ASSIGNMENT-1 ANSWER KEY

(1-MARK QUESTION)

1. (b)

2. (d) Q= ne

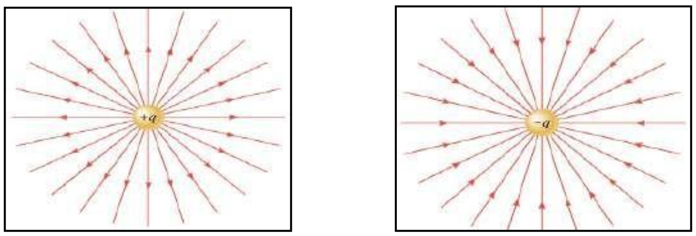
   Q= 5 x 10^{18} x 1.6 x 10^{-15} = 0.8 C

   So net charge = q + Q = 1 – 0.8 = 0.2C

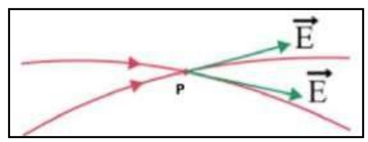
3. F’ = F/K   Where K= dielectric constant

   Hence force is reduced when plastic sheet is inserted

4.

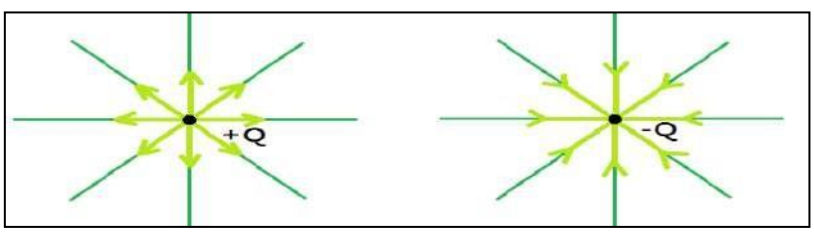


5. If electric field lines cross each other, then at the point of intersection at P, there will be two tangents which is impossible.



6. Since electric field lines emergent from positive charge and terminate at negative charge. If there is a single charge, then emerging field lines terminate at infinity. Therefore, they never form closed loop.

7. (i) Q>0   (ii) Q<0



8. The proton will move in the direction of electric field as it is positively charged. i.e. towards the positive x-axis.

9. (a) 10. (d) 11. (c) 12. (c) 13. (b) 14. (c)

15. (c) [M^1 L^3 $T^{-3}A^{-1}$]

16. (a) $\frac{N}{C}$ x m^2

17. a) There is no net charge present inside the surface.

18. (b) 0 V-m

19.. Total number of electric field lines.

20. Electric Flux.

21. (c) the number of flux lines entering the surface must be equal to the number of flux lines leaving it

22. (d) is the same for all the figures

23. D) 24. A) 25. B) 26. A) 27. A) 28. A)

<u>Answer for Two-mark questions</u>

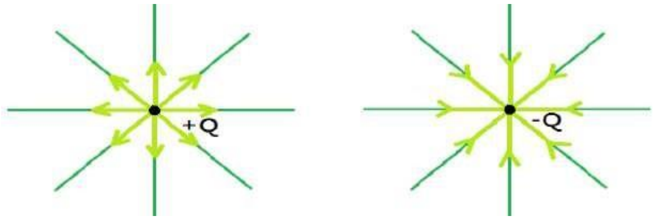
29. The principle of superposition states that the total force on a given charge is the vector sum of the individual forces exerted on it by all other charges, the force between two charges being exerted in such a manner as if all other charges were absent

$F = F_{12} + F_{13} + \ldots\ldots + F_{1N}$

30. The force between q_1 and q_2 remains equal to F.

31. (i) $\lim_{q \to 0}$ tells is that test charge is so small that it does not charge (affect) the source charge.

