Precise

PHYSICS

Vol. II

BASED ON LATEST BOARD PAPER PATTERN

Std. XII
Science

Ms. Meenal Iyer
M.Sc., B.Ed.

Ms. Ketki Deshpande
M.Sc.

Target Publications® Pvt. Ltd.

Written as per the latest textbook prescribed by the Maharashtra State Bureau of Textbook Production and Curriculum Research, Pune.

Precise

PHYSICS (Vol. II)

Std. XII Sci.

Salient Features

- Written as per **Latest Board Paper Pattern**
- Subtopic-wise segregation for powerful concept building
- Complete coverage of Textual Exercise Questions, Intext Questions and Numericals
- Marks provided to the Questions as per relevant weightage as deemed necessary
- Relevant Previous Years' Board Questions:
  - **March 2013 to July 2023**
- Each chapter contains:
  - 'Quick Review' of the chapter for quick revision
  - 'Important Formulae' and 'Solved Examples' to cover numerical aspect in detail
  - 'Exercise' to provide Theory questions, Numericals and MCQs for practice
  - Selective questions from NCERT textbook for practice
- Includes Important Feature to elucidate concept: ***Reading Between the Lines***
- Q.R. codes provide:
  - The Video/pdf links boosting conceptual retention

Printed at: **Print to Print,** Mumbai

Balbharati Registration No.: 2018MH0022

TEID: 3455

P.O. No. 11320

PREFACE

Precise Physics Vol. II, Std. XII Sci. is intended for every Maharashtra State Board aspirant of Std. XII, Science. The scope, sequence, and level of the book consistent with the latest textbook released by Maharashtra State board.

We believe that the study of Physics needs driving desire to learn and willingness to work hard. The earnestness to dive into the subject eventuates naturally when students are presented with meaningful content that is easy to read and understand rather than being mired down with facts and information. Students do much better when they grasp the nub of the subject.

While beginning with a chapter in Physics, students should study to understand the content and not merely read point blankly. They can go slowly, knowing Physics can't be read like a novel, choosing their own pace. But it is essential for students to comprehend the concepts involved, ruminate and reproduce their own versions of the same.

To quote Albert Einstein, **"If you can't explain it simply, you don't understand it yourself."**

Students should then attempt theoretical questions based on these concepts to gauge the level of understanding achieved.

Next advance after gaining command over theory would be numericals. Though Physics is communicated in English, it is expressed in Mathematics. Hence, it is essential to befriend formulae and derivations. These should be learnt and memorized. Once physical mathematics of concept is ingrained, solved numericals should be studied, starting from simple problems to difficult by escalating level of complexity gradually. Students are required to practise numericals and ascertain their command on problem solving. Calculations at this stage must be done using log table keeping in mind that calculators are not allowed in Board Exams. **When it comes to problems in Physics nothing makes students perfect like practice!**

Amongst building concepts, advancing into numbers and equations, it is essential to ponder underlying implications of subject. Students should read from references, visit authentic websites and watch relevant fascinating links.

Such a holistic preparation of subject is the key to succeed in the board examination.

After all, **"Success is no accident. It is hard work, perseverance, learning, studying, sacrifice and most of all, love of what you are doing or learning to do,"** as said by legendary football player Pele and students should bear it in mind!

Our **Precise Physics Vol. II, Std. XII Sci.** adheres to our vision and achieves several goals: **building concepts**, **developing competence to solve numericals, recapitulation and self-study** —all while encouraging students toward cognitive thinking.

Features of the book presented below will explicate more about the same!

We hope the book benefits the learner as we have envisioned.

Publisher

Edition: Sixth

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

KEY FEATURES

Reading between the lines

Reading between the lines provides elaboration or missing fragments of concept essential for complete understanding of the concept.

QR Codes

QR code provides:

Access to a video/PDF in order to boost understanding of a concept or activity

Solved Examples

Solved Examples offer complete solution to numerical including log (as seemed required).

Important Formulae

Important Formulae includes all of the key formulae in the chapter.

Quick Review

Quick review includes tables/ flow chart to summarize the key points in chapter.

Exercise

Exercise includes subtopic-wise additional questions and problems.

Multiple Choice Questions

Multiple Choice Question includes textual as well as additional MCQs.

Board Questions

Includes relevant Board questions from March 2013 to July 2023

PAPER PATTERN

- There will be single question paper of 70 Marks and practical examination of 30 Marks in Physics.
- Duration of the paper will be 3 hours.

Section A: **(18 Marks)**

This section will contain Multiple Choice Questions and Very Short Answer (VSA) type of questions.
There will be 10 MCQs and 8 VSA type of questions, each carrying one mark.
Students will have to attempt all these questions.

Section B: **(16 Marks)**

This section will contain 12 Short Answer (SA-I) type of questions, each carrying 2 marks.
Students will have to attempt any 8 questions.

Section C: **(24 Marks)**

This section will contain 12 Short Answer (SA-II) type of questions, each carrying 3 marks.
Students will have to attempt any 8 questions.

Section D: **(12 Marks)**

This section will contain 5 Long Answer (LA) type of questions, each carrying 4 marks.
Students will have to attempt any 3 questions.

Distribution of Marks According to the Type of Questions

Type of Questions		
MCQ	1 Mark each	10 Marks
VSA	1 Mark each	8 Marks
SA - I	2 Marks each	16 Marks
SA - II	3 Marks each	24 Marks
LA	4 Marks each	12 Marks

Percentage wise distribution of marks	
Theory	63%
Numerical	37%

CONTENTS

[Reference: Maharashtra State Board of Secondary and Higher Secondary Education, Pune - 04**]**

Note:
1. * mark represents Textual question.
2. # mark represents Intext question.
3. + mark represents Textual examples.
4. symbol represents textual questions that need external reference for an answer.

