Electrostatics GATE

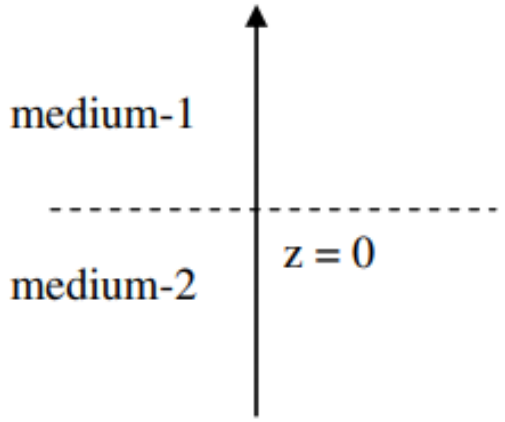
https://snboseplc.com/electrostatics-gate/

GATE Questions

1. GATE-2012

Two infinitely extended homogeneous isotropic dielectric media (medium-1 and medium-2 with dielectric constants $\frac{\varepsilon_1}{\varepsilon_0} = 2$ and $\frac{\varepsilon_2}{\varepsilon_0} = 5$, respectively) meet at the $z = 0$ plane as shown in the figure. A uniform electric field exists everywhere. For $z \geq 0$, the electric field is given by $\vec{E}_1 = 2\hat{i} - 3\hat{j} + 5\hat{k}$. The interface separating the two media is charge free.

The electric displacement vector in the medium-2 is given by



1. $\vec{D}_2 = \varepsilon_0[10\hat{i} + 15\hat{j} + 10\hat{k}]$
2. $\vec{D}_2 = \varepsilon_0[10\hat{i} - 15\hat{j} + 10\hat{k}]$
3. $\vec{D}_2 = \varepsilon_0[4\hat{i} - 6\hat{j} + 10\hat{k}]$
4. $\vec{D}_2 = \varepsilon_0[4\hat{i} + 6\hat{j} + 10\hat{k}]$

2. GATE-2012

In a hydrogen atom, consider that the electronic charge is uniformly distributed in a spherical volume of radius a ($= 0.5 \times 10^{-10}$ m) around the proton. The atom is placed in a uniform electric field $E = 30 \times 10^5$ V/m. Assume that the spherical distribution of the negative charge remains undistorted under the electric field.

In the equilibrium condition, the separation between the positive and the negative charge centers is

1. 8.66×10^{-16} m
2. 2.60×10^{-15} m
3. 2.60×10^{-16} m
4. 8.66×10^{-15} m

3. GATE-2012

In a hydrogen atom, consider that the electronic charge is uniformly distributed in a spherical volume of radius a ($= 0.5 \times 10^{-10}$ m) around the proton. The atom is placed in a uniform electric field $E = 30 \times 10^5$ V/m. Assume that the spherical distribution of the negative charge remains undistorted under the electric field.

The polarizability of the hydrogen atom in unit of (C^2m/N) is

1. 2.0×10^{-40}
2. 1.4×10^{-41}
3. 1.4×10^{-40}
4. 2.0×10^{-39}

4. GATE-2013

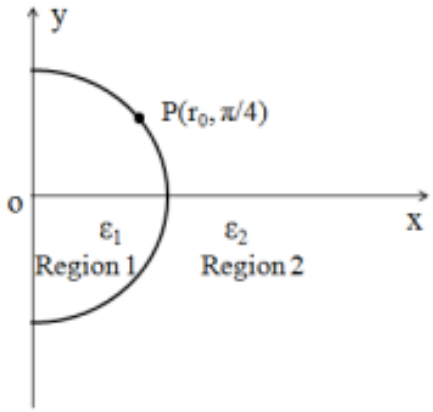
A charge distribution has the charge density given by $\rho = Q\{\delta(x-x_0) - \delta(x+x_0)\}$. For this charge distribution the electric field at $(2x_0, 0, 0)$

1. $\frac{2Q\hat{x}}{9\pi\epsilon_0 x_0^2}$
2. $\frac{Q\hat{x}}{4\pi\epsilon_0 x_0^3}$
3. $\frac{Q\hat{x}}{4\pi\epsilon_0 x_0^2}$
4. $\frac{Q\hat{x}}{16\pi\epsilon_0 x_0^2}$

