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Where Minds Pollinate

Class 11
Physics

Chapter 1

Handwritten Notes

Chapter #04
Measurment
Lecture:- 01

Matter:- Everything that has some mass and occupies space is called matter. Everything around us is matter.
For Example:- Board, book, pen etc

Energy:- Ability / capability, capacity of a body to do work is called energy. It is not visible. It's presence or absence can be felt.

Physics: "Branch of science" that deals with the properties of matter & energy. It also deals with relationship between matter & energy

Physical Quantities:- All these quantities that are measurable or that are can be measured are called physical quantities.
- Each physical quantity has a symbol numerical value and unit

Example :- length time.

Types:- There are two types of physical quantities

Base quantity:- Those physical quantity that are not made up of other quantities but other quantities that are not made up of other quantities but other quantities are made up of them
There are only seven base quantities these include length, time, mass, time, temperature, electric current, intensity of light and amount of a substance, there symbols are

length	l, /s, /d
time	t
mass	m
temperature	T/θ
electric current	i
intensity of light	J
Amount of substance(n)	n

Derived Quantities:- Those physical quantities that made up of base quantities are called derived quantities
Derived quantities are obtained when two two or more base quantities are obtained when two or more than two base quantity are either multiplied, divided or multiplied / divided simultanously.
For Example:-

Speed = distance

Area: $l \times b$
Volume: $l \times b \times h$

Unit of a physical quantity The standard measurment of a physical quantity is called unit. Every unit has a unique symbol.

For Example:- The unit of length is meter and unit of time is second.

Types:-

There are two types of unit

1. **Base Unit**
2. **Derived unit.**

Base Unit:- The unit of a base quantity is called a base unit. The standard unit of a base quantity. Each unit of a base quantity has a unique symbol.

Symbol for base units are given below:-

Quantity	Unit	Symbol
Mass	Kilogram	Kg
length	meter	m
time	second	s
temperature	Kelvin	K
Electric Current	Ampere	A
Amount of substance	Mole	mol
Intensity of light	Candela	Cd.

Derived Units:- The units of derived quantities are called derived units. Derived units are obtained by multiplying or dividing base units

Example:-

① **Speed =** $\frac{\text{distance}}{\text{time}}$

$$V = \frac{S}{t}$$

$$V = \frac{m}{s}$$

$$V = ms^{-1}$$

② **Acceleration:-** $\frac{\text{Velocity}}{\text{Time}}$

$$a = \frac{V}{t}$$

$$a = ms^{-1}$$

$$a = \frac{m}{s^2}$$

$$a = ms^{-2}$$

Momentum = mass × Velocity.

$$P = mv$$

$$= kg \times ms^{-1}$$

$$= kgm/s$$

Derived units in Terms of base units:-

Express units of force in term of base unit:-

We know that:-

$$F = ma$$

$$F = \frac{mv}{t} , \frac{m}{t} \times v$$

$$= \frac{m}{t} \times \frac{S}{t}$$

$$F = \frac{ms}{t^2}$$

Now;

$$N = \frac{kg \times m}{s^2}$$

$$N = \frac{kgm}{s^2}$$

$= kgm/s$ Ans

Express unit of work in Terms of base unit

We know that

$$W = F \times d$$

$$= mad$$

$$= \frac{mvd}{t}$$

$$= \frac{md}{t} \times v$$

$$= \frac{md}{t} \times \frac{d}{t}$$

$$= \frac{kgm}{s} \times \frac{m}{s}$$

$$= \frac{kgm^2}{s^2}$$

$= kgm^2/s^2$ Answer

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Dimension of a Physical quantity

Dimension of a physical quantity refers to the nature of that physical quantity. It is represented by capital letters enclosed in square brackets

Dimension of base quantities are given below

Seriel Num	Physical Quantity	Dimension
1	Mass	[M]
2	length	[L]
3	time	[T]
4	Temperature	[θ]
5	Electric Current	[I]
6	Intensity of light	[J]
7	Amount of substance	[N]

Dimension of Physical derived quantity

Dimensions of physical derived quantities are obtained by multiplying or dividing dimension of base quantities

