ELECTROSTATICS

PREVIOUS EAMCET BITS

1. An infinitely long thin straight wire has uniform linear charge density of 1/3 coul.m^{-2}. Then the magnitude of the electric intensity at a point 18 cm away is : (given $\in_0 = 8.0\times10^{-12} C^2/N-m^2$) **(2009 E)**

1) $0.33\times10^{11} NC^{-1}$ 2) $3\times10^{11} NC^{-1}$ 3) $0.66\times10^{11} NC^{-1}$ 4) $1.32\times10^{11} NC^{-1}$

Ans : 1

Sol: Magnitude of electric intensity at a point due to an infinitely long thin straight wire of uniform linear charge density λ is $E = \dfrac{\lambda}{2\pi \in_0 r}$ $\left[\dfrac{1}{4\pi\in_0} = 9\times10^9\right]$

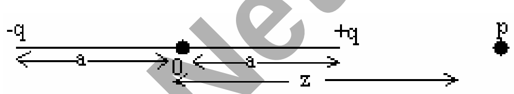
$$= \frac{18\times10^9 \times \frac{1}{3}}{18\times10^{-2}}$$

= 0.33×10^{11} NC^{-1}

2. Two point charges –q and +q are located at points (0,0-1) and (0,0,a) respectively. The electric potential at a point (0,0,z), where z >a is : **(2008 E)**

1) $\dfrac{qa}{4\pi\in_0 z^2}$ 2) $\dfrac{q}{4\pi\in_0 a}$ 3) $\dfrac{2qa}{4\pi\in_0 (z^2-a^2)}$ 4) $\dfrac{2qa}{4\pi\in_0 (z^2+a^2)}$

Ans :3



Sol:

Electric potential at the point P because of the charges –q and +q is $V_p = V_1 + V_2$

$$\therefore V_p = \left[\frac{1}{4\pi\in_0}.\frac{-q}{(z+a)} + \frac{1}{4\pi\in_0}.\frac{+q}{(z-a)}\right] = \frac{q}{4\pi\in_0}\left[\frac{z+a-z+a}{z^2-a^2}\right]$$

$$\Rightarrow V_p = \frac{2qa}{4\pi\in_0 (z^2-a^2)}$$

3. Two charges q and -q are kept apart. Then at any point on the perpendicular bisector of line joining the two charges. **(2008E)**

1) the electric field strength is zero 2) the electric potential is zero

3) both electric potential and electric field strength are zero

4) both electric potential and electric field strength are non-zero

Ans : 1

Sol: Potential at any point on the perpendicular bisector of the line joining the two charges

$$V = V_1 + V_2 = \frac{1}{4\pi\in_0}\frac{q}{r} + \frac{1}{4\pi\in_0}\frac{-q}{r} = 0$$

[r = distance between the charges and any point on perpendicular bisector which is same for both the charges]

4. A charge of $1\mu C$ is divided into two parts such that their charges are in the ratio of 2 : 3. These two charges are kept at a distance 1m apart in vaccum. Then, the electric force between them (in newton) is **(2008E)**

1) 0.216 2) 0.00216 3) 0.0216 4) 2.16

Ans: 2

Sol: $q_1 = \frac{2}{5}\mu C$

$q_2 = \frac{3}{5}\mu C$

$F = \frac{1}{4\pi \in_0}\frac{q_1 q_2}{d^2}$

$= \frac{9\times10^9\times\frac{2}{5}\times\frac{3}{5}\times10^{-6}\times10^{-6}}{(1)^2}$

= 0.00216 N

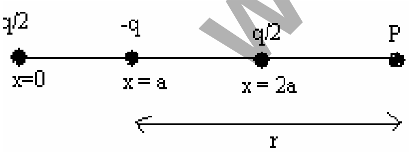
5. Along the x-axis, three charges $\frac{q}{2}, -q$ and $\frac{q}{2}$ are placed at x = 0, x =a and x =2a respectively. The resultant electric potential at a point 'P' located at a distance r from the charge -q $(a << r)$ is ($\in_0$ is the permittivity of free space) **(2007-E)**

