SAMPLE CONTENT

Absolute

NEET-UG & JEE (Main)

PHYSICS Vol - II

For all Medical and Engineering Entrance Examinations held across India.

4248 MCQs with Hints

As per latest syllabus issued by NMC & NTA

Aurora Borealis

'Aurora Borealis' (Northern Lights) seen in the northern skies is caused due to the interaction of the Earth's magnetic field with charged particles or ions travelling down the atmosphere.

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

Ms. Ketki Chaini
M.Sc.

Ms. Divya Gangaramani
M.Sc. (Physics)

Mr. Varun Subramanian
M.Sc., M.Sc.

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Absolute

NEET (UG) & JEE (Main)

Physics Vol. II

Now with more study techniques

Updated as per latest syllabus for:
NEET (UG) 2024 issued by **NMC on 6th October, 2023**
JEE (Main) 2024 issued by **NTA on 1st November, 2023**

Salient Features

- Comprehensive theory for every topic
- Subtopic-wise segregation of MCQs for efficient practice
- Exhaustive coverage of questions including questions from previous years' NEET (UG), JEE (Main) and other competitive examinations till year 2023:
  - **4248** MCQs
  - **91** Numerical Value Type (NVT) questions
  - Solutions to the questions are provided for better understanding
- Multiple study techniques to enhance understanding and problem solving
- Topic Test with answer keys provided in each chapter for self-assessment
- Includes Question Papers and Answer Keys (Solutions through Q.R. code) of:
  - NEET (UG) 2022
  - NEET (UG) 2023
  - NEET (UG) 2023 (Manipur)
  - JEE (Main) 2022 25th July (Shift - I)
  - JEE (Main) 2023 24th Jan (Shift - II)
- Q.R. codes provide:
  - Video links for boosting conceptual retention
  - Solutions to Topic Tests and previous exam papers of year 2022 and 2023
- Separate list of questions excluded from the NEET (UG) and JEE (Main) 2024 syllabus

Scan the adjacent Q.R. Code in Quill - The Padhai App to access solutions/hints to Topic Test.

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PREFACE

'Absolute Physics Vol - II' is a complete guidebook, extremely handy for preparation of various competitive exams like NEET (UG), JEE (Main). This edition provides an unmatched comprehensive amalgamation of theory with MCQs. The chapters are aligned with the syllabus for NEET (UG) and JEE (Main) examinations and runs parallel to NCERT curriculum. The book provides the students with scientifically accurate context, several study techniques and skills required to excel in these examinations.

The sections of **Theory**, **Formulae, MCQs** and **Topic Test** form the backbone of every chapter and ensure adequate revision.

These MCQs are framed considering the importance given to every topic as per the NEET (UG) and JEE (Main) exam. They are a healthy mix of theoretical, numerical and graphical based questions.

The level of difficulty of these questions is at par with that of various competitive examinations held across India. Questions from various examinations such as NEET (UG), JEE (Main), MHT CET, K CET, WB JEE, AP EAMCET, AP EAPCET, TS EAMCET (Med. and Engg.), GUJ CET are exclusively covered.

Previous Years' Question Papers:

Question Papers and Answer Keys of **NEET (UG) 2022**, **2023** and **2023 (Manipur)** as well as **JEE (Main) 2022** 25th July (Shift - I) and **JEE (Main) 2023** 24th Jan (Shift - II) have been provided to offer students glimpse of the complexity of questions asked in entrance examination. Solutions are also provided through a separate Q.R. code.

These papers of latest competitive examinations have been provided and split unit-wise to let the students know which of the units were more relevant as per latest Question paper.

All the questions included in a chapter have been specially created and compiled to enable students solve complex problems which require strenuous effort with promptness.

Considering the latest modifications in the syllabus of NEET (UG) and JEE (Main) examinations, a list of questions based on the concepts excluded from the syllabus is provided. The purpose of providing these questions is to display various question types and their level of difficulty that have been asked in previous examinations.

All the features of this book pave the path of a student to excel in examination. The features are designed keeping the following elements in mind: Time management, easy memorization or revision and non-conventional yet simple methods for MCQ solving.

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

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

Publisher

Edition: Seventh

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.

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KEY FEATURES

Time saver

'**Time Saver**' illustrates quick method over lengthy conventional method of solving numerical.

Smart tip

'**Smart tips**' comprise important theoretical or formula based short tricks considering their usage in solving MCQ.

Smart Code

'**Smart Code**' showcases simple and smart mnemonic created for selected concepts.

Caution

'**Caution**' apprises students about mistakes which are made while solving an MCQs.

QR Code

'**QR code**' provides:

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

ii. Solutions to Topic Test of each chapter, NEET (UG) 2022, 2023 and 2023 (Manipur) as well as JEE (Main) 2022 and 2023 question papers.

Examples

'**Examples**' are provided to elucidate a a concept using theory or MCQ or numerical question and help students hone their problem-solving skills.

Clock Symbol

'**Clock Symbol**' instructs students that given MCQ can be solved apace by applying either smart tips, Time saver or thinking hatke.

Connection

'**Connection**' enables students to interlink concepts covered in different chapters.

Thinking Hatke

'**Thinking Hatke**' reveals quick witted approach to crack the specific question.

Learning Pointers

'**Learning Pointers**' provide compilation of additional notes which involve fusion of two concepts from different chapters or come as indirect extensions of subtopics.

Gyan Guru

'**Gyan Guru**' illustrates real life applications or examples related to the concept discussed.

Knowledge Badhao!

'**Knowledge Badhao**' includes additional information relevant to concept.

Frequently Asked Questions

- **Why Absolute Series?**

  Gradually, every year the nature of competitive entrance exams is inching towards conceptual understanding of topics. Moreover, it is time to bid adieu to the stereotypical approach of solving a problem using a single conventional method.

  To be able to successfully crack the NEET(UG) /JEE (Main) examinations, it is imperative to develop skills such as data interpretation, appropriate time management, knowing various methods to solve a problem, etc. With Absolute Series, we are sure, you'd develop all the aforementioned skills and take a more holistic approach towards problem solving. The way you'd tackle advanced level MCQs with the help of Hints, Examples, Smart tips, Time Saver, Smart codes and Thinking Hatke would give you the necessary practice that would be a game changer in your preparation for the competitive entrance examinations.

