BIHAR
EXAMS WALLAH

Bihar General Science

- Bihar Police Constable & SI
- BPSC Bihar Teacher
- BSSC CGL
- BSSC Inter Level
- High Court ASO/Clerk

and Other Competitive Exam

- Comprehensive Concept Coverage
- Based on Latest exam patterns
- Bullet points and tabular explanation
- Topic-wise MCQs

Bihar JEET

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1 Physical World & Measurement

The physical world encompasses all natural phenomena and their laws, forming a fundamental aspect of physics. This discipline is derived from the Greek word for nature and is essential for understanding the universe's workings.

DEFINITION AND SCOPE OF PHYSICS

Physics is defined as the study of the basic laws of nature and their manifestations, covering a wide range of topics including:

- **Mechanics:** The study of motion and forces.
- **Electromagnetism:** The study of electric and magnetic fields.
- **Thermodynamics:** The study of heat, energy, and work.
- **Optics:** The study of light and its interactions with matter.
- **Quantum Mechanics:** The study of phenomena at atomic and subatomic levels.

The scope of physics is broad, addressing macroscopic (observable) and microscopic (atomic and subatomic) phenomena. Recently, a mesoscopic domain has emerged, focusing on systems with tens or hundreds of atoms.

Fundamental Forces

Four fundamental forces in nature govern physical interactions:

1. **Gravitational Force:** Attracts objects towards one another, primarily significant at macroscopic scales.
2. **Electromagnetic Force:** Acts between charged particles, responsible for electricity and magnetism.
3. **Strong Nuclear Force:** Holds protons and neutrons together in atomic nuclei.
4. **Weak Nuclear Force:** Responsible for certain types of radioactive decay.

These forces are crucial for understanding macroscopic structures like planets and microscopic structures like atoms.

Conservation Laws

Conservation laws are fundamental principles in physics stating that certain quantities remain constant in isolated systems.

Key conservation laws include:

- **Conservation of Mass**
- **Conservation of Energy**
- **Conservation of Momentum**
- **Conservation of Charge**

These laws are deeply connected to the symmetries observed in nature, influencing modern theories in physics.

Physics and Its Interdisciplinary Connections

Physics plays a vital role in various scientific fields:

- **Chemistry:** Understanding atomic interactions and chemical bonding relies heavily on physical principles.
- **Biology:** Physics contributes to biophysics, which explores biological processes through physical concepts.
- **Astronomy:** Advances in optics have revolutionised our understanding of the universe.

Technological advancements often stem from physical discoveries, demonstrating the interdependence between physics, technology, and society.

Physical Quantities

Physical quantities are properties of materials or systems that can be quantified through measurement. They are essential for describing and understanding the physical world, allowing scientists and engineers to communicate measurements and calculations effectively.

Definition and Components

A physical quantity consists of two primary components:

1. **Numerical Value:** This represents the magnitude of the quantity.

2. **Unit of Measurement:** This provides a standard for comparison, such as meters for length or kilograms for mass.

   For example, a mass of 5 kilograms can be expressed as

   m=nkg, where

   n is the numerical value (5) and "kg" is the unit symbol for kilograms.

Classification of Physical Quantities

Physical quantities can be classified into two main categories:

Basic (Fundamental) Quantities: These are defined independently and include:

- Length
- Mass
- Time
- Electric current
- Temperature
- Amount of substance (moles)

Derived Quantities: These are defined in terms of basic quantities. Examples include:

- Speed (length/time)
- Force (mass × acceleration)
- Energy (force × distance)

Derived quantities can be expressed as algebraic combinations of the basic quantities.

Supplementary quantities:

Some quantities have units but no dimensions. These are neither fundamental nor derived. These are called supplementary quantities. Only two quantities are there Plane angle and Solid angles. But recently these quantities are considered as a part of Fundamental Physical quantities.

Types of Supplementary Quantities

1. **Plane Angle:** Measured in radians (rad), it describes the angle formed by two rays originating from a common point.
2. **Solid Angle:** Measured in steradians (sr), it represents the three-dimensional angle that an object subtends at a point.

Units of Measurement

The International System of Units (SI) is commonly used in scientific contexts due to its international acceptance and ease of use. Each physical quantity has a standard unit in the SI system, such as:

- **Length:** meter (m)
- **Mass:** kilogram (kg)
- **Time:** second (s)
- **Electric current:** ampere (A)

Other unit systems may also be used, but SI units are preferred for consistency in scientific communication.

