MEASUREMENT

- Physics is the study of nature and natural phenomena.
- Physics is considered as the base of all science subjects.
- Measurement is the base of all scientific studies and experimentations.
- Measurement is the process of finding an unknown physical quantity by using a standard quantity.
- Three things for a perfect measurement.
- They are (i) an instrument, (ii) a standard quantity and (iii) an acceptable unit.
- Different systems of units for measurement.
- 1. FPS - System (Foot for length, Pound for mass and Second for time)
- 2. CGS -System (Centimetre for length, Gram for mass and Second for time)
- 3. MKS - System (Metre for length, Kilogram for mass and Second for time)
- The 'CGS', 'MKS' and SI units are metric systems of units and 'FPS' is not an metric system.
- It is a British system of units.

International System of Units

- In 1960, in the 11th General Conference on Weights and Measures at Paris in France, the scientists recognized the need of using standard units for physical quantities.
- That was called as "International System of Units" and is popularly known as SI System (abbreviated from the French name 'Systeme International').
- The scientists chose seven physical quantities as 'Base Quantities' and defined a 'Standard Unit' to measure each one.

- They are known as Base Units or Fundamental Units

SI Base Units

Quantity	Unit	Symbol
Length	Metre	M
Mass	Kilogram	kg
Time	Second	S
Temperature	Kelvin	K
Electric Current	Ampere	A
Amount of Substance	Mole	Mol
Luminous Intensity	Candela	Cd

- In December 1998, the National Aeronautics and Space Administration (NASA), USA launched the Mars Climate Orbiter to collect the data of the Martian climate.
- Nine months later, on September 23, 1999, the Orbiter disappeared while approaching Mars at an unexpectedly low altitude.
- An investigation revealed that the orbital calculations were incorrect due to an error in the transfer of information between the spacecraft's team in Colorado and the mission navigation team in California.
- One team was using the English FPS system of units for calculation, while the other group was using the MKS system of units.
- This misunderstanding caused a loss of approximately 125 million dollars.

Temperature

- Temperature is a physical quantity that expresses the degree of hotness or coldness of a substance.
- Temperature is a measure of the average kinetic energy of the particles in a system.
- The SI unit of Temperature is kelvin.
- 'Thermometers' are used to measure temperature directly.
- Celsius, Fahrenheit, Kelvin are the most commonly used scales to measure Temperature.

- Melting point of pure ice (0°C) is taken as Lower Fixed Point (LFP) and Boiling point of water (100°C) is taken as Upper Fixed Point (UFP).

Various Scales to measure Temperature

Types of Scale	Lower Fixed Point (LFP)	Upper Fixed Point (UFP)	No. of divisions in thermometer
Celsius	0° C	100° C	100
Fahrenheit	32° F	212° F	180
Kelvin	273 K	373 K	100

Conversion of Scales of Temperatures

- The general formula for the conversion of scales of temperature is:

$$\frac{C-0}{100} = \frac{F-32}{180} = \frac{K-273}{100}$$

Application of various thermometric scales

- 1. Physicians use 'clinical thermometers'.
- It is graduated in 'Fahrenheit Scale'
- 2. Scientists are using thermometers with kelvin scale.
- 3. Common temperature measurements are made in celsius scale.
- (Example: Weather reports are given in celsius scale.)
- "Normal temperature of the human body is between 98.4° F and 98.6° F".
- Infra red thermometer, measures the temperature of an object without any physical contact.

Electric Current (I)

- Flow of electric charges, in a particular direction is known as 'electric current'.
- The magnitude of an electric current is the amount of electric charges fl owing through a conductor in one second.

$$\text{Total capitalised value of the business} = \frac{\text{Average profit}}{\text{Normal rate of return}} \times 100$$

$$I = \frac{Q}{t}$$

- SI unit of Electric Current is 'ampere' and it is denoted as A.
- Unit of charge is coulomb.
- One ampereis defined as one 'coulomb' of charge moving in a conductor in one second.
- Ammeter is a device used to measure 'electric current'.
- At very low temperature, around 30 K (-243.2° C), some conductors conduct electric current without any loss.
- These conductors are known as 'SUPER CONDUCTORS'.
- The super conductors are used to levitate trains from the track.
- Super conductors can be used as memory or storage element in the computers.

Amount of substance

- It is very difficult to count the number of atoms because the atoms are not visible.
- There is an indirect method to count the number of atoms or molecules in a substance in multiples of mole.
- Amount of substance is a measure of the number of entities (particles) present in a substance.
- The entity may be an atom, molecule, ion, electron or proton etc.
- The amount of substance is directly proportional to the number of atoms or molecules.
- The SI unit of amount of substance is mole and it is denoted as 'mol'.
- Mole is defined as the amount of substance, which contains 6.023×10^{23} entities.
- The number 6.023×10^{23} is also known as Avogadro Number.

Luminous Intensity

- The measure of the power of the emitted light, by a light source in a particular direction, per unit solid angle is called as Luminous Intensity.
- The SI unit of luminous intensity is candela and is denoted as 'cd'.
- The light emitted from a common wax candle is approximately equal to one candela Luminous intensity is measured by a 'photometer'

- Which gives the luminous intensity in terms of candela directly.
- Luminous Flux or luminous power is the measure of the perceived power of light.
- Its SI unit is 'lumen'.
- One lumen is defined as the luminous flux of the light produced by the light source that emits one candela of luminous intensity over a solid angle of one steradian.