- **What is the intention behind the launch of Absolute Series?**

  The sole objective behind the introduction of Absolute Series is to cater to needs of students across a varied background and effectively assist them to successfully crack the NEET(UG) /JEE (Main) examinations. With a healthy mix of MCQs, we intend to develop a student's MCQ solving skills within a stipulated time period.

- **What do I gain out of Absolute Series?**

  After using Absolute Series, students would be able to:

  a. assimilate the given data and apply relevant concepts with utmost ease.

  b. tackle MCQs of different pattern such as match the columns, diagram based questions, multiple concepts and assertion-reason efficiently.

  c. garner the much needed confidence to appear for competitive exams.

  d. easy and time saving methods to tackle tricky questions will help ensure that time consuming questions do not occupy more time than you can allot per question.

- **How to derive the best advantage of the book?**

  To get the maximum benefit of the book, we recommend :

  a. Go through the detailed theory and Examples solved alongwith at the beginning of a chapter for concept clarity. Commit Smart Tips and Time saver into memory and pay attention to Caution.

  b. Read through the Learning pointers section minutely.

  c. Know all the Formulae compiled at the end of theory by-heart.

  d. Using subtopic wise segregation as a leverage, complete MCQs in each subtopic at your own pace. Questions from exams such as JEE (Main), NEET(UG) are tagged and placed along the flow of subtopic. Mark these questions specially to gauge the trends of questions in various exams.

  e. Be extra receptive to Thinking Hatke, Alternate Method and application of Smart Tips and Time saver. Assimilate them into your thinking.

Best of luck to all the aspirants!

CONTENTS

Note: ☒ *Complete chapter excluded from the NEET (UG) and JEE (Main) 2024 syllabus (in index)*

◑ *Part of the chapter excluded from the NEET (UG) and JEE (Main) 2024 syllabus (in index)*

Questions based on the concepts excluded from NEET (UG) and JEE (Main) 2024 Syllabus

Chapter Name	Subtopic Name	Questions excluded from 2024 Syllabus	Page No.
1. Electrostatics	1.1 Electric charges and their conservation, Conductors and insulators, Free and bound charges inside a conductor	-	Theory - 02
2. Capacitors	2.6 Van de Graaff generator	All Questions	Theory - 98 and 99 MCQs - 114 and 115
	Topic Test	12	MCQs - 137
3. Current Electricity	3.1 Electric current and *Flow of electric charges in a metallic conductor*	5	Theory - 138 MCQs - 156
	3.5 Carbon resistors, Colour code for carbon resistors	All Questions	Theory - 142 and 143 MCQs - 162 and 163
	3.14 Potentiometer		Theory - 152 to 154 MCQs - 182 to 185
	Miscellaneous	24, 25	MCQs - 188
	Topic Test	25	MCQs - 226
4. Magnetic Effect of Electric Current	4.3 Motion in a Magnetic Field	34	MCQs - 251
	4.4 Motion in combined electric and magnetic field *(Cyclotron)*	9 to 34, 36 to 38	Theory - 231 and 232 MCQs - 253 to 255
	Miscellaneous	27	MCQs - 278
	Topic Test	16	MCQs - 309
5. Magnetism	5.3 Current loop as a magnetic dipole and its magnetic dipole moment *(Magnetic dipole moment of a revolving electron)*	10, 22 to 44	Theory - 313 and 314 MCQs - 329 to 332
	5.6 Earth's magnetism	All Questions	Theory - 317 to 319 MCQs - 336 to 339
	5.9 Electromagnet and permanent magnet		Theory - 324 MCQs - 345 and 346
	Miscellaneous	5, 8, 9, 10, 13, 14, 17 to 19	MCQs - 346 and 347
	Topic Test	5, 6, 13, 14, 15, 16	MCQs - 364

6. Electromagnetic Induction and Alternating Current	6.8 LC Oscillations *(Qualitative treatment)*	All Questions	Theory - 380 MCQs - 405 and 406
	Miscellaneous	18, 29	MCQs - 414
8. Ray Optics	8.7 Refraction and *dispersion* of light through prism	26 to 40, 46 to 50	Theory - 489 to 491 MCQs - 517 and 518
	8.8 Some natural phenomenon due to Sunlight *(Scattering of light)*	2 to 12	Theory - 491 and 492 MCQs - 519
	8.9 Optical Instruments: Human eye	All Questions	Theory - 492 to 494 MCQs - 519 to 521
	Miscellaneous	28	MCQs - 527
	Topic Test	2, 14, 20	MCQs - 557 and 558
10. Diffraction and Polarisation of light	10.2 Resolving power of microscope and astronomical telescope *(including Rayleigh's criteria)*	All Questions	Theory - 611 to 613 MCQs - 624 to 626
	Miscellaneous	7 to 9	MCQs - 633
	Topic Test	1, 6, 9, 11, 15	MCQs - 644 and 645
11. Dual Nature of Matter and Radiation	11.7 Davisson and Germer experiment	All Questions	Theory - 654 and 655 MCQs - 670 to 672
	Topic Test	7, 16	MCQs - 691 and 692
12. Atoms and Nuclei	12.5 Composition and size of nucleus, *isotopes, isobars, isotones*	24 to 27	Theory - 700 MCQs - 721
	12.8 Radioactivity: α, β particles and γ - rays and their properties 12.9 Radioactive decay law	All Questions	Theory - 702 to 706 MCQs - 723 to 731
	Miscellaneous	8, 15, 19, 29, 38	MCQs - 734 to 736
	Topic Test	2, 8, 13, 15, 17, 21	MCQs - 759 and 760

13. Electronic Devices	13.8 Junction Transistor	All Questions	Theory - 772 to 777 MCQs - 797 to 805
	13.9 Characteristics of a transistor		
	13.10 Transistor as an amplifier *(CE configuration)*		
	13.11 Transistor as an oscillator		
	Miscellaneous	30 to 37	MCQs - 812 and 813
	Numerical Value Type Questions (NVT)	1	814
	Topic Test	7, 9, 11, 12, 20 to 22, 24, 25	MCQs - 829 and 830
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	Numerical Value Type Questions (NVT)	5	872
JEE (Main) 2023 24^{th} January (Shift – II)	MCQ	10	874

Note: i. *The above table contains the list of chapters/subtopics/question numbers that are excluded from the latest syllabus of NEET (UG) and JEE (Main) 2024.*

ii. *Only the concepts highlighted in italics are excluded from the latest syllabus within the specified subtopics.*

iii. *These questions are covered to give an idea about the variety and difficulty levels of questions asked in the examination over the years.*

Page no. **1** to **2** are purposely left blank.

