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As per latest syllabus prescribed by NMC

NEET (UG)

PHYSICS

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NEET PHYSICS

Salient Features

- A compilation of 37 years of AIPMT/NEET questions (1988-2024) that aligns with the most recent syllabus
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- Includes ‘1700+’ AIPMT/NEET MCQs
- Contains Questions from examinations conducted twice in a year:
  - 2013 (Karnataka)
  - 2015 (Re-Test)
  - 2016 (Phase II)
  - 2019 (Odisha)
  - 2020 (Phase II)
  - 2023 (Manipur)
- Chapter-wise and Topic-wise segregation of questions
- Year-wise flow of content concluded with the latest questions
- Solutions provided wherever required
- Graphical representation for trend analysis of questions: Chapter-wise and Topic-wise

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PREFACE

Target's **'NEET Physics: PSP (Previous Solved Papers)'** is a compilation of questions asked in the past 37 years (1988-2024) in the National Eligibility cum Entrance Test (NEET), formerly known as the All India Pre-Medical Test (AIPMT). The book is updated as per the latest syllabus of NEET (UG) examination.

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

A graphical (% wise) analysis of the topics for the past 37 years as well as 12 years (2013 onwards) has been provided at the onset of every chapter. Both the graphs will help the students to understand and analyse each topic's distribution for NEET/AIPMT (37 years) and NEET (UG) (12 Years).

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

The journey to create a complete book is strewn with triumphs, failures and near misses. If you think we've nearly missed something or want to applaud us for our triumphs, we'd love to hear from you.
Please write to us on: mail@targetpublications.org

A book affects eternity; one can never tell where its influence stops.

Best of luck to all the aspirants!

Publisher

Edition: Sixth

Frequently Asked Questions

Why this book?

- This book acts as a go-to tool to find all the AIPMT/NEET questions since the past 37 years at one place.
- The topic 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 majorly remained the same, the chances of a question being asked from a particular topic are 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 chapter can vary i.e., a particular topic having the most weightage for AIPMT may not necessarily be the topic with the most weightage for NEET.

How are the two graphs beneficial to the students?

- The two graphs provide a topic's weightage distribution over the past 37 years (for NEET/AIPMT) and over the past 12 years (for NEET-UG).
- The students can use these graphs as a self-evaluation tool by analysing and comparing a particular topic's weightage with their preparation of the topic. This exercise would help the students to get a clear picture about their strength and weakness based on the topics.
- Students can also use the graphs as a source to know the most important as well as least important topics as per weightage of a particular chapter which will further help them in planning the study structure of a particular chapter.

  (Note: The percentage-wise weightage analysis of topics is solely for the knowledge of students and does not guarantee questions from topics having the most weightage, in the future exams. Question classification of a topic is done as per the authors' discretion and may vary with respect to another individual.)

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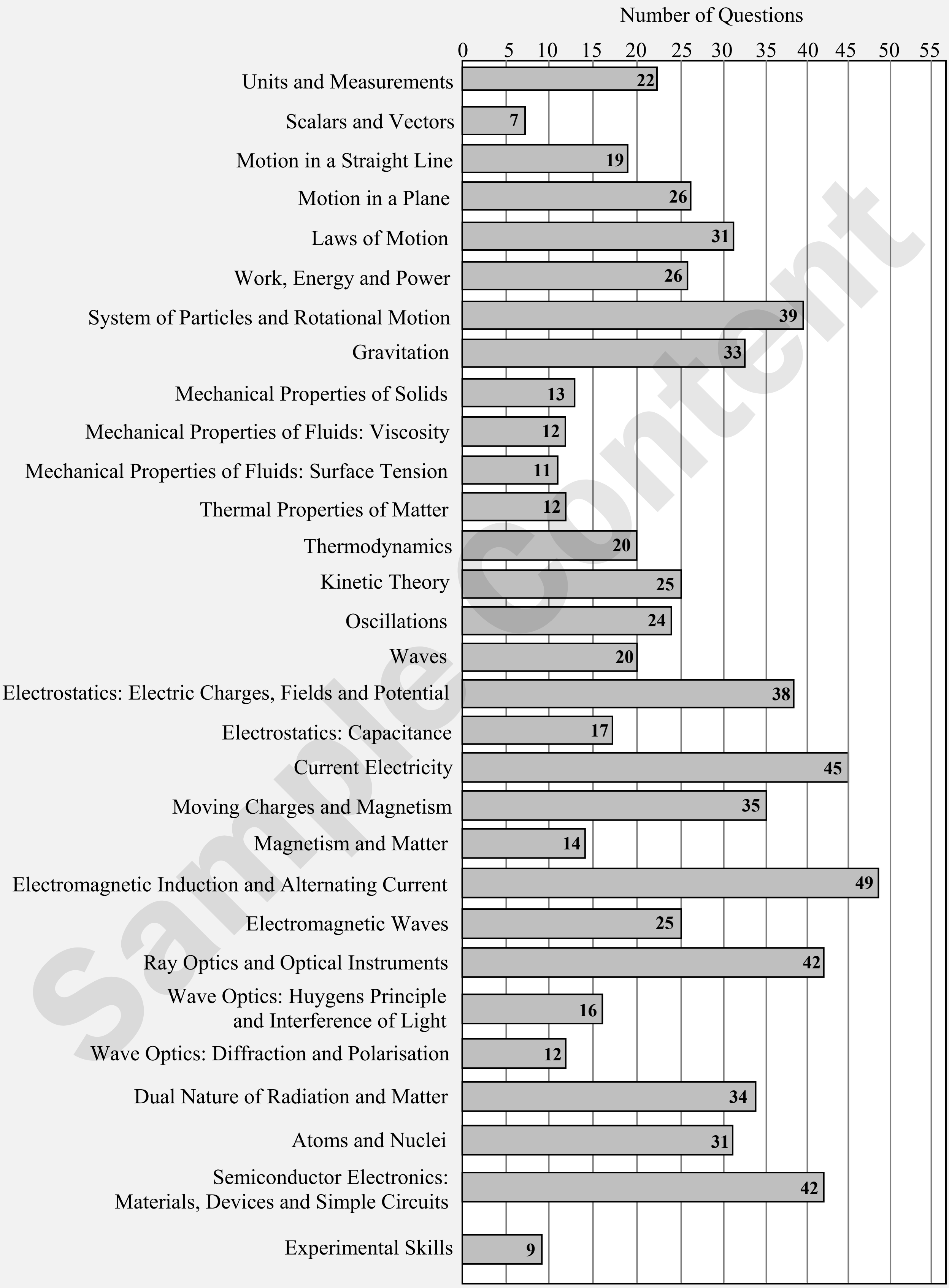
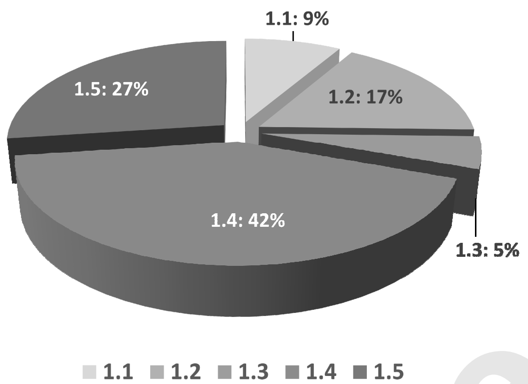
Chapter-wise Weightage Analysis of past 12 Years (2013 Onwards)



