Test paper code
1601

P1-16-06-09

CODE A

PAPER I

Time : 2 Hours **Maximum Marks : 130**

Please read the instructions carefully. You are allotted 5 minutes specifically for this purpose

A. General :

1. This booklet is your Question Paper containing **34 questions.** The booklet has **12 pages**.
2. The question paper CODE is printed on the right hand top corner of this sheet and on the back page of this booklet.
3. The question paper contains 3 blank pages for your rough work. No additional sheets will be provided for rough work.
4. Blank papers, clip boards, log tables, slide rules, calculators, cellular phones, pagers, electronic gadgets in any form are not allowed to be carried inside the examination hall.
5. Fill in the boxes provided below on this page and also write your Name and Registration No. in the space provided on the back page of this booklet.
6. The answer sheet, a machine-readable Objective Response Sheet (ORS), is provided separately.
7. DO NOT TEMPER WITH/MUTILATE THE ORS OR THIS BOOKLET.
8. Do not break the seal of the question paper booklet before being instructed to do by the invigilators.

C. Marking Scheme :

9. **Section I** contains 10 Questions with **single choice correct.** Every correctly answered question will be awarded **3 marks**, left unattempted will be awarded **0 marks** and incorrectly answered will be awarded **–1 marks**.
10. **Section II** contains 6 Questions with **one or more than one choice(s) correct.** Every correctly answered question will be awarded **4 marks**, left unattempted will be awarded **0 marks** and incorrectly answered will be awarded **–1 marks**.
11. **Section III** contains 4 Questions with **one or more than one choice(s) correct.** Every correctly answered question will be awarded **3 marks**, left unattempted will be awarded **0 marks** and incorrectly answered will be awarded **–1 marks**.
12. **Section IV** contains 2 group of 3 Questions each based on comprehension with **single choice correct.** Every correctly answered question will be awarded **4 marks**, left unattempted will be awarded **0 marks** and incorrectly answered will be awarded **–1 marks**.
13. **Section V** contains 2 Questions for matrix match. Every correct match will be awarded 2 marks, left unattempted will be awarded **0 marks**. There will be **no negative marking**.
14. **Section VI** contains 6 Subjective questions with single digit integer answer. Every correctly answered question will be awarded **4 marks**, left unattempted will be awarded **0 marks** and incorrectly answered will be awarded **–1 marks**.

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SECTION – I

Single Correct Choice Type

This section contains 10 multiple choice questions numbered 1 to 10. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE** is correct.

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1. A particle of specific charge q/m moves in an electric field $\vec{\mathbf{E}} = (E_o - ax)\hat{\mathbf{i}}$, where x is the distance from the point where the particle was initially at rest and $\hat{\mathbf{i}}$ is the unit vector in this direction. Then the maximum magnitude of velocity gained by the particle is

(A) $E_0\sqrt{\frac{2q}{ma}}$ (B) $2E_0\sqrt{\frac{q}{ma}}$

(C) $E_0\sqrt{\frac{q}{ma}}$ (D) will keep accelerating for ever

2. A thin conducting ring of radius r has an electric charge Q distributed uniformly on it. A point charge q is placed at the center. Tension in the ring due to repulsive force of charge at the centre is

(A) $\frac{Qq}{8\pi^2 \in_o r^2}$ (B) $\frac{Qq}{4\pi^2 \in_o r^2}$

(C) $\frac{Qq}{2\pi^2 \in_o r^2}$ (D) $\frac{Qq}{\pi^2 \in_o r^2}$

3. In a region of space the electric field is given by $\vec{\mathbf{E}} = 8\hat{\mathbf{i}} + 4\hat{\mathbf{j}} + 3\hat{\mathbf{k}}$. The electric flux through a surface of area of 100 units in x–y plane is