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

iii. In vector notation, force on q_2 due to q_1 is given as,

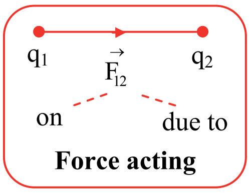
$$\vec{F}_{21} = \frac{1}{4\pi K\varepsilon_0}\frac{q_1q_2}{r_{12}^3}\vec{r}_{12}$$

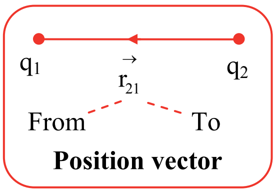
where, $\vec{r}_{12}$ is the position vector from q_1 to q_2.

Force on q_1 due to q_2 is given as,

$$\vec{F}_{12} = \frac{1}{4\pi K\varepsilon_0}\frac{q_1q_2}{r_{21}^3}\vec{r}_{21}$$

where, $\vec{r}_{21}$ is the position vector from q_2 to q_1.





iv. Coulomb's force between charges is central force and acts along the line joining the charges.

v. Coulomb's force between two charges is independent of presence of other charges in the surrounding.

➢ **Electric permittivity:**

Electric permittivity ε is a physical quantity that describes how an electric field affects and is affected by a medium. Its value in free space is $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$.

➢ **Dielectric constant (K or ε_r):**

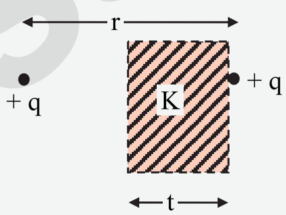
Dielectric constant is defined as the ratio of permittivity of any medium (ε) to the permittivity of free space (ε_0).

i.e., $K = \dfrac{\varepsilon}{\varepsilon_0}$

∴ $\varepsilon = K\varepsilon_0$

Smart tip - 2

When space between the two charges is partially filled with dielectrics of constant K, the thickness t of the dielectric appears to have the thickness $t\sqrt{K}$.



∴ Total distance between two charges,

$r = (r - t) + t\sqrt{K}$

∴ Force between charges will be,

$$F' = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{\left[(r-t)+t\sqrt{K}\right]^2}$$

1.3 Superposition Principle, Forces Between Multiple Charges

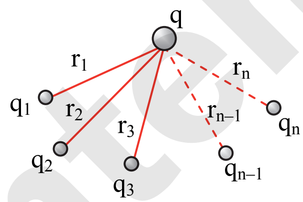
➢ **Superposition principle:**

Total force acting on a given charge due to number of charges is the vector sum of the individual forces acting on that charge due to all the charges.

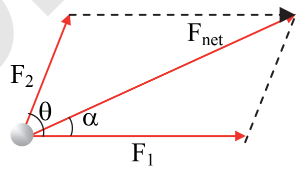
i. Consider number of charges q_1, q_2, q_3…. are applying force on a charge q.

Net force on q will be

$$\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + ... + \vec{F}_{n-1} + \vec{F}_n$$



ii. The magnitude of the resultant of two electric forces is given by,



$$F_{net} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$$

and $\tan\alpha = \dfrac{F_2\sin\theta}{F_1 + F_2\cos\theta}$

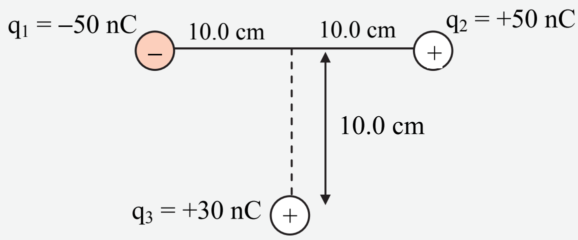
Smart tip - 3

i. The force between any two charges is not affected by the presence or absence of other charges.

ii. The force between two charges is maximum if their magnitude is equal.

EXAMPLE - 1.1

Three charged particles with $q_1 = -50$ nC, $q_2 = +50$ nC, and $q_3 = +30$ nC are placed as shown in figure. What is the net force on charge q_3 due to the other two charges?



Solution:

Defining a co-ordinate system, with charge q_3 at the origin, the forces on charge q_3 can be drawn along with the directions as shown in the figure (a).

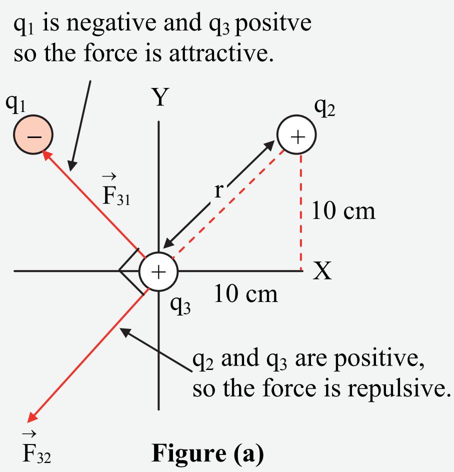


Figure (a)

It can be seen from the geometry that the forces $\vec{F}_{31}$ and $\vec{F}_{32}$ are at right angles with each other. From vector addition the direction of the net force can be determined. The distance r between charges q_2 and q_3 is the same as that between charges q_1 and q_3. It can be calculated as,

$$r = \sqrt{(10.0\ \text{cm})^2 + (10.0\ \text{cm})^2} = 14.14\ \text{cm}.$$

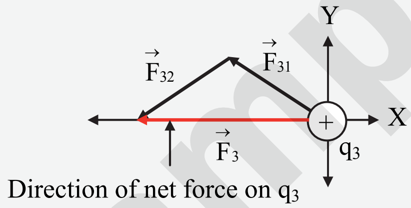


Figure (b)

To determine the net force on charge q_3, use Coulomb's law to compute the magnitudes of the two forces on charge q_3.

$$F_{31} = \frac{k|q_1||q_3|}{r^2}$$

$$= \frac{(9\times10^9\,\text{Nm}^2\text{C}^{-2})(50\times10^{-9}\,\text{C})(30\times10^{-9}\,\text{C})}{(0.14\,\text{m})^2}$$

