

THE SCOPE OF PHYSICS

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SCIENCE

Science is the systematic study of all natural phenomena. It is based on observations, experiments and measurements.

BRANCHES OF SCIENCE:

The subject science has been divided into two main branches

- (i) Physical Sciences
- (ii) Biological Sciences

PHYSICAL SCIENCES:

Physical Sciences deal with the properties and behaviour of non-living things.

Physics, Chemistry, Astronomy, Geology etc.

BIOLOGICAL SCIENCES:

Biological sciences deal with living things.

Botany, Genetics, Zoology, Microbiology etc.

PHYSICS:

The branch of Physical science which deals with the interaction of matter and energy is called Physics. Moreover, it is based on experimental observations and quantitative measurements.

BRANCHES OF PHYSICS:

The main branches of Physics are.

- (i) Classical Physics
- (ii) Quantum Physics or Modern Physics.

Classical Physics believes in singular nature i.e. only the particle nature of matter. It provides ^{large} macroscopic vision of matter. It is based upon Newton's laws of mechanics and Maxwell's laws of Electromagnetism.

Quantum Physics believes in dual nature i.e. both particle and wave nature of matter. It provides ^{small} microscopic vision of matter.

It is based upon Planck's quantum theory of light and de-Broglie's idea of matter wave. In the practical field, common branches of Physics are:

- | | | |
|------------------------------|--------------------------|-------------------------------|
| (i) Mechanics | (ii) Optics | (iii) Heat and Thermodynamics |
| (iv) Electricity & Magnetism | (v) Astro Physics | (vi) Electronics |
| (vii) Fluid mechanics | (viii) Spectroscopy | (ix) Nuclear Physics |
| (x) Waves & Sound. | (xi) Solid state Physics | (xii) Bio Physics |

CONTRIBUTION TO THE PHYSICAL SCIENCES BY THE ISLAMIC WORLD

1. **Ibn-al-Haitham** was a physicist. He developed the laws of reflection and refraction. He constructed the "pinhole camera". He wrote many books. His famous book is "Kitabul-Manazir".
2. **Al Khawarizmi** was a mathematician. He was the founder of analytical algebra. He invented the term logarithm (algorithm). His famous book is "Hisabul-Jubr-wal-Muqabla".
3. **Al-Battani** was an astronomer. He made calculations in connection with the solar system, changes in seasons, eclipses of moon and sun, and other astronomical phenomena.
4. **Jabir-ibne-Hayyan** was a chemist. He derived various laws of chemistry on the basis of experiments.
5. **Omer Khayyam** was a mathematician and poet.
6. **Al-Razi** was the most prominent scientist and a great physician. He wrote about 200 Original monographs.
7. **Abu-Rehan al-Beruni** was an astronomer, physician and mathematician. His famous book is "Kitab-ul-Qanoon-ul-Masoodi". It is considered as an encyclopaedia of astronomy.
8. **Yakoob bin Ishaq Al-Kindi** wrote many books on Mathematics, Astronomy and other subjects.
9. **Ibn-e-Sina** was famous for his original research in the field of medicine. He gave intravenous injections by means of a silver syringe. His famous book is "Al-Qanoon-fil-Tib" (Qanoon). He also wrote Al-Shifa, an encyclopaedia of philosophy.

MEASUREMENTS AND THE SYSTEM OF UNITS

To measure the physical quantities, we need some units.

There are three systems of units.

1. C. G. S. system.
2. British Engineering system and
3. M. K. S. system

1. C. G. S. System:

In this system, the units of length, mass and time are centimetre, gram and second respectively. All these are fundamental units.

2. British Engineering System:

In this system, the units of length, force and time are foot, pound and second respectively. These are fundamental units, while the unit of mass is a derived unit which is "Slug".

3. M. K. S. System:

In this system, the units of length, mass and time are metre, kilogram and second respectively. All these are fundamental units.

BASIC SI UNITS

In this system, the units of length, mass, time, electric currents, thermodynamic temperature, luminous intensity and amount of substance are metre, kilogram, second, Ampere, Kelvin, Candela and Mole respectively.

Metre (m):

It is defined as 1,650,763.73 wavelengths of orange light emitted under certain carefully defined conditions by an atom of single pure isotope of Krypton (Kr^{86}).

Its multiples and submultiples are as follows.

10 millimetres = 1 cm.

100 cm = 1 m.

1000 m = 1 km.