(A) 800 units (B) 300 units

(C) 400 units (D) 1500 units

4. A point charge q is placed at origin. Let $\vec{\mathbf{E}}_A$, $\vec{\mathbf{E}}_B$ and $\vec{\mathbf{E}}_C$ be the electric field at three points A (1, 2, 3), B (1, 1, –1) and C (2, 2, 2) due to charge q. Then

(A) $\vec{\mathbf{E}}_A \perp \vec{\mathbf{E}}_B$ (B) $\vec{\mathbf{E}}_A \,||\, \vec{\mathbf{E}}_C$

(C) $4|\vec{\mathbf{E}}_B| = |\vec{\mathbf{E}}_C|$ (D) $|\vec{\mathbf{E}}_B| = 8|\vec{\mathbf{E}}_C|$

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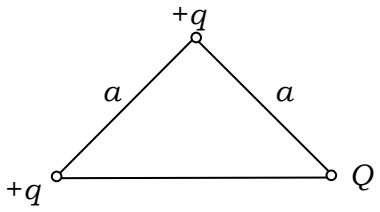
5. Three charges Q, $+q$ and $+q$ are placed at the vertices of a right angled isosceles triangle as shown. The net electrostatic energy of the configuration is zero if Q is equal to



(A) $-\dfrac{q}{1+\sqrt{2}}$ (B) $-\dfrac{2q}{2+\sqrt{2}}$

(C) $-2q$ (D) $+q$

6. A metal sphere A of radius r_1 charged to a potential V is enveloped by a thin-walled conducting spherical shell B of radius r_2 then the potential V' of the sphere A after it is connected by a thin wire to the shell B will be

(A) $V\left(\dfrac{r_1}{r_2}\right)$ (B) $V\left(\dfrac{r_2}{r_1}\right)$

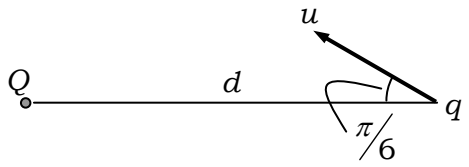
(C) $V\left(\dfrac{r_2-r_1}{r_2}\right)$ (D) $V\left(\dfrac{r_2}{r_2-r_1}\right)$

7. Four charges q, q, $-q$, $-q$ are placed at points $(a,a,0)$, $(-a,a,0)$, $(-a,-a,0)$ and $(a,-a,0)$ respectively. Force experienced by another point charge Q placed at $(0,0,r)$ with $(r >> a)$ is

(A) $-\dfrac{Qqa}{\pi \in_o r^3}\hat{\mathbf{j}}$ (B) $\dfrac{\sqrt{2}Qqa}{\pi \in_o r^3}\hat{\mathbf{j}}$

(C) $\dfrac{Qqa}{\sqrt{2}\pi \in_o r^3}\hat{\mathbf{i}}$ (D) $-\dfrac{2Qqa}{\pi \in_o r^3}\hat{\mathbf{i}}$

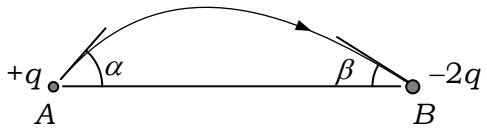
8. A charge $+Q$ is held fixed at a point A in a gravity free space, another charge $+q$ is projected with a speed u forming an angle $\pi/6$ from the line joining the two charges from a point B at a distance d from A as shown in figure. If at the minimum distance of approach the speed of q becomes $u/\sqrt{3}$, the minimum distance of approach is



(A) $\left(\sqrt{3}/2\right)d$ (B) $d/\sqrt{3}$

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

9. Two charges $+q$ and $-2q$ are held fixed at the ends of a line AB as shown. An electric field line emerges from $+q$ at an angle α to the line AB. The angle β at which it terminates at the charge $-2q$ is



(A) α (B) 2α

(C) $2\sin^{-1}\left\{\dfrac{1}{\sqrt{2}}\sin\left(\alpha/2\right)\right\}$ (D) $\sin^{-1}\left\{\dfrac{1}{\sqrt{2}}\sin\left(\alpha/2\right)\right\}$