$= 0.69 \times 10^{-3}$ N

Since the magnitudes of q_1 and q_2 are equal and they are equidistant from q_3, The magnitude of the forces they exert will be equal.

$$\therefore \quad F_{32} = \frac{K|q_2||q_3|}{r^2} = 0.69 \times 10^{-3}\ \text{N}$$

Thus, the net force acting on charge q_3 is given by,

$$F_{net} = \sqrt{F_{31}^2 + F_{32}^2 + 2F_{31}F_{32}\cos\theta}$$

$$= \sqrt{F_{31}^2 + F_{32}^2} \quad \text{.... } (\because \theta = 90°)$$

$$= \sqrt{(0.69\times10^{-3})^2 + (0.69\times10^{-3})^2}$$

$= 0.69 \times 10^{-3} \times \sqrt{2}$

$= 0.98 \times 10^{-3}$ N

Thus the net force on charge q_3, as shown

➢ **Forces between multiple charges:**

i. Principle of superposition is used to calculate electric force on a charge due to other charges in the vicinity.

ii. For N point charges $q_1, q_2, \ldots, q_N$ located at positions $\vec{r}_1, \vec{r}_2, \ldots \vec{r}_N$ with respect to origin respectively, total force $\vec{F}_1$ experienced by charge q_1 due to all other charges is given by,

$$\vec{F}_1 = \vec{F}_{12} + \vec{F}_{13} + \vec{F}_{14} + \ldots\ldots + \vec{F}_{1N}$$

iii. Using vector form of Coulomb's law,

$$\vec{F}_1 = \frac{1}{4\pi\varepsilon_0}\left[q_1q_2\frac{\vec{r}_1-\vec{r}_2}{|\vec{r}_1-\vec{r}_2|^3} + q_1q_3\frac{\vec{r}_1-\vec{r}_3}{|\vec{r}_1-\vec{r}_2|^3} + \ldots\ldots + q_1q_N\frac{\vec{r}_1-\vec{r}_N}{|\vec{r}_1-\vec{r}_N|^3}\right]$$

1.4 Continuous distribution of charges

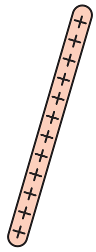
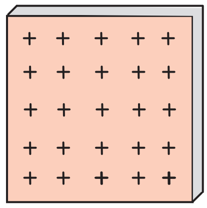
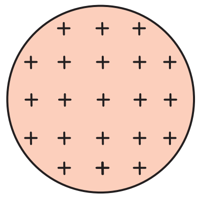
➢ **Continuous distribution of charges:**

A system of closely spaced electric charges form a continuous charge distribution.

On macroscopic level, quantisation of charges is ignored. For a charged body with reasonable size, its charge distribution is treated as continuous.

➢ **Types of charge distribution:** The continuous distribution can be categorized as linear, surface and volume charge distribution. The respective densities can be studied as follows:

	Linear charge distribution	Surface charge distribution	Volume charge distribution
Definition	When charge is distributed along a line, charge distribution is called linear charge distribution.	When charge is distributed over a surface, charge distribution is called surface charge distribution.	When charge is distributed over the volume of an object, it is called volume charge distribution.

Diagram	 Thin long conductor (wire)	 Metal plate	 Metal Sphere
Formula for charge density	$\lambda = q/L$ Where, L is length of rod	$\sigma = q/A$ Where, A is surface area	$\rho = q/V$ Where, V is volume
Unit of charge density	coulomb metre^{-1} (Cm^{-1})	coulomb metre^{-2} (Cm^{-2})	coulomb metre^{-3} (Cm^{-3})
Dimensions of charge density	$[M^0L^{-1}T^1A^1]$	$[M^0L^{-2}T^1A^1]$	$[M^0L^{-3}T^1A^1]$
Force	$\vec{F} = \frac{q_0}{4\pi\varepsilon_0}\int\frac{\lambda dl}{r'^2}\hat{r}'$	$\vec{F} = \frac{q_0}{4\pi\varepsilon_0}\int\frac{\sigma ds}{r'^2}\hat{r}'$	$\vec{F} = \frac{q_0}{4\pi\varepsilon_0}\int\frac{\rho dV}{r'^2}\hat{r}'$
	where, r′ is distance between charge element and point under consideration. $\hat{r}'$ is unit vector directed from charge element to the point.		

1.5 Electric field, Electric field lines, Electric field due to a point charge

➢ **Electric field:**

The space around charge in which its electric force can be experienced is called electric field.

i. The electric field is a vector quantity introduced as an intermediary between charges.

ii. It is an entity which has its existence along with the charge that produces it.

iii. The electric field is characteristic of charge or system of charges and independent of the test charge placed at a point.

iv. A charge does not experience any force due to electric field produced by it.

v. The electric field is quantified by electric field intensity.

➢ **Electric field intensity $\left(\vec{E}\right)$:**

Electric field intensity at any point in an electric field is defined as the force acting per unit test charge at that point in an electric field.

i. Electric field intensity represents strength of electric field.

ii. It is also called as electric field strength or electric field.

Formulae:	$\vec{E} = \lim_{q\to 0}\frac{\vec{F}}{q}$	$\vec{E} = \frac{\vec{F}}{q_0}$
	Where, q_0 = test charge	
Units:	NC^{-1} or Vm^{-1} (SI)	
Dimensions:	$[M^1L^1T^{-3}A^1]$	
Type:	Vector	

iii. In the presence of dielectric of dielectric constant K, electric field decreases and becomes $\frac{1}{K}$ times its value in free space.

➢ **Electric field due to a point charge:**

i. Consider an isolated point charge q at the origin. Force experienced by test charge q_0 at distance $\vec{r}$ is, $\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r^2}\hat{r}$

ii. The electric intensity at the point is given as, $\vec{E} = \frac{\vec{F}}{q_0}$

$\therefore$ $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$

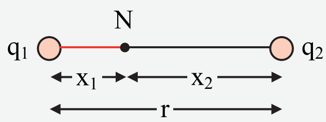
iii. The magnitude of $\vec{E}$ follows inverse square law.

iv. The electric field due to point charge is spherically symmetric.

v. For a positive charge, the electric field will be directed radially outwards from the charge. On the other hand, if the source charge is negative, the electric field vector, at each point, points radially inwards.