5. GATE-2014

A ray of light inside Region 1 in the xy-plane is incident at the semicircular boundary that carries no free charges. The electric field at the point $P(r_0, \pi/4)$ in plane polar coordinates is $\vec{E}_1 = 7\hat{e}_r - 3\hat{e}_\varphi$, where $\hat{e}_r$ and $\hat{e}_\varphi$ are the unit vectors. The emerging ray in Region 2 has the electric field $\vec{E}_2$ parallel to x-axis. If ε_1 and ε_2 are the dielectric constants of Region 1 and Region 2 respectively, then $\frac{\varepsilon_2}{\varepsilon_1}$ is _____

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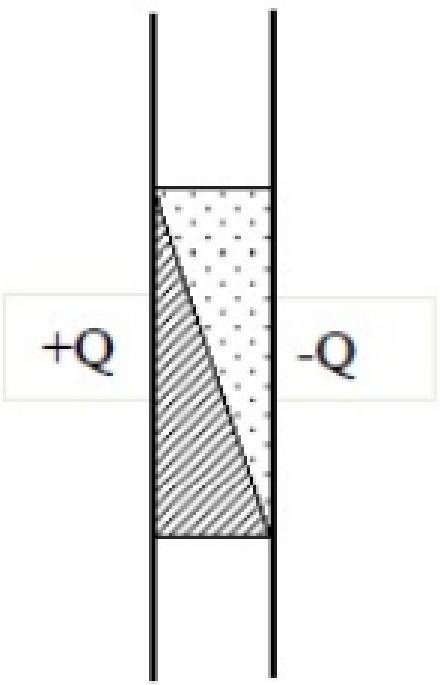
6. GATE-2015

A point charge is placed between two semi-infinite conducting plates which are inclined at an angle of 30° with respect to each other. The number of image charges is

_____

7. GATE-2015

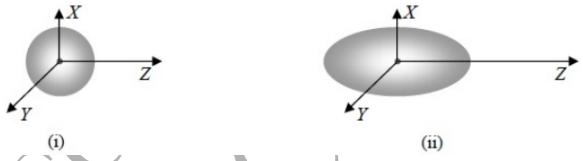
The space between two plates of a capacitor carrying charges $+Q$ and $-Q$ is filled with two different dielectric materials, as shown in the figure. Across the interface of the two dielectric materials, which one of the following statements is correct?



1. $\vec{E}$ and $\vec{D}$ are continuous
2. $\vec{E}$ is continuous and $\vec{D}$ is discontinuous
3. $\vec{D}$ is continuous and $\vec{E}$ is discontinuous
4. $\vec{E}$ and $\vec{D}$ are discontinuous

8. GATE-2015

A charge $-q$ is distributed uniformly over a sphere, with a positive charge q at its center in (i). Also in (ii), a charge $-q$ is distributed uniformly over an ellipsoid with a positive charge q at its center. With respect to the origin of the coordinate system, which one of the following statements is correct?



1. The dipole moment is zero in both (i) and (ii)
2. The dipole moment is non-zero in (i) but zero in (ii)
3. The dipole moment is zero in (i) but non-zero in (ii)
4. The dipole moment is non-zero in both (i) and (ii)

9. GATE-2016

An infinite, conducting slab kept in a horizontal plane carries a uniform charge density σ. Another infinite slab of thickness t, made of a linear dielectric material of dielectric constant k, is kept above the conducting slab. The bound charge density on the upper surface of the dielectric slab is

1. $\frac{\sigma}{2k}$
2. $\frac{\sigma(k-2)}{2k}$
3. $\frac{\sigma}{k}$
4. $\frac{\sigma(k-1)}{k}$

10. GATE-2017

Identical charges q are placed at five vertices of a regular hexagon of side a. The magnitude of the electric field and the electrostatic potential at the centre of the hexagon are respectively

1. $0, 0$

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2. $\frac{q}{4\pi\varepsilon_0 a^2}, \frac{q}{4\pi\varepsilon_0 a}$

3. $\frac{q}{4\pi\varepsilon_0 a^2}, \frac{5q}{4\pi\varepsilon_0 a}$

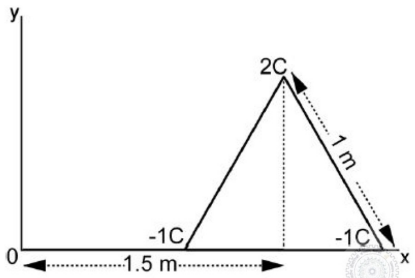
4. $\frac{\sqrt{5}q}{4\pi\varepsilon_0 a^2}, \frac{\sqrt{5}q}{4\pi\varepsilon_0 a}$