10. A small electric dipole of dipole moment $\vec{\mathbf{p}} = \left(\hat{\mathbf{i}} + \sqrt{3}\hat{\mathbf{j}}\right)$ is placed at the origin of coordinates. Magnitude of electric field strength due to this dipole at $(2,0,0)$ is

(A) $\dfrac{1}{4\pi\in_o}\dfrac{\sqrt{13}}{8}$ (B) $\dfrac{1}{4\pi\in_o}\dfrac{\sqrt{13}}{4}$

(C) $\dfrac{1}{4\pi\in_o}\dfrac{\sqrt{7}}{8}$ (D) $\dfrac{1}{4\pi\in_o}\dfrac{\sqrt{7}}{4}$

SECTION – II

Multiple Correct Choice Type

This section contains 6 multiple choice questions numbered 11 to 16. Each question has 4 choices (A), (B), (C) and (D), out of which **ONE or MORE** is/are correct.

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11. A charge particle of mass m and charge $-q$ is revolving around a long, uniformly charged wire with linear charge density $+\lambda$ (wire being at the axis of the circle on which charge is moving), Then

(A) Total mechanical energy of the charge particle will increase with increase in radius of circle

(B) Total mechanical energy of the charge particle will decrease with increase in radius of circle

(C) Kinetic energy of the charge particle will increase with increase in radius of circle

(D) Kinetic energy of the charge particle will not change with change in radius of circle

12. At the distance of 5 cm and 10 cm away from the surface of a uniformly charged solid sphere, the potentials are 100 V and 75 V respectively. Then

(A) potential at its surface is 150 V.

(B) the charge on the sphere is $\left(\frac{5}{3}\right)\times 10^{-10}$ C.

(C) the electric field on the surface is 1500 V/m.

(D) the electric potential at its centre is 225 V.

13. An electric dipole moment $\vec{\mathbf{p}} = \left(2\hat{\mathbf{i}} + 3\hat{\mathbf{j}}\right)$ μC-m is placed in a uniform electric field $\vec{\mathbf{E}} = \left(3\hat{\mathbf{i}} + 2\hat{\mathbf{k}}\right)\times 10^{5}$ N/C.

(A) The torque that $\vec{\mathbf{E}}$ exerts on $\vec{\mathbf{p}}$ is $\left(0.6\hat{\mathbf{i}} - 0.4\hat{\mathbf{j}} - 0.9\hat{\mathbf{k}}\right)$ Nm.

(B) The potential energy of the dipole is –0.6 J.

(C) The potential energy of the dipole is 0.6 J.

(D) If the dipole is rotated in the electric field, the maximum potential energy of the dipole is 1.3 J.

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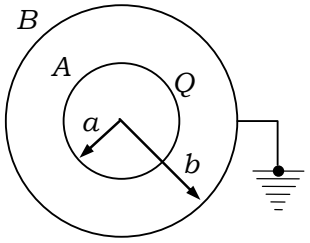
14. A conducting sphere A of radius a, with charge Q, is placed concentrically inside a conducting shell B of radius b. B is earthed. C is the common centre of the A and B.



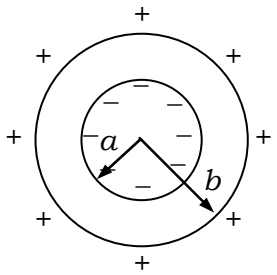
(A) The field is a distance r from C, where $a \le r \le b$ is $\frac{1}{4\pi \in_o}\frac{Q}{r^2}$.

(B) The potential at a distance r from C, where $a \le r \le b$, is $\frac{1}{4\pi \in_o}\frac{Q}{r}$.