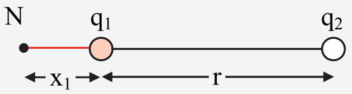
Smart tip - 4

i. If two like charges q_1 and q_2 are separated by distance r, then distance x between charge q_1, and null point (point where net electric field due to both the charges is zero) is, $x = \frac{r}{\sqrt{\frac{q_2}{q_1}}+1}$



Null point for like charges

ii. If two unlike charges q_1 and q_2 are separated by distance r, then distance x between charge q_1, and null is, $x = \dfrac{r}{\sqrt{\dfrac{q_2}{q_1}} - 1}$



Null point for unlike charges

EXAMPLE - 1.2

Calculate the magnitude and direction of the electric field at a point P which is 60 cm to the right of a point charge $Q = -3.0 \times 10^{-6}$ C.

Solution:

The magnitude of the electric field due to a single point charge is given by $E = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{r^2}$. The direction is found using the sign of the charge Q.

The magnitude of the electric field is,

$$E = \frac{kQ}{r^2} = \frac{(9\times10^9\,\text{Nm}^2\text{C}^{-2})(3.0\times10^{-6}\,\text{C})}{(0.60\text{ m})^2}$$

$$= 75 \times 10^3 \text{ N/C}$$

As the charge Q is negative point charge, the direction of the electric field is towards the charge Q (i.e., radially inwards).

➢ **Electric field lines:**

The imaginary path along which a free positive charge moves when placed in an electric field is called as electric field lines .

i. They start from a positive charge and end on a negative charge.

ii. A field line is a space curve, i.e., a curve in three dimensions.

iii. The tangent to the field lines at any point gives the direction of the electric field intensity $\vec{E}$ at that point.

iv. Two field lines do not intersect each other.

v. The field lines are normal to the surface of a charged conductor at any point.

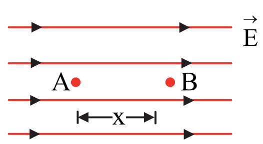
vi. Field lines do not pass through a conductor. Hence the electric field inside a conductor is always zero. Field lines can pass through an insulator.

vii. Electric field lines are crowded together where the field is strong and widely separated from each other where the field is weak.

viii. If electric field intensity is same both in magnitude and direction throughout then electric field is said to be uniform. Uniform electric field is represented by equispaced parallel lines.

➢ **Motion of a charged particle in an electric field:**

Suppose a charged particle having **charge Q** and **mass m** is initially at rest in an electric **field of strength E**. The particle will experience an electric force which causes its motion. Some of the physical quantities related to its motion can be described as follows:

Force	$F = QE$	Where, Q = charge on the particle E = Strength of electric field m = mass of the charged particle
Acceleration	$a = \dfrac{F}{m} = \dfrac{QE}{m}$	
Velocity: Suppose at point A the particle is at rest and in time t it reaches the point B where its velocity becomes v.	$v = \dfrac{QEt}{m} = \sqrt{\dfrac{2Q\Delta V}{m}}$ 	Where, Velocity at point A = 0 v = velocity at point B t = time ΔV = potential difference between A and B x = Separation between A and B.
Momentum	$p = m \times \dfrac{QEt}{m} = QEt$ $p = m \times \sqrt{\dfrac{2Q\Delta V}{m}} = \sqrt{2mQ\Delta V}$	
Kinetic energy	$\text{K.E.} = \dfrac{1}{2}mv^2 = \dfrac{1}{2}m\left(\dfrac{QEt}{m}\right)^2 = \dfrac{Q^2E^2t^2}{2m}$ $\text{K.E.} = \dfrac{1}{2}m \times \dfrac{2Q\Delta V}{2} = Q\Delta V$	

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5. It is interesting to note that dipole field $E \propto \frac{1}{r^3}$ decreases much rapidly as compared to the field of a point charge $\left(E \propto \frac{1}{r^2}\right)$.

6. Electric field intensity and electric potential due to a point charge q, at a distance $t_1 + t_2$ where t_1 is thickness of medium of dielectric constant K_1 and t_2 is thickness of medium of dielectric constant K_2 are:

$$E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{\left(t_1\sqrt{K_1} + t_2\sqrt{K_2}\right)^2};$$

$$V = \frac{1}{4\pi\varepsilon_0} \frac{Q}{\left(t_1\sqrt{K_1} + t_2\sqrt{K_2}\right)}$$

Multiple Choice Questions

1.1 Electric Charges and their Conservation, Conductors and Insulators, Free and Bound Charges Inside a Conductor

1. Which one of the following is the unit of electric charge?
(A) coulomb (B) newton
(C) volt (D) coulomb/volt

2. The electric charge always resides
(A) at the centre of charged conductor.
(B) at the interior of charged conductor.
(C) on the outer surface of charged conductor.
(D) randomly all over the charged conductor.

3. Which among the following is a sure test of electrification?
(A) Attraction (B) Induction
(C) Repulsion (D) Conduction

4. A body can be negatively charged by
(A) giving excess of electrons to it.
(B) removing some electrons from it.
(C) giving some protons to it.
(D) removing some neutrons from it.

5. One metallic sphere A is given positive charge whereas another identical metallic sphere B of exactly same mass as of A is given equal amount of negative charge. Then
(A) mass of A and mass of B still remain equal.
(B) mass of A increases.
(C) mass of B decreases.
(D) mass of B increases.

6. When a glass rod is rubbed with silk, it
(A) gains electrons from silk.
(B) gives electrons to silk.
(C) gains protons from silk.
(D) gives protons to silk.

7. Two identical conductors of copper and aluminium are placed in an identical electric fields. The magnitude of induced charge in aluminium will be
(A) zero
(B) greater than in copper
(C) equal to that in copper
(D) less than in copper

8. When a body is connected to the earth, electrons from the earth flow into the body. This means the body is ________
(A) uncharged.
(B) charged positively.
(C) charged negatively.
(D) an insulator.

9. Five balls numbered 1 to 5 are suspended using separate threads. Pairs (1, 2), (2, 4) and (4, 1) show electrostatic attraction while pairs (2, 3), (4, 5) show repulsion. Therefore, ball 1 must be **[BCECE 2015]**
(A) neutral
(B) metallic
(C) positively charged
(D) negatively charged

10. Transfer of electric charge can take place in such quantities which are integral multiples of
(A) 1 e.s.u. of charge
(B) 1 coulomb
(C) 1 micro coulomb
(D) 1.6×10^{-19} coulomb

11. A glass rod rubbed with silk is used to charge a gold leaf electroscope and the leaves are observed to diverge. The electroscope thus charged is exposed to X-rays for a short period. Then
(A) the divergence of leaves will not be affected.
(B) the leaves will diverge further.
(C) the leaves will collapse.
(D) the leaves will melt.