(ii)



32. Inner surface charge = -Q Outer surface charge = +Q

$E = Q/4\pi\varepsilon_0 r_1^2$

33.. $\vec{E}_{net} = \vec{E}_1 + \vec{E}_2$

$= K\,(\,q_1/r_1^3\,\vec{r}_1 + (\,q_2/r_2^3\,\vec{r}_2)$

Where $\vec{r}_1 = -a\hat{i} + c\hat{k}$ $\vec{r}_2 = -b\hat{j} + c\hat{k}$

$\vec{E}\,net = 1/4\pi E_0\,[q_1\,(-a\hat{i} + c\hat{k})/(a^2 + c^2)^{3/2} + q_2\,(-\hat{j} + c\hat{k})/\,(b^2 + c^2)^{3/2}$

34. A Gaussian surface is an imaginary surface at every point of which electric field is same.

By conveniently choosing the Gaussian surface one can evaluate $\oint_s \vec{E}\cdot\vec{dS}$ over it and find out expression for electric field intensity.

35. Electric flux through S_1, $\Phi_1 = 9Q/\epsilon_o$

Electric flux through S_2, $\Phi_2 = 9Q/\epsilon_o + 3Q/\epsilon_o = 12Q/\epsilon_o$ $\therefore \Phi_1/\Phi_2 = 3/4$

When air inside S_1 is replaced by a medium of $\epsilon_r = 3$

Then electric flux through $S_1 = \Phi_1 = 9Q/\epsilon = 9Q/\epsilon_o\epsilon_r = 9Q/3\epsilon_o = 3Q/\epsilon_o$.

36. Electric flux through cube, $\Phi_E = q/\epsilon_o = 6C/\epsilon_o$

Electric flux through square face, $= 1/6 \times \Phi_E = 1/6 \times 6C/\epsilon_o = 1/\epsilon_o$

Flux through a square face remains same even if 6C charge is distributed ass 4 C and 2 C at two different points since total charge inside the cube remains unchanged.

Answer to Three-mark questions

37. F = ma or qE= ma

$a = qE/m = 2 \times 10^{-6} \times (80\hat{i} + 60\hat{j}) / 1.6 \times 10^{-3}$

$= (100 \times 10^{-3})\hat{i} + (75 \times 10^{-3})\hat{j}$

$V = u + at$

$= 4\hat{i} + ((100 \times 10^{-3})\hat{i} + (75 \times 10^{-3})\hat{j}) \times 5$

$= 4.5\hat{i} + 0.375\hat{j}$

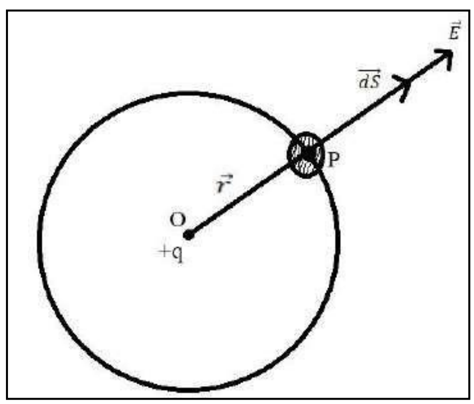
38. Acceleration, $a = qE/m = 5 \times 10^{-6} \times 2 \times 10^{-5} / 10^{-3} = 10^3 m/s^2$

Now $v^2 = u^2 - 2as$

$0 = (20)^2 - 2 \times 1000 \times S$

Therefore, S =400/2000 =1/5 =0.2m

39. Let +q be the point charge located at point O. Consider spherically symmetric Gaussian surface around it as shown. Let P be the point on its surrounding elemental area dS and $\vec{r}$ as the position vector of point P. Electric field $\vec{E}$ due to point charge +q and $\vec{dS}$ are in the same direction as shown. Then the total electric flux through closed surface S is