8 Electrostatics

Contents and Concepts

8.1 Introduction

Q.1. Can you recall? *(Textbook page no. 186)*

What is Gauss' law and what is a Gaussian surface? **[3 Marks]**

Ans: Gauss' law: *The flux of the net electric field through a closed surface equals the net charge enclosed by the surface divided by ε_0.*

$$\int \vec{E} \cdot \vec{ds} = \frac{q}{\varepsilon_0}$$

where q is the total charge within the surface.

Mathematically,

$$\phi = \oint \vec{E} \cdot \vec{ds} = \frac{q}{\varepsilon_0}$$

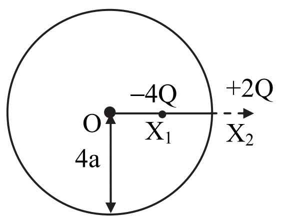
where ϕ is the total flux coming out of a closed surface and q is the total charge inside the closed surface.

Gaussian surface: All the lines of force originating from a point charge penetrate an imaginary three dimensional surface. The total flux $\phi_E = q/\varepsilon_0$. The same number of lines of force will cross the surface of any shape. The total flux through both the surfaces is the same. Calculating flux involves calculating $\int \vec{E} \cdot \vec{ds}$, hence it is convenient to consider a regular surface surrounding the given charge distribution. A surface enclosing the given charge distribution and symmetric about it is a Gaussian surface. For example, if we have a point charge the Gaussian surface will be a sphere. If the charge distribution is linear, the Gaussian surface would be a cylinder with the charges distributed along its axis. Gaussian surface offers convenience of calculating the integral $\int \vec{E} \cdot \vec{ds}$. A Gaussian surface is purely imaginary and does not exist physically.

***Q.2. Two charges of magnitudes –4Q and +2Q are located at points (2a, 0) and (5a, 0) respectively. What is the electric flux due to these charges through a sphere of radius 4a with its centre at the origin?**

[2 Marks]

Ans:



Given: $d(OX_1) = 2a$
$d(OX_2) = 5a$
Radius, r = 4a

A Gaussian surface is of radius 4a and contains charge –4Q inside.

As the flux depends only upon charge enclosed by Gaussian surface, required flux according to Gauss' law would be,

$$\phi = \frac{q}{\varepsilon_0} = \frac{-4Q}{\varepsilon_0}$$

Q.3. Write common steps involved in calculating electric field intensity by using Gauss' theorem. **[2 Marks]**

Ans: Common steps involved in calculating electric field intensity by using Gauss' theorem:

i. Identify the charge distribution as linear/cylindrical/spherical charge density.
ii. Visualize a Gaussian surface justifying its symmetry for the given charge distribution.
iii. Obtain the flux by Gauss' law and mark as equation (1).
iv. With the electric field intensity E as unknown, obtain electric flux by calculation, using geometry of the structure and symmetry of the Gaussian surface and mark as equation (2).
v. Equating equation (1) and equation (2), electric field intensity E can be calculated.

Q.4. State importance of Gauss' law. **[2 Marks]**

Ans:

i. Gauss' law gives the relationship between the electric charge and its electric field.
ii. It also provides equivalent methods for finding electric field intensity by relating values of the field at a closed surface and the total charges enclosed by that surface.
iii. It is a powerful tool which can be applied for the calculation of the electric field when it originates from charge distribution of sufficient symmetry.

Solved Examples

Q.5. A plane area of 100 cm^2 is placed in uniform electric field of 100 N/C such that the angle between area vector and electric field is 60°. Determine the electric flux over the surface. **[2 Marks]**

Solution:

Given: ds = 100 cm^2 = 100×10^{-4} m^2 = 10^{-2} m^2, E = 100 N/C, θ = 60°

To find: Electric flux (ϕ)

Formula: ϕ = Eds cos θ

Calculation: From formula,

$\phi = 100 \times 10^{-2} \times \cos 60°$

$\therefore \phi = 1 \times \frac{1}{2}$

$\therefore$ ϕ = **0.5 Nm^2/C**

Ans: The electric flux over the surface is **0.5 Nm^2/C.**

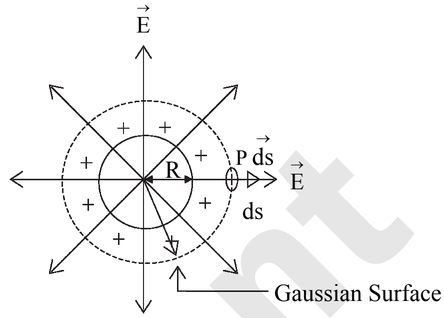
8.2 Application of Gauss' law

Q.6. Obtain expression for electric field intensity due to uniformly charged spherical shell or hollow sphere. **[4 Marks]**

Ans:

i. Consider a sphere of radius R with its centre at O, charged to a uniform surface charge density σ placed in a dielectric medium of permittivity ε (ε = ε_0k). The total charge on the sphere, $q = \sigma \times 4\pi R^2$.

ii. To find the electric field intensity at a point P, at a distance r from the centre of the charged sphere, imagine a concentric Gaussian sphere of radius r passing through P as shown in the figure below. Let ds be a small area around the point P on the Gaussian surface.