Vectors and Scalars

Physical quantities can also be categorised based on their directional properties:

- **Scalars:** Quantities that have magnitude only, such as mass and temperature.
- **Vectors:** Quantities that have both magnitude and direction, such as velocity and force.

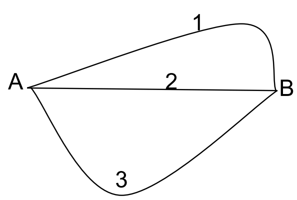
Let's define it further

Distance

The total length of a path covered by an object moving from one point to another. Distance is a scalar quantity because it only has magnitude, and doesn't have direction.

Displacement

The shortest path between an object's initial and final positions, and the direction of that path. Displacement is a vector quantity because it has both magnitude and direction.



Here 1,2 and 3 are all distances that are covered from A to B or B to A

But If we assume A is the initial point and B is the final then among the 3 paths only 2 is the shortest path from A to B(Direction) it will be displacement

Units

Unit: A unit is a specific measure used to represent a physical quantity. For example, the physical quantity 'length' can be measured in units like meters, centimeters, inches, etc. Similarly, 'time' can be measured in seconds, minutes, hours, and so on. Units provide a standard for expressing and comparing these quantities.

System of Units

1. **SI System (International System of Units):** This is the modern form of the metric system and is the most widely used system of measurement. It includes seven base units: kilogram (kg) for mass, meter (m) for length, second (s)

for time, ampere (A) for electric current, kelvin (K) for temperature, mole (mol) for amount of substance, and candela (cd) for luminous intensity.

2. **MKS System(Meter-Kilogram-Second System):** The MKS system, or meter-kilogram-second system, is a system of measurement that uses the meter, kilogram, and second as base units:Length: Measured in meters, Mass: Measured in kilograms, Time: Measured in seconds.MKS system is the basis for the SI system

3. **CGS System (Centimeter-Gram-Second System):** This is an older system of metric units. As the name suggests, it uses centimetre for length, gram for mass, and second for time. It was widely used in the sciences but has been largely replaced by the SI system.

4. **FPS System (Foot-Pound-Second System):** This is an imperial system of units, which uses foot for length, pound for mass, and second for time. It's primarily used in the United States. For example, distances are measured in feet and miles rather than meters or kilometres.

5. **Practical units:** A practical unit is a unit of measurement that's chosen for convenience in size and used for actual measurements. Here are some examples of practical units:

Units of length:

The meter is the standard unit of length in the International System of Units (SI), but other practical units include the centimetre, kilometre, millimetre, and micrometre.

Units of electric energy:

Watt-hour and kilowatt-hour are practical units of electric energy.

Units of time:

Common units of time include the minute, hour, day, week, month, and year.

Units of heat energy:

Common units of heat energy include calorie, Kilocalorie

Units of Area:

Common units of area include barn,hectare.

Fundamental Units of the SI System

The International System of Units (SI) is the globally accepted standard for measurement in science and engineering. It consists of seven fundamental units, each corresponding to a basic physical quantity. These units serve as the building blocks for all other derived units in the SI system.

The Seven SI Base Units

1. **Meter (m):**
- Quantity: Length
- Definition: The meter is defined by the distance light travels in a vacuum in $\frac{1}{1299,792,458}$ seconds.

2. **Kilogram (kg):**
- Quantity: Mass
- Definition: The kilogram is defined by fixing the numerical value of the Planck constant to 6.62607015×10^{-34} joule seconds.

3. **Second (s):**
- Quantity: Time
- Definition: The second is defined by the duration of 9,192,631,770 periods of radiation corresponding to the transition between two hyperfine levels of the ground state of the cesium-133 atom.

4. **Ampere (A):**
- Quantity: Electric Current
- Definition: The ampere is defined as the constant current that, if maintained in two straight parallel conductors of infinite length and negligible circular cross-section, would produce a force equal to
- 2×10^{-7} newtons per meter of length between these conductors.

5. **Kelvin (K):**
- Quantity: Thermodynamic Temperature
- Definition: The kelvin is defined by fixing the numerical value of the Boltzmann constant to 1.380649×10^{-23} joules per kelvin.

6. **Mole (mol):**
- Quantity: Amount of Substance
- Definition: The mole is defined by fixing the numerical value of the Avogadro constant to 6.02214076×10^{23} entities (atoms, molecules, etc.) per mole.

7. **Candela (cd):**
- Quantity: Luminous Intensity
- Definition: The candela is defined as the luminous intensity in a given direction of a source that emits monochromatic radiation of frequency
- 540×10^{12} hertz and has a radiant intensity of $\frac{1}{683}$ watts per steradian.