• Find dimension of:-

i). Speed:

We know that

$$V = \frac{S}{T}$$

$$\text{dimension of speed} = \frac{[L]}{[T]}$$

$$= [LT^{-1}]$$

ii). Acceleration:-

We know that

$$a = \frac{V}{T}$$

$$\text{dimension of } a = \frac{[LT^{-1}]}{[T]}$$

$$= [LT^{-2}]$$

iii). Force

We know that

$$F = ma$$

$$F = [M][LT^{-2}]$$

$$= [MLT^{-2}]$$

iv). Work

We know that

$$W = FS$$

$$\text{dimension of Work} = F \times S$$

$$= [MLT^{-1}][L]$$

$$= [ML^{2}T^{-2}]$$

v). **Potential Energy:-**

We know that

$P.E = mgh$

dimension of $P.E = [M][MLT^{-2}][L]$

$= [ML^2T^{-2}]$

vi). **Kinetic Energy**

We know that

$K.E = \frac{1}{2} mv^2$

$= \frac{1}{2} [M][LT^{-1}]$

$= [M][L^2T^{-2}]$

$K \cdot Energy = [ML^2T^{-2}]$

vii). **Mommentum:-**

We know that

$P = mv$

$P = [M][LT^{-1}]$

$= [MLT^{-1}]$

viii). **Power**

We know that

$P = \frac{W}{T}$

$P = \frac{[ML^2T^{-2}]}{T}$

$P = ML^2T^{-1}$

ix). Torque:-

$$\tau = r \times F \quad \text{(We know that)}$$

$$\tau = r \times F$$

$$\tau = [L] \times [MLT^{-2}]$$

$$= [ML^2T^{-2}]$$

x). Pressure:-

We know that

$$P = \frac{F}{A}$$

$$P = \frac{[MLT^{-2}]}{L^2}$$

$$P = [ML^{-1}T^{-2}]$$

Numerical #02). Determine dimensions for:-

i). $\frac{v^2}{ax}$

$$= \frac{[LT^{-1}]^2}{[LT^{-2}][L]}$$

$$= \frac{[L^2 \cancel{T^{-2}}]}{[L \cancel{T^{-2}}][L]}$$

$$= \frac{[\cancel{L}]}{[\cancel{L}]}$$

= No dimension

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Advantages of dimension

- Dimensional analysis can be used to
  - → Check the corrections of an equation
  - → Derive the formula of an equation containning unknown physical quantity.

Principle of homogenity of dimension

Principle of homogenity of dimension states that, all terms of an equation must have same dimensions. This also means that, only the physical quantities can be added and subtracted that have same dimensions. In other words both sides of an equation must have same dimension

Q#01). Check the correctness of equation

$$2as = V_f^2 - V_i^2$$

Solution:- According to the principle of homogenerity all terms of an equation must have same same dimension

Therefore;

$$LHS = 2[LT^{-2}][L]$$

$$= 2[L^2T^{-2}]$$

$$= [L^2T^2]$$

Dimension for RHS $= [LT^{-1}] - [LT^{-1}]^2$

$= [L^2T^{-1}] = [L^2T^{-1}]$

We can say that equation① is dimensionally correct.

Question #02). Time period of a simple pendulum depends upon mass, length & gravitational. Derive formula for time period?

Solution:

According to statment of question

$T \propto m^x \rightarrow ①$

$T \propto l^y \rightarrow ②$

$T \propto g^z \rightarrow ③$

Combinning equation ①, ② and ③

$T \propto m^x l^y g^z$

$T = k\, m^x l^y g^z \rightarrow ④$

Here, "k" is a dimensionless proportionality constant

According to the princibal of homogenity of dimension, b/s of equation have same dimension.

LHS = RHS

$[T^1] = [M]^x [L]^y [LT^{-2}]^z$

$= [M^x] [L]^y [L^z T^{-2z}]$

$[M^0 L^0 T^1] = [M^x L^{y+z} T^{-2z}]$

Comparing powers

$M^0 = M^x$

$x = 0$

$0 = y+z \quad , \quad y+z=0$

$1 = -2x$ Putt all values

$x = -1/2$ $T = Km^0 l^{1/2} g^{-1/2}$ Where $= K = 2\pi$

and $= y = 1/2$ $= K\sqrt{l/g}$

Question #03) Derive the formula for wavelength (λ). The wavelength of particle depends upon planks constant, velocity & mass of particle.