Kilogram (Kg):

It is the mass of a certain Platinum cylinder kept at the International Bureau of Weights and Measures in Paris.

The submultiples of kilogram are as follows:

1000 gm = 1 Kg

1000 mg = 1 gm

Second (s):

A second is the duration of 9192631770 periods of radiations corresponding to the transition between two hyperfine levels of the ground state of Cesium -133 atoms.

The multiples of second are minute and hour.

60 seconds = 1 minute

60 minutes = 1 hour

Ampere (A):

Ampere is the current, which if maintained in two straight parallel conductors of infinite length of negligible circular cross section, and placed 1m apart in a vacuum, would produce between the conductors, a force equal to 2×10^{-7} N/m of length.

Kelvin (K):

Kelvin is $1/273.16$ of the thermodynamic temperature of the triple point of water. Triple point of water is the point at which the three state of water i.e. liquid, solid and saturated vapours coexist.

Candela (cd):

Candela is the luminous intensity of a surface $\frac{1}{6000000}$ m^2 of a black body at the temperature of freezing Platinum under a pressure of 101325 N/m^2

Mole (mol):

Mole is the amount of substance of a system which contains as many elementary entities as there are atoms in 0.012 kg of Carbon -12.

DIMENSION

It is used to denote the nature of a physical quantity. The symbol L, M and T are used to specify the dimensions of any physical quantity. The nature of a physical quantity is always expressed as some combinations of the fundamental quantities, mass, length and time.

The dimensions of velocity are $\frac{L}{T} = LT^{-1}$

The dimensions of acceleration are $\frac{L}{T^2} = LT^{-2}$

The dimensions of area are L^2

The dimensions of volume are L^3

The dimensions of force are

$$F = ma = MLT^{-2}$$

The dimensions of pressure are

$$P = \frac{F}{A} = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$$

Applications in equations:

In any equation, the dimension of a physical quantity must be the same on both sides of the equation.

EXAMPLES:

$$S = Vt + \frac{1}{2} at^2$$

Dimensionally, this equation can be written as

$$L = \frac{L}{T} T + \frac{L}{T^2} T^2$$

$$L = L + L$$

$$L = L$$

Length = Length

Thus, the above equation is dimensionally correct.

Dimensional checking of the formula of time period of simple pendulum

$$T = 2\pi \sqrt{\frac{\ell}{g}}$$

The dimension of T is T

The dimension of 2π is Nil

The dimension of ℓ is L

The dimension of g is LT^{-2}

Then
$$T = \sqrt{\frac{L}{LT^{-2}}}$$

$$T = \sqrt{T^2}$$

$$T = T$$

Hence, the given formula is verified dimensionally.

SIGNIFICANT FIGURES

The number of digits, which are reasonably reliable, are called significant figures.

OR

All the digits in the measured, quantity about which we are sure, are called significant figures.

OR

In any measurement the correctly known digits and the first doubtful digit are known as significant figures.

RULES TO COUNT SIGNIFICANT FIGURES:

1. Number of non-zero digits in a number are significant figures.
e.g. In 15.2, significant figures are 3.
2. If zero is between two significant figures, it is counted as significant figure.
e.g. In 203, significant figures are 3.
3. Zeros to the right of the significant figure are not counted.
e.g. In 2100, significant figures are 2.
4. Zeros to left of the significant figures are not counted.
e.g. In 0.002, significant figure is 1.
5. Zeros to the right of a fractional number are counted.
e.g. In 10.40, significant figures are four
6. In multiplication of the numbers, the significant figures in the result are reduced to the least number of significant figures of the number involved in of calculation.
7. When we add or subtract the numbers, the number decimal places in the result is reduced to the least number of decimal places involved in calculation.