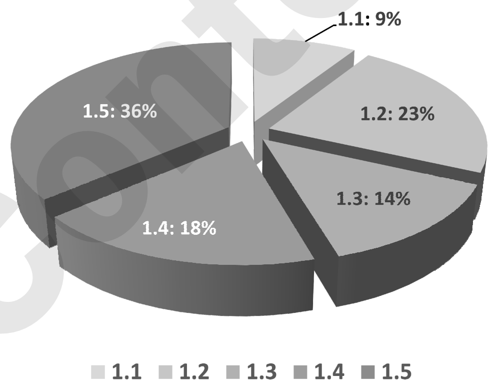
Total No. of Questions: 765

1 Units and Measurement

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



12 Years NEET Analysis (2013 Onwards) (Percentage-wise weightage of 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

4. The angle of 1′ (minute of arc) in radian is nearly equal to **[Phase-II 2020]**
   (A) 1.75×10^{-2} rad (B) 2.91×10^{-4} rad
   (C) 4.85×10^{-4} rad (D) 4.80×10^{-6} rad

5. Plane angle and solid angle have: **[2022]**
   (A) No units and no dimensions
   (B) Both units and dimensions
   (C) Units but no dimensions
   (D) Dimensions but no units

1.2 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 %

8. Time intervals measured by a clock give the following readings:
1.25 s, 1.24 s, 1.27 s, 1.21 s and 1.28 s
What is the percentage relative error of the observations? **[Phase-II 2020]**
(A) 1.6 % (B) 2 %
(C) 4 % (D) 16 %

9. The errors in the measurement which arise due to unpredictable fluctuations in temperature and voltage supply are: **[2023]**
(A) Personal errors
(B) Least count errors
(C) Random errors
(D) Instrumental errors

10. A metal wire has mass (0.4 ± 0.002) g, radius (0.3 ± 0.001) mm and length (5 ± 0.02) cm. The maximum possible percentage error in the measurement of density will nearly be: **[2023]**
(A) 1.3 % (B) 1.6 %
(C) 1.4 % (D) 1.2 %

1.3 Significant figures

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

2. The area of a rectangular field (in m^2) of length 55.3 m and breadth 25 m after rounding off the value for correct significant digits is: **[2022]**
(A) 1382.5 (B) 14×10^2
(C) 138×10^1 (D) 1382

3. The diameter of a spherical bob, when measured with vernier callipers yielded the following values: 3.33 cm, 3.32 cm, 3.34 cm, 3.33 cm and 3.32 cm. The mean diameter to appropriate significant figures is: **[Manipur 2023]**
(A) 3.33 cm (B) 3.32 cm
(C) 3.328 cm (D) 3.3 cm

1.4 Dimensions of physical quantities

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

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

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

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) $[M^0 L^1 T]$
   (C) $[M^0 L^2 T^{-1} A^2]$ (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) i and iv (B) i and v
   (C) ii and iv (D) iii and v

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, 2011]**
   (A) $[L^{1/2}T^{-1/2}]$ (B) $[L^{-1}T]$
   (C) $[LT^{-1}]$ (D) $[L^{1/2}T^{1/2}]$

22. The pair of quantities having same dimensions is: **[Karnataka 2013]**
   (A) Impulse and Surface Tension
   (B) Angular momentum and Work
   (C) Work and Torque
   (D) Young's Modulus and Energy

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

24. The mechanical quantity, which has dimensions of reciprocal of mass (M^{-1}) is: **[Manipur 2023]**
(A) torque
(B) gravitational constant
(C) angular momentum
(D) coefficient of thermal conductivity