Uniformly charged spherical shell or hollow sphere

iii. By Gauss' theorem, the net flux through a closed Gaussian surface,

$$\phi = \frac{q}{\varepsilon_0} \text{ (for air/vacuum k = 1)} \quad ....(1)$$

where q is the total charge inside the closed surface.

iv. Due to symmetry and spheres being concentric, the electric field at each point on the Gaussian surface has the same magnitude E and it is directed radially outward. Also, the angle between the direction of E and the normal to the surface of the sphere (ds) is zero i.e., cos θ = 1

$\therefore \vec{E} \cdot \vec{ds} = E\,ds \cos\theta = E\,ds$

$\therefore$ Flux dϕ through the area ds, dϕ = E ds

Total electric flux through the Gaussian surface

$$\phi = \oint \vec{E} \cdot \vec{ds} = \oint E ds = E \oint ds$$

$$\therefore \phi = E\, 4\pi r^2 \quad ....(2)$$

v. From equations (1) and (2),

$$\frac{q}{\varepsilon_0} = E\, 4\pi r^2$$

$$\therefore E = \frac{q}{4\pi\varepsilon_0 r^2} \quad ....(3)$$

Substituting $q = \sigma \times 4\pi R^2$ in equation (3),

$$E = \sigma \times \frac{4\pi R^2}{4\pi\varepsilon_0 r^2}$$

$$\therefore E = \frac{\sigma R^2}{\varepsilon_0 r^2}$$

From equation (3) it can be seen that, the electric field at a point outside the shell is the same as that due to a point charge.

vi. Direction of electric field is outward if shell or sphere is positively charged and inward if it is negatively charged.

vii. Thus, it can be concluded that a uniformly charged sphere is equivalent to a point charge at its centre.

viii. **Special cases:**

Case (a): If point P lies on the surface of the charged sphere, r = R

$\therefore \quad E = \dfrac{q}{4\pi\varepsilon_0 R^2} = \dfrac{\sigma}{\varepsilon_0}$

Case (b): If point P lies inside the sphere

Since there are no charges inside, $\sigma = 0$

$\therefore \quad E = 0$

Reading between the lines

- *Points (i) to (v) of the above answer are presented as per sequence of common steps described in Q.3.*
- *If charged object is placed in any medium other than air or vacuum, ε_0 in expression will change to $k\varepsilon_0$ where, k is dielectric constant of that medium.*

Q.7. Obtain an expression for electric field intensity due to an infinitely long straight charged wire or charged conducting cylinder. [4 Marks]

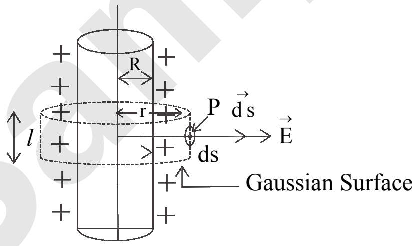
OR

Derive an expression for electric field intensity due to an infinitely long straight charged wire. [2 Marks] [July 23]

Ans:

i. Consider a uniformly charged wire of infinite length having a constant linear charge density λ (charge per unit length), kept in a medium of permittivity $\varepsilon(\varepsilon = \varepsilon_0 k)$.

ii. To find the electric field intensity at P, at a distance r from the charged wire, imagine a coaxial Gaussian cylinder of length l and radius r (closed at each end by plane caps normal to the axis) passing through the point P as shown in the figure. Consider a very small area ds at the point P on the Gaussian surface.



Infinitely long straight charged wire (cylinder)

iii. By Gauss' theorem, the net flux through a closed surface,

$$\phi = \frac{q}{\varepsilon_0} \text{ (for air/vacuum k = 1)} \qquad \text{….(1)}$$

where q is the total charge inside the closed surface.

iv. By symmetry, the magnitude of the electric field will be the same at all the points on the curved surface of the cylinder and will be directed radially outward. The angle between the direction of $\vec{E}$ and the normal to the curved surface of the cylinder $\left(\vec{ds}\right)$ is zero. Similarly the angle is $(\pi/2)$ for the flat surface of the cylinder.

i.e., $\cos\theta = 1$ (for curved surface)

or $\cos\theta = 0$ (for flat surface)

$\therefore \quad \vec{E}\cdot\vec{ds} = Eds\cos\theta = 0$ ....(For flat surface)

$\therefore \quad \vec{E}\cdot\vec{ds} = Eds\cos\theta = Eds$ ....(For curved surface)

Flux $d\phi$ through the area ds, $d\phi = Eds$

Total electric flux through the Gaussian surface

$$\phi = \oint \vec{E}\cdot\vec{ds} = \oint Eds = E\oint ds$$

$\therefore \quad \phi = E \times 2\pi r l \qquad$ ….(2)

v. From equations (1) and (2)

$$\frac{q}{\varepsilon_0} = E \times 2\pi r l$$

Since $\lambda = \dfrac{q}{l}$, $q = \lambda l$

$\therefore \quad \dfrac{\lambda l}{\varepsilon_0} = E 2\pi r l$

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

The direction of the electric field E is directed outward if λ is positive and inward if λ is negative.

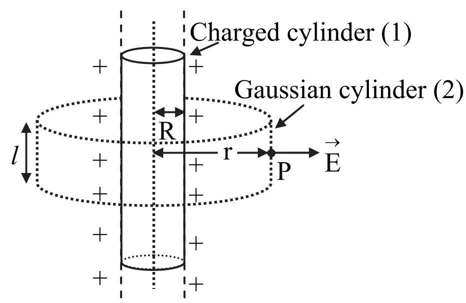
Reading between the lines

- *All points of the above answer are presented as per sequence of common steps described in Q.3.*
- *If charged object is placed in any medium other than air or vacuum, ε_0 in expression will change to $k\varepsilon_0$ where k is dielectric constant of that medium.*

Q.8. Assuming expression for electric field intensity at a point due to infinitely long straight charged wire or charged conducting cylinder, obtain expression for electric field intensity if point lies (i) outside the surface (ii) on the surface and (iii) inside the surface of wire or cylinder. [3 Marks]

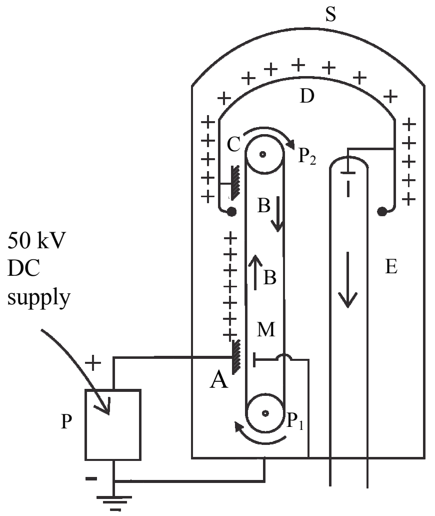
Ans:

i.