Derived Units

Derived units are combinations of the seven base units and are used to measure other physical quantities.

Here are some examples:

a. **Speed:** Speed is a measure of how fast something is moving. It is derived from the base units of distance (meter) and time (second), and its unit is meters per second (m/s). For example, if a car travels 100 meters in 10 seconds, its speed is 10 m/s.

b. **Volume:** Volume is the amount of space that a substance or object occupies. It is derived from the base unit of length (meter), and its unit is cubic meters (m^3). For example, the volume of a box that is 1 meter long, 1 meter wide, and 1 meter high is 1 cubic meter.

c. **Density:** Density is a measure of mass per unit volume. It is derived from the base units of mass (kilogram) and length (meter), and its unit is kilograms per cubic meter (kg/m^3). For example, the density of water is approximately 1000 kg/m^3.

d. **Force:** Force is a measure of the push or pull on an object. It is derived from the base units of mass (kilogram), length (meter), and time (second), and its unit is newtons (N). For example, the force exerted by gravity on a 1-kilogram object near the Earth's surface is approximately 9.8 N.

e. **Pressure:** Pressure is the force applied perpendicular to the surface of an object per unit area. It is derived from the base units of force (Newton) and length (meter), and its unit is pascals (Pa). For example, the atmospheric pressure at sea level is approximately 101,325 Pa.

Conversion of Units:

Units of Length Measurement

Table 1: Units of length measurement

Unit	Description	Equivalent
Meter (m)	Used for general measurements in science	-
Centimeter (cm)	Used for smaller lengths	1 m = 100 cm
Millimeter (mm)	Used for even smaller lengths	1 cm = 10 mm
Micrometer (µm)	Used for microscopic lengths	1 mm = 1,000 µm
Nanometer (nm)	Used in the study of molecules and atoms	1 µm = 1,000 nm
Picometer (pm)	Used in the study of atomic nuclei	1 nm = 1,000 pm
Angstrom (Å)	Used in crystallography and the study of molecular structures	1 Å = 0.1 nm
Fermi (fm)	Used in nuclear physics	1 fm = 1x10^-15 m
Astronomical Unit (AU)	Used in astronomy to measure distances within our solar system	1 AU ≈ 149.6 million km
Light Year (ly)	Used in astronomy to measure interstellar and intergalactic distances	1 ly ≈ 9.461 trillion km
Parsec (pc)	Also used in astronomy	1 pc ≈ 3.26 ly
Mile	Used as practical units of length	1 Mile=1.6 km
Fathom	used in the imperial and the U.S. customary systems	1fath=1.8m

Units of Mass Measurement

Unit	Description	Equivalent
Kilogram (kg)	The base unit of mass in the SI system	-
Gram (g)	Commonly used for smaller masses	1 kg = 1,000 g
Milligram (mg)	Used for very small masses	1 g = 1,000 mg
Microgram (µg)	Used in scientific research for tiny masses	1 mg = 1,000 µg
Tonne (t)	Used for large masses, like vehicles or whales	1 t = 1,000 kg
Quintal	Used for large masses	1q=10^2 kg
Pound	Used in both the British imperial and United States customary systems of measurement.	1P=0.4537kg
Atomic Mass Unit (amu)	Used in chemistry to express the masses of atoms and molecules	1 amu ≈ 1.66 x 10^{-27} kg
Chandrashekhar Limit	the maximum mass at which a star near the end of its life cycle can become a white dwarf and above which the star will collapse to form a neutron star or black hole	1Chandrashekhar Limit=2.8X10^{30}kg

Units of Time Measurement

Unit	Description	Equivalent
Second (s)	The base unit of time in the SI system	-

Minute (min)	Commonly used for short periods of time	1 min = 60 s
Hour (h)	Used for longer periods of time	1 h = 60 min
Day (d)	Used to measure the time from one midnight to the next	1 d = 24 h
Week (wk)	Used to measure a standard working week	1 wk = 7 d
Year (yr)	Used to measure long periods of time	1 yr ≈ 365.25 d
Millisecond (ms)	Used for very short periods of time	1 s = 1,000 ms
Microsecond (µs)	Used in scientific research for extremely short periods of time	1 ms = 1,000 µs
Nanosecond (ns)	Used in computing and telecommunications	1 µs = 1,000 ns
Picosecond (ps)	Used in quantum physics and chemistry	1 ns = 1,000 ps
Femtosecond (fs)	Used in ultrafast science, including femtochemistry	1 ps = 1,000 fs
Attosecond (as)	Used in photonics and the study of electron dynamics	1 fs = 1,000 as