25. The quantities which have the same dimensions as those of solid angle are: **[2024]**
(A) strain and arc
(B) angular speed and stress
(C) strain and angle
(D) stress and angle

1.5 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 **[2011]**
(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) $[FV^{-1}T^{-1}]$ (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) $[E V^{-2}T^{-1}]$ (B) $[E V^{-1}T^{-2}]$
(C) $[E V^{-2}T^{-2}]$ (D) $[E^{-2}V^{-1}T^{-3}]$

11. In dimension of critical velocity v_c, of liquid following through a tube are expressed as $(\eta^x\rho^yr^z)$, 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) $\frac{1}{c}\,G\frac{e^2}{4\pi\varepsilon_0}$

14. If E and G respectively denote energy and gravitational constant, then $\frac{E}{G}$ has the dimensions of: **[2021]**

(A) $[M] [L^{-1}] [T^{-1}]$ (B) $[M] [L^0] [T^0]$
(C) $[M^2] [L^{-2}] [T^{-1}]$ (D) $[M^2] [L^{-1}] [T^0]$

15. If force [F], acceleration [A] and time [T] are chosen as the fundamental physical quantities. Find the dimensions of energy. **[2021]**

(A) $[F][A][T^2]$ (B) $[F][A][T^{-1}]$
(C) $[F][A^{-1}][T]$ (D) $[F][A][T]$

16. A force defined by $F = \alpha t^2 + \beta t$ acts on a particle at a given time t. The factor which is dimensionless, if α and β are constants, is: **[2024]**

(A) $\alpha\beta t$ (B) $\frac{\alpha\beta}{t}$
(C) $\frac{\beta t}{\alpha}$ (D) $\frac{\alpha t}{\beta}$

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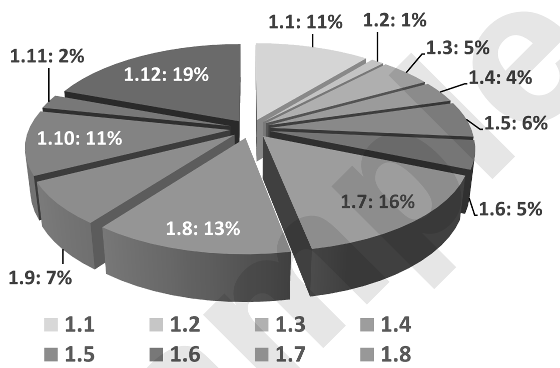
To see complete chapter buy **Target Notes** or **Target E-Notes**

1 Electrostatics: Electric Charges, Fields and Potential

1.1 Coulomb's law – force between two point charges
1.2 Superposition principle, Forces between multiple charges
1.3 Continuous distribution of charges
1.4 Electric field, Electric field lines, Electric field due to a point charge
1.5 Electric dipole and electric field due to a dipole
1.6 Torque on a dipole in uniform electric field, Work of an electric dipole
1.7 Electric potential and potential difference
1.8 Electric potential due to a point charge, a dipole and a system of charges
1.9 Equipotential surface
1.10 Electric potential energy of a system of two point charges and of electric dipoles in electrostatic field
1.11 Electric flux
1.12 Gauss' theorem and its applications

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



12 Years NEET Analysis (2013 Onwards)
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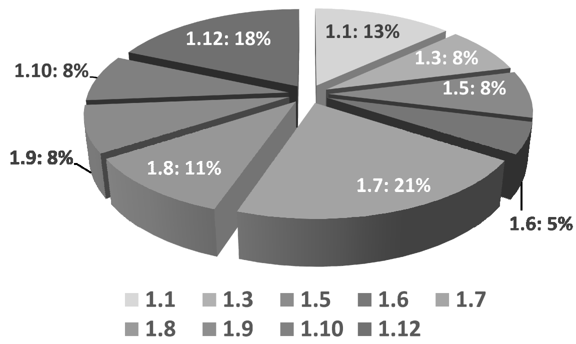

1.1 Coulomb's law – force between two point charges

1. A charge q is placed at the centre of the line joining two exactly equal positive charges Q. The system of three charges will be in equilibrium, if q is equal to **[1995]**
   (A) – Q (B) Q/2
   (C) – Q/4 (D) + Q

2. When air is replaced by a dielectric medium of constant k, the maximum force of attraction between two charges separated by a distance **[1999]**
   (A) decreases k times.
   (B) remains unchanged.
   (C) increases k times.
   (D) increases k^{-1} times.

3. An electron is moving round the nucleus of a hydrogen atom in a circular orbit of radius r. The Coulomb force $\vec{F}$ between the two is **[2003]**
   (A) $K\dfrac{e^2}{r^2}\hat{r}$ (B) $-K\dfrac{e^2}{r^3}\hat{r}$
   (C) $K\dfrac{e^2}{r^3}\vec{r}$ (D) $-K\dfrac{e^2}{r^3}\vec{r}$
   $\left(\text{Where } K = \dfrac{1}{4\pi\varepsilon_0}\right)$

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To see complete chapter buy **Target Notes** or **Target E-Notes**

Std. XI

1. Units and Measurement

1.1 Fundamental and derived units

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

2. **(C)**
$F = \frac{1}{4\pi\varepsilon_0} \frac{Q_1Q_2}{r^2}$
$\therefore \quad \varepsilon_0 \propto \frac{Q^2}{F \times r^2}$
So ε_0 has units of coulomb^2/ newton m^2

