SAMPLE CONTENT

33 YEARS

1988 to 2020

NEET PHYSICS

PSP PREVIOUS SOLVED PAPERS

TOPIC-WISE AND SUBTOPIC-WISE

Includes Solved Questions of 2020

A comprehensive collection of NEET & AIPMT Questions from past 33 Years

1648 MCQs

★ In accordance with Std. XI and Std. XII NCERT Books ★

Target Publications® Pvt. Ltd.

33 YEARS
1988 to 2020

NEET PHYSICS

PSP PREVIOUS SOLVED PAPERS

- TOPIC - WISE AND SUBTOPIC - WISE

Salient Features

- A compilation of 33 years of AIPMT/NEET questions (1988-2020)
- Includes solved questions from NEET 2020
- Includes '1648' AIPMT/NEET MCQs
- Topic - wise and Subtopic - wise segregation of questions
- Year-wise flow of content concluded with the latest questions
- Relevant solutions provided
- Graphical analysis of questions – Topic - wise and Subtopic - wise

Printed at: **India Printing Works,** Mumbai

P.O. No. 1194

TEID: 1672

PREFACE

Target's 'NEET: Physics PSP (Previous Solved Papers)' is a compilation of questions asked in the past 33 years (1988-2020) in the National Eligibility cum Entrance Test (NEET), formerly known as the All India Pre-Medical Test (AIPMT). The book is crafted in accordance with the Std. XI and Std. XII NCERT textbook.

The book consists of topic - wise categorization of questions. Each chapter is further segregated into subtopics and thereafter all the questions pertaining to a subtopic are arranged year-wise starting with the latest year. To aid students, we have also provided hints for questions wherever deemed necessary.

A graphical (% wise) analysis of the subtopics for the past 33 years as well as 8 years (2013 onwards) has been provided at the onset of every topic. Both the graphs will help the students to understand and analyse each subtopic's distribution for AIPMT (33 years) and NEET-UG (8 Years).

We are confident that this book will comprehensively cater to needs of students and effectively assist them to achieve their goal.

We welcome readers' comments and suggestions which will enable us to refine and enrich this book further.

All the best to all Aspirants!