12. There are two metallic spheres of same radii but one is solid and the other is hollow, then
(A) solid sphere can be given more charge.
(B) hollow sphere can be given more charge.
(C) they can be charged equally (maximum).
(D) None of the above

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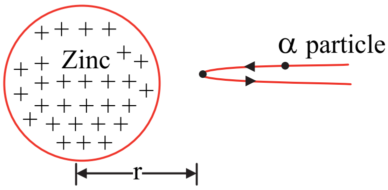
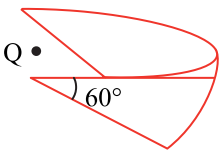
68. An alpha particle with kinetic energy 20 MeV is heading towards a stationary tiny nucleus of zinc as shown in the figure below. Calculate the distance between alpha particle and nucleus when alpha particle is closest to the nucleus. (Atomic number of zinc = 30)



(A) 1.28×10^{-15} m (B) 3.66×10^{-15} m
(C) 4.32×10^{-15} m (D) 5.26×10^{-15} m

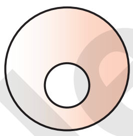
69. A charge Q is placed at the centre of an imaginary surface which is part of an imaginary sphere as shown in figure. The flux of electric field due to this charge through the surface is



(A) $\frac{Q}{\varepsilon_0}$ (B) $\frac{Q}{4\varepsilon_0}$ (C) $\frac{Q}{3\varepsilon_0}$ (D) $\frac{Q}{6\varepsilon_0}$

70. A spherical portion has been removed from a solid sphere having a charge distributed uniformly in its volume as shown in the figure. The electric field inside the emptied space is

(A) zero everywhere.
(B) non-zero and uniform.
(C) non-uniform.
(D) zero only at its centre.



Numerical Value Type Questions

1. An electric dipole consists of charges + 4e and – 4e separated by 0.8 nm. The magnitude of the torque on the dipole when the dipole moment is perpendicular to the electric field of strength $2\pi \times 10^5$ N/C is ________ $\times 10^{-22}$ Nm. (Take $\pi = 3.14$) **[Ans: 3.21]**

2. Three charges –q, +Q and –q are placed in a straight line as shown

If the total potential energy of the system is zero, then the ratio Q/q is ________ **[Ans: 0.22]**

3. Charges of 18 μC are placed at each of the four corners of a square of side $3\sqrt{2}$ m. The potential at the point of intersection of the diagonals is ________ kV. ($k = 9 \times 10^9$ SI unit) **[Ans: 216]**

4. A spherical conductor of radius 2 cm is uniformly charged with 12 nC. The electric field at a distance of 6 cm from the centre of the sphere is ______ $\times 10^4$ V/m **[Ans: 3]**

5. The electric intensity due to a dipole of length 10 cm and having a charge of 500 μC, at a point on the axis at a distance 20 cm from one of the charges in air, is ________ $\times 10^7$ N/C **[Ans: 6.25]**

Answers to MCQs

1.1:	1. (A)	2. (C)	3. (C)	4. (A)	5. (D)	6. (B)	7. (C)	8. (B)	9. (A)	10. (D)
	11. (B)	12. (C)	13. (C)	14. (A)	15. (A)	16. (B)	17. (B)	18. (B)	19. (A)	20. (D)
	21. (C)									
1.2 :	1. (D)	2. (B)	3. (B)	4. (D)	5. (C)	6. (A)	7. (B)	8. (A)	9. (D)	10. (B)
	11. (C)	12. (C)	13. (A)	14. (D)	15. (A)	16. (A)	17. (C)	18. (A)	19. (B)	20. (D)
	21. (B)	22. (A)	23. (A)	24. (D)	25. (A)	26. (D)	27. (D)	28. (A)	29. (A)	30. (A)
	31. (B)	32. (D)	33. (D)	34. (D)						
1.3 :	1. (C)	2. (A)	3. (C)	4. (B)	5. (A)	6. (B)	7. (A)	8. (C)	9. (A)	10. (C)
	11. (B)	12. (C)	13. (C)	14. (D)	15. (A)	16. (B)	17. (C)	18. (A)	19. (B)	20. (A)
1.4 :	1. (C)	2. (A)	3. (B)	4. (A)	5. (D)	6. (D)	7. (C)	8. (C)	9. (A)	10. (A)
	11. (A)	12. (B)	13. (A)							
1.5 :	1. (C)	2. (B)	3. (D)	4. (C)	5. (C)	6. (A)	7. (D)	8. (C)	9. (C)	10. (D)
	11. (D)	12. (D)	13. (B)	14. (C)	15. (A)	16. (B)	17. (C)	18. (C)	19. (B)	20. (D)
	21. (C)	22. (B)	23. (B)	24. (C)	25. (B)	26. (C)	27. (D)	28. (C)	29. (C)	30. (B)
	31. (A)	32. (A)	33. (A)	34. (C)	35. (A)	36. (C)	37. (A)			
1.6 :	1. (A)	2. (A)	3. (A)	4. (A)	5. (A)	6. (D)	7. (D)	8. (C)	9. (C)	10. (A)
	11. (B)	12. (C)	13. (B)	14. (C)	15. (B)	16. (D)	17. (C)	18. (D)	19. (A)	20. (B)
	21. (D)	22. (C)	23. (A)							

