DPP - Daily Practice Problems

Name : ____________________ **Date :** __________

Start Time : __________ **End Time :** __________

PHYSICS 32

SYLLABUS : Electrostatics-1 (Coulomb's law, electric field, field lines, Gauss's law)

Max. Marks : 104 **Time : 60 min.**

GENERAL INSTRUCTIONS

- The Daily Practice Problem Sheet contains 26 MCQ's. For each question only one option is correct. Darken the correct circle/ bubble in the Response Grid provided on each page.
- You have to evaluate your Response Grids yourself with the help of solution booklet.
- Each correct answer will get you 4 marks and 1 mark shall be deduced for each incorrect answer. No mark will be given/ deducted if no bubble is filled. Keep a timer in front of you and stop immediately at the end of 60 min.
- The sheet follows a particular syllabus. Do not attempt the sheet before you have completed your preparation for that syllabus. Refer syllabus sheet in the starting of the book for the syllabus of all the DPP sheets.
- After completing the sheet check your answers with the solution booklet and complete the Result Grid. Finally spend time to analyse your performance and revise the areas which emerge out as weak in your evaluation.

DIRECTIONS (Q.1-Q.18) : There are 18 multiple choice questions. Each question has 4 choices (a), (b), (c) and (d), out of which **ONLY ONE** choice is correct.

Q.1 A total charge Q is broken in two parts Q_1 and Q_2 and they are placed at a distance R from each other. The maximum force of repulsion between them will occur, when

(a) $Q_2 = \frac{Q}{R}, Q_1 = Q - \frac{Q}{R}$ (b) $Q_2 = \frac{Q}{4}, Q_1 = Q - \frac{2Q}{3}$

(c) $Q_2 = \frac{Q}{4}, Q_1 = \frac{3Q}{4}$ (d) $Q_1 = \frac{Q}{2}, Q_2 = \frac{Q}{2}$

Q.2 Two small balls each having the charge $+Q$ are suspended by insulating threads of length L from a hook. This arrangement is taken in space where there is no gravitational effect, then the angle between the two suspensions and the tension in each thread will be

(a) $180^\circ, \frac{1}{4\pi \in_0} \frac{Q^2}{(2L)^2}$ (b) $90^\circ, \frac{1}{4\pi \in_0} \frac{Q^2}{L^2}$

(c) $180^\circ, \frac{1}{4\pi \in_0} \frac{Q^2}{2L^2}$ (d) $180^\circ, \frac{1}{4\pi \in_0} \frac{Q^2}{L^2}$

Q.3 Electric charges of $1\mu C, -1\mu C$ and $2\mu C$ are placed in air at the corners A,B and C respectively of an equilateral triangle ABC having length of each side 10 cm. The resultant force on the charge at C is

(a) 0.9 N (b) 1.8N (c) 2.7 N (d) 3.6 N

Q.4 An electron is moving round the nucleus of a hydrogen atom in a circular orbit of radius r. The coulomb force $\vec{F}$ between the two is (here $K = \frac{1}{4\pi \in_0}$)

(a) $-K\frac{e^2}{r^3}\hat{r}$ (b) $K\frac{e^2}{r^3}\vec{r}$ (c) $-K\frac{e^2}{r^3}\vec{r}$ (d) $K\frac{e^2}{r^2}\hat{r}$

Q.5 Equal charges q are placed at the four corners A, B, C, D of a square of length a. The magnitude of the force on the charge

RESPONSE GRID	1. ⓐⓑⓒⓓ	2. ⓐⓑⓒⓓ	3. ⓐⓑⓒⓓ	4. ⓐⓑⓒⓓ

Space for Rough Work

at B will be

(a) $\frac{3q^2}{4\pi \in_0 a^2}$ (b) $\frac{q^2}{\pi \in_0 a^2}$

(c) $\left(\frac{1+2\sqrt{2}}{2}\right)\frac{q^2}{4\pi \in_0 a^2}$ (d) $\left(2+\frac{1}{\sqrt{2}}\right)\frac{q^2}{4\pi \in_0 a^2}$

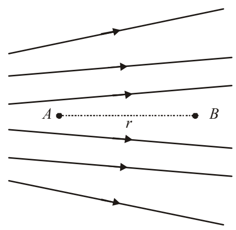
Q.6 The charges on two spheres are $+7\mu C$ and $-5\mu C$ respectively. They experience a force F. If each of them is given an additional charge of $-2\mu C$, the new force of attraction will be