3. **(C)**
$F \propto v$ or $F = kv$
where k is the constant of proportionality
$\therefore \quad k = \frac{F}{v} = \frac{N}{ms^{-1}} = \frac{kg\ ms^{-2}}{ms^{-1}} = kgs^{-1}$

4. **(B)**
$\theta = 1' = \left(\frac{1}{60}\right)^\circ = \left(\frac{1}{60}\right) \times \left(\frac{\pi}{180}\right)$ radian
$= 2.91 \times 10^{-4}$ radian

5. **(C)**

1.2 Errors in measurement

1. **(B)**
Density $(\rho) = \frac{\text{mass (m)}}{\text{volume (V)}}$ ….(i)
Percentage error in density is given by,
$\frac{\Delta\rho}{\rho} \times 100 = \left(\frac{\Delta m}{m} + \frac{\Delta v}{v}\right) \times 100$
$\therefore \quad \frac{\Delta\rho}{\rho} \times 100 = \left[\frac{\Delta m}{m} + \frac{\Delta v}{v}\right] \times 100\%$
$= \left[\frac{0.01}{22.42} + \frac{0.1}{4.7}\right] \times 100\% = 2\%$

2. **(A)**
K.E. $= \frac{1}{2}mv^2$
The percentage error in measurement of kinetic energy is,
$\frac{\Delta K.E.}{K.E.} \times 100 = \left[\frac{\Delta m}{m} + 2 \times \frac{\Delta v}{v}\right]\%$
$= [2 + (2 \times 3)]\ \% = 8\%$

3. **(D)**
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. **(D)**
$V = \frac{4}{3}\pi R^3$;
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
$= 3 \times 2\% = 6\%$

5. **(B)**
$h = ut + \frac{1}{2}gt^2$
$\therefore \quad h = \frac{1}{2}gt^2 \Rightarrow g = \frac{2h}{t^2}$
($\because$ 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. **(A)**
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 $= \left(\frac{\Delta d}{d} \times 100\right) = 4\%$
$\therefore$ 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. **(D)**

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

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)

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

$= 16\%$

8. **(A)**

Mean value,

$t_m = \frac{t_1 + t_2 + t_3 + t_4 + t_5}{5}$

$t_m = \frac{1.25 + 1.24 + 1.27 + 1.21 + 1.28}{5}$

$t_m = 1.25$ s

Mean absolute error,

$\Delta t_m = \frac{|t_m - t_1| + |t_m - t_2| + |t_m - t_3| + |t_m - t_4| + |t_m - t_5|}{5}$

$\Delta t_m = \frac{0 + 0.01 + 0.02 + 0.04 + 0.03}{5} = 0.02$

Percentage error $= \frac{\Delta t_m}{t_m} \times 100 = \frac{0.02}{1.25} \times 100$

$= 1.6\ \%$

9. **(C)**

10. **(B)**

The density of a metal wire is given by,

$\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{m}{\pi r^2 l}$

The relative error in density is,

$\frac{\Delta\rho}{\rho} = \frac{\Delta m}{m} + 2\frac{\Delta r}{r} + \frac{\Delta l}{l}$

$= \left(\frac{0.002}{0.4} + \frac{2 \times 0.001}{0.3} + \frac{0.02}{5}\right)$

∴ $\frac{\Delta\rho}{\rho} = (0.005) + (0.0067) + (0.004) = 0.0157$

$\frac{\Delta\rho}{\rho} \times 100 = 0.0157 \times 100$

$\frac{\Delta\rho}{\rho}\ \% = 1.57\% \approx 1.6\%$

1.3 Significant figures

1. **(A)**

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

2. **(B)**

Area = length × breadth = $55.3 \times 25 = 1382.5\ m^2$

According to rules for significant figures, the final answer must have as many significant figures as that of the number with least significant figures.

The value of the area correct upto 2 significant figures is,

$A = 14 \times 10^2\ m^2$

3. **(A)**

Mean diameter

$= \frac{(3.33 + 3.32 + 3.34 + 3.33 + 3.32)}{5}$

= 3.328 cm

After rounding off to 2 decimal places,

mean diameter = 3.33 cm

1.4 Dimensions of physical quantities

1. **(D)**

Angular momentum (L)

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

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

2. **(A)**

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. **(A)**

Torque (τ) = Force × distance

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

4. **(C)**

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. **(D)**

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

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

Angular momentum = [L]= [mvr] = $[ML^2T^{-1}]$
So angular momentum has different dimensions.

6. **(A)**

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

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

7. **(B)**

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

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

8. **(C)**

$[R] = [M^1L^2T^{-3}A^{-2}]$
$[C] = [M^{-1}L^{-2}T^4A^2]$
$\therefore [RC] = [M^1L^2T^{-3}A^{-2}][M^{-1}L^{-2}T^4A^2] = [T]$

9. **(B)**

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. **(A)**

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

11. **(B)**

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

12. **(C)**

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. **(B)**

[force] $= [MLT^{-2}]$
[impulse] $= [MLT^{-1}]$
[energy] and [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. **(C)**

[Planck's constant] $= \frac{[\text{Energy}]}{[\text{Frequency}]} = \frac{[ML^2T^{-2}]}{[T^{-1}]}$
$= [ML^2T^{-1}]$

[angular momentum] = [Moment of inertia] × [Angular velocity]
$= [ML^2][T^{-1}]$
$= [ML^2T^{-1}]$

[momentum] $= [M^1L^1T^{-1}]$
[power] $= [M^1L^2T^{-3}]$
$\therefore$ [Planck's constant] = [angular momentum]

15. **(A)**

$F = G\frac{Mm}{R^2}$

$\therefore G = \frac{F(R)^2}{Mm}$

$\therefore [G] = \frac{[MLT^{-2}][L^2]}{[M][M]} = [M^{-1}L^3T^{-2}]$

16. **(B)**

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

17. **(C)**

$R = \frac{V}{I}$

$[V] = \frac{[W]}{[q]} = \frac{[ML^2T^{-2}]}{[IT]}$

$\therefore [R] = \frac{[ML^2T^{-2}/IT]}{[I]} = [ML^2T^{-3}I^{-2}]$

18. **(A)**

[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

[Magnetic field] = $[M^1T^{-2}I^{-2}]$
[Young's modulus] = $[ML^{-1}T^{-2}]$
$\therefore$ Energy density and young's modulus have same dimensions.