(C) The potential difference between A and B is $\frac{1}{4\pi \in_o}Q\left(\frac{1}{a}-\frac{1}{b}\right)$

(D) The potential at a distance r from C, where $a \le r \le b$, $\frac{1}{4\pi \in_o}Q\left(\frac{1}{r}-\frac{1}{b}\right)$

15. An empty thick conducting shell of inner radius a and outer radius b is shown in figure. If it is observed that the inner face of the shell carries a uniform charge density $-\sigma$ and the surface carries a uniform charge density σ. If a point charge q_A is placed at the center of the shell. If another point charge q_B is also placed at a distance c ($>b$) from the center of shell, then choose the correct statements



(A) force experienced by charge A is $\frac{\sigma q_A b^2}{\in_o c^2}$

(B) force experienced by charge A is zero

(C) The force experienced by charge B is $\frac{\sigma q_B b^2}{\in_o c^2}$

(D) The force experienced by charge B is $\frac{q_A q_B}{4\pi \in_o c^2}$

16. Charge q is distributed non-uniformly over a ring of radius R. P is a point on the axis of the ring at a distance $\sqrt{3}R$ from its centre. Which of the following is/are wrong statement(s).

(A) Potential at P is $\frac{1}{4\pi \in_o}\frac{q}{2R}$

(B) Magnitude of electric field at P may be greater than $\frac{\sqrt{3}}{4\pi \in_o}\frac{q}{8R^2}$

(C) Magnitude of electric field at P must be equal to $\frac{\sqrt{3}}{4\pi \in_o}\frac{q}{8R^2}$

(D) Magnitude of electric field at P cannot be less than $\frac{\sqrt{3}}{4\pi \in_o}\frac{q}{8R^2}$

SECTION – III

Assertion – Reason Type

This section contains 4 questions numbered 17 to 20. Each question contains STATEMENT-1 (Assertion) and STATEMENT-2 (Reason). Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE** is correct.

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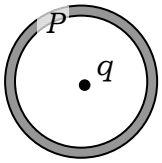
17. STATEMENT-1
A charge q is placed at the centre of a metallic shell. The resultant electric field at a point P inside the thickness of the shell is zero.



because
STATEMENT-2

Resultant electric field inside a conducting material under electrostatic conditions is always zero since it is an equipotential volume.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

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18. STATEMENT-1

Elelctric field at a point on the axis of a thin, nonuniformly charged ring, with no net charge on the ring must be zero.

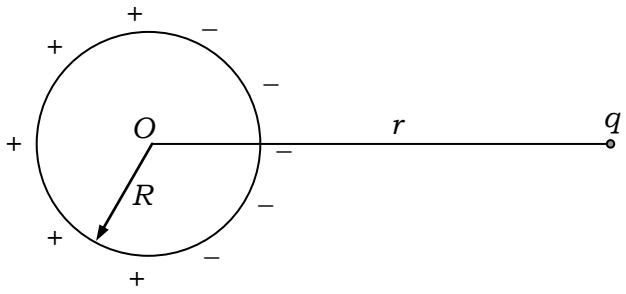
because
STATEMENT-2

Electric potential at all points on the axis of the thin, non-uniformly charged ring, with no net charge on the ring is zero. And electric field in a particular direction is the gradient of potential in that particular direction.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

19. STATEMENT-1

Consider a conducting sphere of radius R. Now a charge q is placed in front of sphere. The resultant Electric potential at the centre of sphere O is $\frac{1}{4\pi \in_o}\frac{q}{r}$.



because
STATEMENT-2
Electric potential at the centre of sphere due to induced charges is zero.
(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

20. STATEMENT-1

There can be Coulombic attraction between two bodies, each having no net charge.

because
STATEMENT-2
Force vector between two point charges depends upon their relative position as well as their magnitudes.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement-1.
(B) Statement-1 is True, Statement-2 is True; Statement-2 **is NOT** a correct explanation for Statement-1.
(C) Statement-1 is True, Statement-2 is False
(D) Statement-1 is False, Statement-2 is True

SECTION – IV

Linked Comprehension Type

This section contains 2 groups of 3 questions. Each group has 3 multiple choice questions base on a paragraph. Each question has 4 choices (A), (B), (C) and (D), out of which **ONLY ONE** is correct.