(a) F (b) F/2 (c) $F/\sqrt{3}$ (d) 2F

Q.7 Electric lines of force about negative point charge are

(a) Circular, anticlockwise (b) Circular, clockwise
(c) Radial, inward (d) Radial, outward

Q.8 Figure shows the electric lines of force emerging from a charged body. If the electric field at A and B are E_A and E_B respectively and if the distance between A and B is r then



(a) $E_A > E_B$

(b) $E_A < E_B$

(c) $E_A = \frac{E_B}{r}$

(d) $E_A = \frac{E_B}{r^2}$

Q.9 The magnitude of electric field intensity E is such that, an electron placed in it would experience an electrical force equal to its weight is given by

(a) mge (b) $\frac{mg}{e}$ (c) $\frac{e}{mg}$ (d) $\frac{e^2}{m^2}g$

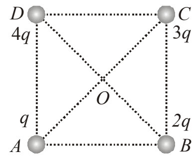
Q.10 A charge particle is free to move in an electric field. It will travel

(a) Always along a line of force
(b) Along a line of force, if its initial velocity is zero
(c) Along a line of force, if it has some initial velocity in the direction of an acute angle with the line of force
(d) None of the above

Q.11 Two point charges Q and $-3Q$ are placed at some distance apart. If the electric field at the location of Q is E then at the locality of $-3Q$, it is

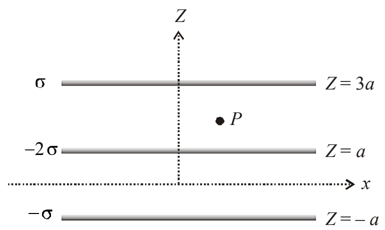
(a) –E (b) E/3 (c) –3E (d) –E/3

Q.12 Charges q, $2q$, $3q$ and $4q$ are placed at the corners A, B, C and D of a square as shown in the following figure. The direction of electric field at the centre of the square is parallel to side.



(a) AB
(b) CB
(c) BD
(d) AC

Q.13 Three infinitely long non-conducting charge sheets are placed as shown in figure. The electric field at point P is



(a) $\frac{2\sigma}{\varepsilon_0}\hat{k}$

(b) $-\frac{2\sigma}{\varepsilon_0}\hat{k}$

(c) $\frac{4\sigma}{\varepsilon_0}\hat{k}$

(d) $-\frac{4\sigma}{\varepsilon_0}\hat{k}$

Q.14 Gauss's law is true only if force due to a charge varies as

(a) r^{-1} (b) r^{-2} (c) r^{-3} (d) r^{-4}

Q.15 The electric intensity due to an infinite cylinder of radius R and having charge q per unit length at a distance $r (r > R)$ from its axis is

(a) Directly proprotional to r^2
(b) Directly proprotional to r^3
(c) Inversely proprotional to r
(d) Inversely proprotional to r^2

Q.16 A sphere of radius R has a uniform distribution of electric charge in its volume. At a distance x from its centre, for $x < R$, the eletric field is directly proportional to

(a) $\frac{1}{x^2}$ (b) $\frac{1}{x}$ (c) x (d) x^2

Q.17 A charged ball B hangs from a silk thread S, which makes an angle θ with a large charged conducting sheet P, as shown

RESPONSE GRID

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10. ⓐⓑⓒⓓ	11. ⓐⓑⓒⓓ	12. ⓐⓑⓒⓓ	13. ⓐⓑⓒⓓ	14. ⓐⓑⓒⓓ
15. ⓐⓑⓒⓓ	16. ⓐⓑⓒⓓ			

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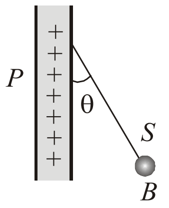
in the figure. The surface charge density σ of the sheet is proportional to



(a) $\sin\theta$

(b) $\tan\theta$

(c) $\cos\theta$

(d) $\cot\theta$

Q.18 A charge q is placed at the centre of a cube. Then the flux passing through one face of cube will be

(a) $\frac{q}{\epsilon_0}$ (b) $\frac{q}{2\epsilon_0}$ (c) $\frac{q}{4\epsilon_0}$ (d) $\frac{q}{6\epsilon_0}$

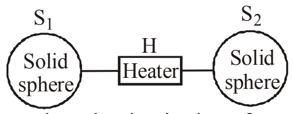
DIRECTIONS (Q.19-Q.20) : In the following questions, more than one of the answers given are correct. Select the correct answers and mark it according to the following codes:

Codes :

(a) 1, 2 and 3 are correct **(b)** 1 and 2 are correct

(c) 2 and 4 are correct **(d)** 1 and 3 are correct

Q.19 A solid sphere S_1 is connected to a charge reservoir through a heater H as shown in figure.