SI Prefixes and Symbols Used to Denote Powers of 10

Prefix	Multiple	Symbol
yotta	10^{24}	Y
zetta	10^{21}	Z
exa	10^{18}	E
peta	10^{15}	P
tera	10^{12}	T
giga	10^{9}	G
mega	10^{6}	M
kilo	10^{3}	k
hecto	10^{2}	h
deca	10	da
deci	10^{-1}	d
centi	10^{-2}	c
milli	10^{-3}	m
micro	10^{-6}	mu
nano	10^{-9}	n
pico	10^{-12}	p
femto	10^{-15}	f
atto	10^{-18}	a
zepto	10^{-21}	z
yotto	10^{-24}	y

Largest and Smallest Units of Measurement

Here is a summary of the largest and smallest units for length, mass, time, temperature, and electric current based on the provided information.

Length

Smallest Unit: Fermi (fm)

- 1 fermi=10^{-15} m.

Largest Unit: Parsec (pc)

- 1 parsec≈3.086×10^{16} m

Mass

Smallest Unit: Yoctogram (yg)

- 1 yoctogram=10^{-24} g

Largest Unit: Kilogram (kg)

- The Chandrashekhar Limit is the base unit of mass in the SI system.
- 1Chandrashekhar Limit=$2.8\text{X}10^{30}$kg

Time

Smallest Unit: Planck Time (t_p)

- 1 Planck time≈5.39×10^{-44} s.

Largest Unit: Galactic Year

- Approximately
- 2.5×10^{16} s, representing the time it takes for the Solar System to orbit the Milky Way galaxy.

Temperature

Smallest Unit: Femtokelvin (fK)

- 1 femtokelvin=10^{-15} K.

Largest Unit: Kelvin (K)

- The kelvin is the base unit of temperature in the SI system.

Electric Current

Smallest Unit: Picoampere (pA)

- 1 picoampere=10^{-12} A

Largest Unit: Kiloampere (kA)

- 1 kiloampere=1000 A

Examples of Unit Conversion:

Let's Convert The value of gravitational constant in CGS unit

We get the idea of gravitational constant from the law of universal gravitation law.The law states that the gravitational force between two point object is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

Mathematically it will be expressed as

$F = \frac{Gm_1m_2}{r^2}$

$G = \frac{Fr_2}{m_1m_2}$

We kow the SI unit of Force is Newton.

1 N= 10^5Dyne

SI unit of Mass is Kilogram

- 1Kg= 1000gm
- SI unit of length(Radius in this case) is a meter
- 1m=100cm
- The value of G in SI= 6.67 X 10^{-11} N m^2 Kg^{-2}
- The value of G in CGS= 6.67 X 10^{-11}(10^5Dyne) X $(100cm)^2$ X $(1000gm)^{-2}$
- The value of G in CGS= 6.67 X 10^{-11} X 10^3 Dyne cm^2 gm^{-2}
- The value of G in CGS=6.67 X 10^{-8} Dyne cm^2 gm^{-2}

Dimensions of Physical Quantities

The dimensions of a physical quantity are the powers to which the fundamental units are raised in order to obtain the units of the quantity.

Dimensional Symbol of Fundamental Physical Quantities:

Fundamental Physical Quantities	Dimensional Symbol	SI Unit	CGS Unit
Distance	L	Meter	Centimeter
Mass	M	Kilogram	Gram
Time	T	Second	Second
Temperature	θ	Kelvin	Kelvin
Electric Current	I	Ampere	Biot
Luminous Intensity	C	Candela	Stilb
Amount of Substance	N	Mole	Mole

Dimensional Formula:

Physical Quantity	Formula	Dimensional formula	
Speed	$\frac{\text{Distance}}{\text{Time}}$	$\frac{L}{T}$ =$[M^0L^1T^{-1}]$	Same Dimension
Velocity	$\frac{\text{Displacement}}{\text{Time}}$	$\frac{L}{T}$=$[M^0L^1T^{-1}]$	
Acceleration	$\frac{\text{Velocity}}{\text{Time}}$	$\frac{LT-1}{T}$ =$[M^0L^1T^{-2}]$	
Momentum	Mass × Velocity	$M^1XL^1T^{-1}$=$M^1L^1T^{-1}$	Same Dimension
Impulse	Force × Time	$M^1L^1T^{-2}$ × T^1= $M^1L^1T^{-1}$	
Force	Mass × Acceleration	$M^1XL^1T^{-2}$=$M^1L^1T^{-2}$	
Work	Force × Distance	$M^1L^1T^{-2}$ × L=$M^1L^2T^{-2}$	Same Dimension
Energy	$\frac{1}{2}$ Mass × Acceleration	$M^1X(L^1T^{-1})^2$= $M^1L^2T^{-2}$	
Pressure	$\frac{\text{Force}}{\text{Area}}$	$\frac{M1L1T-2}{L2}$= $M^1L^{-1}T^{-2}$	Same Dimension
Stress	$\frac{\text{Force}}{\text{Area}}$	$\frac{M1L1T-2}{L2}$= $M^1L^{-1}T^{-2}$	
Angular Momentum	Mass × Velocity × Radius	MXLT-1XL=ML^2T^{-1}	Same Dimension
Planck's Constant	$\frac{\text{Energy}}{\text{Frequency}}$	$\frac{M1L2T-2}{T-1}$ =ML^2T^{-1}	
Light Year	Distance	$M^0L^1T^0$	Same Dimension
Wavelength	Distance	$M^0L^1T^0$	
Surface Tension	$\frac{\text{Force}}{\text{Length}}$	$\frac{M1L1T-2}{L}$ =$M^1L^0T^{-2}$	Same Dimension
Surface Energy	$\frac{\text{Energy}}{\text{Area}}$	$\frac{M1L1T-2}{L}$= $M^1L^0T^{-2}$	
Frequency	$\frac{1}{\text{Time}}$	$\frac{1}{T}$= $M^0L^0T^{-1}$	Same Dimension
Angular Frequency (ω)	2π/T	$\frac{1}{T}$= $M^0L^0T^{-1}$	
Angular Velocity	$\frac{\text{Angle}}{\text{Time}}$	$\frac{1}{T}$= $M^0L^0T^{-1}$	

Dimensionless Physical Quantity:

A dimensionless quantity is a physical quantity that has no dimensions and is either unitless or a scalar number.

Examples of Dimensionless Physical quantities are:

1. Strain = $\frac{\text{Change in Length}}{\text{Original Length}}$ = $\frac{L}{L}$= Both the numerator and denominator have the same units, so they will cancel each other out, resulting in a unitless and dimensionless quantity.

2. Plane Angle $\frac{\text{Arc}}{\text{Radius}} = \frac{L}{L} =$ Both the numerator and denominator have the same units, so they will cancel each other out, resulting in a unitless and dimensionless quantity.

3. Solid Angle $\frac{\text{Area}}{\text{Radius}^2} = \frac{L^2}{L^2}$ = Both the numerator and denominator have the same units, so they will cancel each other out, resulting in a unitless and dimensionless quantity.

4. Refractive Index(n)=$\frac{\text{the velocity of light in vacuum}(C)}{\text{the velocity of light in medium}(v)} = \frac{LT^{-1}}{LT^{-1}}$ = Both the numerator and denominator have the same units, so they will cancel each other out, resulting in a unitless and dimensionless quantity.

5. Mach Number(M)= $\frac{\text{Speed of an object}}{\text{speed of sound}} = \frac{LT^{-1}}{LT^{-1}}$ = Both the numerator and denominator have the same units, so they will cancel each other out, resulting in a unitless and dimensionless quantity.

Measurement:

Measurement is the process of determining the ratio of a physical quantity, such as a length, time, temperature etc., to a unit of measurement, such as the meter, second or degree Celsius. For example, when we say a room is 10 meters long, we're expressing a measurement. The quantity is length, the unit is meters, and the measurement is 10 meters.

Measurement of Length, Mass and Time

Measurement of Length

a. **Ruler:** A ruler is a straightedge with equally spaced markings along its length. It's used for measuring short lengths and can be graduated in millimeters, centimeters, inches, or other units.

b. **Measuring Tape:** A measuring tape is a flexible ruler that can measure longer lengths. It's often used in construction and tailoring.

c. **Vernier Calipers:** Vernier calipers are a precision instrument that can measure internal and external dimensions extremely accurately. They're used in fields where precision is important, like engineering and scientific research.

d. **Micrometer Screw Gauge:** This is a device used for precision measurement of components in mechanical engineering and machining as well as most mechanical trades, along with other meteorological instruments such as dial, vernier, and digital calipers.

e. **Laser Measure:** A laser measure is a tool that uses a laser to measure distances. It's often used in construction and interior design.

f. **Optical Comparator:** An optical comparator (also known as a profile projector) is a device that applies the principles of optics to the inspection of manufactured parts.

g. **Interferometer:** An interferometer is a type of scientific instrument that can measure small displacements, refractive index changes, and surface irregularities.

h. **Atomic Force Microscope (AFM):** AFM is a type of scanning probe microscopy, with demonstrated resolution on the order of fractions of a nanometer, more than 1000 times better than the optical diffraction limit.