Paragraph for Question Nos. 21 to 23

Consider two fixed positive point charges, placed on the y-axis at the points $(0, a)$ and $(0, -a)$. Another positively charged particle of charge q_0 and mass m is slightly displaced from the origin in the direction of positive x-axis.

21. Speed of charge q_0 at $x \to \infty$ is

(A) $\sqrt{\dfrac{qq_0}{\pi \in_o m}}$ (B) $\sqrt{\dfrac{qq_0}{\pi \in_o a}}$

(C) $\sqrt{\dfrac{qq_0}{\in_o am}}$ (D) $\sqrt{\dfrac{qq_0}{\pi \in_o am}}$

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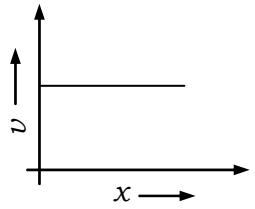
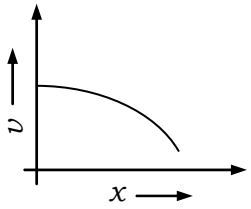
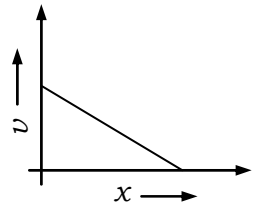
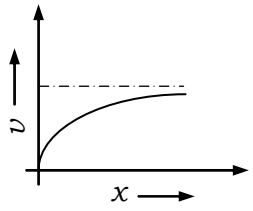
22. Which of the following graphs represents the velocity of q_0 as a function of x?

(A) 

(B) 

(C) 

(D) 

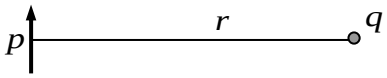
23. If same positively charged particle is projected towards left along the x-axis from a point at a large distance to the right of origin, with a velocity half that acquired in previous question, at what distance will it come to rest?

(A) $\sqrt{14}\,a$ (B) $\sqrt{14.5}\,a$

(C) $\sqrt{15}\,a$ (D) $\sqrt{15.5}\,a$

Paragraph for Question Nos. 24 to 26

A point charge $+q$ is placed at a distance r on a point on the equatorial line of an electric dipole of magnitude of electric dipole moment p as shown in figure.



24. Net force experienced by the dipole in this situation is

(A) perpendicular to r parallel to dipole moment vector $\vec{\mathbf{p}}$

(B) perpendicular to r anti-parallel to dipole moment vector $\vec{\mathbf{p}}$

(C) along r away from q

(D) along r towards q

25. If charge q is moved away from the dipole (r is increased) the electric potential energy of charge particle q will

(A) increase
(B) decrease
(C) not change
(D) data is insufficient to conclude

26. If the dipole is small, the amount of work done by the system in rotating the dipole anticlockwise through $\pi/2$ to make it pointing away from q is

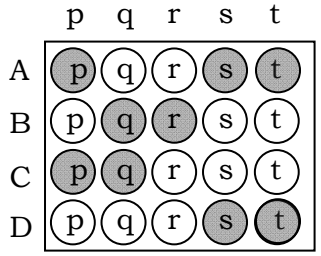
(A) zero
(B) $-\frac{1}{4\pi \in_o}\frac{pq}{r^2}$
(C) $-\frac{1}{2\pi \in_o}\frac{pq}{r^2}$
(D) $\frac{1}{4\pi \in_o}\frac{pq}{r^2}$

SECTION – V

Matrix-Match Type

This section contains 2 questions, 27 and 28. Each question contains statement given in two columns which have to be matched. The statements in **Column I** are labeled (A, B, C and D) while the statements in **Column II** are labeled p, q, r, s and t. Any given statement in **Column I** can have correct matching with **ONE OR MORE** statement(s) in **Column II.** The appropriate bubbles corresponding to the answers to these questions have to be darkening of bubbles will look like the following.