If σ is surface charge density (charge per unit area) of wire/cylinder, Page no. **4** to **32** are purposely left blank.

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



Schematic diagram of Van de Graff generator

P_1 P_2 = Pulleys
BB = Conveyer belt
A = Spray brush
C = Collector brush
D = Dome shaped hollow conductor
E = Evacuated accelerating tube
I = Ion source
P = DC power supply
S = Steel vessel filled with nitrogen
M = Earthed metal plate

ii. There are two pulleys P_1 and P_2. P_2 is mounted at the centre of sphere D while P_1 is mounted near the bottom. A long narrow belt made of insulating material such as rubber or silk passes over the pulleys. The belt BB is driven by an electric motor (not shown in the diagram), connected to the lower pulley P_1.

iii. The spray brush A, consisting of a large number of pointed wires, is connected to the positive terminal of a high voltage DC power supply. From this brush positive charge can be sprayed on the belt which can be collected by another similar brush C connected to D.

iv. E is an evacuated accelerating tube having an electrode I at its upper end, connected to the dome-shaped conductor.

v. To prevent the leakage of charge from the dome, the pulley and belt arrangement, the dome and a part of the evacuated tube are enclosed inside a large steel vessel S, filled with nitrogen at high pressure. A small quantity of Freon gas is mixed with nitrogen to ensure better insulation between the vessel S and its contents.

vi. A metal plate M held opposite to the brush A on the other side of the belt is connected to the vessel S, which is earthed.

Working:

i. The electric motor connected to the pulley P_1 is switched on, to set the conveyor belt into motion. The DC supply is then switched on.

ii. From the pointed ends of the spray brush A, positive charge is continuously sprayed on the belt B.

iii. The belt carries this charge in the upward direction, which is collected by the collector brush C and sent to the dome shaped conductor.

iv. As the dome is hollow, the charge is distributed over the outer surface of the dome. Its potential rises to a very high value due to the continuous accumulation of charges on it. The potential of the electrode I also rises to this high value.

v. The positive ions such as protons or deuterons from a small vessel (not shown in the figure) containing ionised hydrogen or deuterium are then introduced in the upper part of the evacuated accelerator tube.

vi. These ions, repelled by the electrode I, are accelerated in the downward direction due to the very high fall of potential along the tube, these ions acquire very high energy.

vii. These high energy charged particles are then directed so as to strike a desired target.

Students can scan the adjacent Q. R. Code in *Quill - The Padhai App* to get conceptual clarity about **construction and working of Van de Graaff generator** with the aid of a linked video.

Q.103. State uses of Van de Graaff generator. **[2 Marks]**

Ans: **Uses:** The main use of Van de Graff generator is to produce very high energy charged particles having energies of the order of 10 MeV. Such high energy particles are used

i. to carry out the disintegration of nuclei of different elements,
ii. to produce radioactive isotopes,
iii. to study the nuclear structure,
iv. to study different types of nuclear reactions,
v. accelerating electrons to sterilize food and to process materials.

Quick Review

Gauss' theorem

- $\oint \vec{E} \cdot \vec{ds} = \phi = \frac{q}{\varepsilon_0}$
- Electric field due to a:
  - i. Circular closed cylinder: $E = \lambda / 2\pi\varepsilon_0 r$
  - ii. Infinite plane sheet: $E = \frac{\sigma}{2\varepsilon_0}$
  - iii. Infinite plane sheet having uniform thickness: $E = \frac{\sigma}{2\varepsilon_0}$
  - iv. Spherical shell (for $r \geq R$): $E = \frac{q}{4\pi r^2 \varepsilon_0}$
  - v. Spherical shell (for $r < R$): $E = 0$

Electrostatics

The study of electricity/electric charges at rest

→ Van de Graaff generator

Charge gives rise to:

- Electric field
- Electrostatic force
- Electric potential
- Electric potential energy

Electric potential

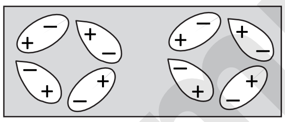
- Electric potential: $V = \frac{W}{q_0}$
- Potential difference: $\Delta V = V_B - V_A$, $\Delta V = \frac{W_{AB}}{q_0}$
- Relation between electric field intensity and pontential difference: $E = -\frac{dV}{dx}$
- Electrostatic potential due to a point charge: $V = \frac{1}{4\pi\varepsilon_0} \frac{q}{r}$
- Electric potential due to system of charges: $V = \frac{1}{4\pi\varepsilon_0} \sum_{i=1}^{n} \frac{q_i}{r_i}$
- Electric potential at any point due to electric dipole: $V = \frac{1}{4\pi\varepsilon_0} \frac{p\cos\theta}{\left(r^2 - a^2\cos^2\theta\right)}$