$$\Phi_{E\,Total} = \oint_s \vec{E}\cdot\vec{dS}$$

$$=\oint_s E\ dS \cos\theta = \oint_s E\ dS \cos 0^o$$

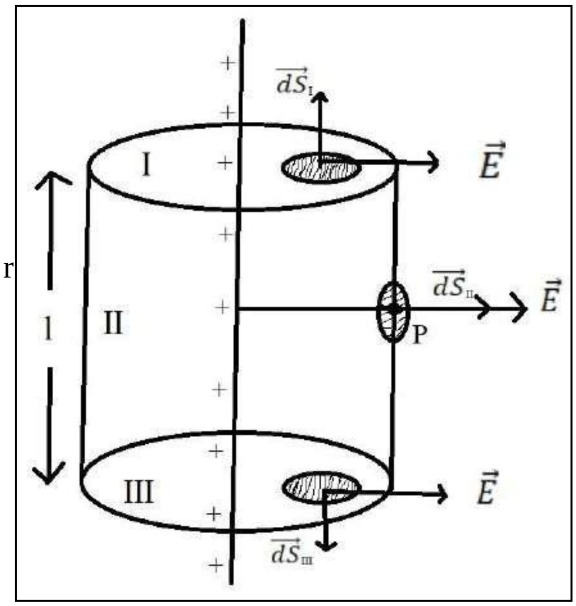
$$\Phi_{E\ Total} = E \oint_S dS = q/4\pi\epsilon_o r^2 \oint dS \quad (\because E = q/4\pi\epsilon_o r^2)$$

$$= q/4\pi\epsilon_o r^2 \times (4\pi r^2)$$

$$\Phi_{E\ Total} = q/\epsilon_o$$

40. <u>Electric field due to infinitely long uniformly charged straight wire</u>

Consider uniformly charged infinitely long straight wire. In order to find electric field intensity at point 'P' distance 'r' from the wire we consider cylindrical Gaussian surface with portion of length'l' of charged wire as axis.



Applying Gauss Theorem to this situation,

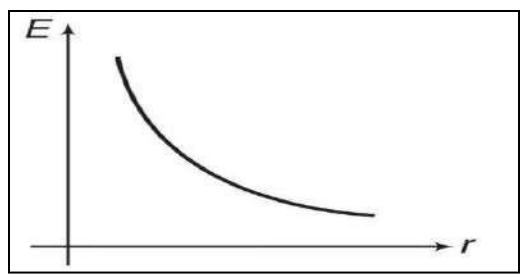
$$\oint_S \vec{E}\cdot\vec{dS} = q/\epsilon_o \text{ -------------(1)}$$

but $\oint_S \vec{E}\cdot\vec{dS} = \oint_I \vec{E}\cdot\vec{dS} + \oint_{II} \vec{E}\cdot\vec{dS} + \oint_{III} \vec{E}\cdot\vec{dS}$

but $\oint_I \vec{E}\cdot\vec{dS} = \oint_{III} \vec{E}\cdot\vec{dS} = 0 \quad (\because \vec{E} \perp \vec{dS})$

$$\therefore \oint_s \vec{E}\cdot\vec{dS} = \oint_{II} \vec{E}\cdot\vec{dS} = \oint_{II} E\ dS \cos 0^o$$

$$= E \oint_{II} dS = E\ 2\pi rl \text{ ----------(2)}$$



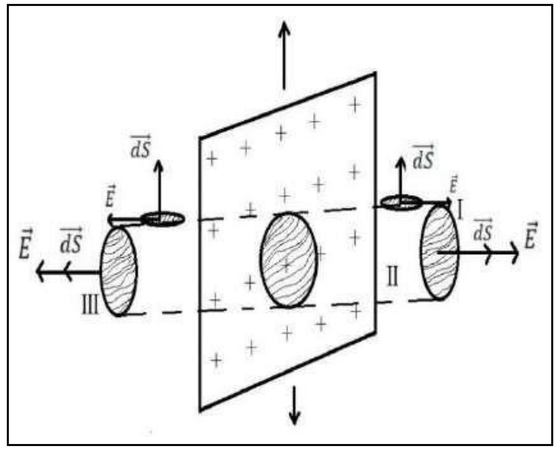
From (1) &(2), we get

$$E\ 2\pi rl = q/\epsilon_o$$

$E = q/2\pi\epsilon_o rl = \lambda/2\pi\epsilon_o r$ $\quad$ ($\because \lambda = q/l$ is linear charge density)