Measurement of Mass

Measurement of mass is a fundamental concept in science and our daily lives. Here are some tools used for measuring mass and their real-life applications:

a. **Balance:** A balance is a device that measures mass by balancing an object with a known mass. One common type of balance is the beam balance, where you place the object on one side of the beam and add known masses to the other side until the beam is level. Balances are often used in laboratories for precise measurements.

b. **Electronic Weighing Machine:** An electronic weighing machine measures the weight of an object and converts it to mass. These are commonly used in various settings like your bathroom scale at home, a grocery store scale, or a postage scale at the post office.

c. **Spring Scale:** A spring scale measures weight (the force exerted on an object due to gravity), which can be converted to mass knowing the acceleration due to gravity. These are often used in physics classrooms.

Measurement of Time

Tools used for measuring time:

a. **Clock:** A clock is a device that tells the time. It can be analog (with hands pointing to hours, minutes, and sometimes seconds) or digital (displaying time numerically). Clocks are everywhere in our daily lives, from the wall clock in your home to the clock on your computer or smartphone.

b. **Stopwatch:** A stopwatch is a handheld timepiece designed to measure the amount of time that elapses between its activation and deactivation. It's used for timing events where precision is important, such as races or experiments.

c. **Timer:** A timer is a specialized type of clock used for measuring specific time intervals. It can be used for a variety of purposes, such as cooking, studying, or exercising.

d. **Calendar:** A calendar is used to measure longer periods of time, from days to weeks, months, and years. It helps us keep track of important dates and plan for future events.

Units used in measuring time

The 2023 Nobel Prize in Physics holds relevance in our discourse on units and measurements, honouring Pierre Agostini, Ferenc Krausz, and Anne L'Huillier for their groundbreaking experimental methods generating attosecond pulses of light to study electron dynamics in matter. An attosecond, an extraordinarily brief unit of time, is so minute that there are as many attoseconds in one second as there have been seconds since the birth of the universe. The laureates' experiments, measuring pulses in attoseconds, unveil the potential to capture images of processes within atoms and molecules. This breakthrough enables scientists to observe and comprehend previously inaccessible ultrafast processes, exemplifying how advancements in measurement techniques drive breakthroughs in our understanding of the world.

Accuracy, Precision, and Errors in Measurement

Accuracy and Precision

Accuracy refers to how close a measured value is to the true value or the standard value. For example, if in the lab you obtain a weight measurement of 3.2 kg for a given substance, but the actual or known weight is 10 kg, then your measurement is not accurate.

On the other hand, Precision refers to how close the agreement is between repeated measurements (which are repeated under the same conditions). Consider you are weighing the same substance five times, and you get 3.2 kg each time, then your measurement is very precise. Precision tells you about the repeatability of your measurement.

To differentiate between Accuracy and Precision, consider an archery target. Accuracy is hitting the centre of the target, while precision is hitting the same spot on the target over and over again, regardless of whether that spot is the center of the target. A measurement system can be accurate but not precise, precise but not accurate, neither, or both.

For example, if an experiment contains a systematic error, then increasing the sample size generally increases precision but does not improve accuracy. The result would be a consistent yet inaccurate string of results from the flawed experiment. Eliminating the systematic error improves accuracy but does not change precision.

A measurement system is considered valid if it is both accurate and precise. Related terms include bias (non-random or directed effects caused by a factor or factors unrelated to the independent variable) and error (random variability).

Error

The measured value of a quantity typically deviates from the true value of the physical quantity. This disparity between the true value and the measured value is termed as an error, calculated as the difference between the true value and the measured value:

Error = true value – measured value.

Types of errors and how to minimize them

In the process of measurement, two types of errors commonly occur: systematic errors and random errors.

a. **Systematic Errors:** These are errors that are consistent and repeatable, which can be due to a fault in the equipment or the design of the experiment. For example, if a stopwatch used in an experiment is consistently slow by 0.5 seconds, then this would be a systematic error.

b. **Random Errors:** These are errors that occur unpredictably and vary from one measurement to another. They often result from the experimenter's inability to take the same measurement in exactly the same way to get exactly the same number.