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

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

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

22. **(C)**
$W = Fs = ML^2T^{-2}$
$\tau = r \times F = ML^2T^{-2}$

23. **(C)**
$[\text{Stress}] = \frac{[F]}{[A]} = \frac{[M^1L^1T^{-2}]}{[L^2]} = [M^1L^{-1}T^{-2}]$

24. **(B)**
We know that, $F = \frac{GM_1M_2}{r^2}$
$\therefore$ $[G] = \frac{[F][r^2]}{[M_1][M_2]} = [M^{-1}L^3T^{-2}]$
i.e., gravitational constant has dimensions of reciprocal of mass $[M^{-1}]$.

25. **(C)**
Solid angle = dimensionless
Strain and angle = dimensionless

1.5 Dimensional analysis and its applications

1. **(D)**
$[F] = [MLT^{-2}]$
$\left[\frac{\Delta v}{\Delta Z}\right] = \frac{[LT^{-1}]}{[L]} = [T^{-1}]$
$\therefore$ 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. **(D)**
$f = am^xk^y$
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. **(C)**
given that, $P^x S^y c^z$ is dimensionless
$\therefore$ $[P]^x [S]^y [c]^z = [M^0 L^0 T^0]$
$\therefore$ $[P] = \frac{\text{Force}}{\text{Area}} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$
$[S] = \frac{\text{Energy}}{\text{Area} \times \text{time}} = \frac{[ML^2T^{-2}]}{[L^2][T]} = [MT^{-3}]$
$[c] = [LT^{-1}]$
$\therefore$ $[M^0 L^0 T^0] = [ML^{-1} T^{-2}]^x [MT^{-3}]^y [LT^{-1}]^z$ ….(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. **(D)**
$[P] = [ML^{-1}T^{-2}]$
$[r] = [L]$
$[v] = [LT^{-1}]$
$[l] = [L]$
$\therefore$ $[\eta] = \frac{[P][r^2 - x^2]}{[4vl]} = \frac{[ML^0T^{-2}][L^0]}{[LT^0][L]} = [ML^{-1}T^{-1}]$

5. **(B)**
$p = p_0e^{-\alpha t^2}$
αt^2 is dimensionless
$\therefore$ $\alpha = \frac{1}{t^2} = \frac{1}{[T^2]} = [T^{-2}]$

6. **(C)**
$\left(P + \frac{a}{V^2}\right) = b\frac{\theta}{V}$
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. **(D)**
$v = at + \frac{b}{t+c}$
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]
∴ Dimensions of a, b, c are $[LT^{-2}]$, [L] and [T] respectively.

8. **(C)**
$n_2 = n_1 \left(\frac{M_1}{M_2}\right)^1 \left(\frac{L_1}{L_2}\right)^{-3}$
$= 4 \left(\frac{gm}{kg}\right)^1 \left(\frac{cm}{m}\right)^{-3}$
$= 4 \left(\frac{gm}{100gm}\right)^1 \left(\frac{cm}{10cm}\right)^{-3}$
∴ $n_2 = \frac{4}{0.1} = 40$

9. **(D)**
Let $m \propto F^x V^y T^z$
∴ $[M^1] = [M^1L^1T^{-2}]^x [L^1T^{-1}]^y \; [T^1]^z$
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)
$x = 1$, $y = -1$, $z = 1$
∴ $[m] = [F^1V^{-1}T^1]$

10. **(C)**
Surface tension (T) is given as,
$[T] = \left[\frac{F}{L}\right]$
where, {F ≡ force, L ≡ length}
But energy [E] = [F][L]
∴ $[F] = \left[\frac{E}{L}\right]$
∴ $[T] = \left[\frac{E}{L^2}\right]$
But velocity $[V] = \left[\frac{L}{T}\right]$
∴ [L] = [VT]
∴ $[T] = \left[\frac{E}{V^2T^2}\right] = [EV^{-2}T^{-2}]$

11. **(B)**
$[v_c] = [\eta^x\rho^yr^z]$
$[M^0\, L^1T^{-1}] = [M^1L^{-1}T^{-1}]^x\, [M^1L^{-3}]^y[L^1]^z$
$[M^0L^1T^{-1}] = [M^{x+y}]\, [L^{-x-3y+z}][T^{-x}]$
Comparing both sides,
x + y = 0, –x – 3y + z = 1, –x = –1
∴ x = 1, y = –1, z = –1