Flux through a closed spherical surface around S_1 is given by $\phi = \alpha t^2$ where α is a constant and t is time in seconds. If resistance of heater is R then select correct statements

(1) Power consumed by heater will be $4\alpha^2\varepsilon_0^2 Rt^2$.

(2) Electric flux through a closed spherical surface around S_2 will be $-\alpha t^2$.

(3) Rate of change of electric flux through a closed spherical surface around S_2 will be $-2\alpha t$

(4) All of the above are correct

Q.20 A simple pendulum has a time period T. The bob is now given some positive charge –

(1) If some positive charge is placed at the point of suspension, T will increases

(2) If some positive charge is placed at the point of suspension, T will not change

(3) If a uniform downward electric field is switched on, T will increase

(4) If a uniform downward electric field is switched on, T will decrease

DIRECTIONS (Q.21-Q.23) : Read the passage given below and answer the questions that follows :

A sphere of radius R contains charge density $\rho(r) = A(R-r)$, for $0 < r < R$. The total electric charge inside the sphere is Q.

Q.21 The value of A in terms of Q and R is

(a) $\frac{2Q^2}{\pi R^4}$ (b) $\frac{3Q}{\pi R^4}$ (c) $\frac{3Q^2}{\pi R^3}$ (d) $\frac{3Q}{\pi R}$

Q.22 The electric field inside the sphere is

(a) $\frac{3Q}{\epsilon_0 R^2}\left[\frac{1}{3}\left(\frac{r}{R}\right)-\frac{1}{4}\left(\frac{r}{R}\right)^2\right]$ (b) $\frac{12Q^2}{R^3}\left[\frac{1}{3}\left(\frac{r}{R}\right)-\frac{1}{4}\left(\frac{r}{R}\right)^2\right]$

(c) $\frac{120Q}{5\epsilon_0 R^2}\left[\frac{1}{4}\left(\frac{r}{R}\right)-\frac{1}{3}\left(\frac{r}{R}\right)^2\right]$ (d) $\frac{12}{R^2 Q}\left[\frac{1}{3}\left(\frac{r}{R}\right)-\frac{1}{4}\left(\frac{r}{R}\right)^2\right]$

Q.23 The electric field outside the sphere is $\left(k = \frac{1}{4\pi\epsilon_0}\right)$

(a) $\frac{kQ}{r}$ (b) $\frac{kQ}{r^2}$ (c) $\frac{kQ}{r^3}$ (d) $\frac{kQ^2}{r^2}$

DIRECTIONS (Q. 24-Q.26) : Each of these questions contains two statements: Statement-1 (Assertion) and Statement-2 (Reason). Each of these questions has four alternative choices, only one of which is the correct answer. You have to select the correct choice.

(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 False, Statement-2 is True.

(d) Statement -1 is True, Statement-2 is False.

Q.24 Statement-1 : Electric lines of force cross each other.

Statement-2 : Electric field at a point superimpose to give

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	22. ⓐⓑⓒⓓ	23. ⓐⓑⓒⓓ			

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one resultant electric field.

Q.25 Statement-1 : A point charge is brought in an electric field. The field at a nearby point will increase, whatever be the nature of the charge.

Statement-2 : The electric field is dependent on the nature of charge.

Q.26 Statement-1 : Direction of electric field at a point signifies direction of force experienced by a point charge placed at that point.

Statement-2 : Electric field is a vector quantity.