Yours faithfully,
Authors
Edition: Second

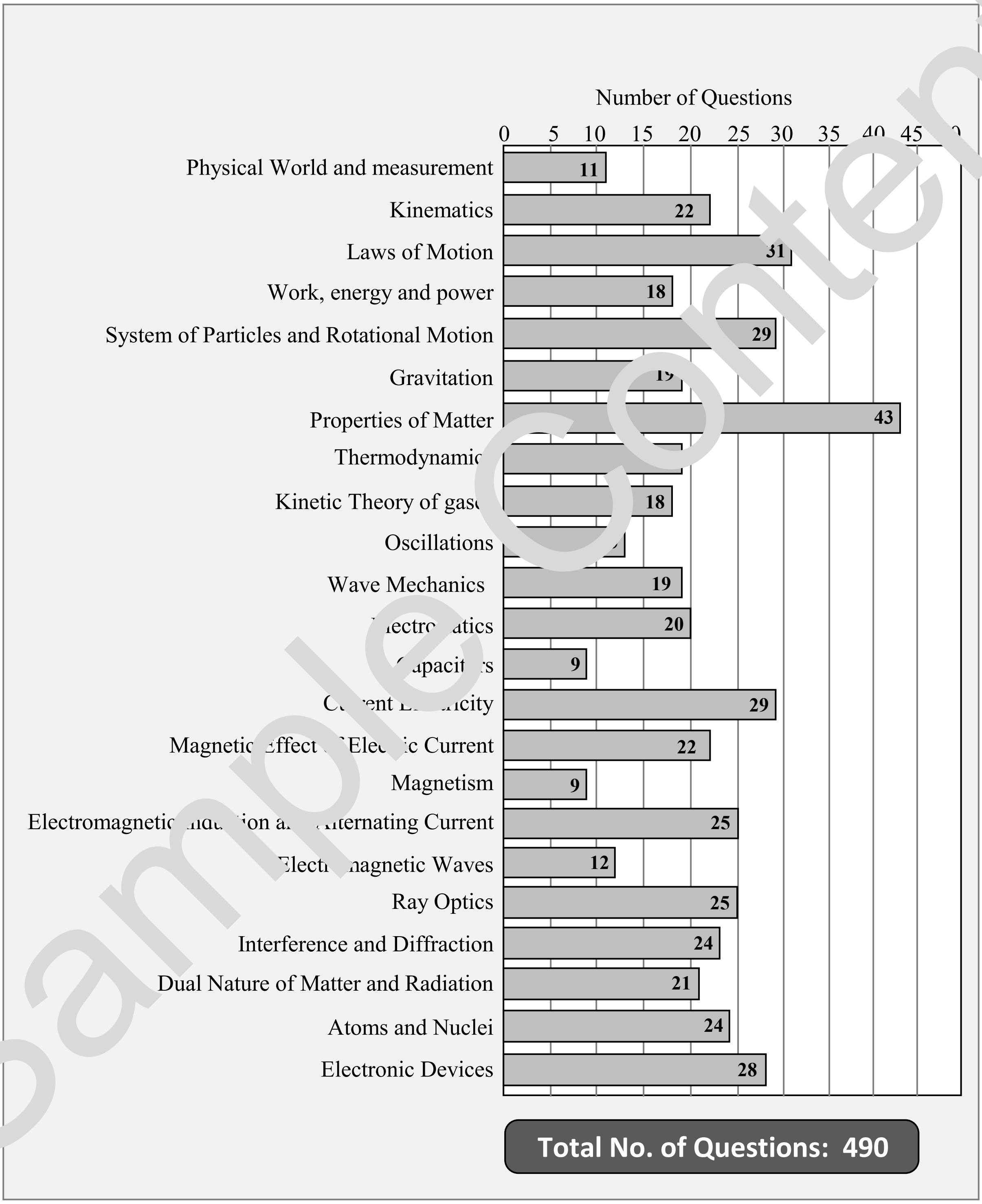
Frequently Asked Questions

Why this book?	• This book acts as a go-to tool to find all the AIPMT/NEET questions since the past 33 years at one place. • The subtopic wise arrangement of questions provides the break-down of a chapter into its important components which will enable students to design an effective learning plan. • The graphical analysis guides students in ascertaining their own preparation of a particular topic.
Why the need for two graphs?	Admission for undergraduate and post graduate medical courses underwent a critical change with the introduction of NEET in 2013. Although it received a huge backlash and was criticised for the following two years, NEET went on to replace AIPMT in 2016. The introduction of NEET brought in a few structural differences in terms of how the exam was conducted. Although the syllabus has fairly remained the same, the chances of asking a question from a particular subtopic is seen to vary slightly with the inception of NEET. The two graphs will fundamentally help the students to understand that the (weightage) distribution of a particular topic can vary i.e., a particular subtopic having the most weightage for AIPMT may not necessarily be the subtopic with the most weightage for NEET.
How are the two graphs beneficial to the students?	• The two graphs provide a subtopic's weightage distribution over the past 33 years (for AIPMT) and over the past 8 years (for NEET-UG). • The students can use these graphs as a self-evaluation tool by analyzing and comparing a particular subtopic's weightage with their preparation of the subtopic. This exercise would help the students to get a clear picture about their strength and weakness based on the subtopics. • Students can also use the graphs as a source to know the most important as well as least important subtopics as per weightage of a particular topic which will further help them in planning the study structure of a particular chapter. *(Note: The percentage-wise weightage analysis of subtopics is solely for the knowledge of students and does not guarantee questions from subtopics having the most weightage, in the future exams.* *Question classification of a subtopic is done as per the authors' discretion and may vary with respect to another individual.)*

Index

No.	Topic Name	Page No.
01	Physical World and measurement	1
02	Kinematics	10
03	Laws of Motion	29
04	Work, energy and power	4[illegible]
05	System of Particles and Rotational Motion	[illegible]
06	Gravitation	77
07	Properties of Matter	89
08	Thermodynamics	104
09	Kinetic Theory of gases	114
10	Oscillations	120
11	Wave Mechanics	132
12	Electrostatics	145
13	Capacitors	160
14	Current Electricity	166
15	Magnetic Effect of Electric Current	191
16	Magnetism	207
17	Electromagnetic Induction and Alternating Current	213
18	Electromagnetic Waves	230
19	Ray Optics	235
20	Interference and Diffraction	251
21	Dual Nature of Matter and Radiation	259
22	Atoms and Nuclei	273
23	Electronic Devices	292

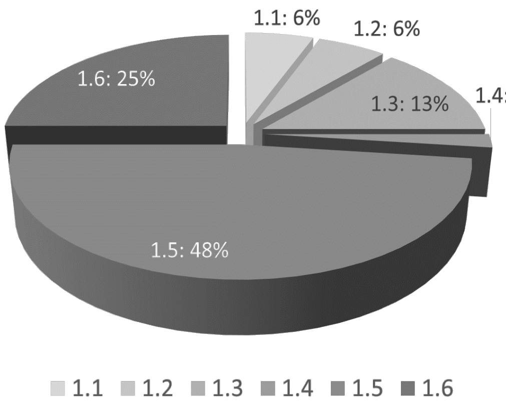
Topic-wise Weightage Analysis of past 8 Years (2013 Onwards)



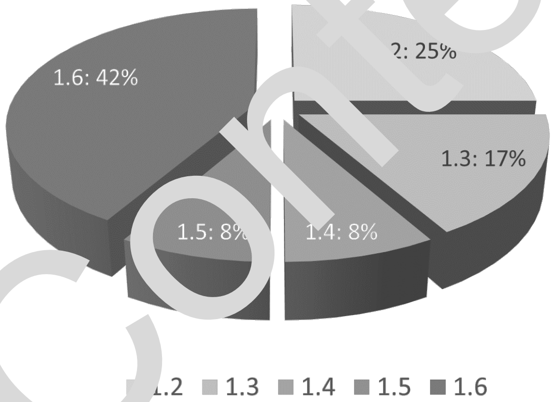
1 Physical World and Measurement

- 1.1 Fundamental and derived units
- 1.2 Accuracy, precision and least count of measuring instruments
- 1.3 Errors in measurement
- 1.4 Significant figures
- 1.5 Dimensions of physical quantities
- 1.6 Dimensional analysis and its applications

33 Years NEET/AIPMT Analysis
(Percentage-wise weightage of sub-topics)



8 Years NEET Analysis (2013 Onwards)
(Percentage-wise weightage of sub-topics)



1.1 Fundamental and derived units

1. If $x = at + bt^2$, where x is the distance travelled by the body in kilometres while t is the time in seconds, then the units of b is [1989]
   (A) km/s (B) km s
   (C) km/s^2 (D) $km\ s^2$

2. The unit of permittivity of free space ε_0 is **[2004]**
   (A) coulomb/(newton metre)
   (B) newton metre^2/coulomb^2
   (C) coulomb^2/newton metre^2
   (D) coulomb^2/(newton metre)^2

3. The damping force on an oscillator is directly proportional to the velocity. The units of the constant of proportionality are **[2012]**
   (A) $kg\ m\ s^{-1}$ (B) $kg\ m\ s^{-2}$
   (C) $kg\ s^{-1}$ (D) kg s

1.2 Accuracy, precision and least count of measuring instruments

1. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of –0.004 cm, the correct diameter of the ball is **[2018]**
   (A) 0.521 cm
   (B) 0.525 cm
   (C) 0.053 cm
   (D) 0.529 cm