12. **(B)**
$[G] = [M^{-1}\, L^3\, T^{-2}]$
$[c] = [M^0\, L^1\, T^{-1}]$
$[h] = [M^1\, L^2\, T^{-1}]$
Now, let the relation between given quantities and length be,
$L = G^x c^y h^z$
∴ $[L^1] = [M^{-1}\, L^3\, T^{-2}]^x\, [M^0\, L^1\, T^{-1}]^y\, [M^1\, L^2\, T^{-1}]^z$
∴ We get,
–x + z = 0
i.e. z = x ….(i)
3x + y + 2z = 1 ....(ii)
–2x – y – z = 0 ….(iii)
∴ y = – 3x ….[from (i) and (iii)]
Substituting the value in eq. (ii)
∴ 3x – 3x + 2z = 1
i.e. $z = \frac{1}{2}$
Substituting this value we get,
$x = \frac{1}{2}$ and $y = \frac{-3}{2}$
∴ $L = \frac{\sqrt{hG}}{c^{3/2}}$

13. **(A)**
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 $[G]^y = [M^{-1}L^3T^{-2}]^y$
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,
$x = -2$, $y = \frac{1}{2}$, $z = \frac{1}{2}$
∴ $L = \frac{1}{c^2} \left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{\frac{1}{2}}$

14. **(D)**
Unit of energy (E) = $\frac{kg\,m^2}{s^2}$
Unit of gravitational constant (G) = $\frac{m^3}{s^2 kg}$
∴ Unit of $\left(\frac{E}{G}\right) = \frac{kg\,m^2}{s^2} \times \frac{s^2 kg}{m^3} = \frac{kg^2}{m}$
∴ Dimension of $\left(\frac{E}{G}\right) = [M^2L^{-1}T^0]$

15. **(A)**
Using dimensional analysis,
$E \propto [F]^a[A]^b[T^2]^c$
$[M^1][L^2][T^{-2}] \propto [M^1L^1T^{-2}]^a \; [LT^{-2}]^b \, [T]^c$
Comparing, $a = 1$, $a + b = 2 \Rightarrow b = 1$,
$-2a - 2b + c = -2 \Rightarrow c = 2$
$\therefore$ $a = 1$, $b = 1$, $c = 2$
$\therefore$ $E \propto [F][A][T^2]$

16. **(D)**
Using dimensional analysis, we get
$[\alpha t^2] = [F]$
$\therefore$ $[\alpha] = \left[\dfrac{MLT^{-2}}{T^2}\right] = [MLT^{-4}]$
and $[\beta t] = [F]$
$[\beta] = \dfrac{MLT^{-2}}{T} = [MLT^{-3}]$
$\therefore$ $\dfrac{\alpha t}{\beta} = \dfrac{[MLT^{-4}][T]}{[MLT^{-3}]} = [M^0L^0T^0]$
Hence, quantity in option (D) is dimensionless.

2. Scalars and Vectors

2.1 Scalars and vectors

1. **(B)**
Angular momentum has both magnitude and direction, therefore is a vector quantity

2. **(A)**

2.2 Resolution of vectors

1. **(B)**
Magnitude of vector = 1
$\sqrt{a_x^2 + a_y^2 + a_z^2} = 1$
$\therefore$ $\sqrt{0.5^2 + 0.8^2 + c^2} = 1$
$\sqrt{c^2 + 0.89} = 1$
$\therefore$ $c^2 = 0.11$
$\therefore$ $c = \sqrt{0.11}$

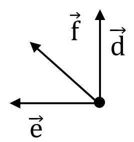
2. **(D)**
$\vec{R} = 4\sin(2\pi t)\,\hat{i} + 4\cos 2\pi t\,\hat{j}$
$\vec{v} = \dfrac{d\vec{R}}{dt} = 8\pi\cos 2\pi t\hat{i} - 8\pi\sin 2\pi t\hat{j}$
$|\vec{v}| = \sqrt{v_x^2 + v_y^2}$
$= \sqrt{(8\pi\cos 2\pi t)^2 + (-8\pi\sin 2\pi t)^2}$
$= 8\pi$ m/s

2.3 Addition and subtraction of vectors

1. **(C)**
$|\vec{A} + \vec{B}| = |\vec{A}| + |\vec{B}|$ when $(\vec{A} \| \vec{B})$.
$\therefore$ $\theta = 0°$.

2. **(B)**
$\vec{u} = (3\hat{i} + 4\hat{j})$, $\vec{a} = 0.4\hat{i} + 0.3\hat{j}$, t = 10 s
$\vec{v} = \vec{u} + \vec{a}t$
$\therefore$ $\vec{v} = (3\hat{i} + 4\hat{j}) + (0.4\hat{i} + 0.3\hat{j})(10)$
$= 3\hat{i} + 4\hat{j} + 4\hat{i} + 3\hat{j} = 7\hat{i} + 7\hat{j}$
Speed of the particle after 10 s
$= |\vec{v}| = \sqrt{(7)^2 + (7)^2} = 7\sqrt{2}$ units

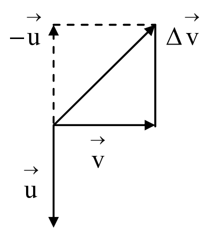
3. **(C)**
Two non – zero vectors ($\vec{d}$ and $\vec{e}$) are represented y two adjacent sides of a parallelogram, then the resultant ($\vec{f}$) is the diagonal of the parallelogram passing through the point of intersection of two vectors.