RESPONSE GRID	24. ⓐⓑⓒⓓ	25. ⓐⓑⓒⓓ	26. ⓐⓑⓒⓓ

DAILY PRACTICE PROBLEM SHEET 32 - PHYSICS			
Total Questions	26	Total Marks	104
Attempted		Correct	
Incorrect		Net Score	
Cut-off Score	25	Qualifying Score	40
Success Gap = Net Score – Qualifying Score			
Net Score = (Correct × 4) – (Incorrect × 1)			

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DAILY PRACTICE PROBLEMS

PHYSICS SOLUTIONS

32

1. **(d)** $Q_1 + Q_2 = Q$ .....(i)

and $F = k\dfrac{Q_1Q_2}{r^2}$ ..... (ii)

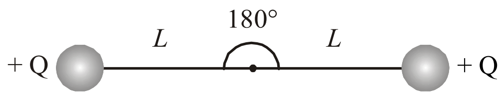
From (i) and (ii)

$$F = \frac{kQ_1(Q - Q_1)}{r^2}$$

For F to be maximum

$$\frac{dF}{dQ_1} = 0 \Rightarrow Q_1 = Q_2 = \frac{Q}{2}$$

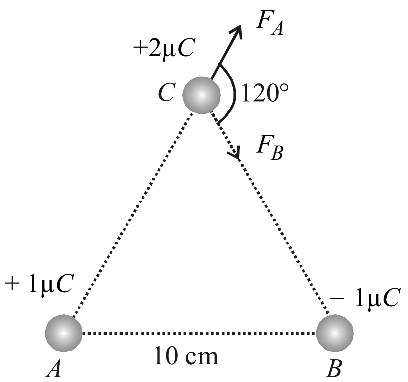
2. **(a)** The position of the balls in the satellite will become as shown below



Thus angle $\theta = 180^\circ$

and force $= \dfrac{1}{4\pi \in_0}.\dfrac{Q^2}{(2L)^2}$

3. **(b)** F_A = Force on C due to charge placed at A



$$= 9\times10^9 \times \frac{10^{-6}\times2\times10^{-6}}{(10\times10^{-2})^2} = 1.8N$$

F_B = force on C due to charge placed at B

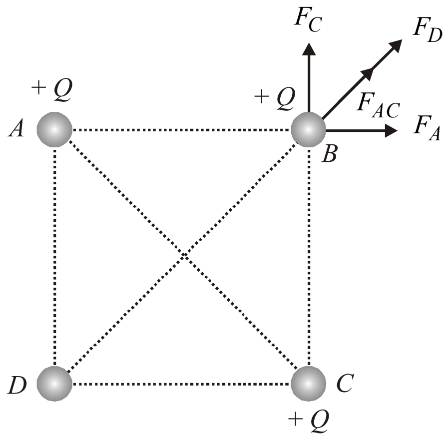
$$= 9\times10^9 \times \frac{10^{-6}\times2\times10^{-6}}{(0.1)^2} = 1.8N$$

Net force on C

$$F_{net} = \sqrt{(F_A)^2 + (F_B)^2 + 2F_AF_B\cos120^\circ} = 1.8N$$

4. **(c)** $\vec{F} = -k\dfrac{e^2}{r^2}\hat{r} = -k.\dfrac{e^2}{r^3}\vec{r}$ $\left(\because \hat{r} = \dfrac{\vec{r}}{r}\right)$

5. **(c)** After following the guidelines mentioned above



$$F_{net} = F_{AC} + F_D = \sqrt{F_A^2 + F_C^2} + F_D$$

Since $F_A = F_C = \dfrac{kq^2}{a^2}$ and $F_D = \dfrac{kq^2}{(a\sqrt{2})^2}$

$$F_{net} = \frac{\sqrt{2}kq^2}{a^2} + \frac{kq^2}{2a^2} = \frac{kq^2}{a^2}\left(\sqrt{2} + \frac{1}{2}\right) = \frac{q^2}{4\pi \in_0 a^2}\left(\frac{1+2\sqrt{2}}{2}\right)$$

6. **(a)**

$$F = \frac{1}{4\pi\varepsilon_0}\frac{(+7\times10^{-6}(-5\times10^{-6})}{r^2} = -\frac{1}{4\pi\varepsilon_0}\frac{35\times10^{-12}}{r^2}N$$

$$F' = \frac{1}{4\pi\varepsilon_0}\frac{(+5\times10^{-6}(-7\times10^{-6})}{r^2} = -\frac{1}{4\pi\varepsilon_0}\frac{35\times10^{-12}}{r^2}N$$