2. The main scale of a vernier callipers has n divisions/cm. n divisions of the vernier scale coincide with (n – 1) divisions of main scale. The least count of the vernier callipers is, **[Odisha 2019]**
   (A) $\frac{1}{n(n+1)}$ cm (B) $\frac{1}{(n+1)(n-1)}$ cm
   (C) $\frac{1}{n}$ cm (D) $\frac{1}{n^2}$ cm

3. A screw gauge has least count of 0.01 mm and there are 50 divisions in its circular scale. The pitch of the screw gauge is: **[2020]**
   (A) 0.25 mm (B) 0.5 mm
   (C) 1.0 mm (D) 0.01 mm

1.3 Errors in measurement

1. A certain body weighs 22.42 g and has a measured volume of 4.7cc. The possible error in the measurement of mass and volume are 0.01 g and 0.1 cc. Then maximum error in the density will be **[1991]**
   (A) 22% (B) 2%
   (C) 0.2% (D) 0.02%

2. Percentage errors in the measurement of mass and speed are 2% and 3% respectively. The error in the estimate of kinetic energy obtained by measuring mass and speed will be **[1995]**
(A) 8% (B) 2%
(C) 12% (D) 10%

3. The density of a cube is measured by measuring its mass and length of its sides. If the maximum error in the measurement of mass and length are 3% and 2% respectively, the maximum error in the measurement of density would be **[1996]**
(A) 12% (B) 14%
(C) 7% (D) 9%

4. If the error in the measurement of radius of a sphere is 2%, then error in the determination of volume of the sphere will be **[2008]**
(A) 8% (B) 2%
(C) 4% (D) 6%

5. A student measures the distance traversed in free fall of a body, initially at rest, in a given time. He uses this data to estimate g, the acceleration due to gravity. If the maximum percentage errors in measurement of the distance and the time are e_1 and e_2 respectively, the percentage error in the estimation of g is **[2010]**
(A) $e_2 - e_1$ (B) $e_1 + 2e_2$
(C) $e_1 + e_2$ (D) $e_1 - 2e_2$

6. In an experiment, four quantities a, b, c and d are measured with percentage errors 1%, 2%, 3% and 4% respectively. Quantity P is calculated as follows:
$P = \frac{a^3b^2}{cd}$ % error in P is **[2013]**
(A) 14% (B) 10%
(C) 7% (D) 4%

7. In an experiment the percentage of error occurred in the measurement of physical quantities A, B, C and D are 1%, 2%, 3% and 4% respectively. Then the maximum percentage of error in the measurement X, where $X = \frac{A^2 B^{\frac{1}{2}}}{C^{\frac{1}{3}} D^3}$, will be: **[2019]**
(A) –10 % (B) 10 %
(C) $\left(\frac{3}{13}\right)$ % (D) 16 %

1.4 Significant figures

1. Taking into account of the significant figures, what is the value of 9.99 m – 0.0099 m? **[2020]**
(A) 9.98 m (B) 9.980 m
(C) 9.9 m (D) 9.9801 m

1.5 Dimensions of physical quantities

1. The dimensional formula of angular momentum is **[1988]**
(A) $[ML^2T^{-2}]$ (B) $[ML^{-2}T^{-1}]$
(C) $[MLT^{-1}]$ (D) $[ML^2T^{-1}]$

2. If C and R denote capacitance and resistance, the dimensional formula of CR is **[1988]**
(A) $[M^0L^0T^1]$
(B) $[M^0L^0T^0]$
(C) $[M^0L^0T^{-1}]$
(D) not expressible in terms of MLT

3. The dimensional formula of torque is **[1989]**
(A) $[ML^2T^{-2}]$ (B) $[MLT^{-2}]$
(C) $[ML^{-1}T^{-2}]$ (D) $[ML^{-2}T^{-2}]$

4. Dimensional formula of self inductance is **[1989]**
(A) $[MLT^{-2}A^{-2}]$ (B) $[ML^2T^{-1}A^{-2}]$
(C) $[ML^2T^{-2}A^{-2}]$ (D) $[ML^2T^{-2}A^{-1}]$

5. Of the following quantities, which one has dimensions different from the remaining three? **[1989]**
(A) Energy per unit volume
(B) Force per unit area
(C) Product of voltage and charge per unit volume
(D) Angular momentum.

6. The dimensional formula of permeability of free space μ_0 is **[1991]**
(A) $[MLT^{-2}A^{-2}]$ (B) $[M^0L^1T]$
(C) $[M^0L^2T^{-1}A^2]$ (D) none of these

7. Which of the following has the dimensions of pressure? **[1994, 1990]**
(A) $[MLT^{-2}]$ (B) $[ML^{-1}T^{-2}]$
(C) $[ML^{-2}T^{-2}]$ (D) $[M^{-1}L^{-1}]$

8. The dimensions of RC is **[1995]**
(A) square of time
(B) square of inverse time.
(C) time
(D) inverse time.

9. Which of the following is a dimensional constant? **[1995]**
(A) Relative density
(B) Gravitational constant
(C) Refractive index
(D) Poisson ratio

10. Which of the following dimensions will be the same as that of time? **[1996]**
(A) $\frac{L}{R}$ (B) $\frac{C}{L}$
(C) LC (D) $\frac{R}{L}$

11. The dimensions of impulse are equal to that of **[1996]**
(A) pressure
(B) linear momentum
(C) force
(D) angular momentum

12. The dimensional formula of magnetic flux is **[1999]**
(A) $[M^0L^{-2}T^{-2}A^{-2}]$ (B) $[ML^0T^{-2}A^{-2}]$
(C) $[ML^2T^{-2}A^{-1}]$ (D) $[ML^2T^{-1}A^3]$

13. Which pair do not have equal dimensions? **[2000]**
(A) Energy and torque
(B) Force and impulse
(C) Angular momentum and Planck constant
(D) Elastic modulus and pressure.