1) $\frac{qa}{4\pi \in_0 r^2}$ 2) $\frac{qa^2}{4\pi \in_0 r^3}$ 3) $\frac{q\left(\frac{a^2}{4}\right)}{4\pi \in_0 r^3}$ 4) $\frac{q}{4\pi \in_0 r}$

Ans :2

Sol: The potential at P is V which is given by $V = V_1 + V_2 + V_3$

$$V = \frac{1}{4\pi \in_0}\frac{q}{2(r+a)} + \frac{1}{4\pi \in_0}\frac{-q}{r} + \frac{1}{4\pi \in_0}\frac{q}{2(r-a)}$$



$$V = \frac{1}{4\pi \in_0}\frac{q}{2}\left[\frac{1}{r+a} - \frac{2}{r} + \frac{1}{r-a}\right]$$

$$= \frac{1}{4\pi \in_0}\frac{q}{2}\left[\frac{r(r-a) - 2r(r+a)(r-a) + (r-a)r}{r(r+a)(r-a)}\right]$$

$$= \frac{1}{4\pi \in_0}\frac{q}{2}\left[\frac{r^2 - ra - 2r^2 + 2a^2 + r^2 + ar}{r\left[r^2 - a^2\right]}\right]$$

$$= \frac{1}{4\pi \in_0}\frac{q}{2}\left[\frac{2a^2}{r\left[r^2 - a^2\right]}\right]$$

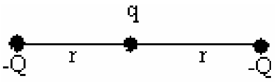
= $\frac{1}{4\pi\in_0}\frac{qa^2}{r^3}$ as a<<r

6. Two unit negative charges are placed on a straight line. A positive charge q is placed exactly at the mid point between these unit charges. If the system of these three charges is in equilibrium, the value of q (in C) is **(2007-E)**

1) 1.0 2) 0.75 3) 0.5 4) 0.25

Ans: 4

Sol: If the system of these three charges is in equilibrium if repulsive force between –Q and –Q is balanced by attraction forces between q and -Q



$= F_1 + F_2 = 0 \Rightarrow F_1 = -F_2$

$$\Rightarrow \frac{1}{4\pi\in_0}\frac{(-Q)(-Q)}{(2r)^2} = \frac{-1}{4\pi\in_0}\left[\frac{q(-Q)}{r^2}\right]$$

On solving $q = \frac{Q}{4} = 0.25$

7. Along the X-axis, three charges $\frac{q}{2}$,-q and $\frac{q}{2}$ are placed at x-0, x =a and x =2a respectively . The resultant electric potential at x =a+r(if a , <<r) is ($\in_0$ is the permittivity of free space) **(2006-E)**

1) $\frac{qa}{4\pi\in_0 r^2}$ 2) $\frac{qa^2}{4\pi\in_0 r^3}$ 3) $\frac{q(a^2/4)}{4\pi\in_0 r^3}$ 4) $\frac{q}{4\pi\in_0 r}$

Ans: 2

Sol: Electric potential at a point P = V = $V_1 + V_2 + V_3$

$$= \frac{1}{4\pi\in_0}\left[\frac{q}{2(a+r)} - \frac{q}{r} + \frac{q}{2(r-a)}\right]$$

$$= \frac{q}{4\pi\in_0}\left[\frac{1}{2(a+r)} - \frac{1}{r} + \frac{1}{2(r-a)}\right]$$

$$= \frac{q}{4\pi\in_0}\left[\frac{r^2 - ar - 2(r^2 - a^2) + r^2 + ar}{2(r+a)(r-a)r}\right]$$

$$= \frac{q}{4\pi\in_0}\left[\frac{r^2 - ar - 2r^2 + 2a^2 + r^2 + ar}{2(r^3 - a^2 r)}\right]$$

