# REVISION SHEETS

# MEASUREMENT

## PHYSICAL QUANTITIES

"The quantities that can be measured and laws of physics are expressed in terms of these quantities are known as physical quantities."

→ Physical Quantities are divided into:

### BASE QUANTITIES

**DEFINITION**

'Those quantities which cannot be expressed in terms of other quantities are called base quantities'

**NUMBER**

They are **seven** in number.

**EXAMPLES**

- length
- Mass
- current
- Temperature
- Intensity of light
- Amount of substance

### DERIVED QUANTITIES

**DEFINITION**

'Those quantities which are expressed in terms of base quantities'

**NUMBER**

Derived quantities are **infinite**

**EXAMPLES**

- Area
- Volume
- Force
- Power
- velocity
- Speed.

# SYSTEM OF UNITS

MKS ⇒ meter - kilogram - second
CGS ⇒ centimeter - gram - second
FPS ⇒ feet - pound - second

# SI UNITS

"The international system of units is a scientific method of expressing the magnitudes or quantities of important natural phenomena"

| BASE UNITS | DERIVED UNITS | SUPPLEMENTRY UNITS |
| --- | --- | --- |
| **DEFINITION** | **DEFINITION** | **DEFINITION** |
| The units containing base quantities are called base units | The units which contain derived quantities are called derived units. | The units which neither contain base units nor derived units. They contain geometrical units or angles |
| **EXAMPLES** | **EXAMPLES** | **EXAMPLES** |
| meter m | Area $m^2$ | Radian rad |
| kilogram kg | Volume $m^3$ | Steradian sr |
| second s | acceleration $ms^{-2}$ | |
| kelvin K | Speed $ms^{-1}$ | |
| mole mol | pressure $kgm^{-1}s^{-2}$ | |
| ampere A | | |
| candela cd | | |

# RADIAN

## STATEMENT

"one radian is the angle subtended at the center of a circle by an arc with a length equal to the radius of the circle"

## MATHEMATICAL EXPLANATION

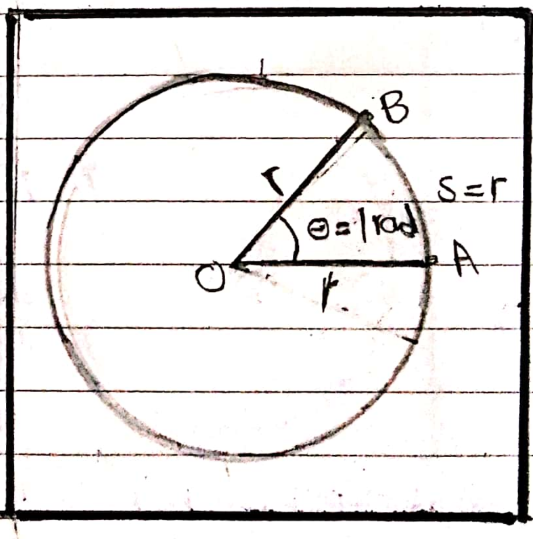
$$\text{No. of radians} = \frac{\text{arc length}}{\text{Radius}} = \frac{S}{r}$$

**one revolution = 360°**

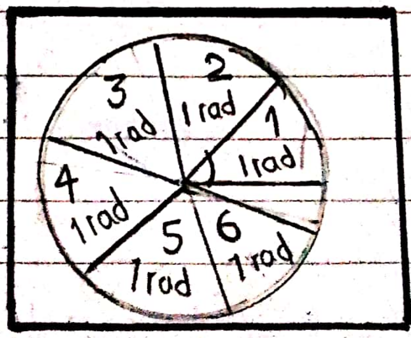
$$\text{No. of radian in one revolution} = \frac{2\pi r}{r}$$
$$= 2\pi$$
$$= 2(3.14)$$

$$\boxed{\text{No. of radian in one revolution} = 6.28 \text{ rad}}$$

$$2\pi \text{ rad} = 360^\circ$$
$$1 \text{ rad} = \frac{360}{2\pi}$$
$$1 \text{ rad} = \frac{360}{2(3.14)}$$
$$\boxed{1 \text{ rad} = 57.3^\circ}$$




$$1^\circ = \frac{1 \text{ rad}}{57.3}$$
$$\boxed{1^\circ = 0.017 \text{ rad}}$$




* Radian is plane angle
* It is 2 dimensional (2D)

# STERADIAN

## STATEMENT

"steradian is the solid angle subtended at the center of sphere by an area of its surface equal to the radius of that sphere."