14. The dimensions of Planck's constant equals to that of **[2001]**
(A) energy
(B) momentum
(C) angular momentum
(D) power

15. The dimensions of universal gravitational constant are **[2004, 1992]**
(A) $[M^{-1}L^3T^{-2}]$ (B) $[ML^2T^{-1}]$
(C) $[M^{-2}L^3T^{-2}]$ (D) $[M^{-2}L^2T^{-1}]$

16. The ratio of the dimensions of Planck's constant and that of moment of inertia has the dimensions of **[2005]**
(A) time
(B) frequency
(C) angular momentum
(D) velocity

17. Dimensions of resistance in an electrical circuit, in terms of dimension of mass M, of length L, of time T and of current I, would be **[2007]**
(A) $[ML^2T^{-2}]$ (B) $[ML^2T^{-1}I^{-1}]$
(C) $[ML^2T^{-3}I^{-2}]$ (D) $[ML^2T^{-3}I^{-1}]$

18. Which two of the following five physical parameters have the same dimensions? **[2008]**
i. energy density
ii. refractive index
iii. dielectric constant
iv. Young's modulus
v. magnetic field
(A) 1 and 4 (B) 1 and 5
(C) 2 and 4 (D) 3 and 5

19. If the dimensions of a physical quantity are given by $M^aL^bT^c$, then the physical quantity will be **[2009]**
(A) velocity if a = 1, b = 0, c = –1
(B) acceleration if a = 1, b = 1, c = –2
(C) force if a = 0, b = –1, c = –2
(D) pressure if a = 1, b = –1, c = –2

20. The dimensions of $\frac{1}{2}\varepsilon_0E^2$, where ε_0 is permittivity of free space and E is electric field, is **[2010]**
(A) $[ML^2T^{-2}]$ (B) $[ML^{-1}T^{-2}]$
(C) $[ML^2T^{-1}]$ (D) $[MLT^{-1}]$

21. The dimensions of $(\mu_0\varepsilon_0)^{-1/2}$ are **[2012, 20[illegible]]**
(A) $[L^{1/2}T^{-1/2}]$ (B) $[L^{-1}T]$
(C) $[LT^{-1}]$ (D) $[L^{1/2}T^{1/2}]$

22. Dimensions of stress are: **[2020]**
(A) $[ML^2T^{-2}]$ (B) $[ML^0T^{-2}]$
(C) $[ML^{-1}T^{-2}]$ (D) $[MLT^{-2}]$

1.6 Dimensional analysis and its applications

1. According to Newton, the viscous force acting between liquid layers of area A and velocity gradient $\Delta v/\Delta Z$ is given by $F = -\eta A\frac{\Delta v}{\Delta Z}$, where η is constant called coefficient of viscosity. The dimensional formula of η is **[1990]**
(A) $[ML^{-2}T^{-2}]$ (B) $[M^0L^0T^0]$
(C) $[ML^2T^{-2}]$ (D) $[ML^{-1}T^{-1}]$

2. The frequency of vibration f of a mass m suspended from a spring of spring constant k is given by a relation $f = am^xk^y$, where a is a dimensionless constant. The values of x and y are **[1990]**
(A) $x = \frac{1}{2}, y = \frac{1}{2}$
(B) $x = -\frac{1}{2}, y = -\frac{1}{2}$
(C) $x = \frac{1}{2}, y = -\frac{1}{2}$
(D) $x = -\frac{1}{2}, y = \frac{1}{2}$

3. P represents radiation pressure, c represents speed of light and S represents radiation energy striking per unit area per sec. The non zero integers x, y, z such that $P^x\ S^y\ c^z$ is dimensionless are **[1992]**
(A) x = 1, y = 1, z = 1
(B) x = –1, y = 1, z = 1
(C) x = 1, y = –1, z = 1
(D) x = 1, y = 1, z = –1

4. Turpentine oil is flowing through a tube of length l and radius r. The pressure difference between the two ends of the tube is P. The viscosity of oil is given by $\eta = \frac{P(r^2 - x^2)}{4vl}$ where v is the velocity of oil at a distance x from the axis of the tube. The dimensions of η are **[1993]**
(A) $[M^0L^0T^0]$ (B) $[MLT^{-1}]$
(C) $[ML^2T^{-2}]$ (D) $[ML^{-1}T^{-1}]$

5. The time dependence of a physical quantity p is given by $p = p_0 \exp(-\alpha t^2)$, where α is a constant and t is the time. The constant α **[1993]**
   (A) is dimensionless
   (B) has dimensions $[T^{-2}]$
   (C) has dimensions $[T^2]$
   (D) has dimensions of p

6. An equation is given here $\left(P + \frac{a}{V^2}\right) = b\frac{\theta}{V}$ where P = Pressure, V = Volume and θ = Absolute temperature. If a and b are constants, the dimensions of a will be **[1996]**
   (A) $[ML^{-5}T^{-1}]$ (B) $[ML^5T^1]$
   (C) $[ML^5T^{-2}]$ (D) $[M^{-1}L^5T^2]$

7. The velocity v of a particle at time t is given by $v = at + \frac{b}{t + c}$, where a, b and c are constant. The dimensions of a, b and c are respectively **[2006]**
   (A) $[L^2]$, [T] and $[LT^2]$
   (B) $[LT^2]$, [LT] and [L]
   (C) [L], [LT] and $[T^2]$
   (D) $[LT^{-2}]$, [L] and [T]

8. The density of a material in CGS system of units is 4 g cm^{-3}. In a system of units in which unit of length is 10 cm and unit of mass is 100 g, the value of density of material will be **[201[illegible]]**
   (A) 0.04 (B) 0.4
   (C) 40 (D) 400

9. If force (F), velocity (V) and time (T) are taken as fundamental units, then the dimensions of mass are **[2014]**
   (A) $[FVT^{-1}]$ (B) $[FVT^{-2}]$
   (C) $[FV^{-1}T^{[illegible]}]$ (D) $[FV^{-1}T]$