IMPORTANT QUESTIONS

- Q.1. Name three Muslim scientists. Write their contributions in the field of science. (1994)
- Q.2. What are the dimensions of angular velocity? Show that the equation $T = 2\pi \sqrt{\frac{l}{g}}$ is dimensionally correct, where "T" is the time period of simple pendulum of length "l" at the place where acceleration due to gravity is "g". (1995)
- Q.3. Give the names of three Muslim scientists who made remarkable contributions in the field of Physics. (1998)
- Q.4. Show that the following equations are dimensionally correct. (2001)
- (i) $T = 2\pi \sqrt{\frac{l}{g}}$ (ii) $v = f\lambda$
- Q.5. Show that equation $S = V_i t + \frac{1}{2} a t^2$ is dimensionally correct. (2004 Failures)
- Q.6. Prove that the following equations are dimensionally correct.
- (i) $V_f^2 - V_i^2 = 2aS$ (2005 Failures) (ii) $T = 2\pi \sqrt{\frac{m}{k}}$ (2004)
- Q.7. What is Physics? What are its main branches?
- Q.8. What are basic units? Give basic S.I. units.
- Q.9. Define Significant figures. Define rules for deciding the number of significant figures in a measured quantity.
- Q.10. Find the dimensions of Momentum, Pressure, Kinetic energy and Acceleration. (2006 Failures)
- Q.11. Give the dimensions of the following: (2012)
- (i) Torque (ii) Angular momentum (iii) Pressure (iv) K.E.

NUMERICAL PROBLEMS

- Q.1 Find the area of a rectangular plate having length (21.3 ± 0.2) cm and width (9.80 ± 0.10) cm.

SOLUTION:

Area of rectangular plate = Length x Width.

$$A = (21.3 \pm 0.2) \times (9.80 \pm 0.10)$$

$$A = (21.3 \times 9.80) \pm (21.3 \times 0.10) \pm (0.20 \times 9.80) \pm (0.2 \times 0.10).$$

$$= 208.76 \pm 2.13 \pm 1.96$$

$$= 208.78 \pm 4.09$$

$$= (208.8 \pm 4.1) \text{ cm}^2.$$

$$\boxed{A = (209 \pm 4) \text{ cm}^2} \text{ Ans.}$$

- Q.2 Calculate (a) the circumference of a circle of radius 3.5cm and (b) area of a circle of radius 4.65cm.

SOLUTION:

- (a) Circumference of circle

$$S = 2\pi r$$

$$S = 2 \times 3.141 \times 3.5$$

$$\boxed{S = 21.99 \text{ cm}} \text{ Ans.}$$

- (b) Area of circle

$$A = \pi r^2$$

$$= 3.141 \times (4.65)^2$$

$$= 3.141 \times 21.6225$$

$$\boxed{A = 67.89 \text{ cm}^2} \text{ Ans.}$$

- Q.4 Find the dimension of 'C' in the equation $S = Ct^3$.

SOLUTION:

The dimension of 'S' is L

The dimension of t is T

The dimension of C =

$$\frac{S}{t^3} = \frac{L}{T^3}$$

$$\boxed{= LT^{-3}} \text{ Ans.}$$

- Q.5 Estimate the number of litres of gasoline used by cars in Pakistan each year (consider cars in Pakistan = 500000).

DATA:

$$\text{No. of cars} = 500000 = 5 \times 10^5$$

$$\text{Average distance/year} = 16000 \text{ km}$$

$$\text{Gasoline consumption} = 6 \text{ km/litre}$$

$$\text{No. of litres of gasoline used/year} = ?$$

SOLUTION:

$$\begin{aligned} \text{Total distance covered by all cars/year} &= 5 \times 10^5 \times 16000 \\ &= 8 \times 10^9 \text{ km} \end{aligned}$$

$$\text{Gasoline consumption} = 6 \text{ km/litre}$$

$$\text{Gasoline consumption} = 1/6 \text{ litre}$$

$$\text{Gasoline consumption} = 8 \times 10^9 \text{ km} = \frac{1}{6} \times 8 \times 10^9$$

$$\boxed{\text{Gasoline consumption} = 1033 \times 10^9 \text{ litres.}}$$

Dimension of 'r' = L

Dimension of 'm₁' = M

Dimension of 'm₂' = M

Dimension of 'G' = $\frac{M L/T^2 (L)^2}{M M}$

Dimension of 'G' = $\frac{M L^3}{M^2 T^2}$

Dimension of 'G' = $\frac{L^3}{M T^2}$

Dimension of 'G' = $M^{-1} L^3 T^{-2}$

SELF TEST: (2)

Q.4. What is the dimension of spring constant "k" in the formula:

$F = kx$, where F = force & x = displacement?

Q.5. What is the dimension of angular velocity "ω" in the formula:

$V = r\omega$

where V = Linear velocity

r = Radius?

Q.6. What is the dimension of angular acceleration "α" in the formula:

$a = r\alpha$

where a = linear acceleration

r = radius?