11. GATE-2017

A parallel plate capacitor with square plates of side 1 m separated by 1 micro meter is filled with a medium of dielectric constant of 10. If the charges on the two plates are 1 C and -1 C, the voltage across the capacitor is _____ kV. (up to two decimal places). ($\varepsilon_0 = 8.854 \times 10^{-12}$ F/m)

12. GATE-2017

Three charges $(2C, -1C, -1C)$ are placed at the vertices of an equilateral triangle of side 1 m as shown in the figure. The component of the electric dipole moment about the marked origin along the $\hat{y}$ direction is _____ C m.



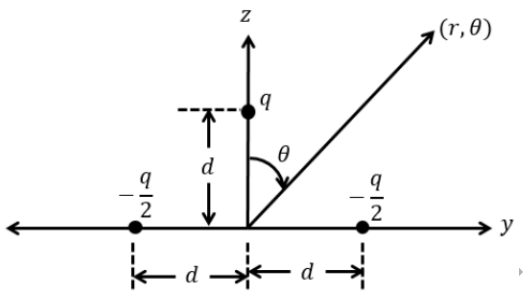
13. GATE-2019

An infinitely long thin cylindrical shell has its axis coinciding with the z-axis. It carries a surface charge density $\sigma_0 \cos\phi$, where ϕ is the polar angle and σ_0 is a constant. The magnitude of the electric field inside the cylinder is

1. 0
2. $\frac{\sigma_0}{2\epsilon_0}$
3. $\frac{\sigma_0}{3\epsilon_0}$
4. $\frac{\sigma_0}{4\epsilon_0}$

14. GATE-2019

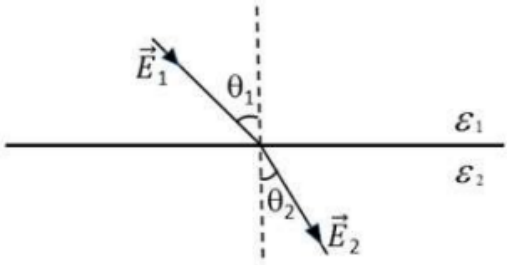
Consider a system of three charges as shown in the figure below:



For $r = 10$ m; $\theta = 60$ degrees; $q = 10^{-6}$ Coulomb, and $d = 10^{-3}$ m, the electric dipole potential in volts (rounded off to three decimal places) at a point (r, θ) is _____ [Use: $\frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \frac{Nm^2}{C^2}$]

15. GATE-2020

Which one of the following relations determines the manner in which the electric field lines are refracted across the interface between two dielectric media having dielectric constants ε_1 and ε_2 (see figure)?



1. $\varepsilon_1 \sin\theta_1 = \varepsilon_2 \sin\theta_2$
2. $\varepsilon_1 \cos\theta_1 = \varepsilon_2 \cos\theta_2$
3. $\varepsilon_1 \tan\theta_1 = \varepsilon_2 \tan\theta_2$
4. $\varepsilon_1 \cot\theta_1 = \varepsilon_2 \cot\theta_2$

16. GATE-2020

A conducting sphere of radius 1 m is placed in air. The maximum number of electrons that can be put on the sphere to avoid electrical breakdown is about 7×10^n, where n is an integer. The value of n is _____

Assume:

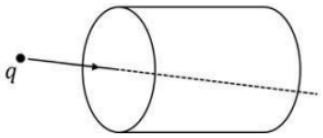
- Breakdown electric field strength in air is $|\vec{E}| = 3 \times 10^6$ V/m

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- Permittivity of free space $\varepsilon_0 = 8.85 \times 10^{-12}$ F/m
- Electron charge $e = 1.60 \times 10^{-19}$ C

17. GATE-2020

A charge q moving with uniform speed enters a cylindrical region in free space at $t = 0$ and exits the region at $t = \tau$ (see figure). Which one of the following options best describes the time dependence of the total electric flux $\varphi(t)$, through the entire surface of the cylinder?