10. If energy (E), velocity (V) and time (T) are chosen as the fundamental quantities, the dimensional formula of surface tension will be **[2015]**
   (A) $[EV^{-2}T^{-1}]$ (B) $[EV^{-1}T^{-2}]$
   (C) $[EV^{-2}T^{-2}]$ (D) $[E^{-2}V^{-1}T^{-3}]$

11. In dimension of critical velocity v_c, of liquid following through a tube are expressed as $(\eta^x \rho^y r^z)$, where η, ρ and r are the coefficient of viscosity of liquid, density of liquid and radius of the tube respectively, then the values of x, y and z are given by **[Re-Test 2015]**
   (A) 1, 1, 1 (B) 1, −1, −1
   (C) −1, −1, 1 (D) −1, −1, −1

12. Planck's constant (h), speed of light in vacuum (c) and Newton's gravitational constant (G) are three fundamental constants. Which of the following combinations of these has the dimension of length? **[Phase-II 2016]**
   (A) $\sqrt{\frac{Gc}{h^{3/2}}}$ (B) $\frac{\sqrt{hG}}{c^{3/2}}$
   (C) $\frac{\sqrt{hG}}{c^{5/2}}$ (D) $\sqrt{\frac{hc}{G}}$

13. A physical quantity of the dimensions of length that can be formed out of c, G and $\frac{e^2}{4\pi\varepsilon_0}$ is [c is velocity of light, G is universal constant of gravitation and e is charge]: **[2017]**
   (A) $\frac{1}{c^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$ (B) $c^2\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$
   (C) $\frac{1}{c^2}\left[\frac{e^2}{G4\pi\varepsilon_0}\right]^{1/2}$ (D) $\frac{1}{c}G\frac{e^2}{4\pi\varepsilon_0}$

Answers to MCQ's

1.1 :	1. [illegible] 2. (C) 3. (C)
1.2 :	1. (D) 2. (D) 3. (B)
1.3 :	1. (B) 2. (A) 3. (D) 4. (D) 5. (B) 6. (A) 7. (D)
1.4 :	1. (A)
1.5 :	1. (D) 2. (A) 3. (A) 4. (C) 5. (D) 6. (A) 7. (B) 8. (C) 9. (B) 10. (A) 11. (B) 12. (C) 13. (B) 14. (C) 15. (A) 16. (B) 17. (C) 18. (A) 19. (D) 20. (B) 21. (C) 22. (C)
1.6 :	1. (D) 2. (D) 3. (C) 4. (D) 5. (B) 6. (C) 7. (D) 8. (C) 9. (D) 10. (C) 11. (B) 12. (B) 13. (A)

Hints to MCQ's

1.1 Fundamental and derived units

1. $[x] = [bt^2] \Rightarrow [b] = [x/t^2] = km/s^2$

2. $F = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 Q_2}{r^2}$

   $\therefore \quad \varepsilon_0 \propto \frac{Q^2}{F \times r^2}$

   So ε_0 has units of coulomb²/ newton m²

3. $F \propto v$ or $F = kv$

   where k is the constant of proportionality

   $\therefore \quad k = \frac{F}{v} = \frac{N}{ms^{-1}}$

   $= \frac{kg\ ms^{-2}}{ms^{-1}}$

   $= kgs^{-1}$

1.2 Accuracy, precision and least count of measuring instruments

1. Least count of screw gauge = 0.001 cm
   = 0.01 mm
   Main scale reading = 5 mm,
   Zero error = – 0.004 cm
   = – 0.04 mm
   Zero correction = +0.04 mm
   Observed reading = Main scale reading + (Division × least count)
   Observed reading = 5 + (25 × 0.01) = 5.25 mm

   Corrected reading = Observed reading + zero correction

   Corrected reading = 5.25 + 0.04
   = 5.29 mm
   = 0.529 cm

2. $1\ V.S.D = \frac{(n-1)}{n} M.S.D.$

   L.C. = 1 M.S.D. – 1 V.S.D.

   $= 1\ M.S.D. - \frac{(n-1)}{n} M.S.D.$

   $= \frac{1}{n} M.S.D.$

   $= \frac{1}{n} \times \frac{1}{n}$ cm

   $\therefore \quad L.C. = \frac{1}{n^2}$ cm

3. $L.C. = \frac{\text{Pitch of screw}}{\text{Total number of division on circular scale}}$

   $\therefore$ Pitch = 0.01 mm × 50 = 0.5 mm

1.3 Errors in measurement

1. Density $(\rho) = \frac{\text{mass (m)}}{\text{volume (V)}}$ ….(i)

   Percentage error in density is given by,

   $\frac{\Delta\rho}{\rho} \times 100 = \left(\frac{\Delta m}{m} + \frac{\Delta v}{v}\right) \times 100$

   $\therefore \quad \frac{\Delta\rho}{\rho} \times 100 = \left[\frac{\Delta m}{m} + \frac{\Delta v}{v}\right] \times 100\%$

   $= \left[\frac{0.01}{22.42} + \frac{0.1}{\text{[illegible]}}\right] \times 100\%$

   $= 2\%$

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

   The percentage error in measurement of kinetic energy is,

   $\frac{\Delta K}{K} \times 100 = \left[\frac{\Delta m}{m} + 2 \times \frac{\Delta v}{v}\right]\%$

   $= [2 + (2 \times 3)]\% = 8\%$

3. Density $(\rho) = \frac{\text{Mass}}{\text{Volume}} = \frac{m}{l^3}$ …(for cube $V = l^3$)

   Percentage relative error in density will be,

   $\frac{\Delta\rho}{\rho} \times 100 = \left[\frac{\Delta m}{m} + 3\frac{\Delta l}{l}\right]\%$

   $= [3 + (3 \times 2)]\%$

   $= (3 + 6)\% = 9\%$

4. $V = \frac{4}{3}\pi R^3$;