Electric potential energy

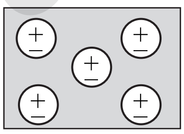
- Electric potential energy of a point charge: $U = \frac{1}{4\pi\varepsilon_0 k} \frac{qq_0}{r}$
- Electric potential energy of a system of two point charges: $U = W = \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$
- Electric potential energy of an electric dipole in uniform electric field: $U = -\vec{p} \cdot \vec{E} = -pE\cos\theta$

Dielectrics

- Polar dielectrics: It has permanent electric dipole moment even if the electric field is absent.
  Example: HCl, water, alcohol, NH_3



- Non polar dielectrics: Every molecule has zero dipole moment in its normal state.
  Examples: H_2, N_2, O_2, CO_2, benzene, methane



Capacitors

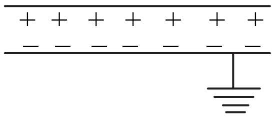
- Capacitance: The ability of a conductor to store charge.
  $C = \frac{Q}{V}$

- Types of capacitor:

i. Parallel plate capacitor:

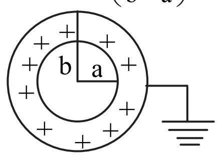
a. $C = \frac{k\varepsilon_0 A}{d}$

b. $C_m = k\,C_{air}$



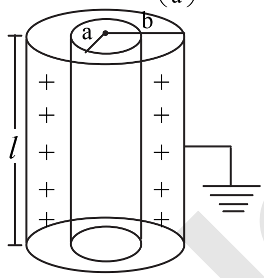
ii. Spherical capacitor:

$C = 4\pi k\varepsilon_0\left(\frac{ab}{b-a}\right)$



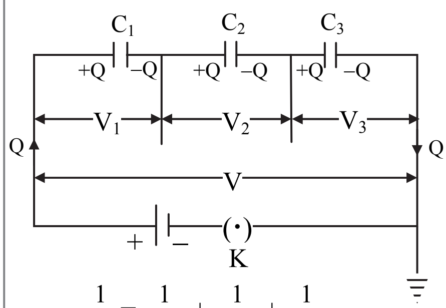
iii. Cylindrical capacitor:

$C = \frac{2\pi k\varepsilon_0 l}{2.303\log\left(\frac{b}{a}\right)}$



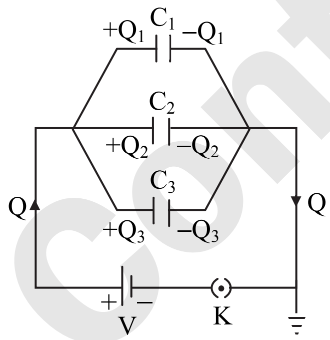
Combinations

i. Capacitors in series:



$\frac{1}{C_S} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$

ii. Capacitors in parallel:



$C_P = C_1 + C_2 + C_3$

Energy stored

- Energy:
  $U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}QV = \frac{1}{2}CV^2$

Important Formulae

1. **Charge per unit length (Linear charge density):** $\lambda = \frac{q}{l}$
2. **Charge per unit surface area (Surface charge density):** $\sigma = \frac{q}{A}$
3. **Electric flux:**

i. $\phi = \vec{E}\cdot\vec{ds} = Es\cos\theta$ ii. $\phi = \frac{q}{\varepsilon_0}$

iii. $\phi = \frac{q}{k\varepsilon_0}$

4. **Dielectric constant of a medim:** $k = \frac{\varepsilon}{\varepsilon_0}$
5. **Electric intensity:** $E = \frac{1}{4\pi k\varepsilon_0}\frac{q}{r^2}$
6. **Electric intensity at a point outside a charged spherical conductor:**

i. $E_{medium} = \frac{q}{4\pi k\varepsilon_0 r^2} = \frac{\sigma R^2}{k\varepsilon_0 r^2}$ ….(r > R)

ii. $E_{vacuum} = \frac{q}{4\pi\varepsilon_0 r^2} = \frac{\sigma R^2}{\varepsilon_0 r^2}$ ….(r > R)

where, $\sigma = \frac{q}{4\pi R^2}$

iii. $E_{inside} = 0$ ….(r < R)

7. **Electric intensity at a point outside a charged cylindrical conductor:**

i. Cylinder in any medium,

$E = \frac{\lambda}{2\pi\varepsilon r} = \frac{\lambda}{2\pi k\varepsilon_0 r} = \frac{\sigma R}{k\varepsilon_0 r}$ ….(r > R)

ii. Cylinder in free space or vacuum,

$E = \frac{\lambda}{2\pi\varepsilon_0 r} = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda}{r}$ ….(r > R)

iii. $E_{inside} = 0$ ….(r < R)

8. **Electric intensity at short distance from a charged conductor of any shape:**

i. $E = \frac{\sigma}{k\varepsilon_0}$

ii. Conductor in free space or air or vacuum,

$E_0 = \frac{\sigma}{\varepsilon_0} = kE$

9. Electric intensity at a point outside a uniformly charged infinite plane sheet: $E = \frac{\sigma}{2\varepsilon}$

10. Work done:

i. $W = qV$ ii. $W = q(V_B - V_A)$

11. Torque on a dipole:

i. $\vec{\tau} = \vec{p} \times \vec{E}$ ii. $\tau = pE \sin\theta$

iii. For $\theta = 90°$, $\tau_{max} = pE$ iv. For $\theta = 0$, $\tau_{min} = 0$

12. Work done by the external torque on dipole:

$$W = \int_{\theta_0}^{\theta} \tau_{ext}(\theta)d\theta = \int_{\theta_0}^{\theta} pE\sin\theta\, d\theta = pE[\cos\theta_0 - \cos\theta]$$