Solutions:

According to the statement of question

$\lambda \propto h^x \rightarrow ①$

$\lambda \propto V^y \rightarrow ②$

$\lambda \propto m^z \rightarrow ③$

Combinning ① ② and ③

we get; $\lambda \propto h^x v^y m^z$

$\lambda = K h^x v^y m^z$

Here, K is a diamensionless propotionally constant

According to the principal of homogenerity of dimension

Dimension of LHS = Dimension of RHS

$[M^0 L^1 T^0] = [ML^2T^{-1}]^x [LT^{-1}]^y [M]^z$

$[M^0 L^1 T^0] = [M^x L^{2x} T^{-x}] [L^y T^{-y}] [M^z]$

$[M^0 L^1 T^0] = [M^{x+z} L^{2x+y} T^{-x-y}]$

Compairing both sides

We get;

$M = \quad 0 = x + z$

$x + z = 0 \rightarrow eq ①$

$L = \quad 1 = 2x + y$

$2x + y = 1$

$T = \quad 0 = -x - y$

$x + y = 0 \rightarrow eq ③$

Subtracting eq ③ from ②

$$2x+y=1$$
$$+x+y=0$$
$$x=1$$

Put in eq ③

$$1+y=0$$
$$y=-1$$

Put in equation ①

$$1+z=0$$
$$z=-1$$

Put in equation Ⓐ

$$\lambda = km^{-1}h^{-1}v^{-1}$$
$$\lambda = \frac{kh}{mv}$$

$$h=\frac{E}{f} = \frac{[ML^2T^{-2}]}{[T^{-1}]}$$
$$= [ML^2T^{-2}]$$

Exercise Questions

Question)- Which of following can be used as valid formula to calculate speed of ocean wave?

g = acceleration due to gravity
λ = wavelength
ρ = density

i)- $v=\sqrt{\lambda g}$

$[LT^{-1}]$ $\sqrt{[L][LT^{-2}]}$

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$$[LT^{-1}] = \sqrt{\frac{[L^2]^2}{[T]^2}}$$ Proved

$$[LT^{-1}] = [LT^{-1}]$$

$v = \rho g h$:-

$$[LT^{-1}] = \frac{[M]}{[L^3]}\frac{[L]}{[T^{-2}]}[L]$$

$$= [ML^{-1}T^2]$$ Not proved.

$v = gh/\lambda$

$$[LT^{-1}] = \frac{[LT^{-2}][\cancel{L}]}{[\cancel{L}]}$$

$$= [LT^{-2}]$$

$v = \lambda gh \Rightarrow [LT^{-1}] = [L][LT^{-2}][L]$

$[LT^{-1}] \neq [L^3T^{-2}]$ Not proved

Question). Dimensions :- $L^a M^b T^{-c}$

A Force :- $F = ma = [M][LT^{-2}] = [MLT^{-2}]$

$a=1$, $b=1$, $c-2$ Not equal.

B Pressure :- $P = \frac{F}{A} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$

$a=1$, $b=-1$, $c=-2$ Not equal.

© Velocity :- $V = \frac{S}{t} = \frac{[L]}{[T]} = [LT^{-1}]$

$a=1$ $b=0$ $c=-1$

d). Acceleration : $a = \frac{[L]}{[T^2]} = [LT^{-2}]$

$a=1$, $b=0$, $c=-2$

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Uncertainity

The magnitude of doubt in a measurment is called "uncertainity".

Types:-

Mainly there are three types of uncertainity.

1). Absolute uncertainity
2). Fractional / relative uncertainity
3). Percentage uncertainity

Absolute Uncertainity:- The maximum value of uncertainity in measurement is called absolute uncertainity.

→ It is represented by Δ. It has a unit.

→ The value of absolute uncertainity depends upon the least count (L.C) of instrument involved in measurment.