   Taking natural logarithm on both side,

   $ln\ V = ln\left(\frac{4}{3}\pi\right) + ln\ R^3$

   Differentiating, $\frac{dV}{V} = 3\frac{dR}{R}$

   Error in the determination of the volume
   = 3 × 2% = 6%

5. $h = ut + \frac{1}{2}gt^2$

   $\therefore \quad h = \frac{1}{2}gt^2 \Rightarrow g = \frac{2h}{t^2}$

   ($\because$ u = 0, as body is initially at rest)

   Percentage error in estimation of g will be,

   $\left(\frac{\Delta g}{g} \times 100\right) = \left(\frac{\Delta h}{h} \times 100\right) + 2 \times \left(\frac{\Delta t}{t} \times 100\right)$ ….(i)

   $\frac{\Delta h}{h} \times 100 = e_1$ and $\frac{\Delta t}{t} \times 100 = e_2$ ….(given)

   Substituting in equation (i),

   $\left(\frac{\Delta g}{g} \times 100\right) = e_1 + 2e_2$

6. Given that: $P = \frac{a^3b^2}{cd}$

error contributed by a $= 3 \times \left(\frac{\Delta a}{a} \times 100\right)$

$= 3 \times 1\% = 3\%$

error contributed by b $= 2 \times \left(\frac{\Delta b}{b} \times 100\right)$

$= 2 \times 2\% = 4\%$

error contributed by c $= \left(\frac{\Delta c}{c} \times 100\right) = 3\%$

error contributed by d $= \left(\frac{\Delta d}{d} \times 100\right) = 4\%$

∴ Percentage error in P is given as,

$\frac{\Delta p}{p} \times 100$ = (error contributed by a) + (error contributed by b) + (error contributed by c) + (error contributed by d)

$= 3\% + 4\% + 3\% + 4\%$

$= 14\%$

7. Given: $X = \frac{A^2B^{\frac{1}{2}}}{C^{\frac{1}{3}}D^3}$

Error contributed by A $= 2 \times \left(\frac{\Delta A}{A} \times 100\right)$

$= 2 \times 1\% = 2\%$

Error contributed by B $= \frac{1}{2} \times \left(\frac{\Delta B}{B} \times 100\right)$

$= \frac{1}{2} \times 2\% = 1\%$

Error contributed by C $= \frac{1}{3} \times \left(\frac{\Delta C}{C} \times 100\right)$

$= \frac{1}{3} \times 3\% = 1\%$

Error contributed by D $= 3 \times \left(\frac{\Delta D}{D} \times 100\right)$

$= 3 \times 4\% = 12\%$

∴ Percentage error in x is given as,

$\frac{\Delta x}{x} \times 100$ = (error contributed by A) + (error contributed by B) + (error contributed by C) + (error contributed by D)

$= 2\% + 1\% + 1\% + 12\%$

$= 16\%$

1.4 Significant figures

Performing subtraction we get,

$9.99 - 0.0099 = 9.9801$

But number of significant digits after decimal place in 9.99 is 2 and number of significant digits after decimal place in 0.0099 is also 2. Hence, subtraction carried out should be considered upto 2 significant figures after decimal, i.e., 9.98

1.5 Dimensions of physical quantities

1. Angular momentum (L) = Moment of inertia (I) × Angular velocity (ω).

∴ $[L] = [ML^2]\,[T^{-1}] = [ML^2\,T^{-1}]$

2. Capacitance $= \frac{\text{charge}}{\text{Potential difference}}$

$[C] = \frac{[AT]}{[ML^2T^{-3}A^{-1}]} = [M^{-1}\,L^{-2}\,T^4\,A^2]$

Resistance $R = \frac{\text{Potential difference}}{\text{current}}$

∴ $[R] = \frac{[ML^2T^{-3}A^{-1}]}{[A]} = [ML^2\,T^{-3}\,A^{-2}]$

∴ $[CR] = [M^{-1}\,L^{-2}\,T^4\,A^2]\,[ML^2\,T^{-3}\,A^{-2}] = [T]$

3. Torque (τ) = Force × distance

∴ $[\tau] = [MLT^{-2}]\,[L] = [ML^2\,T^{-2}]$

4. induced emf (e) $= L\frac{dI}{dt}$

∴ $L = \frac{e}{dI/dt} = \frac{w/dq}{dI/dt} = \frac{w}{\frac{dq}{dt}\,dI} = \frac{w}{IdI}$

∴ $[L] = \frac{[w]}{[I][dI]} = \frac{[M^1L^2T^{-2}]}{[A^2]} = [M^1L^2T^{-2}A^{-2}]$

5. Energy per unit volume $= \frac{E}{V} = \frac{[ML^2T^{-2}]}{[L^3]}$

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

Force per unit area $= \frac{F}{A} = \frac{[MLT^{-2}]}{[L^2]}$

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

Product of voltage and charge per unit volume

$= \frac{V \times Q}{\text{Volume}} = \frac{VIt}{\text{Volume}} = \frac{\text{Power} \times \text{Time}}{\text{Volume}}$

∴ $\frac{[ML^2T^{-3}]\,[T]}{[L^3]} = [ML^{-1}T^{-2}]$

Angular momentum = [L]= [mvr] = $[ML^2T^{-1}]$

So angular momentum has different dimensions.

6. $\mu_0 = \frac{2\pi \times \text{force} \times \text{distance}}{\text{current} \times \text{current} \times \text{length}}$

∴ $[\mu_0] = \frac{[MLT^{-2}]\,[L]}{[A][A][L]} = [MLT^{-2}\,A^{-2}]$

7. Pressure $= \frac{\text{Force}}{\text{Area}}$

∴ $[\text{pressure}] = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$

8. $[R] = [M^1L^2T^{-3}A^{-2}]$

$[C] = [M^{-1}L^{-2}T^4A^2]$

∴ $[RC] = [M^1L^2T^{-3}A^{-2}][M^{-1}L^{-2}T^4A^2] = [T]$

9. Relative density, refractive index and Poisson ratio are all ratios of similar quantities, therefore they are dimensionless constants. Gravitational constant is a dimensional constant.

