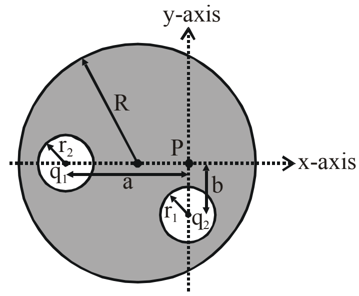
# CLASS TEST



## SECTION-I

**Single Correct Answer Type** **6 Q. [3 M (–1)]**

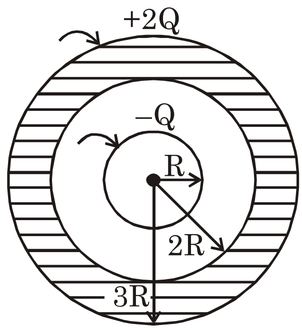
**1.** A charge $q_1$ & $q_2$ are placed inside a spherical cavity made inside uncharged conducting sphere of radius R. Electric field at P due all induced charge on the sphere :-




(A) $\frac{kq_1}{a^2}\hat{i}+\frac{kq_2}{b^2}\hat{j}$ (B) $-\frac{kq_1}{a^2}\hat{i}-\frac{kq_2}{b^2}\hat{j}$

(C) $\frac{kq_1}{r_1^2}\hat{i}+\frac{kq_2}{r_2^2}\hat{j}$ (D) $-\frac{kq_1}{r_1^2}\hat{i}-\frac{kq_2}{r_2^2}\hat{j}$

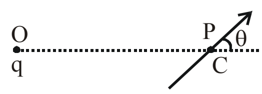
**2.** Consider a metallic sphere of radius R concentric with another hollow metallic sphere of inner radius 2R and outer radius 3R as shown in the figure. The inner sphere is given a charge –Q and outer +2Q. The electrostatic potential energy of the system is :-




(A) $\frac{Q^2}{16\pi\varepsilon_0 R}$ (B) $\frac{3Q^2}{16\pi\varepsilon_0 R}$

(C) $\frac{5Q^2}{48\pi\varepsilon_0 R}$ (D) $\frac{11Q^2}{48\pi\varepsilon_0 R}$

**3.** A small dipole P and a fixed point charge +q are kept in free space. Net electrostatic force on dipole due to charge q is F and torque on dipole about point O is $\tau$ then :-

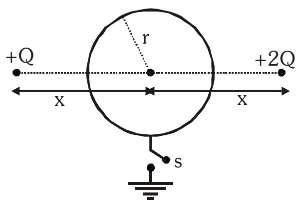



(A) for every value of $\theta$ ; $F = 0$ and $\tau = 0$
(B) for every value of $\theta$ ; $F \neq 0$ and $\tau = 0$
(C) for every value of $\theta$ ; $F \neq 0$ and $\tau \neq 0$
(D) $\tau$ is zero or nonzero, depends on value of $\theta$.

**4.** A bead of mass m and charge q is threaded on a smooth wire kept along x-axis. A second charge Q is fixed at the point x = 0, y = –d. Now bead is moved with constant speed v so that it is initially near $x = -\infty$ and it ends up near $x = +\infty$. Find the impulse exerted by the fixed charge on the bead. Neglect gravity.

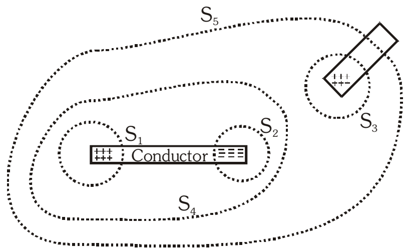
(A) $\frac{qQ}{2\pi\varepsilon_0 vd}$ (B) $\frac{qQ}{4\pi\varepsilon_0 vd}$ (C) $\frac{qQ}{\pi\varepsilon_0 vd}$ (D) $\frac{2qQ}{\pi\varepsilon_0 vd}$

**5.** Two particles having positive charges +Q and +2Q are fixed at equal distance x from centre of a conducting solid sphere having zero net charge and radius r as shown. Initially the switch S is open. After the switch S is closed, the net charge flowing out of sphere is