→ Absolute uncertainity is measured taken by scale is 0.1 cm. by vernier calliper is 0.01 cm, and by screw guage is 0.001 cm.

Fractional Uncertainity:- The ratio of absolute uncertainity (L.C) and measured value of a physical quantity is called a fractional uncertainity.

$$\text{Fractional Uncertainity} = \frac{\text{Absolute uncertainity}}{\text{Measured Value}}$$

$$= \frac{\text{least Count}}{\text{M.V}}$$

Percentage Uncertainity:- Percentage uncertainity is obtained by multiplying fractional uncertainity with 100

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Percentage uncertainity = Fraction

$$= \frac{A \cdot U}{M \cdot V} \times 100\%$$

$$= \frac{L \cdot C}{M \cdot V} \times 100\%$$

Precesion :

"The degree of closeness of measurment of a physical quantity is called precesion"

- Precesion tells us about consistency of a measurment.
- Precesion of a physical measurement related to least count of instrument involved in measurment
- It is related to absoluted uncertainity the greater is the absolute uncertainity (L·C) in measurment, the lesser is precesion in the measurment.

Accuracy :

The degree of closeness of measurment to the true value of a physical quantity is called accuracy

- Accuracy is related to fractional or percentage uncertainaty.
- Greater is the fractional or percentage

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uncertainity in measurment, the lesser is the accuracy in measurment & vice versa.

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Rules for calculating uncertainities in result

- Suppose x and y are two physical quantities with uncertainity Δx & Δy
- If x is obtained by operating the quantities x and y the uncertainity in z is given by following rules.

Addition & Subtraction:

If two physical quantities are added then the uncertainity in field final result is obtained by adding uncertainities of all indivual quantities

Suppose;

$Z = x + y$ $\quad\quad$ $Z = x + y$

Then; $\quad\quad$ $\Delta Z = \Delta x + \Delta y$

$\Delta Z = \Delta x + \Delta y$ $\quad\quad$ $\Delta Z = \Delta x + \Delta y$

Multiplication & Division

If two or more physical quantities are multiplied or divided, then uncertainity in final result is obtained by adding percentage uncertainity of indivual quantities

$x = x \times y$

% uncertainity in z = % uncertainity in x + % uncertainity in y

$\% \Delta x = \% \Delta x + \% \Delta y$

Q1). If $R_1 = (12 + 0.01)\,\Omega$ and $R_2 = (3 \pm 0.3)\,\Omega$. Find their sum & difference along with uncertainities?

Solutions:-

Given Data:-

$R_1 = (12.01)\,\Omega$

$R_2 = (3 \pm 0.3)\,\Omega$

① $Re = R_1 + R_2 = ?$

$\Delta Re = ?$

② $Re = R_1 - R_2 = ?$

$\Delta Re = ?$

A.

$Re = R_1 + R_2$

$Re = 12 + 3$

$Re = 15\,\Omega$

Now,

$\Delta Re = \Delta R_1 + \Delta R_2$

$\Delta Re = 0.1 + 0.3$

$\Delta Re = 0.4\,\Omega$

$Re \pm \Delta Re = (15.04)\,\Omega$

B.

$Re = R_1 - R_2$

$Re = 12 - 3$

$Re = 9\,\Omega$

Now,

$\Delta Re = \Delta R_1 + \Delta R_2$

$\Delta Re = 0.1 + 0.3$

$\Delta Re = 0.4\,\Omega$

$Re + \Delta Re = 9\,\Omega + 0.45\,\Omega$

$= (9 + 0.4)\,\Omega$

Question #02) If $x = (15 \pm 0.3)$ m and $x_2 = (5 + 0.5)$ m. Find their product & quotient along with uncertainties.