4. **(B)**
Here, $\vec{u} = 2\hat{i} + 3\hat{j}$, $\vec{a} = 0.3\hat{i} + 0.2\hat{j}$, t = 10s
$\vec{v} = \vec{u} + \vec{a}t$
$\therefore$ $\vec{v} = (2\hat{i} + 3\hat{j}) + (0.3\hat{i} + 0.2\hat{j}) \times 10$
$= 2\hat{i} + 3\hat{j} + 3\hat{i} + 2\hat{j} = 5\hat{i} + 5\hat{j}$
$|\vec{v}| = \sqrt{(5)^2 + (5)^2} = 5\sqrt{2}$ units

5. **(D)**
As $|\vec{A} + \vec{B}| = |\vec{A} - \vec{B}|$,
$\therefore$ $A^2 + B^2 + 2AB\cos\theta = A^2 + B^2 - 2AB\cos\theta$
$\therefore$ $4AB\cos\theta = 0$, i.e. $\cos\theta = 0 = \cos 90°$
$\therefore$ $\theta = 90°$

6. **(B)**
Initial velocity = $\vec{u} = u(-\hat{j})$
Final velocity = $\vec{v} = v\,(\hat{i})$
$\therefore$ $\Delta\vec{v} = \vec{v} - \vec{u} = v\hat{i} + u\hat{j}$
$\therefore$ The direction is $(\hat{i} + \hat{j})$
i.e., along north-east.



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To see complete chapter buy **Target Notes** or **Target E-Notes**

Std. XII

1. Electrostatics: Electric Charges, Fields and Potential

1.1 Coulomb's law – force between two point charges

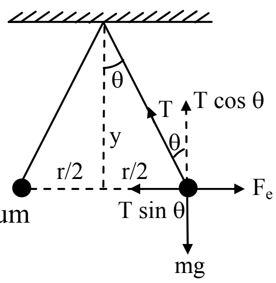
1. **(C)**
For equilibrium, net force on Q = 0
$\therefore \frac{KQQ}{(2x)^2} + \frac{KqQ}{x^2} = 0$
$\therefore \frac{K}{x^2}\left[\frac{Q^2}{4} + qQ\right] = 0$
$\therefore q = -Q/4$

2. **(A)**
$F' = \frac{1}{4\pi\varepsilon_0 k}\frac{q_1q_2}{r^2} = \frac{F}{k}$
If F is the force in air, then F′ is less than F since k > 1.

3. **(D)**

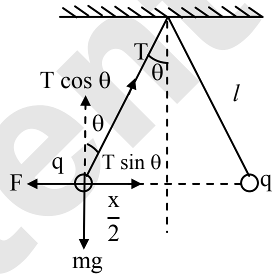
4. **(C)**
According to Coulomb's law,
$F = \frac{1}{4\pi\varepsilon_0}\frac{(+q)(+q)}{d^2}$
$\therefore q^2 = 4\pi\varepsilon_0 Fd^2$
Now, q = ne
Where, e = charge on electron and
n = number of electrons
$\therefore n^2e^2 = 4\pi\varepsilon_0 Fd^2$
$\therefore n^2 = \frac{4\pi\varepsilon_0 Fd^2}{e^2}$
$\therefore n = \sqrt{\frac{4\pi\varepsilon_0 Fd^2}{e^2}}$

5. **(B)**
In the equilibrium position, T cos θ = mg
$T\sin\theta = F_e = \frac{Kq^2}{r^2}$
$\therefore \tan\theta = \frac{Kq^2}{r^2 mg}$
i.e., $\frac{r/2}{y} = \frac{Kq^2}{mgr^2}$
$\therefore y = \frac{mgr^3}{2Kq^2}$
$\therefore r \propto y^{1/3}$



Now, the equilibrium separation for (y/2) is,
$\therefore r' \propto \left(\frac{y}{2}\right)^{1/3} \propto \frac{r}{(2)^{1/3}}$

6. **(A)**
From figure
F = Tsinθ ….(i)
mg = Tcosθ ….(ii)
$\therefore \frac{F}{mg} = \tan\theta$
$\therefore \frac{Kq^2}{x^2 mg} = \frac{\frac{x}{2}}{\sqrt{l^2 - \frac{x^2}{4}}}$ ....$\left(\because \tan\theta = \frac{\frac{x}{2}}{\sqrt{l^2 - \frac{x^2}{4}}}\right)$
As x << l, neglecting $\frac{x^2}{4}$
$\frac{Kq^2}{x^2 mg} = \frac{x}{2l}$
$\therefore q^2 \propto x^3$
$\therefore q \propto x^{3/2}$
$\therefore \frac{dq}{dt} \propto \frac{d(x^{3/2})}{dt}$
$\therefore \frac{dq}{dt} \propto \frac{d(x^{3/2})}{dx}\frac{dx}{dt}$
$\therefore \frac{dq}{dt} \propto x^{1/2}v$ ....$\left\{\because \frac{dx}{dt} = v\right\}$
$\therefore v \propto \frac{1}{x^{1/2}}$



7. **(B)**
Net charge on one H-atom = –e + (e + Δe) = Δe
Net electrostatic force between two H-atoms
$= \frac{1}{4\pi\varepsilon_0}\frac{(\Delta e)(\Delta e)}{r^2}$ repulsive
Net gravitational force between two H-atoms
$= \frac{G(m)(m)}{r^2}$
$\therefore \frac{1}{4\pi\varepsilon_0}\frac{(\Delta e)(\Delta e)}{r^2} = \frac{G(m)(m)}{r^2}$
$\frac{1}{4\pi\varepsilon_0}\Delta e^2 = Gm^2$
$9 \times 10^9 \times \Delta e^2 = 6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2$
$\Delta e^2 = \frac{6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2}{9 \times 10^9}$
$\Delta e^2 = \sqrt{\frac{6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2}{9 \times 10^9}}$
$\Delta e = 1.437 \times 10^{-37}$ C.
$\therefore$ Order of Δe is 10^{-37} C.