(A) $\frac{Qr}{x}$ (B) $-\frac{Qr}{x}$ (C) $\frac{3Qr}{x}$ (D) $-\frac{3Qr}{x}$

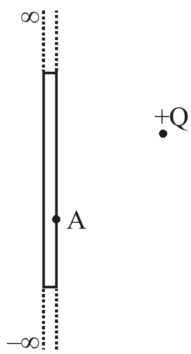
**6.** A rod containing charge +Q is brought near an initially uncharged isolated conducting rod as shown. Regions with total surface charge +Q and –Q are induced in the conductor as shown in the figure. The only regions where the net charge in this configuration is non–zero are indicated by the "+" and "–" signs. Let us denote the total flux of electric field outward through closed surface $S_1$ as $\phi_1$, through $S_2$ as $\phi_2$, etc. Which of the following is necessarily false.




(A) $\phi_1 > 0$ (B) $\phi_2 = \phi_1$ (C) $\phi_3=\phi_1$ (D) $\phi_4=0$

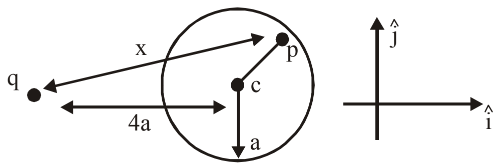
## Multiple Correct Answer Type 2 Q. [4 M (–1)]

**7.** A positive point charge is kept in front of an infinite large uncharged conducting plate as shown in figure. What must not be the direction of electric field at the point A on the surface of plate due to charges appearing on plate:-




(A) $\longrightarrow$ (B) $\longleftarrow$ (C) $\swarrow$ (D) $\nwarrow$

**8.** There is a spherical conductor of radius a. A point charge is placed at a distance 4a from the centre of the spherical conductor as shown in figure.




(A) The electric field at 'c' due to spherical conductor is $\frac{kq}{16a^2}\left(-\hat{i}\right)$

(B) Potential at P due to induced charge on spherical conductor is $\left(\frac{kq}{4a}-\frac{kq}{x}\right)$

(C) Net electric field at 'P' is ZERO.

(D) Now the conductor is earthed then charge on the spherical conductor is $\left(-\frac{q}{4}\right)$

## Linked Comprehension Type (2 Para × 3Q.) [3 M (-1)]
## (Single Correct Answer Type)

**Paragraph for Questions 9 to 11**

In physics, Gauss's law, also known as Gauss's flux theorem, is a law relating the distribution of electric charge to the resulting electric field. It states that,

"The net electric flux through any closed surface is equal to $\frac{1}{\in_0}$ time the net electric charge enclosed within that closed surface".

Mathematically it states that,

$$\oint \vec{E}.\overrightarrow{ds} = \frac{Q_{enclosed}}{\in_0} \rightarrow \text{Integral form of Gauss's law}$$

In differential form the law can be stated mathematically as,

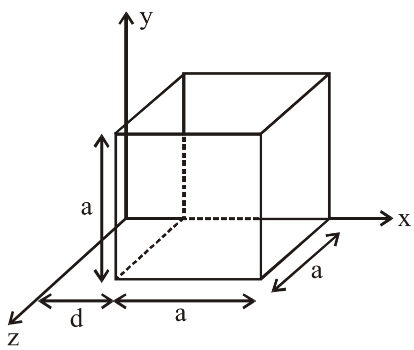
$\vec{\nabla}.\vec{E} = \frac{\rho}{\in_0}$ ( $\rho$ is charge density in the enclosed area)

where $\vec{\nabla} = \frac{\partial}{dx}\hat{i} + \frac{\partial}{dy}\hat{j} + \frac{\partial}{dz}\hat{k}$ (in cartesian coordinate)

and in spherical coordinate system, $\vec{\nabla}$ is written as,

$\vec{\nabla} = \frac{d}{dr}\hat{r}$ for radial dependence only.