## MATHEMATICAL EXPLANATION

$$\text{No. of steradian in sphere} = \frac{\text{Area of sphere}}{\text{square of radius}}$$

$$= \frac{4\pi r^2}{r^2}$$

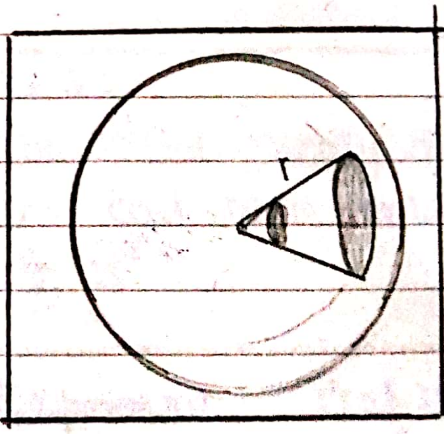
$$= 4\pi$$

$$= 4(3.14)$$

$$\boxed{\text{No. of steradian in sphere} = 12.56\ sr}$$

* Steradian is a solid angle

* It is three dimensional (3D)



# Scientific Notation

" Writing a number in a powers of ten or in a standard form is called scientific notation "

## Examples

1) 4500000 ⇒ $4.5 \times 10^6$
2) 0.00453 ⇒ $4.53 \times 10^{-3}$

# Prefixes

" A mechanism through which a term in scientific notation is expressed by giving a proper name to its power of ten is called prefix. "

## Examples

$5 \times 10^{-3}$ m ⇒ 5 mm
$6 \times 10^9$ ⇒ 6 G

**WAY TO REMBER PREFIXES:**
' Young Zoey Earns Pennies That's Got Mighty King Henry's Daughter Beth. Beth Drinks Cold Milk until Nine Pm for A Zillion Years'

| Exponent | Prefix | Exponent | Prefix |
|---|---|---|---|
| 24 $10^{24}$ | Yotta | 0 $10^0$ | Base |
| 21 $10^{21}$ | Zetta | -1 $10^{-1}$ | deci |
| 18 $10^{18}$ | Exa | -2 $10^{-2}$ | centi |
| 15 $10^{15}$ | Peta | -3 $10^{-3}$ | milli |
| 12 $10^{12}$ | Tera | -6 $10^{-6}$ | micro |
| 9 $10^9$ | Giga | -9 $10^{-9}$ | nano |
| 6 $10^6$ | mega | -12 $10^{-12}$ | pico |
| 3 $10^3$ | Kilo | -15 $10^{-15}$ | femto |
| 2 $10^2$ | hecto | -18 $10^{-18}$ | atto |
| 1 $10^1$ | deca | -21 $10^{-21}$ | zepto |
| 0 $10^0$ | Base | -24 $10^{-24}$ | Yocto |

# Non- SI UNITS

| | |
|---|---|
| Light Year | The distance that light travels in a vaccum in one year is called Light year. <br> 1 light year = $9.4607 \times 10^{15}$ m |
| Angstrom | type of prefix that measure small length. <br> $1 A^\circ = 1 \times 10^{-10}$ m OR 0.1 nm |
| Micron | obsolate name of μm which is decimal fraction of the meter <br> 1 Micron = $1 \times 10^{-6}$ m |

## WRITING UNIT SYMBOLS

1. Unit symbols are printed in roman type e.g
   - m ⇒ meter
   - s ⇒ second
   - Pa ⇒ pascal

2. A prefix is never used in isolalation and in a compound form e.g
   - ☑ nm ☑ pm
   - ☒ mμm ☒ μμm

3. Multiplication must be indicated by space or dot
   e.g Nm OR N·m
   - Division is indicated by horizontal line, by '/' or by -ive exponents.
     e.g m/s OR $ms^{-1}$

4. Abbreviations for unit symbols or unit names are not allowed. e.g,
   - sec for second OR s
   - sq.mm for $mm^2$ OR square millimeter
   - cc for $cm^3$ OR cubic centimeter
   - mps for $ms^{-1}$ OR meter per second

5. When multiple of unit is raised to the power, it applies to the whole ~~multiple~~ multiple not just the unit e.g
   $cm^3$ → for whole cm not just m.