Plane angle

- It is the angle between the intersection of two straight lines or intersection of two planes.
- The SI unit of Plane Angle is 'radian' and is denoted as 'rad'.
- Radian is the angle subtended at the centre of a circle by an arc whose length is equal to the radius of the circle.

π radian = 180°

1 radian = $\frac{180^\circ}{\pi}$

Solid Angle

- It is the angle formed by three or more planes intersecting at a common point.
- It can also be defined as 'angle formed at the vertex of the cone'
- The SI unit of solid angle is 'steradian' and is denoted as 'sr'.
- Steradian is the solid angle at the centre of a sphere subtended by a portion whose surface area is equal to the square of its radius of the sphere.
- Until 1995, Plane Angle and Solid Angle were classified under supplementary quantities.
- In 1995, they were shifted to derived quantities.

Difference between Plane Angle and Solid Angle

Plane Angle	Solid Angle
Angle between the intersection of two lines or planes	Angle between the intersection of three or more planes at a common point
It is two dimensional	It is three dimensional

Unit is radian	Unit is steradian

Clocks

- Clocks are used to measure time intervals.

Types of clocks based on display:

1. Analog clocks

- It looks like a classic clock.
- It has three hands to show the time.
- Hours Hand: It is short and thick. It shows 'hour'.
- Minutes Hand: It is long and thin.
- It shows 'minute'.
- Seconds Hand: It is long and very thin.
- It shows 'second'.
- It makes one rotation in one minute and 60 rotations in one hour.
- Analog clocks can be driven either mechanically or electronically.

2. Digital clocks

- A digital clock displays the time directly.
- It shows the time in numerals or other symbols.
- It may have a 12 hours or 24 hours display.
- Digital clocks are often called as Electronic Clocks.

Types of clocks based on working mechanism

1. Quartz Clock:

- These clocks are activated by 'electronic oscillations', which are controlled by a 'quartz crystal'.
- The frequency of a vibrating crystal is very precise.
- So, the quartz clock is more accurate than the mechanical clock.
- These clocks have an accuracy of one second in every 10^9 seconds.
- The principle of a quartz clock is the Piezo - electric property of a crystal.
- Piezo-electric property means that when a pressure is applied along a particular axis of a crystal, an electric potential difference is developed in a perpendicular axis.
- In the reverse piezo-electric effect, a crystal becomes mechanically stressed when a voltage is applied across its opposite faces.

2. Atomic Clock:

- These clocks are making use of periodic vibrations occurring within the atom.
- These clocks have an accuracy of one second in every 10^{13} seconds.
- Atomic clocks are used in Global Positioning System (GPS), Global Navigation Satellite System (GLONASS) and International time distribution services.
- The first atomic clock was developed in 1949 at the US National Bureau of Standards.
- But, it was less accurate than the quartz clock.
- The first accurate atomic clock (based on Caesium - 133) was built by Lauis Essan and Jack Penny in 1955, at the National Physics Laboratory in the United Kingdom.
- Greenwich Mean Time (GMT) is the mean solar time at the Royal Observatory, located at Greenwich in London.
- It is measured at the longitude of zero degree.
- The Earth is divided into 24 zones, each of a width of 15 degree longitude.
- These regions are called as 'Time Zones'.
- Time difference between two adjacent time zones is 1 hour.

Indian Standard Time (IST):

- The location of Mirzapur in Uttar Pradesh is taken as the reference longitude of the Indian Standard Time.
- It is located at 82.5 degree longitude.
- IST = GMT + 5:30 hours

Accuracy in Measurements

- Measurement is the base of all experiments in science and technology.
- The value of every measurement contains some uncertainty.
- These uncertainties are called as 'Errors'.
- The difference between the real value and the observed value is called an error.

Accuracy

- Accuracy is the closeness of a measured value to the actual value or true value.

Precision

- Precision is the closeness of two or more measurements to each other.

Approximation

- Approximation is the process of finding a number, which is acceptably close to the exact value of the measurement of a physical quantity.
- It is an estimation of a number obtained by rounding off a number to its nearest place value.
- Calculators are widely used in day to day life to do the calculations.
- The result given by a calculator has too many digits.
- Hence, the result containing more digits should be rounded off.

Rules for rounding off

- Decide which is the last digit to keep.
- Leave it the same, if the next digit is less than 5.
- Increase it by one, if the next digit is 5 or greater than 5.
- Convert 80° C into kelvin.

Solution:

K = C + 273
K = 80 + 273
K = 353 kelvin

- Convert 300 K into celsius.

Solution:

C = K - 273
C = 300 - 273
C = 27 celsius.

- When 2 coulomb of charge, flows through a circuit for 10 seconds, calculate the current?

Solution:

Given: Charge Q = 2 C; time t = 10 s

$I=\frac{Q}{t}$ or $I=\frac{2}{10}$

I = 0.2 A

- Convert 60° into radian.

$1^0 = \frac{\pi}{180}$

$60^0 = \frac{\pi}{180} * 60$

$= \frac{\pi}{3}$ radian

Convert $\frac{\pi}{4}$ into degrees.

π radian = 180°

$\frac{\pi}{4}$ radian $\frac{180}{4}$ =45°

- Round off the number 1.864 to two decimal places

Step:1 Identify the last digit to be kept.

6 is the last digit to be kept.

Step:2 The following digit, i.e. 4 is less

than 5. So, retain it as 6.

The answer is 1.86

- Round off the number 1.868 to two decimal places

Step:1 Identify the last digit to be kept.

6 is the last digit to be kept.

Step:2. The following digit, i.e. 8 is

greater than 5. So, increase 6 by one.

The answer is 1.87