10. $[L] = [M^1L^2T^{-2}A^{-2}]$
$[R] = [M^1L^2T^{-3}A^{-2}]$
∴ $[L]/[R] = \frac{[M^1L^2T^{-2}A^{-2}]}{[M^1L^2T^{-3}A^{-2}]} = [T]$

11. $[\text{impulse}] = [M^1L^1T^{-1}]$
$[\text{linear momentum}] = [M^1L^1T^{-1}]$
$[\text{force}] = [M^1L^1T^{-2}]$
$[\text{angular momentum}] = [M^1L^2T^{-1}]$
∴ impulse and linear momentum have same dimensions.

12. Magnetic flux, $\phi = BA = \left(\frac{F}{Il}\right) A$
$= \left[\frac{[MLT^{-2}][L^2]}{[A]\,[L]}\right]$
$= [ML^2T^{-2}A^{-1}]$

13. $[\text{force}] = [MLT^{-2}]$
$[\text{impulse}] = [MLT^{-1}]$
$[\text{energy}]$ and $[\text{Torque}] = [M^1L^2T^{-2}]$
[Angular momentum] and [Planck's Constant] $= [M^1L^2T^{-1}]$
[elastic modulus] and [Pressure] $= [M^1L^{-1}T^{-2}]$

14. $[\text{Planck's constant}] = \frac{[\text{Energy}]}{[\text{Frequency}]} = \frac{[ML^2T^{-2}]}{[T^{-1}]}$
$= [ML^2T^{-1}]$
[angular momentum] = [Moment of inertia] × [Angular velocity]
$= [ML^2][T^{-1}]$
$= [ML^2T^{-1}]$
$[\text{momentum}] = [M^1L^1T^{-1}]$
$[\text{power}] = [M^1L^2T^{-3}]$
∴ [Planck's constant] = [angular momentum]

15. $F = G\frac{Mm}{R^2}$
∴ $G = \frac{F(R)^2}{Mm}$
∴ $[G] = \frac{[MLT^{-2}][L^2]}{[M][M]} = [M^{-1}L^3T^{-2}]$

16. Unit of Planck's constant (h) is J-s
∴ Dimension of h $= [M^1L^2T^{-2}]\,[T^1] = [M^1L^2T^{-1}]$
Unit of moment of inertia is kg m^2
∴ Dimension of M.I. $= [M^1L^2]$
∴ $\frac{[h]}{[I]} = \frac{[M^1L^2T^{-1}]}{[M^1\,L^2]} = [T^{-1}] = [\text{frequency}]$

17. $R = \frac{V}{I}$
$[V] = \frac{[W]}{[q]} = \frac{[ML^2T^{-2}]}{[IT]}$
∴ $[R] = \frac{[ML^2T^{-2}/IT]}{[I]} = [ML^2T^{-3}I^{-2}]$

18. $[\text{Energy density}] = \frac{[\text{Work done}]}{[\text{Volume}]} = \frac{[MLT^{-2}L]}{[L^3]}$
$= [ML^{-1}T^{-2}]$
Refractive index and dielectric constant are dimensionless quantities
$[\text{Magnetic field}] = [M^1T^{-2}I^{-1}]$
$[\text{Young's modulus}] = [ML^{-1}T^{-2}]$
∴ Energy density and young's modulus have same dimensions.

19. $P = \frac{\text{force}}{\text{area}} = \frac{\text{mass} \times \text{acceleration}}{\text{area}}$
∴ $[P] = \frac{[M^1L^1T^{-2}]}{[L^2]} = [M^1L^{-1}T^{-2}]$
∴ $a = 1,\ b = -1,\ c = -2$

20. Energy density of an electric field E is
$u_E = \frac{1}{2}\varepsilon_0E^2$
where ε_0 is permittivity of free space
$u_E = \frac{\text{Energy}}{\text{Volume}} = \frac{[ML^2\,T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$
Hence, the dimensions of $\frac{1}{2}\varepsilon_0E^2$ is $[ML^{-1}T^{-2}]$

21. $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}} = (\mu_0\varepsilon_0)^{-1/2}$
∴ $(\mu_0\varepsilon_0)^{-1/2} = [c] = [LT^{-1}]$

22. $[\text{Stress}] = \frac{[F]}{[A]}$
$= \frac{[M^1L^1T^{-2}]}{[L^2]} = [M^1L^{-1}T^{-2}]$

1.6 Dimensional analysis and its applications

1. $[F] = [MLT^{-2}]$
$\left[\frac{\Delta v}{\Delta Z}\right] = \frac{[LT^{-1}]}{[L]} = [T^{-1}]$
∴ Dimensional formula for coefficient of viscosity,
$\eta = \frac{F}{(A)\left(\frac{\Delta v}{\Delta Z}\right)} = \frac{[MLT^{-2}]}{[L^2][T^{-1}]} = [ML^{-1}T^{-1}]$

2. $f = am^x k^y$

Dimensions of frequency $f = [M^0L^0T^{-1}]$

Dimensions of constant $a = [M^0L^0T^0]$

Dimensions of mass $m = [M]$

Dimensions of spring constant $k = [MT^{-2}]$

Putting these values in equation (i), we get

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

Applying principle of homogeneity of dimensions, we get

$x + y = 0$ ….(i)

$-2y = -1$ ….(ii)

$\therefore$ $y = \frac{1}{2}, x = -\frac{1}{2}$

3. given that, $P^x S^y c^z$ is dimensionless

$\therefore$ $[P]^x [S]^y [c]^z = [M^0 L^0 T^0]$

$\therefore$ $[P] = \frac{\text{Force}}{\text{Area}} = \frac{[MLT^{-2}]}{[L^2]} = [M L^{-1} T^{-2}]$

$[S] = \frac{\text{Energy}}{\text{Area} \times \text{time}} = \frac{[ML^2T^{-2}]}{[L^2][T]} = [M T^{-3}]$