**9.** Consider a cube of side "a" placed such that it faces are parallel to x-y; y-z & z-x plane. (see figure) An electric field exists in the region as $y\hat{i} + x\hat{j} = \vec{E}$. The net charge enclosed in the cube will be :-




(A) $2a^3\in_0$ (B) zero (C) $a^3\in_0$ (D) Information insufficient

**10.** In a region it was found that electric field varies radially as $E = \alpha r^3$, $\alpha$ is constant. Then in the region charge density linked with the field will be :

(A) $5\alpha r^4\in_0$ (B) $\alpha r\in_0$ (C) $3\alpha r^2\in_0$ (D) 0

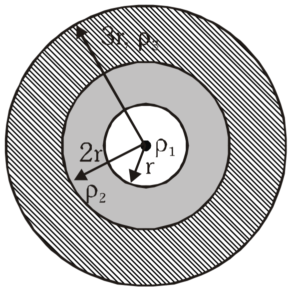
**11.** Considering area vector to be positive along inward normal for a closed surface, flux linked to a charge Q enclosed in a sphere of same radius will be (assume flux to be defined in the same way as is defined in normal system)

(A) $\frac{Q}{\in_0}$ (B) $-\frac{Q}{\in_0}$

(C) zero (D) depends on radius of sphere

## Paragraph for Questions 12 to 14

A solid sphere is made by 3 materials taken as shown. Total charge on system is Q. If magnitude of it electric field at every boundary point is same then




**12.** Ratio of charges in material 1, material 2 and material 3.

(A) 1 : 2 : 3 (B) 1 : 3 : 5 (C) 1 : 4 : 9 (D) 1 : 1 : 1

**13.** Charge density of material 1 will be

(A) $\frac{Q}{12\pi r^3}$ (B) $\frac{3Q}{4\pi r^3}$ (C) $\frac{Q}{4\pi r^3}$ (D) $\frac{Q}{8\pi r^3}$

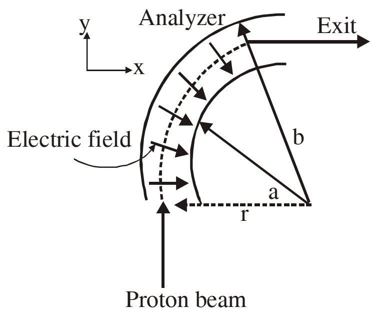
**14.** Electric field at distance r/2 from centre will be

(A) $\frac{1}{56\pi\varepsilon_0}\frac{Q}{r^2}$ (B) $\frac{1}{72\pi\varepsilon_0}\frac{Q}{r^2}$ (C) $\frac{1}{36\pi\varepsilon_0}\frac{Q}{r^2}$ (D) $\frac{Q}{r^2}$

## Linked Comprehension Type (1 Para × 2 Q.) [4 M (–1)]
## (Multiple Correct Answer Type)

### Paragraph for Questions 15 & 16

Figure shows a schematic view of an electrostatic analyzer. It can sort out charged particles by speed and charge to mass ratio. Spacecraft uses such analyzers to characterize charged particles in interplanetary space. Two curved metal plates establish an electric field given by $E=E_0(b/r)$ where $E_0$ and b are positive constants. The field points towards the centre of curvature and r is distance from centre. There is no influence of gravity. Proton (charge + e; mass 'm') enters along y-axis and exits along x-axis while moving along a circular path.




**15.** Mark the **CORRECT** option (s) :-

(A) Speed with which proton is to be projected is given by $v=\sqrt{\frac{eE_0b}{m}}$

(B) centripetal acceleration of electron is $a_c$ is given by $a_c=\frac{e}{m}E_0\left(\frac{b}{r}\right)$

(C) Electric force on proton is given by $\frac{e}{2}E_0\left(\frac{b}{r}\right)$

(D) Electric force on proton is given by $2eE_0\left(\frac{b}{r}\right)$

**16.** Mark the **CORRECT** option(s)

(A) Work done by electric field on proton is zero.

(B) If $v = \sqrt{\dfrac{2eE_0b}{m}}$ proton may strike outer surface of analyzer.

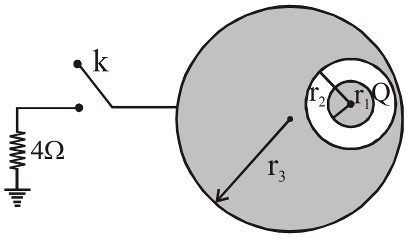
(C) If $v = \sqrt{\dfrac{2eE_0b}{m}}$ proton may strike inner surface of analyzer.