## WRITING UNIT NAMES

1. Names of the units starts with a lower case letter e.g joule, hertz, meter

2. The symbol of units named after a scientist has initial captial e.g 'A' for ampere.

3. Unit can be written in symbols or spelled out in full e.g 2.1 $ms^{-1}$ OR 2.1 meter per second.

4. For writing prefix, there should not be space or hyphen b/w prefix name and unit name. e.g
   ☑ milligram
   ☒ milli-gram

# ERRORS

"Error is the doubt that exist about the result of any instrument. For every measurement there is always a margin of doubt which is called error"

## TYPES OF ERRORS

### SYSTEMATIC ERRORS

⇒ Those errors that tend to be in one direction (+ive or -ive)

#### INSTRUMENTA ERRORS

**CAUSE**

- Due to wrong calibration
- Due to L.C of instrument.

**REDUCTION**

1. By changing the instrument
2. By applying correction factor

$C.F = \text{measured value} \pm Z.E$

#### PERSONAL ERRORS

**CAUSE**

- Inexperience of a person
- Due to carelessness
- wrong way of taking reading

**REDUCTION**

1. Doing work with care
2. advanced, experienced person

### RANDOM ERRORS

⇒ Those errors which occur irregularly and random with respect to size and sign

**CAUSE**

unknown

**REDUCTION**

By taking several readings and then having their mean

# LEAST COUNT

"The smallest value that can be measured by measuring instrument"

# EXAMPLE

Least Count of meter rule = 0.1 cm
Least count of vernier calliper = 0.01 cm
Least count of screw guage = 0.001 cm

# LEAST COUNT ERROR

" Error associated with least count is called least count error "

# METHODS TO REDUCE LEAST COUNT ERROR

1. By using instrument with smaller least count (higher resolution)

2. By improving experimental techniques.

⇒ Least Count Error belongs to random errors.

# UNCERTANITIES

| | |
|---|---|
| **DEFINITION** | The amount of possible error associated with a measuring instrument is called uncertainty. |
| **PURPOSE** | Uncertainty estimate how small or large the error is. <br> Physical Quantity = Observed value ± Least Count |
| **CAUSES** | 1. Imperfection of person's senses <br> 2. Limitation of measuring instrument <br> 3. Natural variation in objects |

## TYPES OF UNCERTANITY

| | ABSOLUTE UNCERTANITY (LEAST COUNT) | RELATIVE/ FRACTIONAL UNCERTANITY | PERCENTAGE UNCERTANITY |
|---|---|---|---|
| **SYMBOL** | It is represented by $\Delta$ | It is represented by $\varepsilon$ | % is written with the value |
| **UNIT** | has same unit as the quantity | has no unit | '%' is written with the answer |
| **FORMULA** | It is the L.C <br> e.g (0.1 ± 2.1) <br> ⇒ 2.1 is absolute uncertanity <br> To convert % uncertanity to Absolute <br> $=$ %age Un $\times$ measurement | Relative uncertanity: <br> $= \frac{\text{Absolute uncertanity}}{\text{Measurement}}$ | %age uncertanity <br> $= \frac{\text{absolute uncertanity}}{\text{measurement}} \times 100$ |

# INDICATING UNCERTANITIES IN CALCULATION

⇒ For Sum and difference, "Absolute uncertanities are added"

## EXAMPLE

### SUM

Let

$l_1 \pm \Delta l_1 = (6.4 \pm 0.1)\,m$

$l_2 \pm \Delta l_2 = (5.3 \pm 0.01)\,m$

Sum $= l_1 + l_2$

$= 6.4 + 5.3$

$= 11.7\ m$

Uncertanity $= \Delta l_1 + \Delta l_2$

$= 0.1 + 0.01$

$= 0.11\ m$

$l \pm \Delta l = (11.7 \pm 0.11)\,m$

### DIFFERENCE

Let $d_1 \pm \Delta d_2 = (7.4 \pm 0.2)\,m$

$d_2 \pm \Delta d_2 = (11.1 \pm 0.2)\,m$

difference $= d_1 + d_2$

$= 7.4 + 11.1$

$= 18.5\ m$

Uncertanity $= \Delta d_1 + \Delta d_2$

$= 0.2 + 0.2$

$= 0.4\ m$

$d_{\phi} \pm \Delta d_{\phi} = (18.5 \pm 0.4)\,m$

⇒ For product and quotient, "Absolute uncertanities are converted into %age uncertamities then they are added"