To minimize these errors, we can use the following methods:

a. **Calibration:** Equipment should be properly calibrated. This means checking them against a standard and adjusting them as necessary to ensure they give accurate readings.

b. **Repeated Trials:** Conducting multiple trials and then averaging the results can help to minimize random errors.

c. **Careful Procedure:** Following the experimental procedure carefully and accurately can help to reduce errors. This includes things like reading measurements at eye level to avoid parallax error, and ensuring measuring instruments are clean and zeroed before use.

d. **Use of Appropriate Tools:** Using the right tool for the measurement can also reduce errors. For example, it would be more accurate to use a thermometer rather than estimating the temperature by touch.

e. **Error Analysis:** After the experiment, error analysis can be done to identify any systematic errors and correct for them.

Remember, while it's impossible to completely eliminate errors in an experiment, these steps can help to minimize them and improve the accuracy and reliability of your results.

Scientific Instruments and their uses:

Instrument	Uses
Accumulator	It serves as a kind of electrical energy storage.
Altimeter	It is used in aeroplanes to measure altitude.
Ammeter	Electric current strength is measured by this instrument (in amperes).
Anemometer	It calculates the wind's speed and force.
Audiometer	It gauges the intensity of sound.
Audiphones	It is used for improving the imperfect sense of hearing.
Barograph	It is utilised for continuous atmospheric pressure recording.

Barometer	It is used to measure atmospheric pressure. It is used in weather forecasting.
Binocular	It is utilised to see faraway objects.
Bolometer	It measures heat radiation
Calorimeter	It is used to gauge how much heat a material emits or absorbs. It is employed in thermodynamics and chemistry.
Carburettor	It is used in an internal combustion engine for charging the air with petrol vapour.
Cardiogram	It tracks the heart's motion as it is captured on a cardiograph.
Chronometer	It establishes a location's longitude on a ship.
Cinematography	It is a tool used in filmmaking to project an enlarged picture of the photograph on the screen.
Colorimeter	a device for contrasting hue intensity.
Commutator	An instrument to change or remove the direction of an electric current, in dynamo is used to convert alternating current into direct current.
Cresco graph	It measures the growth in plants.
Cyclotron	It is a charged particle accelerator that is capable of raising the energy of charged particles.
Dynamo	Mechanical energy is transformed into electrical energy by it.
Dynamometer	It computes power, torque, and force.
Electroscope	It detects the presence of an electric charge.
Endoscope	It looks at the body's interior organs.
Eudiometer	a glass tube used to measure volume changes in gas chemical processes.
Fathometer	It computes the ocean's depth.
Galvanometer	It measures small-amplitude electric currents.
Hydrometer	It computes the liquids' specific gravities.
Hydrophone	It gauges underwater sound.
Hygrometer	It gauges the air's humidity.
Kymograph	It graphically records physiological movements (Blood pressure and heartbeat).
Lactometer	It determines the purity of milk.
Manometer	Gas pressure is measured by it.

Mariner's compass	It is a tool that sailors use to identify the direction.
Microphone	It amplifies the sound and changes the sound waves into electrical vibrations
Microscope	It is used to view small objects or organisms that cannot be seen with the naked eye. It is used in biology, medicine, and research.
Odometer	An instrument by which the distance covered by wheeled vehicles is measured.
Periscope	It is used to view objects above sea level (used in submarines)
Phonograph	An instrument for producing sound.
Photometer	The instrument compares the luminous intensity of the source of light
Potentiometer	It is used for comparing the electromotive force of cells.
Pyrometer	It measures very high temperatures.
Quartz Clock	A highly accurate clock used in astronomical observations and other precision work
Radar	Radio, angle, detection and range is used to detect the direction and range of an approaching aeroplane by means of radio microwaves
Radiometer	It measures the emission of radiant energy.
Rain Gauge	An apparatus for recording rainfall at a particular place.
Rectifier	An instrument used for the conversion of AC into DC.
Refractometer	It measures the refractive index.
Saccharimeter	It measures the amount of sugar in the solution.
Salinometer	It determines the salinity of the solution.
Seismograph	It measures the intensity of earthquake shocks.
Sextant	This is used by navigators to find the latitude of a place by measuring the elevation above the horizon of the sun or another star.
Spectrometer	It is used to measure the intensity of light absorbed by a substance. It is used in chemistry and biology.
Spectroscope	An instrument used for spectrum analysis
Speedometer	It is an instrument placed in a vehicle to record its speed.