13. Potential energy of electric dipole in external electric field:

$U(\theta) - U(\theta_0) = pE(\cos\theta_0 - \cos\theta)$

14. Capacity of condenser: $C = \frac{Q}{V}$

15. Parallel plate condenser:

i. Intensity between the plates,

$$E = \frac{\sigma}{\varepsilon} = \frac{Q}{A\varepsilon} = \frac{\sigma}{k\varepsilon_0} = \frac{Q}{Ak\varepsilon_0}$$

ii. Potential difference between the plates,

$V = Ed$

iii. Capacity between the plates,

$$C = \frac{A\varepsilon}{d} = k\,C_0$$

iv. Capacity of vacuum, $C_0 = \frac{A\varepsilon_0}{d}$

16. Capacitance of capacitor with dielectric:

$$C_d = C_0 \frac{E_0}{E_d}$$

where, C_0 is original capacitance

E_0 is original electric field

E_d is electric field with dielectric

17. Energy stored in a charged capacitor:

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$$

18. Series combination of 'n' condensers:

i. $V = V_1 + V_2 + V_3 \ldots\ldots + V_n$

ii. $Q = Q_1 = Q_2 = Q_3 = \ldots\ldots = Q_n$

iii. $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots.. + \frac{1}{C_n}$

19. Parallel combination of 'n' condensers:

i. $Q = Q_1 + Q_2 + \ldots.. + Q_n$

ii. $V = V_1 = V_2 = V_3 = \ldots.. = V_n$

iii. $C = C_1 + C_2 + C_3 + \ldots\ldots + C_n$

Exercise

8.1 Introduction

1. Give importance of Gauss' law. **[2 Marks]**

Ans: *Refer Q.4.*

2. A point charge of 10 μC is situated at the centre of a sphere of radius 10 cm. Calculate the electric flux through its surface. **[2 Marks]**

Ans: 1.13×10^6 Nm^2/C

3. The electric intensity on the surface of a charged conductor of area 0.5 m^2 is 200 V/m. If the electric flux is found to be 86.6 Nm^2/C, find the angle between the normal drawn to the surface and the electric intensity. **[2 Marks]**

Ans: 30°

8.2 Application of Gauss' law

4. Derive an expression for electric field intensity due to uniformly charged spherical shell or hollow sphere. **[4 Marks]**

Ans: *Refer Q.6.*

5. State the formula for electric field intensity at a point outside an infinitely long charged cylindrical conductor. **[1 Mark] [July 18, 22]**

Ans: Formula for electric field intensity at a point outside an infinitely long charged cylindrical conductor is, $E = \frac{\lambda}{2\pi k \varepsilon_0 r}$

6. Obtain an expression for electric field intensity at a point outside uniformly charged thin plane sheet. **[4 Marks] [July 17]**

Ans: *Refer Q.9.*

7. A metal sphere of radius 10 cm is situated in air and carries a charge of 44 μC. Calculate intensity of electric field at a point close to its surface. **[2 Marks]**

Ans: 3.96×10^7 N/C

8. A plane metal sheet of area 400 cm^2 is given a charge of 5×10^{-4} C on its surface. Calculate the surface charge density on its surface. **[2 Marks]**

Ans: 1.25×10^{-2} C/m^2

9. A 2 km long cylindrical cable of radius 1 mm is given a charge of 10 millicoulomb. Find the electric intensity at a point on the surface of the cable. **[2 Marks]**

Ans: 9×10^7 N/C

10. A metal cylinder of length 2 km is charged with 2×10^{-2} C. Calculate the linear charge density of the cylinder. **[2 Marks]**

Ans: 10 μC/m

11. A metal sphere of radius 1 metre is given a charge of 223 μC. Calculate the surface charge density and intensity of electric field at a point near its surface. **[3 Marks]**

Ans: 17.7×10^{-6} C/m^2, 2×10^6 N/C

8.3 Electric Potential and Potential Energy

12. Obtain an expression for electrostatic potential energy. **[4 Marks]**

Ans: *Refer Q.15.*

Page no. **37** to **38** are purposely left blank.

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

8.11 Displacement current

56. Discuss origin of Displacement current. **[3 Marks]**
Ans: *Refer Q.91.*

57. Obtain relation between conduction current and displacement current. **[2 Marks]**
Ans: *Refer Q.92.*

8.12 Energy Stored in a Capacitor

58. Obtain an expression for energy stored in a capacitor. **[3 Marks]**
Ans: *Refer Q.94.*

59. A cube of marble, of each side 5 m long, is placed in an electric field of intensity of 300 V/m. Determine the energy stored in the marble, if its dielectric constant is 8. **[2 Marks]**
Ans: 3.983×10^{-4} J

60. The capacity of a parallel plate air capacitor is 10 μF and it is given a charge of 40 μC. Find the electrical energy stored in the capacitor. **[2 Marks]**
Ans: 800 erg

61. Two capacitors each of capacity 5 μF and a battery of e.m.f 180 V are given to you. Which combination gives the maximum energy? What is its value? Also find the charge on each capacitor of that combination. **[4 Marks]**
Ans: Parallel combination, 0.1620 J Charge on each capacitor of parallel arrangement = 900 μC.

8.13 Van de Graaff Generator

62. State principle of Van de Graaff generator. **[2 Marks]**
Ans: *Refer Q.101.*

63. Explain the construction of a Van de Graaff generator. **[4 Marks]**
Ans: *Refer Q.102. (Construction and diagram only)*

64. How does a Van de Graaff generator work? **[3 Marks]**
Ans: *Refer Q.102 (Working only)*

65. State any four applications of Van de Graaff generator. **[2 Marks]**
Ans: *Refer Q.103. (Any four uses)*

Multiple Choice Questions

[1 Mark Each]

1. Gauss' law helps in
   (A) determination of electric field due to symmetric charge distribution.
   (B) determination of electric potential due to symmetric charge distribution.
   (C) determination of electric flux.
   (D) situations where Coulomb's law fails.