(D) If an electron is released with zero initial velocity from inner surface of analyzer, it will strike outer surface with velocity $v = \sqrt{\dfrac{2eE_0b}{m_e}\ell n\left(\dfrac{b}{a}\right)}$, where $m_e$ is mass of electron.

## SECTION-III

**Numerical Grid Type (Ranging from 0 to 9) 3 Q. [4 M (0)]**

**1.** Charge Q = 2μC is distributed on a small conducting sphere (radius $r_1 = 0.1$ m) as shown inside a spherical cavity of radius $r_2 = 0.5$ m made inside a neutral solid conducting sphere of radius $r_3 = 2$m as shown in the figure. The outer surface is grounded using a resistance of 4Ω by closing key k. The heat dissipated on switching on the key is given by α mJ. Fill the value of α.



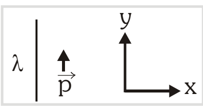
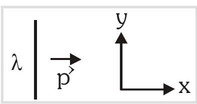
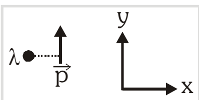
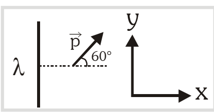

**2.** Electric dipole of moment $P = P\,\hat{i}$ is kept at a point (x,y) in an electric field, $E = 4\,xy^2\,\hat{i} + 4\,x^2y\,\hat{j}$. Find the forces on the dipole. If your answer is $n\,py\,(y^2 + 4\,x^2)^{1/2}$ Then find n.

**3.** Two charges q and –2q are placed at (–3,0) and (3,0) in x–y plane. The locus of the point in the plane of the charges, where the field potential is zero is $(x + \alpha)^2 + y^2 = 4\beta^2$. Find the value of $(\alpha+\beta)$.

## SECTION-IV

**Matrix Match Type (4 × 4) 1 Q. [8 M (for each entry +2(0)]**

**1.** A dipole with an electric dipole moment $\vec{p}$ is located at distance r from a long thread charged uniformly with a linear density λ. Orientation of dipole is given in column-I & electric force on the dipole is given incolumn-II.

| | **Column-I** | | | **Column -II** |
|---|---|---|---|---|
| (A) |  | Along the thread | (P) | $-\dfrac{\lambda p}{2\pi \epsilon_0 r^2}\hat{i}$ |
| (B) |  | Along the radius vector | (Q) | $-\dfrac{\lambda p}{4\pi \epsilon_0 r^2}\hat{i}$ |
| (C) |  | At right angles to the thread and radius vector r | (R) | Zero |
| (D) |  | At angle 60° from the radius vector in the plane carrying wire & radius vector | (S) | $\dfrac{\lambda \vec{p}}{2\pi \epsilon_0 r^2}$ |

**CLASS TEST # 16** **ANSWER KEY**

## SECTION-I

**Single Correct Answer Type** **6 Q. [3 M (–1)]**

| | | | |
|---|---|---|---|
| **1. Ans. (B)** | **2. Ans. (C)** | **3. Ans. (B)** | **4. Ans. (A)** |
| **5. Ans. (C)** | **6. Ans. (B)** | | |

**Multiple Correct Answer Type** **2 Q. [4 M (–1)]**

**7. Ans. (A,B,C)** **8. Ans. (A,B,C,D)**

**Linked Comprehension Type** **(2 Para × 3Q.) [3 M (-1)]**

**(Single Correct Answer Type)**

| | | | |
|---|---|---|---|
| **9. Ans. (B)** | **10. Ans. (C)** | **11. Ans. (B)** | **12. Ans. (B)** |
| **13. Ans. (A)** | **14. Ans. (B)** | | |

**Linked Comprehension Type** **(1 Para × 2 Q.) [4 M (–1)]**

**(Multiple Correct Answer Type)**

**15. Ans. (A,B)** **16. Ans. (A,B,D)**

## SECTION-III

**Numerical Grid Type (Ranging from 0 to 9)** **3 Q. [4 M (0)]**

**1. Ans. 9** **2. Ans. 4** **3. Ans. 7**

## SECTION-IV

**Matrix Match Type (4 × 4)** **1 Q. [8 M (for each entry +2(0)]**

**1. Ans. (A)→(R); (B)→(P); (C)→(S); (D)→(Q)**