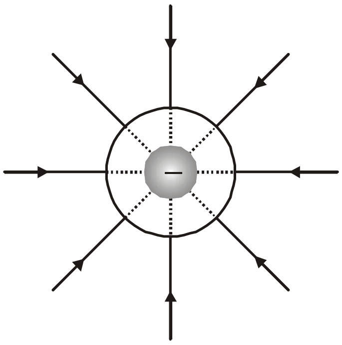
7. **(c)** Electric field outside of the sphere $E_{out} = \dfrac{kQ}{r^2}$ ...(i)

Electric field inside the dielectric shphere $E_{in} = \dfrac{kQx}{R^3}$ ...(ii)

From (i) and (ii), $E_{in} = E_{out} \times \dfrac{r^2x}{R}$

$\Rightarrow$ At 3 cm, $E = 100 \times \dfrac{3(20)^2}{10^3} = 120$ V/m

8. (c) Electric lines force due to negative charge are radially inward.



9. (a) In non-uniform electric field, intensity is more, where the lines are more denser.

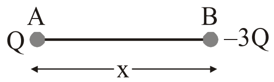
10. (b) According to the question,

$$eE = mg \Rightarrow E = \frac{mg}{e}$$

11. (b) Because E points along the tangent to the lines of force. If initial velocity is zero, then due to the force, it always moves in the direction of E. Hence will always move on some lines of force.

12. (b) The field produced by charge - $3Q$ at A, this is E as mentioned in the example.

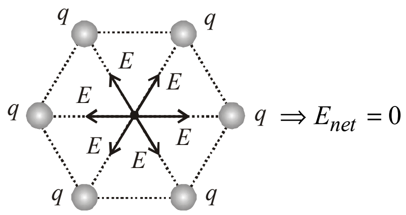
$\therefore E = \frac{3Q}{x^2}$ (along AB directed towards negative charge)

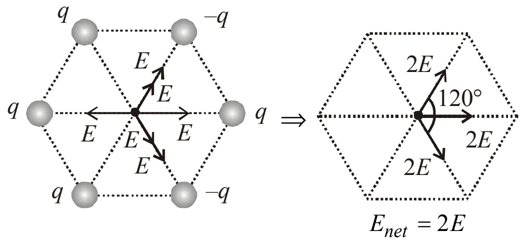


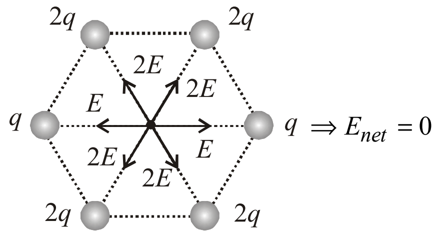
Now field at location of $-3Q$ *i.e.* field at B due to charge Q will be $E' = \frac{Q}{x^2} = \frac{E}{3}$ (along AB directed away from positive charge)

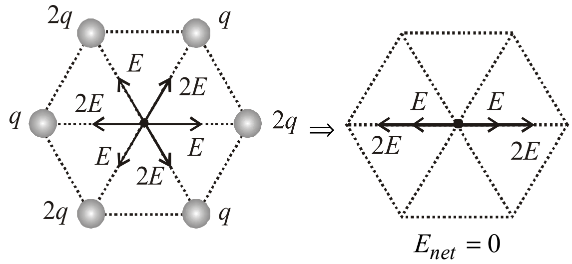
13. (c) The electric field is due to all charges present whether inside or outside the given surface.

14. (b)

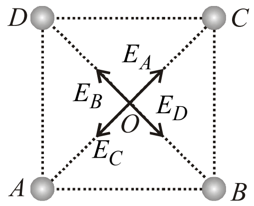


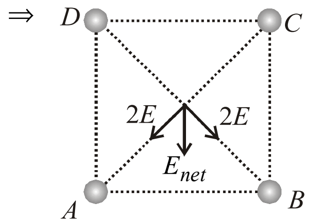






15. (b)





$E_A = E, E_B = 2E, E_C = 3E, E_D = 4E$

16. (b) $\vec{E} = -\frac{\sigma}{2\varepsilon_0}\hat{k} - \frac{2\sigma}{2\varepsilon_0}\hat{k} - \frac{\sigma}{2\varepsilon_0}\hat{k} = -\frac{2\sigma}{\varepsilon_0}\hat{k}$

17. (b)

18. (c) According to Gauss law $\oint E.ds = \frac{q_1}{\varepsilon_0}$

$\oint ds = 2\pi rl$; (E is constant)

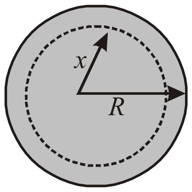
$\therefore \quad E.\, 2\pi rl = \frac{q_1}{\varepsilon_0} \Rightarrow E = \frac{q}{2\pi\varepsilon_0 r}$ *i.e.* $E \propto \frac{1}{r}$

19. (c) Let sphere has uniform chare density $\rho\left(\frac{3Q}{4\pi R^3}\right)$ and E is the electric field at distance x from the centre of the sphere.