## EXAMPLE

### PRODUCT

Let $l \pm \Delta l = (1.50 \pm 0.02)m$
$w \pm \Delta w = (0.20 \pm 0.01)m$

1) Multiply the product
$A = l \times w$
$= 1.50 \times 0.20$
$= 0.3$

2) Convert absolute uncertanity to %age uncertamity

- $\frac{\Delta l}{l} \times 100$

$= \frac{0.02}{1.50} \times 100 \Rightarrow 1.33\%$

- $= \frac{0.01}{0.20} \times 100 \Rightarrow 5\%$

3) Add %age uncertamity
$= 1.33\% + 5\%$
$= 6.33\%$

4) Convert to absolute uncertamity
$= \frac{6.33}{100} \times 0.3$
$= 0.02$

$A \pm \Delta A = (0.3 \pm 0.02)m^2$

### QUOTIENT

Let $V \pm \Delta V = (5.2 \pm 0.1)V$
$I \pm \Delta I = (0.84 \pm 0.5)A$

1) Divide the measurement
$R = \frac{5.2}{0.84}$
$= 6.2\,\Omega$

2) Convert absolute uncertanity to %age uncertamity

- $\frac{0.1}{5.2} \times 100$

$= 1.92\%$

- $\frac{0.5}{0.84} \times 100 \Rightarrow 59.5$

3) Add %age uncertamity
$= 59.5 + 1.92$
$= 61.42\%$

4) Convert back to absolute uncertanity
$= \frac{61.42}{100} \times 6.2$
$= 3.8$

$R \pm \Delta R = (6.2 \pm 3.8)\,\Omega$

⇒ For Power, "%age uncertainty is multiplied with the power"

## EXAMPLE

### POWER

Let radius:

$r \pm \Delta r = (2.25 \pm 0.01)\,cm$.

For example, we have to find 'area of sphere'

1) Find the volume using formula of area of sphere

$$V = \frac{4}{3} \pi r^3$$

$$= \frac{4}{3}(3.14)(2.25)^3$$

$$= 47.6 \; cm^3$$

2) Convert absolute uncertainty to %age uncertainty

$$\frac{0.01}{2.25} \times 100 \Rightarrow 0.44\%$$

3) Multiply the power in the 'formula' with %age uncertainty

$$3(0.44) \Rightarrow 1.33\%$$

4) Convert back to absolute uncertainty

$$\frac{1.33}{100} \times 47.6 \Rightarrow 0.6$$

$$(47.6 \pm 0.6)\; cm^3$$

# SIGNIFICANT FIGURES

**Def:** In any measurement the accurately known digits and the first doubtful digit are called Significant Figures.

## RULES

1. **NON-ZERO DIGITS** Non zero digits are significant. **e.g** 47.872 [5 S.F]
2. **ZERO b/w two S. digits** zero b/w 2 S. digits is always significant **e.g** 301.5006 [7 S.F]
3. **ZEROS TO THE LEFT OF S. digits** Zeros to the left of S. F are **not** significant **e.g** 0.000 538 [3 S.F]
4. **ZEROS TO THE RIGHT OF S.F** Zeros to the right of S.F **may** or **may not** be significant **e.g** 5.200 [4 S.F]
5. **SCIENTIFIC NOTATION** In scientific notation OR standard form, figures other than power of ten are significant **e.g** $2.1000 \times 10^4$ [5 S.F]

## SIGNIFICANT FIGURES IN CALCULATION

| Addition And Subtraction | Multiplication And Division |
|---|---|
| ⇒ least decimal place | ⇒ least Significant figure |

### EXAMPLES

| | |
|---|---|
| • 246.24 + 238.278 + 98.3 = 582.818 ⇒ 582.8 | • 0.9935 × 10.48 × 13.4 = 139.519192 ⇒ 140 |
| • 0.35 − 0.1 0.25 ⇒ 0.2 | • 5.5 ÷ 1.1 = 5 ⇒ 5.0 |

# PRECISION

- It refers to the degree of exactness
- describe the closeness of set of measurement of same quantity made in same way
- Depends upon the Least count
- Multiple Readings are required

$$\text{Precision} \propto \frac{1}{\text{Least Count}}$$

### Examples

| Measurement | Precision |
|---|---|
| 2642 m | 1 m |
| 2050 m | 10 m |
| 203.05 km | 0.01 km |
| 100.050 km | 0.001 km |

# ACCURACY

- describe the closeness of measured value to the actual value.
- does not depend on the Least count
- A single reading can be accurate

$$\text{Accuracy} \propto \text{Significan Figures}$$

### Examples

| Measurement | Accuracy |
|---|---|
| 2642 | 4 |
| 2050 | 3 |
| 203.05 | 5 |
| 100.050 | 6 |

# DIMENSIONS

## DEFINITION

Dimensions describe the physical nature of quantity. Each measurable quantity is represented by specific symbol and written within square bracket is called dimension.