2. Electric intensity at a point near a charged sphere of charge q is given by
   (A) $E = \frac{1}{4\pi\varepsilon_0 k}\frac{q}{r^2}$ (B) $E = \frac{1}{2\pi\varepsilon_0 k}\frac{q}{r}$
   (C) $E = \frac{\sigma}{\varepsilon_0 k}$ (D) $E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

3. The electric intensity due to a charged sphere at a point outside the sphere increases with increase in
   (A) dielectric constant .
   (B) distance from the centre of sphere.
   (C) charge on sphere.
   (D) square of distance from the centre of sphere.

4. Intensity of electric field at a point close and outside a charged conducting cylinder is proportional to _______. **[Mar 14]**
   (r is the distance of a point from the axis of cylinder)
   (A) $\frac{1}{r}$ (B) $\frac{1}{r^2}$ (C) $\frac{1}{r^3}$ (D) r^3

5. When a capacitor is connected to a battery,
   (A) an alternating current flows in the circuit.
   (B) no current flows at all.
   (C) a current flows for some time and finally it decreases to zero.
   (D) current keeps on increasing and reaches maximum after some time.

6. If the air surrounding a charged conductor is changed by other insulating medium, its
   (A) capacity increases.
   (B) capacity decreases.
   (C) capacity does not change.
   (D) capacity becomes zero.

7. The energy of a charged capacitor resides in
   (A) the electric field only.
   (B) the magnetic field only.
   (C) both the electric and magnetic fields.
   (D) neither in the electric nor in the magnetic field.

8. Van de Graaff generator produces _________.
   (A) zero potential (B) high potential
   (C) breakdown voltage (D) low potential

9. If the charge on the condenser of 10 μF is doubled, then the energy stored in it becomes ______. **[Mar 17]**
   (A) zero
   (B) twice that of initial energy
   (C) half the initial energy
   (D) four times the initial energy

10. _______ of conductors and insulators can be understood on the basis of free and bound charges.
   (A) The mechanical properties
   (B) The electrical behaviour
   (C) The magnetic behaviour
   (D) The dielectric behaviour

11. The _______ dielectrics develop net dipole moment in presence of an electric field.
(A) polar (B) non-polar
(C) polar and non-polar (D) solid

12. Dielectric constant of metals is _______.
(A) 0 (B) 1
(C) –1 (D) ∞

13. Match the two columns in correct sequence.

	Common units of capacitance		Their values
i.	1 pF	a.	10^{-6} F
ii.	1 μF	b.	10^{-12} F
iii.	1 nF	c.	10^{-9} F

(A) (i – b), (ii – c), (iii – a)
(B) (i – c), (ii – b), (iii – a)
(C) (i – b), (ii – a), (iii – c)
(D) (i – a), (ii – b), (iii – c)

*14. A parallel plate capacitor is charged and then isolated. The effect of increasing the plate separation on charge, potential, capacitance respectively is
(A) Constant, decreases, decreases
(B) Increases, decreases, decreases
(C) Constant, decreases, increases
(D) Constant, increases, decreases

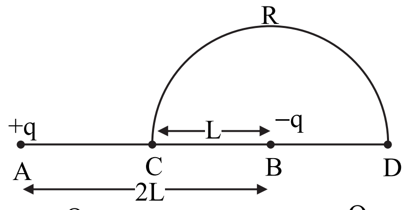
*15. A slab of material of dielectric constant k has the same area A as the plates of a parallel plate capacitor and has thickness (3d /4), where d is the separation of the plates. The capacitance when the slab is inserted between the plates is
(A) $C = \frac{A\varepsilon_0}{d}\left(\frac{k+3}{4k}\right)$ (B) $C = \frac{A\varepsilon_0}{d}\left(\frac{2k}{k+3}\right)$
(C) $C = \frac{A\varepsilon_0}{d}\left(\frac{k+3}{2k}\right)$ (D) $C = \frac{A\varepsilon_0}{d}\left(\frac{4k}{k+3}\right)$

***[Note:** Framing of the question is modified to arrive at appropriate option]*.

*16. Energy stored in a capacitor and dissipated during charging a capacitor bear a ratio
(A) 1 : 1 (B) 1 : 2
(C) 2 : 1 (D) 1 : 3

*17. A parallel plate capacitor has circular plates of radius 8 cm and plate separation 1mm. What will be the charge on the plates if a potential difference of 100 V is applied?
(A) 1.78×10^{-8} C (B) 1.78×10^{-5} C
(C) 4.3×10^{4} C (D) 2×10^{-9} C

*18. Charge +q and –q are placed at points A and B respectively which are distance 2L apart. C is the midpoint of A and B. The work done in moving a charge +Q along the semicircle CRD as shown in the figure below is



(A) $\frac{-qQ}{6\pi\varepsilon_0 L}$ (B) $\frac{qQ}{2\pi\varepsilon_0 L}$
(C) $\frac{qQ}{6\pi\varepsilon_0 L}$ (D) $\frac{-qQ}{4\pi\varepsilon_0 L}$

19. The permittivity of medium is 26.55×10^{-12} C^2/Nm^2. The dielectric constant of the medium will be
(A) 2 (B) 3 (C) 4 (D) 5

20. Which of the following produces uniform electric field?
(A) point charge
(B) linear charge
(C) two parallel plates
(D) charge distributed on circular disc

21. A charge of + 7 μC is placed at the centre of two concentric spheres with radius 2.0 cm and 4.0 cm respectively. The ratio of the flux through them will be
(A) 1:4 (B) 1:2
(C) 1:1 (D) 1:16

22. Which of the following is NOT the property of equipotential surfaces?
(A) They do not intersect each other.
(B) They are concentric spheres for uniform electric field.
(C) Potential at all points on the surface has constant value.
(D) Separation of equipotential surfaces increases with decrease in electric field.