1.7:	1.	(A)	2.	(B)	3.	(A)	4.	(A)	5.	(A)	6.	(C)	7.	(D)	8.	(C)	9.	(C)	10.	(C)
	11.	(D)	12.	(A)	13.	(A)	14.	(D)	15.	(D)										
1.8:	1.	(A)	2.	(B)	3.	(C)	4.	(D)	5.	(C)	6.	(A)	7.	(C)	8.	(B)	9.	(D)	10.	(D)
	11.	(A)	12.	(B)	13.	(D)	14.	(C)	15.	(B)	16.	(B)	17.	(C)	18.	(D)	19.	(B)	20.	(C)
	21.	(C)	22.	(C)	23.	(A)	24.	(D)	25.	(B)	26.	(D)	27.	(C)	28.	(D)	29.	(C)	30.	(A)
	31.	(B)	32.	(B)	33.	(D)	34.	(D)	35.	(A)	36.	(D)	37.	(A)						
1.9:	1.	(D)	2.	(D)	3.	(C)	4.	(A)	5.	(D)	6.	(D)	7.	(B)	8.	(D)	9.	(D)	10.	(B)
	11.	(C)	12.	(C)	13.	(C)	14.	(B)	15.	(A)	16.	(A)	17.	(D)	18.	(A)	19.	(A)	20.	(C)
	21.	(A)	22.	(C)	23.	(B)	24.	(D)	25.	(C)	26.	(D)	27.	(C)	28.	(C)	29.	(C)	30.	(D)
	31.	(C)	32.	(A)	33.	(D)	34.	(C)	35.	(C)	36.	(D)								
1.10:	1.	(B)	2.	(B)	3.	(B)	4.	(C)	5.	(D)	6.	(C)	7.	(B)	8.	(A)	9.	(D)	10.	(C)
	11.	(C)	12.	(C)	13.	(D)	14.	(B)	15.	(B)	16.	(B)	17.	(D)	18.	(B)				
1.11:	1.	(A)	2.	(B)	3.	(C)	4.	(A)	5.	(C)	6.	(C)	7.	(C)	8.	(D)	9.	(A)	10.	(C)
	11.	(A)	12.	(A)	13.	(A)	14.	(B)	15.	(A)	16.	(B)	17.	(B)	18.	(B)	19.	(B)	20.	(B)
	21.	(A)	22.	(B)	23.	(C)	24.	(D)	25.	(C)	26.	(B)	27.	(C)						
1.12:	1.	(C)	2.	(A)	3.	(D)	4.	(A)	5.	(B)	6.	(C)	7.	(B)	8.	(B)	9.	(B)	10.	(C)
	11.	(A)	12.	(A)	13.	(A)	14.	(D)	15.	(A)	16.	(D)								
1.13:	1.	(A)	2.	(C)	3.	(A)	4.	(C)	5.	(C)	6.	(D)	7.	(A)	8.	(C)	9.	(B)	10.	(B)
	11.	(D)	12.	(B)	13.	(C)	14.	(C)	15.	(C)	16.	(D)	17.	(A)	18.	(A)	19.	(B)	20.	(D)
	21.	(B)	22.	(C)	23.	(C)	24.	(C)	25.	(B)	26.	(B)	27.	(B)	28.	(B)	29.	(D)	30.	(B)
	31.	(C)	32.	(D)	33.	(A)	34.	(C)	35.	(A)	36.	(C)	37.	(A)	38.	(B)	39.	(C)	40.	(B)
	41.	(A)	42.	(A)	43.	(A)	44.	(A)	45.	(D)	46.	(A)	47.	(B)	48.	(C)	49.	(C)	50.	(B)
	51.	(C)	52.	(A)	53.	(C)	54.	(C)	55.	(C)	56.	(B)	57.	(A)	58.	(C)	59.	(C)	60.	(C)
	61.	(D)																		
1.14:	1.	(D)	2.	(D)	3.	(B)	4.	(D)	5.	(D)										
Misc:	1.	(B)	2.	(D)	3.	(A)	4.	(B)	5.	(A)	6.	(C)	7.	(B)	8.	(D)	9.	(C)	10.	(A)
	11.	(C)	12.	(C)	13.	(B)	14.	(D)	15.	(C)	16.	(C)	17.	(B)	18.	(D)	19.	(B)	20.	(A)
	21.	(D)	22.	(A)	23.	(B)	24.	(B)	25.	(A)	26.	(C)	27.	(C)	28.	(C)	29.	(A)	30.	(B)
	31.	(A)	32.	(B)	33.	(B)	34.	(A)	35.	(B)	36.	(B)	37.	(B)	38.	(C)	39.	(A)	40.	(D)
	41.	(A)	42.	(A)	43.	(D)	44.	(D)	45.	(D)	46.	(C)	47.	(C)	48.	(A)	49.	(D)	50.	(C)
	51.	(A)	52.	(A)	53.	(B)	54.	(D)	55.	(A)	56.	(C)	57.	(D)	58.	(B)	59.	(B)	60.	(A)
	61.	(C)	62.	(A)	63.	(D)	64.	(B)	65.	(D)	66.	(A)	67.	(C)	68.	(C)	69.	(D)	70.	(B)

Hints to MCQs

1.1 Electric Charges and their Conservation, Conductors and Insulators, Free and Bound Charges Inside a Conductor

4. Excess of electron gives the negative charge on body.

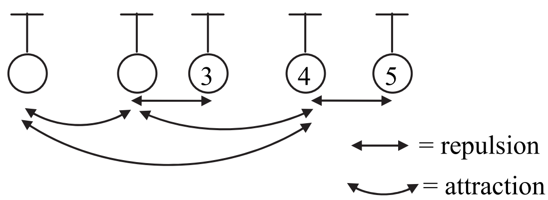
5. Negative charge means excess of electrons which increases the mass of sphere B. Whereas positive charge on sphere A is given by removal of electrons.

6. On rubbing glass rod with silk, excess electrons are transferred from glass to silk. So glass rod becomes positive and silk becomes negative.

7. Since both are metals so equal amount of charge will be induced in them.

8. When a positively charged body is connected to the earth, electrons flows from earth to body and body becomes neutral.

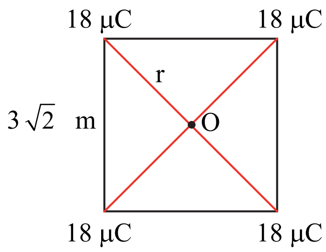
9. As 2 and 3 repel and also 4 and 5 repel; 2, 3, 4 and 5 must be charged.
As 2 and 4 attract, they must be oppositely charged.
As 1 attracts both 2 and 4, this is possible only for a neutral ball. Hence, 1 is neutral.



$\therefore \quad \frac{3}{2}\frac{qQ}{x} = \frac{q^2}{3x}$

$\therefore \quad \frac{Q}{q} = \frac{1}{3} \times \frac{2}{3} = \frac{2}{9} = 0.22$

3.



The potential at point O is the addition of the potentials created by all four charges.