8. **(D)**
Force acting between given charges + Q and – Q is, $F = \frac{-Q^2}{4\pi\varepsilon_0 r^2}$
When 25% of charges are transferred, charge on point A becomes,
$q_1 = +Q - 0.25Q = +0.75Q = +\frac{3}{4}Q$

Charge on point B becomes,

$q_2 = -Q + 0.25Q = -0.75Q = -\frac{3}{4}Q$

∴ The new force between points A and B will be,

$F' = \frac{(+3/4)Q \times (-3/4)Q}{4\pi\varepsilon_0 r^2} = -\frac{\left(\frac{9}{16}\right)Q^2}{4\pi\varepsilon_0 r^2} = \frac{9}{16}F$

9. **(D)**

Using Coulomb's law of electrostatics,

$F = \frac{1}{4\pi\varepsilon_0 r^2}\frac{e^2}{r^2}$

∴ $m_e a = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$ …. ($\because F_e = m_e a$)

$a = \frac{e^2}{4\pi\varepsilon_0 m_e r^2}$

$= \frac{9\times10^9\times\left(1.6\times10^{-19}\right)^2}{9\times10^{-31}\times\left(1.6\times10^{-10}\right)^2}$

$= 10^{22}\ m/s^2$

1.2 Superposition principle, Forces between multiple charges

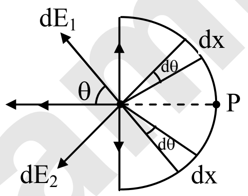
1. **(C)**

The net force acting on each charge is zero. Hence, all the charges are in equilibrium. Since, all charges are not similar, the change in configuration of the system will change the equilibrium state. Hence, all the charges are in unstable equilibrium.

1.3 Continuous distribution of charges

1. **(C)**

Consider two area elements on the arc as shown in the figure.



From figure, the components of electric fields due to these area elements dx, acting perpendicular to PO cancel each other.

Hence, the components that act along PO are added to get the resultant electric field acting on centre of the semicircle.

Now, charge on the element dx, dq = λdx

∴ $dE = \frac{1}{4\pi\varepsilon_0}\frac{(\lambda dx)}{a^2}$

$E = \Sigma dE \cos\theta$

or $E = \int \frac{1}{4\pi\varepsilon_0}\frac{(\lambda dx)}{a^2}\cos\theta$

But $d\theta = \frac{dx}{a} \Rightarrow dx = a\,d\theta$

∴ $E = \int_{-\pi/2}^{\pi/2}\frac{\lambda d\theta}{4\pi\varepsilon_0 a}\cos\theta$

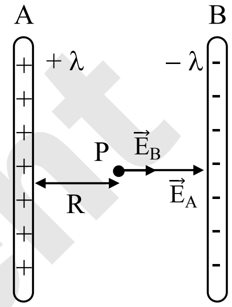
$= \frac{\lambda}{4\pi\varepsilon_0 a}\int_{-\pi/2}^{\pi/2}\cos\theta\cdot d\theta$

$= \frac{\lambda}{4\pi\varepsilon_0 a}[\sin\theta]_{-\pi/2}^{\pi/2}$

$= \frac{\lambda}{4\pi\varepsilon_0 a}(2) = \frac{\lambda}{2\pi\varepsilon_0 a}$

2. **(A)**

Electric field at point P due to line charge A as shown in figure is,



$\vec{E}_A = \frac{q}{2\pi\varepsilon_0 r}$

$= \frac{\lambda}{2\pi\varepsilon_0 R}\hat{i}$

Similarly, electric field due to line charge B,

$\vec{E}_B = \frac{\lambda}{2\pi\varepsilon_0 R}\hat{i}$

Total electric field at point P is,

$\vec{E} = \vec{E}_A + \vec{E}_B$

$= \frac{\lambda}{2\pi\varepsilon_0 R}\hat{i} + \frac{\lambda}{2\pi\varepsilon_0 R}\hat{i} = \frac{\lambda}{\pi\varepsilon_0 R}$ N/C

3. **(A)**

Initially, charges on the two spheres will be,

$q_1 = \sigma(4\pi R^2)$ and

$q_2 = \sigma[4\pi(2R)^2] = \sigma(16\pi R^2)$

∴ $q_1 + q_2 = 20\sigma\pi R^2$

After redistribution of charges, final charges on the spheres will be, $\frac{Q_1}{Q_2} = \frac{R}{2R}$

∴ $Q_2 = 2Q_1$

As charges are conserved, total number of charges on both the spheres will remain constant.

i.e., $q_1 + q_2 = Q_1 + Q_2$

∴ $Q_1 + 2Q_1 = 20\sigma\pi R^2$

∴ $Q_1 = \frac{20}{3}\sigma\pi R^2 = \frac{5}{3}\sigma(4\pi R^2)$

and $Q_2 = \frac{40}{3}\sigma\pi R^2 = \frac{5}{6}\sigma(16\pi R^2)$

∴ $\sigma_1 = \frac{5}{3}\sigma$ and $\sigma_2 = \frac{5}{6}\sigma$

4. **(A)**

Electric potential, $V = \frac{q_1}{C_1} = \frac{q_2}{C_2}$

∴ $\frac{q_1}{4\pi\varepsilon_0 R_1} = \frac{q_2}{4\pi\varepsilon_0 R_2}$

∴ $\frac{q_1}{q_2} = \frac{R_1}{R_2}$ ….(i)

Surface charge density, $\sigma = \frac{q}{4\pi R^2}$