Applying Gauss law,

$$E.4\pi x^2 = \frac{q}{\varepsilon_0} = \frac{\rho V'}{\varepsilon_0} = \frac{\rho}{\varepsilon_0} \times \frac{4}{3}\pi x^3$$

(V = Volume of dotted sphere)



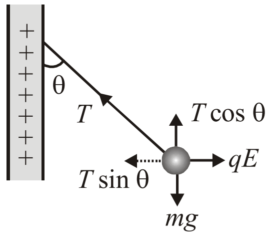
$$\therefore \quad E = \frac{\rho}{3\varepsilon_0} x \Rightarrow E = \propto x$$

20. **(b)** $T\sin\theta = \theta E$

and $T\cos\theta = mg$

$$\Rightarrow \quad \tan\theta = \frac{qE}{mg}$$

$$= \frac{q}{mg}\left(\frac{\sigma}{2\varepsilon_0}\right)$$



$$\Rightarrow \quad \sigma \propto \tan\theta.$$

21. **(d)** Next flux through the cube $\phi_{net} = \frac{Q}{\varepsilon_0}$; so flux through one face $\phi_{face} = \frac{q}{6\varepsilon_0}$

22. **(d).** For A : Power consumed $P = I^2R$

But $\frac{q}{\varepsilon_0} = \phi$,

so $q = \alpha\, \varepsilon_0 t^2 \Rightarrow I = \frac{dq}{dt} = 2\alpha\, \varepsilon_0 t \Rightarrow P = 4\alpha^2\, \varepsilon_0^2 R t^2$

For B : Assuming initial charge in reservoir be q_0 then electric flux through a closed

Spherical surface around S_2 will be $\phi_{S_2} = \frac{q_0 - \alpha\varepsilon_0 t^2}{\varepsilon_0}$

For C : $\frac{d\phi_{S_2}}{dt} = -2\alpha t$

23. **(c).** The time period will change only when the additional electrostatic force has a component along the direction of the displacement, which is always perpendicular to the string.

24. ()

25. **(b)** Net charge inside the sphere $= \int_{sphere} \rho\, dV$

Due to spherical symmetry, we get

$$Q = \int_0^R 4\pi r^2 \rho(r) dr = 4\pi A \int_0^R r^2 (R - r)\, dr$$

$$= 4\pi A \left(\frac{R^4}{3} - \frac{R^4}{4}\right)$$

$$\therefore \quad A = \frac{3Q}{\pi R^4}$$

26. **(a)** According to Gauss law

$$\oint_s \vec{E}.\vec{dS} = 4\pi r^2 E(r)$$

$$= \frac{\int_0^r 4\pi r^2 \rho(r)\, dr}{\epsilon_0}$$

$$\Rightarrow \quad 4\pi r^2 E(r) = \frac{4\pi A \int_0^r r^2 (R - r) dr}{\epsilon_0}$$

$$= \frac{4\pi A}{\epsilon_0}\left(\frac{r^3 R}{3} - \frac{r^4}{4}\right)$$

Hence, $E(r) = \frac{A}{\epsilon_0}\left(\frac{rR}{3} - \frac{r^2}{4}\right)$, for $0 < r < R$

But $A = \frac{3Q}{\pi R^4}$

$$\therefore \quad \text{We get, } E(r) = \frac{3Q}{\epsilon_0 R^2}\left[\frac{1}{3}\left(\frac{r}{R}\right) - \frac{1}{4}\left(\frac{r}{R}\right)^2\right]$$

27. **(b)** The electric field outside the sphere is given by :

$$E(r) = \frac{kQ}{r^2}, \text{ for } r \geq R$$

28. **(c)** If electric lines of forces cross each other, then the electric field at the point of intersection will have two direction simultaneously which is not possible physically.

29. **(c)** Electric field at the nearby point will be resultant of existing field and field due to the charge brought. It may increase or decrease if the charge is positive or negative depending on the position of the point with respect to the charge brought.

30. ()