As ‘a’ is very small compared to r. $\therefore\ r^2 - a^2 \approx r^2$

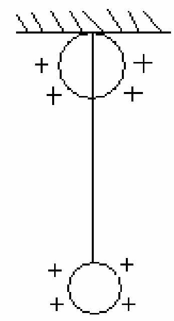
$$= \frac{q}{4\pi\in_0}\frac{2a^2}{2(r^3 - a^2 r)} = \frac{qa^2}{4\pi\in_0 r(r^2 - a^2)}$$

$$V = \frac{qa^2}{4\pi\in_0 r^3}$$

8. The bob of a simple pendulum is hanging vertically down from a fixed identical bob by means of a string of length If both bobs are charged with a charge ‘q ‘ each , time period of the pendulum is (ignore the radii of the bobs) **(2006-E)**

1) $2\pi\sqrt{\frac{l}{g+_{-}\left(\frac{q^2}{l^2m}\right)}}$ 2) $2\pi\sqrt{\frac{l}{g-\left(\frac{q^2}{l^2m}\right)}}$ 3) $2\pi\sqrt{\frac{l}{g}}$ 4) $2\pi\sqrt{\frac{l}{g-\left(\frac{q^2}{l^2m}\right)}}$

Ans :3



Sol:

Between the two charged bobs, there is only electrostatic repulsion which does not affect the motion of pendulum.

$\therefore$ Time period $T = 2\pi\sqrt{\frac{\ell}{g}}$

9. Two charges 2C and 6C are separated by finite distance. If a charge of -4C is added to each of them. The initial force of 12 $\times 10^3$N will change to **(2005 E)**

1) 4 $\times 10^3$N repulsion 2) 4 $\times 10^2$N repulsion

3) 6 $\times 10^3$N attraction 4) 4 $\times 10^3$N attraction

Ans : 4

Sol: Initial force between the charge

$F_{ini} = \frac{1}{4\pi \in_0}\frac{2\times 6}{d^2} = 12\times 10^{+3}$ repulsive

Final force between the charges = $F_F = \frac{1}{4\pi \in_0}\frac{(2-4)(6-4)}{d^2}$

$F_F = \frac{1}{4\pi \in_0}\frac{(-2)(2)}{d^2} = \frac{+F_i}{3} = 4\times 10^{+3}\,N$ Attraction

10. A $4\mu F$ capacitor is charged by a 200V battery. It is then disconnected from the supply and is connected to another uncharged 2 μF capacitor. During this process, Loss of energy (in J) is:

(2005E)

1) Zero 2) 5.33×10^{-2} 3) 4×10^{-2} 4) 2.67×10^{-2}

Ans : 4

Sol:

Loss of energy = initial energy – final energy

$$\frac{1}{2}\frac{C_1C_2}{C_1+C_2}V^2 = 2.7\times10^{-2}J$$

For unchanged capacitor potential is zero.

11. The plates of a parallel plate capacitor are charged upto 200votts. A di-electric slab of thickness 4mm is inserted between the plates. Then to maintain the same potential difference between the plates of the capacitor, the distance between the plates is increased by 3.2mm. The di-electric constant of di-electric slab is **(2004 E)**

1) 1 2) 4 3) 5 4) 6

Ans: 3

Sol: $C_0 = \frac{\epsilon_0 A}{d}$ after the dielectric slab of thickness 't' is introduced

$$\Rightarrow C = \frac{\epsilon_0 A}{d' - t\left(1-\frac{1}{K}\right)}$$

$$C = C_0$$

$$\Rightarrow d = d' - t\left(1-\frac{1}{K}\right)$$

$$\Rightarrow t\left(1-\frac{1}{K}\right) = d' - d$$

$$\Rightarrow 4\left(1-\frac{1}{K}\right) = 3.2$$

$$\Rightarrow K = 5$$

12. Three point charges 1C, 2C, -2C are placed at the vertices of an equilateral triangle of side one metre. The work done by an external force to increase the separation of the charges 2 metres in joules is **(2004 E)**

1) $\frac{1}{4\pi \epsilon_o}$ 2) $\frac{1}{8\pi \epsilon_o}$ 3) $\frac{1}{16\pi \epsilon_o}$ 4) 0

Ans: 4

Sol: Initially and finally the net force is zero. (i.e.) work done by the external force is zero.