## SIGNIFICANCE

1. Deriving a formula
2. Check the correctness of equation

## DRAWBACK

1. Dimension-less constants can't be obtained
2. Can't tell exact relationship b/w quantities in equation
3. does not distinguish b/w quantities having same dimensions.

### TERMS USED WITH DIMENSIONS

| Dimensional Variables | Dimensional Constants | Dimension-less Variables | Dimension-less constants |
|---|---|---|---|
| **DEFINITION** | | | |
| The physical quantities which have dimensions of variable magnitude | The physical quantities which have dimensions but are constant in magnitude | The physical quantities which have no dimensions but changing magnitude | The physical quantities which have no dimensions but having constant magnitude. |
| **EXAMPLES** | | | |
| • Force<br>• Energy<br>• Torque<br>• acceleration | • Speed of light<br>• plank's constant<br>• Gravitational constant | • Radian<br>• Steradian<br>• Strain | • pure numbers<br>• $\pi$ |

| | | | |
|---|---|---|---|
| mass ⇒ | m ⇒ | kg ⇒ | [M] |
| length ⇒ | l ⇒ | m ⇒ | [L] |
| time ⇒ | t ⇒ | S ⇒ | [T] |

## VELOCITY

$v = \frac{d}{t}$

$v = \frac{m}{S}$

$v = \frac{[L]}{[T]}$

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

## FORCE

$F = ma$

$F = kg\,ms^{-2}$

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

## MOMENTUM

$P = mv$

$P = kg\,ms^{-1}$

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

## ACCELERATION

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

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

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

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

## DENSITY

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

$\rho = \frac{kg}{l \times b \times h}$

$\rho = \frac{kg}{m^3}$

$\rho = [ML^{-3}]$

## PRESSURE

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

$P = \frac{kg\,ms^{-2}}{m^2}$

$P = kg\,ms^{-2}\,m^{-2}$

$P = kg\,m^{-1}\,s^{-2}$

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

## TORQUE

$\tau = F \times r$

$= kg\,ms^{-2} \times m$

$= kg\,m^2 s^{-2}$

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

## WORK

$W = F \times d$

$= kg\,ms^{-2} \times m$

$= kg\,m^2 s^{-2}$

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

## DISTANCE

$S = vt$

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

$= m$

$= [L]$

## $S = v_i t + \frac{1}{2} a t^2$

$m = ms^{-1} \cdot s + \frac{1}{2} \cdot ms^{-2} \cdot s^2$

$[L] = m + m$

$[L] = 2\,m$

$[L] = [L]$

## $v_f = v_i + at$

$ms^{-1} = ms^{-1} + ms^{-2} \cdot s$

$[LT^{-1}] = [LT^{-1}] + [LT^{-2}T]$

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

$[LT^{-1}] = 2[LT^{-1}]$

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

## $2aS = v_f^2 - v_i^2$

$2\,ms^{-2} \cdot m = (ms^{-1})^2 - (ms^{-1})^2$

$m^2 s^{-2} = m^2 s^{-2} - m^2 s^{-2}$

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

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

$E = mc^2$
$= kg(ms^{-1})^2$
$= kg\,m^2 s^{-2}$
$= [ML^2T^{-2}]$

**K.E**
$= \frac{1}{2} mv^2$
$= kg(ms^{-1})^2$
$= kg\,m^2s^{-2}$
$= [ML^2T^{-2}]$

**P.E**
$= mgh$
$= kg \cdot ms^{-2} \cdot m$
$= kg\,m^2s^{-2}$
$= [ML^2T^{-2}]$

# Important Points

→ All types of energy has same dimension $[ML^2T^{-2}]$

→ All the velocity will have same dimension $v_i$, $v_f$, $v_{average}$, $v_r$

→ Torque and work have same dimension but unit of $\vec{\tau}$ is Nm and it is a vector quantity while unit of W is Joule and it is a scalar quantity.