Q.7. Show that the expression $S = V_i t + \frac{1}{2} a t^2$ is dimensionally correct:

SOLUTION:

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

L.H.S. = S

Dimension of S = L

Dimension of L.H.S. = L

$$R.H.S. = V_i t + \frac{1}{2} a t^2$$

Dimension of $V_i = \frac{L}{T}$

Dimension of t = T

Dimension of a = $\frac{L}{T^2}$

Dimension of $\frac{1}{2} = \text{nil}$

$$\text{Dimension of R.H.S.} = \frac{L}{T} \times T + \frac{L}{T^2} \times T^2$$

Dimension of R.H.S. = L + L

Dimension of R.H.S. = 2L

Dimension of R.H.S. = L

Dimension of L.H.S. = Dimension of R.H.S.

The equation is dimensionally correct.

Q.8. Show that the following equations are dimensionally correct:

$$(i) T = 2\pi \sqrt{\frac{m}{k}} \quad (ii) H = \frac{V_0^2 \sin^2 \theta}{2g}$$

L. H. S. = T

Dimension of L.H.S. = T

$$R.H.S. = 2\pi \sqrt{\frac{m}{k}}$$

2π is a number having no dimension.

Dimension of $m = M$

$$\text{Dimension of } k = \frac{M}{T^2}$$

$$\text{Dimension of R.H.S.} = \sqrt{\frac{M}{\frac{M}{T^2}}}$$

$$\text{Dimension of R.H.S.} = \sqrt{\frac{MT^2}{M}}$$

$$\text{Dimension of R.H.S.} = \sqrt{T^2}$$

Dimension of R.H.S. = T

Dimension of L.H.S. = Dimension of R.H.S.

The equation is dimensionally correct.

$$(ii) H = \frac{V_0^2 \sin^2 \theta}{2g}$$

L.H.S. = H (Height)

Dimension of H = L

Dimension of L.H.S. = L

$$R.H.S. = \frac{V_0^2 \sin^2 \theta}{2g}$$

$\sin^2 \theta$ is a number having no dimension

$$\text{Dimension of } V_0 = \frac{L}{T}$$

$$\text{Dimension of } g = \frac{L}{T^2}$$

$$\text{Dimension of R.H.S.} = \frac{\left(\frac{L}{T}\right)^2}{\frac{L}{T^2}}$$

$$\text{Dimension of R.H.S.} = \frac{L^2}{\frac{L}{T^2}}$$

Dimension of R.H.S. = L

Dimension of L.H.S. = Dimension of R.H.S.

The equation is dimensionally correct.

SELF TEST:(3)

Q.9. Show that the expression $V_f = V_i + at$ is dimensionally correct.

Q.10. Show that the expression $T = 2\pi \sqrt{\frac{l}{g}}$ is dimensionally correct.

Q.11. Show that the following equations are dimensionally correct.

$$(i) V = \lambda f \quad (ii) T = \frac{2V_0 \sin \theta}{g} \quad (iii) R = \frac{V_0^2 \sin 2\theta}{g}$$

Where V_0 = Initial Velocity g = Acceleration due to gravity

SCALARS:

Physical quantities, having magnitude only but no direction, are called Scalars. Scalars are completely described by

- i) a number
- ii) a suitable unit

Scalars can be added, subtracted, multiplied and divided by simple arithmetical rules. For example: mass, distance, time, speed, temperature, energy, work, volume and density etc.

VECTORS:

Physical quantities, having both magnitude and direction and also obeying commutative law of vector addition, are called vectors. Vectors are completely described by

- i) a number
- ii) a suitable unit
- iii) a certain direction

Vectors can not be added, subtracted, multiplied and divided by simple arithmetical rules. For example: displacement, velocity, acceleration, force, angular velocity, torque, weight, electric field strength etc.

Representation of a Vector:

A vector is represented graphically by a directed line segment or an arrowhead line segment. The length of the line, according to the scale chosen, represents the magnitude of the vector while the arrowhead indicates the direction. To represent a vector, we need:

1. A suitable scale.
2. Reference axes i.e. x, y and z-axis, or horizontal and vertical directions or the directions of north, south, east and west.

Types of Vectors:

- | | | |
|--------------------|----------------|--------------------|
| 1) Unit vector | 2) Free vector | 3) Position vector |
| 4) Negative vector | 5) Null vector | |

1) Unit Vector:

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A unit vector is that whose magnitude is unity i.e. equal to 1 and it represents the direction of a vector only.