Spherometer	It measures the curvatures of surfaces.
Sphygmomanometer	It measures blood pressure.
Stereoscope	It is used to view two-dimensional pictures.
Stethoscope	An instrument which is used by doctors to hear and analyse heart and lung sounds.
Stroboscope	It is used to view rapidly moving objects.
Tachometer	An instrument used in measuring the speeds of aeroplanes and motor boats.
Teleprinter	This instrument receives and sends typed messages from one place to another.
Telescope	It is used to view distant objects in space. It is used in astronomy.
Theodolite	It measures horizontal and vertical angles.
Thermometer	It is used to measure temperature. It is used in medicine, meteorology, and other fields that require temperature measurement.
Thermostat	It regulates the temperature at a particular point.
Transistor	A small device which may be used to amplify currents and perform other functions usually performed by a thermionic valve
Udometer	It is used to measure the amount of liquid precipitation over a set period of time. It is also called Rain Gauge.
Vernier	An adjustable scale for measuring small subdivisions of scale
Viscometer	It measures the viscosity of liquids.
Voltmeter	It measures the electric potential difference between two points.

STUDENT'S NOTES

EXERCISE

1. What is the fundamental unit of length in the International System of Units (SI)?

(a) Meter (b) Kilometer

(c) Centimeter (d) Millimeter

2. Which of the following is a scalar quantity?

(a) Velocity (b) Acceleration

(c) Force (d) Temperature

3. The standard unit of mass in the SI system is:

(a) Gram (b) Kilogram

(c) Pound (d) Ounce

4. The process of measuring an angle in degrees is known as:

(a) Radian measurement

(b) Angular measurement

(c) Trigonometry

(d) Geometry

5. Which instrument is used to measure atmospheric pressure?

(a) Barometer (b) Anemometer

(c) Hygrometer (d) Thermometer

6. What is the SI unit of force?

(a) Joule (b) Newton

(c) Pascal (d) Watt

7. If an object moves with uniform speed, its acceleration is:

(a) Zero (b) Constant

(c) Increasing (d) Decreasing

8. Which of the following quantities has both magnitude and direction?

(a) Speed (b) Distance

(c) Displacement (d) Mass

9. The measurement of how much matter is contained in an object is called:

(a) Volume (b) Density

(c) Mass (d) Weight

10. The unit of energy in the SI system is:

(a) Joule (b) Calorie

(c) Electronvolt (d) Watt-hour

11. Which of the following is not a derived unit?

(a) Area (m^2) (b) Volume (m^3)

(c) Time (s) (d) Velocity (m/s)

12. The speed of light in a vacuum is approximately:

(a) 3×10^6 m/s (b) 3×10^8 m/s

(c) 3×10^9 m/s (d) 3×10^{10} m/s

13. Which physical quantity is measured in Hertz (Hz)?

(a) Energy (b) Frequency

(c) Force (d) Pressure

14. The temperature at which all molecular motion ceases is known as:

(a) Absolute zero (b) Freezing point

(c) Boiling point (d) Room temperature

15. The term “accuracy” in measurement refers to:

(a) The closeness of a measured value to the actual value

(b) The repeatability of measurements

(c) The range of values obtained

(d) The precision of instruments

16. What instrument measures electrical current?

(a) Voltmeter (b) Ammeter

(c) Ohmmeter (d) Multimeter

17. In physics, what does the term “displacement” refer to?

(a) Total distance traveled by an object

(b) Change in position from initial to final point

(c) Speed of an object

(d) Directional distance only

18. Which law states that pressure exerted by a gas at constant temperature varies inversely with its volume?

(a) Boyle’s Law (b) Charles’s Law

(c) Avogadro’s Law (d) Ideal Gas Law

19. What is the primary purpose of significant figures in measurements?

(a) To indicate precision and accuracy of measurements

(b) To simplify calculations

(c) To convert units

(d) To round off numbers

20. Which of the following describes a vector quantity?

(a) It has only magnitude

(b) It has only direction

(c) It has both magnitude and direction

(d) It has no relation to motion

ANSWER KEY

1. (a)	**2. (d)**	**3. (b)**	**4. (b)**	**5. (a)**
6. (b)	**7. (a)**	**8. (c)**	**9. (c)**	**10. (a)**
11. (c)	**12. (b)**	**13. (b)**	**14. (a)**	**15. (a)**
16. (b)	**17. (b)**	**18. (a)**	**19. (a)**	**20. (c)**

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