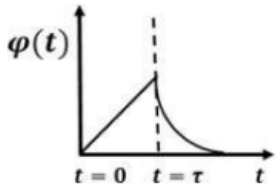


Figure 1: * (A)

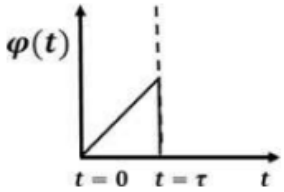


Figure 2: * (B)

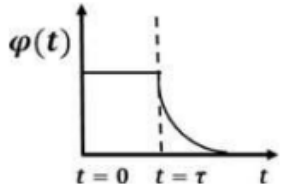


Figure 3: * (C)

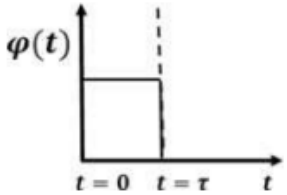
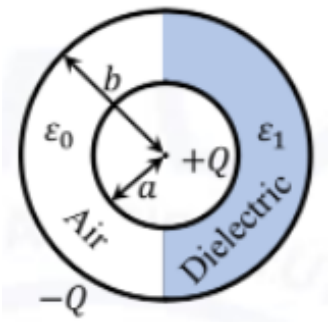


Figure 4: * (D)

18. GATE-2021

Consider two concentric conducting spherical shells as shown in the figure. The inner shell has a radius a and carries a charge $+Q$. The outer shell has a radius b and carries a charge $-Q$. The empty space between them is half-filled by a hemispherical shell of a dielectric having permittivity ε_1. The remaining space between the shells is filled with air having the permittivity ε_0.



The electric field at a radial distance r from the center and between the shells ($a < r < b$) is

1. $\frac{Q}{2\pi(\varepsilon_0+\varepsilon_1)}\frac{\hat{r}}{r^2}$ everywhere
2. $\frac{Q}{4\pi\varepsilon_0}\frac{\hat{r}}{r^2}$ on the air side and $\frac{Q}{4\pi\varepsilon_1}\frac{\hat{r}}{r^2}$ on the dielectric side
3. $\frac{Q}{2\pi\varepsilon_0}\frac{\hat{r}}{r^2}$ on the air side and $\frac{Q}{2\pi\varepsilon_1}\frac{\hat{r}}{r^2}$ on the dielectric side
4. $\frac{Q}{4\pi(\varepsilon_0+\varepsilon_1)}\frac{\hat{r}}{r^2}$ everywhere

19. GATE-2022

On the surface of a spherical shell enclosing a charge free region, the electrostatic potential values are as follows: One quarter of the area has potential ϕ_0, another quarter has potential $2\phi_0$ and the rest has potential $4\phi_0$. The potential at the centre of the shell is

1. $\frac{11}{4}\phi_0$
2. $\frac{11}{2}\phi_0$
3. $\frac{7}{3}\phi_0$
4. $\frac{7}{4}\phi_0$

20. GATE-2022

Electric field is measured along the axis of a uniformly charged disc of radius 25 cm. At a distance d from the centre, the field differs by 10% from that of an infinite plane having the same charge density. The value of d is _____ cm. (Round off to one decimal place)

21. GATE-2022

A parallel plate capacitor with spacing d and area of cross-section A is connected to a source of voltage V. If the plates are pulled apart quasistatically to a spacing of $2d$, then which of the following statements are correct?

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1. The force between the plates at spacing $2d$ is $\frac{1}{8}\left(\frac{\epsilon_0 AV^2}{d^2}\right)$
2. The work done in moving the plates is $\frac{1}{8}\left(\frac{\epsilon_0 AV^2}{d}\right)$
3. The energy transferred to the voltage source is $\frac{1}{2}\left(\frac{\epsilon_0 AV^2}{d}\right)$
4. The energy of the capacitor reduces by $\frac{1}{4}\left(\frac{\epsilon_0 AV^2}{d}\right)$

22. GATE-2023

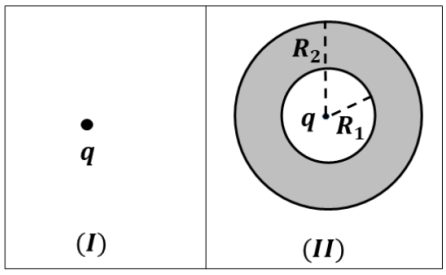
An electric field as a function of radial coordinate r has the form

$$\vec{E} = \alpha \frac{e^{-r^2}}{r}\hat{r}$$

where α is a constant. Assume that dimensions are appropriately taken care of. The electric flux through a sphere of radius $\sqrt{2}$, centered at the origin, is Φ. What is the value of $\frac{\Phi}{2\pi\alpha}$ (rounded off to two decimal places)?