A unit vector can be obtained by dividing the vector with its magnitude i.e.

$$\text{unit vector} = \frac{\text{Vector}}{\text{magnitude of vector}}$$

If unit vector of a vector $\vec{A}$ is $\hat{a}$, then

$$\hat{a} = \frac{|\vec{A}|}{|\vec{A}|} = \frac{\vec{A}}{A}$$

Unit vectors along x, y and z-axis are denoted by $\hat{i}$, $\hat{j}$ and $\hat{k}$ respectively.

Descriptive Questions and Answers

Q1. Discuss in brief the condition of South Asia before the advent of Islam and write in detail the influence of Islam on South Asian Society.

Ans. Introduction:

Pakistan, our dear mother land, came into existence vitally due to the advent of Islam in South Asian region. Islam came to this region through Arab traders. Regular preaching of Islam started after the invasion of Muhammad Bin Qasim, who defeated Raja Dahir in 712.

Condition of South Asia before the advent of Islam:

Before the advent of Islam South Asian society was divided into many small kingdoms who were always at daggers drawn with each other. The Hindus were in majority and they kept on torturing other minorities like Buddhist. The Hindu society was full of social injustice. The following were the discrepancies of this society.

- i. They were divided into four major castes
 - a) Brahmins (The priests)
 - b) The Kashatriyas (warrior class)
 - c) The Vashiya (the artists)
 - d) The Shudras (Lowest worker class)
- ii. The Barhamins and Kashatriyas enjoyed power and status and the other two classes were in miserable condition.
- iii. Narrow mindedness had plagued Hindu society.
- iv. Women were given the lowest status.
- v. Widows were treated badly, mostly they were burned with husband's dead body (sutti)

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Impact of Islam:

i. Civilizational Influence:

Muslim culture imbibed the culture characteristics of the entire civilized world so Muslim civilization held an upper status which changed the inferior and backward culture of South Asia and it brought many significant changes in the culture of South Asia.

ii. Political influence:

- a) Muslims laid the foundation of strong central government and thus brought an end to lawlessness.
- b) .With political unity, administrative equality was also introduced, which created Social equality.
- c) As Muslim conquerers were a part of bigger Islamic Society so they connected South Asia to the outer world.
- d) The new military strategies, disciplines, and ways of fighting were introduced. Naval forces were introduced for the first time.

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PHYSICS – X

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Chapter # 1 (Introduction To Physics)

- Q.1. Define Physics and its branches.
Q.2. Define scientific method with steps.
Q.3. Define Error. What are the different types of Error?
Q.4. Write down the contribution of:
(a) Yaqub-Al-Kindi (b) Ibn-Al Haitham
(c) Dr. Abdul Qadeer Khan (d) Al-Beruni

Chapter # 2 (Measurement)

- Q.1. Define standard of:
(a) Mass (b) Length (c) Time
Q.2. Define:
(a) Least count (b) Significant figure (c) Accuracy
Q.3. Write down some derived quantities with their units and symbols.
Q.4. Advantages of S.I units.
Q.5. Conversions of different units of mass, length and time.

Solved examples: 2.4**Important Problems:** 2.2, 2.3, 2.4

Chapter # 3 (Kinematics Of Linear Motion)

- Q.1. Difference between
(a) Scalar quantity & Vector quantity.
Q.2. Define:
(a) Kinematics (b) Mechanics (c) Dynamics
(d) Distance (e) Displacement (f) Speed
(g) Velocity (h) Acceleration
Q.3. Derive the second and third equation of motion.
Q.4. Define motion and its types.
Q.5. State Newton's First, Second and Third law of motion.

Solved examples: 38, 40, 41**Important Problems:** 3.1, 3.3, 3.6, 3.9, 3.11, 3.12 3.13

Chapter # 4 (Force And Motion)

- Q.1. State Newton's Laws of Motion (1st, 2nd, 3rd)
Q.2. Define tension. Motion of two bodies connected with string (case I and II) find acceleration and tension.
Q.3. What is Momentum? Also state law of Conservation of Momentum.
Q.4. Define friction. Write down its expression and on what factors it depends?
Q.5. Write down the different types of friction. Also write advantages and disadvantages of friction.
Q.6. Write some methods of reducing friction.

Solved examples: 4.2, 4.5**Important Problems:** 4.2, 4.3, 4.5, 4.6, 4.7