Given Data:

$x_1 = (15 + 0.3)m$ and $x_2 = (5 \pm 0.5)m$

① $Z = x_1 + x_2 = ?$

$\Delta Z = ?$

② $Z = \frac{x_1}{x_2} = ?$

Ⓐ

$Z = x_1 \times x_2$

$Z = 15 \times 5$

$Z = 75m^2$

Now,

% uncertainity $= \frac{\Delta x_1}{x_1} \times 100\%$

$= \frac{0.3}{15} \times 100\%$

$= 2\%$

% uncertainity in $= \frac{\Delta(2 \times 100\%)}{x_2}$

$= \frac{0.5}{5}$

$= 10\%$

% uncertainity in $= 2\% + 10\%$

$= 12\%$

$Z \pm \Delta Z = 75\ m^2 \pm 12\%$

$= 75m^2 \pm \frac{12}{100} \times 75m^2$

$= 75m^2 \pm 9m^2$

$= (75 \pm 9)m^2$

Question #03) Length of a cube is $l = (12 \pm 0.1)$ m Find its valume and area of each other

Given datas

$l = (12 \pm 0.1)m$

$A = ?$ $\Delta A = ?$

$V = ?$ $\Delta V = ?$

(A) We know that

$A = l^2$

$A = 144m^2$

% uncertainity = 2 × % uncertainity in l

$= 2 \times \frac{\Delta l}{l} \times 100\%$

$= 2 \times \frac{0.1}{12} \times 100\%$

$A + \Delta A = 144m^2 \pm 2\% = 144 \pm \frac{2}{100} \times 144$

$= 144m^2 \pm 2.86\ m^2.$

Rule for finding uncertainity in time period

Uncertainity in time period is given by relation:-

$$\Delta T = \frac{\text{Least Count}}{\text{Total no. of cycles}}$$

$$\Delta T = \frac{\text{Least count}}{n}$$

Question #02) A simple pendulum competes 10 cycles in 20s. Find uncertainities in time period if least count of device is 0.01s

Sol:-

We know that

$$\Delta T = \frac{\text{Least Count}}{n}$$

$$\Delta T = \frac{0.01s}{10}$$

$$\Delta T = 0.001s$$

Rule 05) Uncertainities in average values of many uncertainities

Question #02) Radii of circle are 1.50 cm, 1.58 cm and 1.51 cm. Find uncertainity in measurement

Given Data:-

Step: 1

Find average of all values / measurments

$$\bar{r} = \frac{r_1 + r_2 + r_3}{3}$$

$$= \frac{1.50 + 1.51 + 1.52}{3}$$

$$\bar{r} = 1.51\ cm$$

Step 2:-

Deviation: each measurment

$\Delta r_1 = \bar{r} - r_1 = 1.51 - 1.50 = 0.01\ cm$

$\Delta r_2 = \bar{r} - r_2 = 1.51 - 1.52 = \pm 0.01\ cm$

$\Delta r_3 = r - r_3 = 1.51 - 1.51 = 0\ cm$

Step 3:-

Mean / Deviation / uncertainity $= \frac{\Delta r_1 + \Delta r_2 + \Delta r_3}{3}$

$$= \frac{0.01 + 0.01 + 0}{3}$$

$\boxed{= 0.0067\ cm}$ ← Answer.

Question):- A student is measuring the time of an event by using stopwatch. He takes 5 measurement as: 3.0s, 3.2s, 3.4s, 2.8s, 3.1s What is uncertainity in results?

Datas:-

$t_1 = 3.0s$

$t_2 = 3.2s$

$t_3 = 3.4s$

$t_4 = 2.8s$

$t_5 = 3.1s$

Sol:-

$$\text{Average time} = \frac{3.0s + 3.2 + 3.4 + 2.8 + 3.1}{5}$$

average t = 3.1 seconds.

- Find deviation:-

$\Delta t = t - t_1 = 3.1 - 3.0$

$\Delta t = 0.1s$

$\Delta t = t - t_2 = 3.1 - 3.2$

$\Delta t = -0.1s$

$\Delta t = t - t_3 = 3.1 - 3.4$

$\Delta t = -0.3s$

$\Delta t = t - t_4 = 3.1 - 2.8$

$= 0.3s$

$\Delta t = t - t_5 = 3.1 - 3.1s$

$= 0s.$

Average time

$$\Delta t = \frac{0.1 + (+0.1) + (+0.3) + 0.3 + 0}{5}$$

$\Delta t = 0.8/5$