23. GATE-2023

Two independent electrostatic configurations are shown in the figure. Configuration (I) consists of an isolated point charge $q = 1$ C, and configuration (II) consists of another identical charge surrounded by a thick conducting shell of inner radius $R_1 = 1$ m and outer radius $R_2 = 2$ m, with the charge being at the center of the shell. $W_I = \frac{\epsilon_0}{2}\int E_I^2 dV$ and $W_{II} = \frac{\epsilon_0}{2}\int E_{II}^2 dV$, where E_I and E_{II} are the magnitudes of the electric fields for configurations (I) and (II) respectively, ϵ_0 is the permittivity of vacuum, and the volume integrations are carried out over all space. If $\frac{8\pi}{\epsilon_0}|W_I - W_{II}| = \frac{1}{n}$, what is the value of the integer n?



24. GATE-2024

The electric field in a region depends only on x and y coordinates as

$$\vec{E} = k\left(\frac{x\hat{x} + y\hat{y}}{x^2 + y^2}\right)$$

where k is a constant. The flux of $\vec{E}$ through the surface of a sphere of radius R with its center at the origin is $n\pi kR$, where the value of n is _____ (in integer).

25. GATE-2024

Two point charges of charge $+q$ each are placed a distance $2d$ apart. A grounded solid conducting sphere of radius a is placed midway between them. Assume $a^2 \ll d^2$. Which of the following statement is/are true?

1. If $a > \frac{d}{8}$, the net force acting on the charges is directed towards each other
2. The potential at the surface of the sphere is zero
3. Total induced charge on the sphere is $(-2aq/d)$
4. The potential at the center of the sphere is non-zero

26. GATE-2024

In a parallel plate capacitor, the plate at $x = 0$ is grounded and the plate at $x = d$ is maintained at a potential V_0. The space between the two plates is filled with a linear dielectric of permittivity $\varepsilon = \varepsilon_0(1 + \frac{x}{d})$, where ε_0 is the permittivity of free space. Neglecting the edge effects, the electric field ($\vec{E}$) inside the capacitor is

1. $-\frac{V_0}{(d+x)\ln 2}\hat{x}$
2. $-\frac{V_0}{d}\hat{x}$
3. $-\frac{V_0}{(d+x)}\hat{x}$
4. $-\frac{V_0 d}{(d+x)x}\hat{x}$

27. GATE-2025

A linear dielectric sphere of radius R has a uniform frozen-in polarization along the z-axis. The center of the sphere initially coincides with the origin, about which the electric dipole moment is $\vec{p}_1$. When the sphere is shifted to the point $(2R, 0, 0)$, the corresponding dipole moment with respect to the origin is $\vec{p}_2$. The value of $\frac{|\vec{p}_1|}{|\vec{p}_2|}$ (an integer) is _____

28. GATE-2025

A thin circular ring of radius R lies in the xy-plane with its centre at the origin. The ring carries a uniform line charge density λ. The quadrupole contribution to the electrostatic potential at the point $(0, 0, d)$, where $d \gg R$, is

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1. $-\frac{\lambda R^3}{4\epsilon_0 d^3}$
2. 0
3. $\frac{\lambda R^3}{4\epsilon_0 d^3}$
4. $-\frac{\lambda R^3}{2\epsilon_0 d^3}$

29. GATE-2025

A point charge q is placed at a distance d above an infinite, grounded conducting plate placed on the xy-plane at $z = 0$. The electrostatic potential in the $z > 0$ region is given by

$$\phi = \phi_1 + \phi_2,$$

where

$$\phi_1 = \frac{1}{4\pi\epsilon_0}\frac{q}{\sqrt{x^2+y^2+(z-d)^2}} \quad \text{and} \quad \phi_2 = -\frac{1}{4\pi\epsilon_0}\frac{q}{\sqrt{x^2+y^2+(z+d)^2}}.$$

Which of the following option(s) is/are correct?

1. The magnitude of the force experienced by the point charge q is $\frac{1}{16\pi\epsilon_0}\frac{q}{d^2}$.
2. The electrostatic energy of the system is $\frac{1}{8\pi\epsilon_0}\frac{q^2}{d}$.
3. The induced surface charge density on the plate is proportional to $\frac{1}{\sqrt{x^2+y^2+d^2}}$.
4. The electrostatic potential ϕ_1 satisfies Poisson's equation for $z > 0$.