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

$\therefore$ $[M^0 L^0 T^0] = [ML^{-1} T^{-2}]^x [MT^{-3}]^y [LT^{-1}]^z$ ….(i)

Applying the principle of homogeneity of dimensions, we get

$x + y = 0$ ….(ii)

$-x + z = 0$ ….(iii)

$-2x - 3y - z = 0$ ….(iv)

Solving (ii), (iii) and (iv), we get

$x = 1, y = -1, z = 1$

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

$[r] = [L]$

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

$[l] = [L]$

$\therefore$ $[\eta] = \frac{[P][r^2 - x^2]}{[v][l]} = \frac{[ML^0T^{-2}][L^0]}{[LT^0][L]}$

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

5. $p = p_0 e^{-\alpha t^2}$

αt^2 is dimensionless

$\therefore$ $\alpha = \frac{1}{t^2} = \frac{1}{[T^2]} = [T^{-2}]$

6. $\left(P + \frac{a}{V^2}\right) = b\frac{\theta}{V}$ Since $\frac{a}{V^2}$ is added to the pressure,

$[P] = \frac{[a]}{[V^2]}$

$\therefore$ $[a] = [P]\,[v^2]$

$\therefore$ $[a] = [ML^{-1}T^{-2}]\,[L^6]$

$\therefore$ $[a] = [ML^5T^{-2}]$

7. $v = at + \frac{b}{t + c}$

As c is added to time t, therefore, c must have the dimensions of time [T].

From $v = at$, $a = \frac{v}{t}$

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

From $[t + c] = [T] = [c]$,

$[T] = [c]$

From $[v] = \left[\frac{b}{t + c}\right]$,

$[b] = [v][t] = [LT^{-1}]\,[T]$

$[b] = [L]$

$\therefore$ Dimensions of a, b, c are $[LT^{-2}]$, [L] and [T] respectively.

8. $n_2 = n_1\left(\frac{M_1}{M_2}\right)^1\left(\frac{L_1}{L_2}\right)^{-3}$

$= 4\left(\frac{gm}{kg}\right)^1\left(\frac{cm}{m}\right)^{-3}$

$= 4\left(\frac{gm}{100gm}\right)^1\left(\frac{cm}{10cm}\right)^{-3}$

$\therefore$ $n_2 = \frac{4}{0.1} = 40$

9. Let $m \propto F^x V^y T^z$

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

equating powers on both sides, we get,

$x = 1$ ….(i)

$x + y = 0$ ….(ii)

$-2x - y + z = 0$ ….(ii)

From equations (i),(ii) and (iii)

$x = 1$, $y = -1$, $z = 1$

$\therefore$ $[m] = [F^1V^{-1}T^1]$

10. Surface tension (T) is given as,

$[T] = \left[\frac{F}{L}\right]$

where, {F ≡ force, L ≡ length}

But energy $[E] = [F][L]$

$\therefore$ $[F] = \left[\frac{E}{L}\right]$

$\therefore$ $[T] = \left[\frac{E}{L^2}\right]$

But velocity $[V] = \left[\frac{L}{T}\right]$

$\therefore$ $[L] = [VT]$

$\therefore$ $[T] = \left[\frac{E}{V^2T^2}\right]$

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

11. $[v_c] = [\eta^x \rho^y r^z]$

$[M^0 L^1 T^{-1}] = [M^1 L^{-1} T^{-1}]^x [M^1 L^{-3}]^y [L^1]^z$

$[M^0 L^1 T^{-1}] = [M^{x+y}] [L^{-x-3y+z}] [T^{-x}]$

Comparing both sides,

$x + y = 0, -x - 3y + z = 1, -x = -1$

$\therefore$ $x = 1, y = -1, z = -1$

12. $[G] = [M^{-1} L^3 T^{-2}]$

$[c] = [M^0 L^1 T^{-1}]$

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

Now, let the relation between given quantities and length be,

$L = G^x c^y h^z$

$\therefore$ $[L^1] = [M^{-1} L^3 T^{-2}]^x [M^0 L^1 T^{-1}]^y [M^1 L^2 T^{-1}]^z$

$\therefore$ We get,

$-x + z = 0$

i.e. $z = x$ ….(i)

$3x + y + 2z = 1$ ....(ii)

$-2x - y - z = 0$ ….(iii)

$\therefore$ $y = -3x$ ….[from (i) and (iii)]

Substituting the value in eq. (ii)

$\therefore$ $3x - 3x + 2z = 1$

i.e. $z = \frac{1}{2}$

Substituting this value we get,

$x = \frac{1}{2}$ and $y = \frac{-3}{2}$

$\therefore$ $L = \frac{\sqrt{hG}}{c^{3/2}}$

13. Let the physical quantity formed of the dimensions of length be given as,

$[L] = [c]^x [G]^y \left[\frac{e^2}{4\pi\varepsilon_0}\right]^z$ ….(i)

Now,

Dimensions of velocity of light $[c]^x = [LT^{-1}]^x$

Dimensions of universal gravitational constant $[G]^y = [M^{-1} L^3 T^{-2}]^y$

Dimensions of $\left[\frac{e^2}{4\pi\varepsilon_0}\right]^z = [ML^3T^{-2}]^z$

Substituting these in equation (i)

$[L] = [LT^{-1}]^x [M^{-1}L^3T^{-2}]^y [ML^3T^{-2}]^z$

$= [L^{x+3y+3z} M^{-y+z} T^{-x-2y-2z}]$

Solving for x, y, z

$x + 3y + 3z = 1$

$-y + z = 0$

$x + 2y + 2z = 0$

Solving the above equations,

$x = -2, y = \frac{1}{2}, z = \frac{1}{2}$

$\therefore$ $L = \frac{1}{c^2} \left[G \frac{e^2}{4\pi\varepsilon_0}\right]^{\frac{1}{2}}$