23. In a uniform electric field, a charge of 3 C experiences a force of 3000 N. The potential difference between two points 1 cm apart along the electric lines of force will be
(A) 10 V (B) 3 V (C) 0.1 V (D) 20 V

24. The angle at which maximum torque is exerted by the external uniform electric field on the electric dipole is _______. **[Mar 22]**
(A) 0° (B) 30°
(C) 45° (D) 90°

Answers to Multiple Choice Questions

1.	(A)	2.	(A)	3.	(C)	4.	(A)
5.	(C)	6.	(A)	7.	(A)	8.	(B)
9.	(D)	10.	(B)	11.	(C)	12.	(D)
13.	(C)	14.	(D)	15.	(D)	16.	(A)
17.	(A)	18.	(A)	19.	(B)	20.	(C)
21.	(C)	22.	(B)	23.	(A)	24.	(D)

Hints to Multiple Choice Questions

14. For a parallel plate capacitor:
Charge is conserved. Hence, remains constant.

i. $C = \frac{A\varepsilon_0}{d} \Rightarrow C \propto \frac{1}{d}$ ii. $V = Ed \Rightarrow V \propto d$

15. Without slab, capacitance $C = \frac{A\varepsilon_0}{d}$

With slab capacitance, $C' = \frac{A\varepsilon_0}{d - t\left(1 - \frac{1}{k}\right)}$

$$\therefore \quad C' = \frac{A\varepsilon_0}{d - \frac{3}{4}d\left(1 - \frac{1}{k}\right)} = \frac{A\varepsilon_0}{\frac{d}{4} + \frac{3d}{4k}}$$

$$= \frac{A\varepsilon_0}{\frac{d}{4}\left(1 + \frac{3}{k}\right)} = \frac{A\varepsilon_0}{d}\left(\frac{4k}{k+3}\right)$$

17. For circular plates, $A = \pi r^2 = \pi(0.08)^2 \text{ m}^2$

$$Q = CV = \frac{A\varepsilon_0}{d} V = \frac{\pi(0.08)^2 \times 8.85 \times 10^{-12}}{10^{-3}} \times 100$$

$$= 1.78 \times 10^{-8} \text{ C}$$

18. Work done $W_{CD} = Q(V_D - V_C)$
Where, V_D is net electric potential at D and
V_C is net electric potential at C.
Here, $V_C = 0$

$$\therefore \quad W_{CD} = QV_D = Q\left[\frac{+q}{4\pi\varepsilon_0 3L} + \frac{(-q)}{4\pi\varepsilon_0 L}\right] = \frac{-qQ}{6\pi\varepsilon_0 L}$$

19. Dielectric constant of medium

$$k = \frac{\varepsilon}{\varepsilon_0} = \frac{26.55 \times 10^{-12}}{8.85 \times 10^{-12}} = 3$$

21. Total flux is independent of shape and radius.

23. $E = \frac{F}{q_0} = \frac{3000}{3} = 1000 \text{ N/C}$

$$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} \times r = E \times r$$

$$= 1000 \times 0.01 \qquad (\because r = 1 \text{ cm} = 0.01 \text{ m})$$

$$= 10 \text{ V}$$

AVAILABLE NOTES FOR STD. XI & XII:

SCIENCE

Perfect Series:

For students who want to excel in board exams and simultaneously study for entrance exams.

- Physics Vol. I
- Physics Vol. II
- Chemistry Vol. I
- Chemistry Vol. II
- Mathematics & Statistics Part - I
- Mathematics & Statistics Part - II
- Biology Vol. I
- Biology Vol. II

Precise Series:

For students who want to excel in board exams.

- Physics
- Chemistry
- Biology

Additional Books for Std. XII Sci. & Com.:

- A collection of Board Questions (PCMB)
- A collection of Board Questions with solutions (PCMB)
- Solution to HSC Board Question Bank (Science)
- Solution to HSC Board Question Bank (Commerce)
- Supplementary Questions (BK • Eco • OCM • SP)
- HSC 30 Question Papers & Activity Sheets With Solutions (Commerce)
- HSC 25 Question Papers & Activity Sheets With Solutions (Science)
- Marathi Yuvakbharati Model Question Paper Set With Solutions
- Hindi Yuvakbharati Model Question Paper Set With Solutions
- Basic Concept of Physics Simplified

COMMERCE (ENG. & MAR. MED.)

Smart Notes / Precise Notes:

- Book-Keeping and Accountancy
- Book Keeping and Accountancy (Practice)
- Economics
- Organisation of Commerce and Management
- Secretarial Practice
- Mathematics and Statistics - I
- Mathematics and Statistics - II

ARTS (ENG. & MAR. MED.)

- History
- Geography
- Political Science
- Psychology
- Sociology

Languages:

- English Yuvakbharati
- Hindi Yuvakbharati
- Marathi Yuvakbharati

Books available for MHT-CET, NEET & JEE

Scan the QR code to buy e-book version of Target's Notes on Quill - The Padhai App

OUR PRODUCT RANGE

Children Books | School Section | Junior College
Degree College | Entrance Exams | Stationery

Target Publications® Pvt. Ltd.
Transforming lives through learning.

Address:
B2, 9th Floor, Ashar, Road No. 16/Z,
Wagle Industrial Estate, Thane (W)- 400604

Tel: 88799 39712 / 13 / 14 / 15
Website: www.targetpublications.org
Email: mail@targetpublications.org

Explore our range of STATIONERY

Visit Our Website