30. GATE-2025

A neutral conducting sphere of radius R is placed in a uniform electric field of magnitude E_0, that points along the z-axis. The electrostatic potential at any point $\vec{r}$ outside the sphere is given by

$$V(r,\theta) = V_0 - E_0 r\left(1 - \frac{R^3}{r^3}\right)\cos\theta,$$

where V_0 is the constant potential of the sphere. Which of the following option(s) is/are correct?

1. The induced surface charge density on the sphere is proportional to $\sin\theta$.
2. As $r \to \infty$, $\vec{E} = E_0 \cos\theta\, \hat{r}$.
3. The electric field at any point is curl free for $r > R$.
4. The electric field at any point is divergence free for $r > R$.

31. GATE-2025

A point charge q is placed at the origin, inside a linear dielectric medium of infinite extent, having relative permittivity ε_r. Which of the following option(s) is/are correct?

1. The magnitude of the polarization varies as $\frac{1}{r^2}$.
2. The magnitude of the polarization varies as $\frac{1}{r^3}$.
3. The magnitude of the screened charge due to the dielectric medium is less than the magnitude of the point charge q for $\varepsilon_r > 1$.
4. The magnitude of the screened charge due to the dielectric medium is more than the magnitude of the point charge q for $\varepsilon_r = 1$.

32. GATE-2026

An infinitely large non-conducting thin sheet in the xy-plane ($z = 0$) carries a uniform surface charge density

$$\sigma = 17.70 \times 10^{-12}\ \text{C.m}^{-2}.$$

The electric field in the region $z < 0$ is

$$\vec{E}_2 = \hat{x} + 2\hat{y} + 3\hat{z}.$$

Then, the electric field $\vec{E}_1$ in the region $z > 0$ will be

_____

$$\left(\epsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2.\text{N}^{-1}.\text{m}^{-2}\right)$$

1. $\vec{E}_1 = \hat{x} + 2\hat{y} + 5\hat{z}$
2. $\vec{E}_1 = \hat{x} + 2\hat{y} + 4\hat{z}$
3. $\vec{E}_1 = \hat{x} + 2\hat{y} + 3\hat{z}$
4. $\vec{E}_1 = \hat{x} + 4\hat{y} + \hat{z}$

33. GATE-2026

A dielectric sphere carries a uniform polarization

$$P = 26\,\mu\text{C.cm}^{-2}.$$

The magnitude of the electric field at the center of the sphere is

$$E \times 10^9\ \text{N.C}^{-1}.$$

The value of E (rounded off to one decimal place) is

_____

$$\left(\epsilon_0 = 8.85 \times 10^{-12}\ \text{C}^2.\text{N}^{-1}.\text{m}^{-2}\right)$$

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34. GATE-2026

A positive point charge is fixed at the origin. At some distance from it on the x-axis, a point dipole is kept pointing in the $+y$ direction. The force on the dipole is

1. 0
2. in the $+y$ direction
3. in the $-y$ direction
4. in the $+x$ direction

Question No.	Entrance with year	Answers
1	GATE-2012	Option B
2	GATE-2012	Option C
3	GATE-2012	Option B
4	GATE-2013	Option A
5	GATE-2014	Ans 2.3–2.4
6	GATE-2015	Ans 11
7	GATE-2015	Option C
8	GATE-2015	Option A
9	GATE-2016	Option D
10	GATE-2017	Option C
11	GATE-2017	Ans 11.25–11.34
12	GATE-2017	Ans 1.72–1.75
13	GATE-2019	Option B
14	GATE-2019	Ans 0.044–0.046
15	GATE-2020	Option B
16	GATE-2020	Ans 14–15
17	GATE-2020	Option D
18	GATE-2021	Option A
19	GATE-2022	Option a
20	GATE-2022	Ans 2.4–2.6
21	GATE-2022	Option a, c, d
22	GATE-2023	Ans 0.36–0.40
23	GATE-2023	Ans 2
24	GATE-2024	Ans 4
25	GATE-2024	Option A, B, C
26	GATE-2024	Option A
27	GATE-2025	Ans 1
28	GATE-2025	Option A
29	GATE-2025	Option D
30	GATE-2025	Option C, D
31	GATE-2025	Option A, C
32	GATE-2026	Option A
33	GATE-2026	Ans 9–10
34	GATE-2026	Option B

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