphere of diameter 6 mm can hold is
   (a) 3 $nC$
   (b) 20 $nC$
   (c) 1.5 $nC$
   (d) 2 $nC$

5. An electric dipole is placed at an angle of 60º with an electric field of intensity $10^5$ NC$^{-1}$. It experiences a torque equal to $8\sqrt{3}$ $Nm$. Calculate the charge on the dipole, if the dipole length is 2 cm.
   (a) $-8 \times 10^3$ C
   (b) $8.54 \times 10^{-4}$ C
   (c) $8 \times 10^{-3}$ C
   (d) $0.85 \times 10^{-6}$ C

6. An electric field exists in the space around a point charge $+Q$. A positive charge $+q$ is carried from $A$ to $B$ and $A$ to $C$, where $B$ and $C$ lie on a circle with $+Q$ at the centre, Work done is

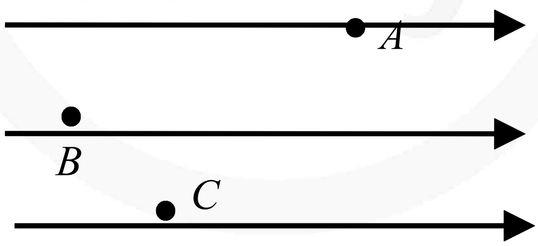



Figure

(a) greater along the path $AC$ than along $AB$
(b) greater along the path $AB$ than along $AC$
(c) same in both the cases
(d) zero in both the cases.

7. An α-particle and a proton are accelerated through same potential difference from rest. Find the ratio of their final velocity
(a) $\sqrt{2} : 1$
(b) $1 : 1$
(c) $1 : \sqrt{2}$
(d) $1 : 2$

8. A, B and C are three points in a uniform electric field, in Figure. The electric potential is :




(a) Same at all the three points $A$, $B$ and $C$
(b) Maximum at $A$
(c) Maximum at $B$
(d) Maximum at $C$

9. $n$ small drops of same size are charged to $V$ volt each. If they coalesce to form a single large drop, then the potential will be
(a) $Vn$
(b) $Vn^{-1}$
(c) $Vn^{1/3}$
(d) $Vn^{2/3}$

10. A long string with a charge of $\lambda$ per unit length passes through an imaginary cube of edge $a$. The maximum flux of the electric field through the cube will be

(a) $\lambda a/\epsilon_0$

(b) $\sqrt{2}\ \lambda a/\epsilon_0$

(c) $6\lambda\ a^2/\epsilon_0$

(d) $\sqrt{3}\lambda\ a/\epsilon_0$