If the correct matches are A – p, s and t, B – q and r, C – p and q; and D – s and t; then the correct darkening of bubbles will look like the following.



27. Match the statements in **Column 1** with statements in **Column II** and indicate your answer by darkening bubbles in the 4 × 5 matrix given in the ORS.

	Column I		**Column II**
(A)	Electric field due to a point charge in its neighboring space	(p)	Is always conservative
(B)	Electric field due to a large, uniformly charged surface near it	(q)	Is non conservative
(C)	Electric field inside a conducting spherical surface in electrostatic conditions	(r)	Is uniform
(D)	Electric field in a space due to time varying magnetic field	(s)	Must be zero in all cases
		(t)	Is non-uniform

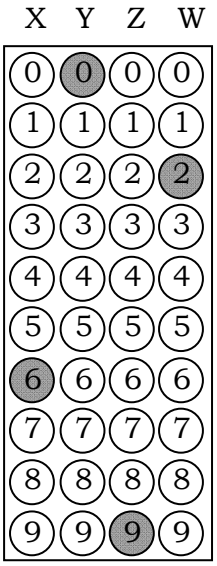
28. Match the statements in **Column 1** with statements in **Column II** and indicate your answer by darkening bubbles in the 4 × 5 matrix given in the ORS.

	Column I		**Column II**
(A)	$\sigma^2 / \in_o$	(p)	$\frac{C^2}{J\text{-}m}$
(B)	$\in_o$	(q)	$\frac{C}{V}$
(C)	$\frac{\text{Ampre second}}{\text{volt}}$	(r)	$\frac{J}{m^3}$
(D)	V/E	(s)	Metre
		(t)	$\frac{C^2}{J}$

SECTION – VI

Integer Answer Type

This section contains 6 questions numbered 29 to 34. The answer to each of the questions is a single digit integer, ranging from 0 to 9. The appropriate bubbles below the respective question numbers in the ORS have to be darkened. For example, if the correct answers to question numbers X, Y, Z and W (say) are 6, 0, 9 and 2, respectively, then the correct darkening of bubbles will look like the following:



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29. A charge +12 μC is located at the origin in free space & another charge Q at (9 m, 8 m, 4 m). If the x-component of the electric field at (6 m, 8 m, 0 m) is zero, calculate the value of Q (**in μC**).

30. Eight identical oil drops, 3 of which charged to 4 volts each, 2 are charged to 3 volts, 2 are charged to V volts and one uncharged are combined to form a bigger drop. The value of V (**in volts**) if potential of bigger drop comes out to be 15 volts is.

31. Two identically charged identical balls each of density 5 gm/c^3 are suspended from a common point by two insulating strings of equal length. The angle between threads does not change when the system is immersed in a liquid. If the dielectric constant of the liquid is 2.5 find the density of liquid (**in gm/c^3**).

32. Three charges +6 μC, +6 μC and –3 μC are placed at the vertices of an equilateral triangle of side 3 cm. Calculate the amount of work done (**in Joules**) in increasing the side of the triangle to 9 cm.

33. A charge 20 μC is distributed uniformly on a ring of radius 3 cm in y-z plane with centre at origin. A charge particle of mass 20 gm and charge –10 μC is projected along the +ve x-axis from $x = -\sqrt{7}$ cm with a velocity 30 m/s. The maximum x-coordinate (**in cm**) the charge particle may reach is.

34. Two conducting spherical shells, one of radius 2 m charged to 100 kV, and another conducting spherical shell of radius 0.5 m charged to 10 kV placed far from each other are connected with the help of a conductor. The amount of charge transferred from one sphere to the other in the process (**in μC**) is.