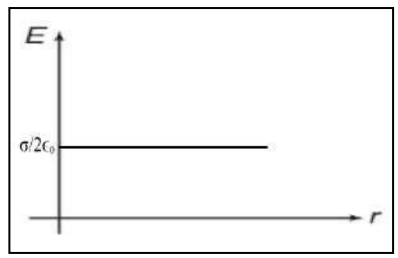
$E = \lambda/2\pi\epsilon_o r = 2\lambda/4\pi\epsilon_o r$

41. <u>Electric field intensity due to uniformly charged thin infinite plane sheet.</u>



Consider uniformly charged infinitely long thin plane sheet as shown in diagram. Let 'σ' be the surface charge density. In order to find out electric field intensity at point 'P' due plane charged sheet we consider circular elemental area 'A' of the sheet carrying total charge q. Considering cylindrical Gaussian surface enclosing the given charged area A and applying Gauss Theorem to situation

$$\oint_S \vec{E}\cdot\vec{dS} = \oint_I \vec{E}\cdot\vec{dS} + \oint_{II} \vec{E}\cdot\vec{dS} + \oint_{III} \vec{E}\cdot\vec{dS}$$



but $\oint_S \vec{E}\cdot\vec{dS} = \oint_I \vec{E}\cdot\vec{dS} + \oint_{III} \vec{E}\cdot\vec{dS}$ $\quad (\because \oint_{II} \vec{E}\cdot\vec{dS} = 0)$

$$= E\oint_I dS + E\oint_{III} dS$$

$$= E(A) + E(A) = 2EA$$

but $\oint_S \vec{E}\cdot\vec{dS} = q/\epsilon_o = \sigma A/\epsilon_o$

$$\therefore 2EA = \sigma A/\epsilon_o$$

$$\boxed{E = \sigma/2\epsilon_o}$$

Answer for Four-mark questions

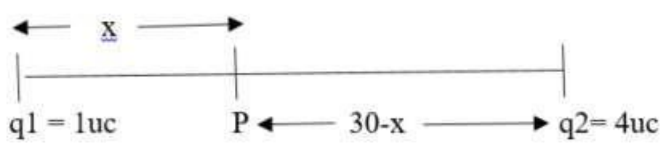
42. 1 a) 6C/ ϵ o 2 c) 6C/ ϵ o

3 c) Glittering intensity is always constant whether the fan inside is switched ON or OFF

4 d) Gauss theorem in electrostatics

Answer to Five-mark questions

43. Let at point P, the net electric field is zero, then



$$1/x^2 = 4/(30-x)^2$$

After solving x = 10cm

44. a. Electric field Intensity – It is defined as the force per unit charge.

$\vec{E}$= F/q , SI unit of $\vec{E}$ = N/C or volt per meter V/m

b. Let the required point is at a distance x from 2μc charge k 4 μc / x^2= k 1 μc /$(2-x)^2$ = 4/x^2= 1/(4+x^2-2x)

= $(2/x)^2$ = $(1/2-x)^2$ = 2/x =

+- 1/(2-x)x=4/3m or 4m

x= 4 does not satisfy therefore, x=4/3m

45. Expression for intensity of electric field due to a point charge

According to coulomb's law,

F= 1/4πε_0(q_0 q/r^2)

E= F/q_0 =1/4πε_0(q_0 q/q_0r^2)

E= 1/4πε_0(q/r^2)

N/CE=9.0 X

10^9 q/r^2