$\therefore \quad V = 4\,V_q$

Now, $V_q = k\frac{q}{r}$ where, $r = \frac{1}{2} \times \text{Diagonal}$

but, Diagonal of a square = $\sqrt{2}(\text{side of square})$

$\therefore \quad \text{Diagonal} = \sqrt{2} \times 3\sqrt{2} = 6$ m

$\therefore \quad r = \frac{1}{2} \times 6 = 3$ m

$\therefore \quad V_q = 9 \times 10^9 \times \frac{18 \times 10^{-6}}{3} = 54 \times 10^3$

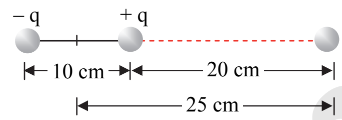
$\therefore \quad V = 4\,V_q = 216 \times 10^3$ volt = 216 kV

4. $E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$

$\therefore \quad E = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{(6 \times 10^{-2})^2}$

$= 3 \times 10^4$ V/m

5.



By using $E = 9 \times 10^9 \times \frac{2pr}{(r^2 - l^2)^2}$;

$p = (500 \times 10^{-6}) \times (10 \times 10^{-2})$

$= 5 \times 10^{-5}$ Cm

r = 25 cm = 0.25 m, l = 5 cm = 0.05 m

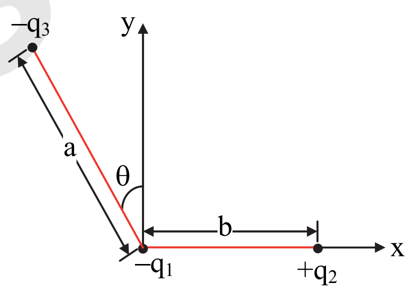
$E = \frac{9 \times 10^9 \times 2 \times 5 \times 10^{-5} \times 0.25}{\{(0.25)^2 - (0.05)^2\}^2} = 6.25 \times 10^7$ N/C

Topic Test

1. A charge of 5.8×10^{-18} C
   (A) does exists.
   (B) does not exist.
   (C) exists for a short time.
   (D) exists only if placed in higher orbits.

2. Two point charges repel each other with a force of 100 N. One of the charges is increased by 10% and other is reduced by 10%. The new force of repulsion at the same distance would be
   (A) 100 N (B) 121 N
   (C) 99 N (D) 90 N

3. Three charges $-q_1$, $+q_2$ and $-q_3$ are placed as shown in figure. The x component of the force on $-q_1$ is proportional to



   (A) $\frac{q_2}{b^2} - \frac{q_3}{a^2}\sin\theta$ (B) $\frac{q_2}{b^2} - \frac{q_3}{a^2}\cos\theta$
   (C) $\frac{q_2}{b^2} + \frac{q_3}{a^2}\sin\theta$ (D) $\frac{q_2}{b^2} + \frac{q_3}{a^2}\cos\theta$

4. A square is centered at origin having sides parallel to x and y-axis. It has surface charge density σ (x, y) = σ_0 xy within its boundaries. The measure of charge of each side of square is Q. What is the total charge on the square?
   (A) $4\sigma_0 Q^2$ (B) $2\sigma_0 a^3$
   (C) $\sigma_0 a^2$ (D) Zero

5. Two positive charges of 20 coulomb and Q coulomb are situated at a distance of 60 cm. The neutral point between them is at a distance of 20 cm from the 20 coulomb charge. Charge Q is
   (A) 30 C (B) 40 C
   (C) 60 C (D) 80 C

6. An electric dipole, when held at 30° with respect to a uniform electric field of 10^4 NC^{-1} experiences a torque of 9×10^{-26} Nm. Calculate dipole moment of the dipole.
   (A) 1.7×10^{-29} Cm (B) 1.8×10^{-30} Cm
   (C) 1.8×10^{-29} Cm (D) 1.7×10^{-30} Cm

7. A charge Q is enclosed by a Gaussian spherical surface of radius R. If the radius is doubled, then the outward electric flux will
   (A) increase four times.
   (B) be reduced to half.
   (C) remain the same.
   (D) be doubled.

8. Two charged conducting spheres of radii R_1 and R_2 separated by a large distance are connected by a long wire. The ratio of the charges on them is

(A) $\frac{R_1}{R_2}$ (B) $\frac{R_2}{R_1}$

(C) $\frac{R_1^2}{R_2^2}$ (D) $\frac{R_2^2}{R_1^2}$

9. The electric potential due to the nucleus of the hydrogen atom at a distance of 5.3×10^{-11} m is 27.2 V. What is the potential due to the helium nucleus at the same distance?

(A) 27. 2 V (B) 54.4 V

(C) 13.6 V (D) 20.4 V

10. The electric field in a region is radially outward with magnitude E = Ar. Find the charge contained in a sphere of radius 20 cm. Given: A = 100 V m^{-2}

(A) 9.89×10^{-11} C

(B) 7.85×10^{-11} C

(C) 8.89×10^{-11} C

(D) 8.19×10^{-11} C

11. Two positive point charges 12 μC and 8 μC are placed 10 cm apart in air. How much work must be done to bring them close by 6 cm?

(A) 2.8 J (B) 3.8 J

(C) 4.8 J (D) 13.0 J

12. A thin charged shell of surface charge density -1.77×10^{-6} Cm^{-2} is placed in air. The electric field at its surface is,

(A) 2×10^6 NC^{-1} (B) -2×10^6 NC^{-1}

(C) 2×10^{-5} NC^{-1} (D) -2×10^5 NC^{-1}

13. Two equal charges are separated by a distance d. A third charge placed on a perpendicular bisector at x distance will experience maximum Coulomb force when

(A) $x = d/\sqrt{2}$ (B) $x = d/2$

(C) $x = d/2\sqrt{2}$ (D) $x = d/2\sqrt{3}$

14. The energy density per unit volume of medium in an electric field of intensity 400 V/m is (dielectric constant of material is 2 and $\varepsilon_0 = 8.85 \times 10^{-12}$ units)

(A) 35.40×10^{-8} J/m^3

(B) 40.35×10^{-8} J/m^3

(C) 43.5×10^{-8} J/m^3

(D) 1.416×10^{-6} J/m^3

Answers

1.	(B)	2.	(C)	3.	(C)	4.	(D)
5.	(D)	6.	(C)	7.	(C)	8.	(A)
9.	(B)	10.	(C)	11.	(D)	12.	(D)
13.	(C)	14.	(D)				