13. An infinite no. of electric charges each equal to 5 nano coulombs are placed along X-axis at x = 1 cm, x = 2cm, x = 4cm, x=8cm,…. and so on. In this setup, if the consecutive charges have opposite sign, then the electric field in newton/coulomb at x = 0 is **(2004 E)**

1) 12×10^4 2) 24×10^4 3) 36×10^4 4) 48×10^4

Ans: 3

Sol: E = Resultant electric field = $E_1 + E_2 + E_3 + ...$

$$= \frac{1}{4\pi t_0}\left[\frac{Q_1}{r_1^2} - \frac{Q_2}{r_2^2} + \frac{Q_3}{r_3^2} + ...\right]$$

$$= \frac{1}{4\pi t_0}\left[\frac{Q}{\left(1\times10^{-2}\right)^2} - \frac{Q}{\left(2\times10^{-2}\right)^2} + \frac{Q}{\left(4\times10^{-2}\right)^2} + ...\right]$$

$$\therefore E = \frac{9\times10^9}{10^{-4}}\left[\frac{1}{1-\left(\frac{-1}{4}\right)}\right]\times 5\times10^{-9}$$

[Since $S_\infty = \frac{a}{1-r}$]

$$\therefore E = \frac{45}{10^{-4}}\times\frac{4}{5} = 36\times10^4 \text{ NC}^{-1}$$

14. A parallel plate capacitor of capacity C_o is charged to a potential V_o.

A) The energy stored in the capacitor when the battery is disconnected and the plate separation is doubled is E_1

B) The energy stored in the capacitor when the charging battery is kept connected and the separation between the capacitor plates is doubled is E_2. Then $\frac{E_1}{E_2}$ value is **(2003E)**

1) 4   2) $\frac{3}{2}$ 3) 2   4) $\frac{1}{2}$

Ans: 1

Sol: A : $E_1 = \frac{Q^2}{2C_1} = \frac{Q^2}{2\left(\frac{C}{2}\right)} = \frac{Q^2}{C} = \frac{C^2V^2}{C} = CV^2$

Since as battery is disconnected charge remains same

B: $E_2 = \frac{1}{2}C_1V^2 = \frac{1}{2}\left(\frac{C}{2}\right)V^2 = \frac{CV^2}{4}$

$\therefore \frac{E_1}{E_2} = \frac{CV^2\times4}{CV^2}$ = 4

15. The time in seconds required to produce a P.D at 20V across a capacitor at $1000\ \mu F$ when it is charged at the steady rate of $200\ \mu C/\sec$ is ...... **(2002 E)**

1. 50   2. 100   3. 150   4. 200

Ans: 2

Sol: $q = cV = 1000\times10^{-6}\times20 = 2\times10^{-2}$

$t = \frac{q}{\Delta q/\Delta t} = \frac{2\times10^{-2}}{200\times10^{-6}} = 100s \left[\sin ce\ \ i = \frac{ch\arg e}{time}\right]$

16. A body of mass 1 gm and carrying a charge $10^{-8}C$ passes from the point P to Q which one at electric potentials 600 V and 0V respectively. The velocity of the body at Q is 20 cm/sec. Its velocity in m/sec at 'P' is... **(2002 E)**

1. $\sqrt{0.028}$ 2. $\sqrt{0.056}$ 3. $\sqrt{0.56}$ 4. $\sqrt{5.6}$

Ans : 1

Sol : According to the law of conservation of energy

Gain in KE = $\frac{1}{2}mv^2 - \frac{1}{2}mu^2 = qV$

$\Rightarrow u^2 = v^2 - \frac{2qV}{m}$

= $(0.2)^2 - \frac{2\times10^{-8}\times600}{10^{-3}} = 0.028$

$\Rightarrow u = \sqrt{0.028} = 0.167ms^{-1} = 16.7cm/s$

17. There is a uniform electric field of strength $10^3 V/m$ along y-axis. A body of mass 1 g and charge $10^{-6}C$ is projected into the field from origin along the positive x-axis with a velocity 10 m/s. Its speed in m/s after 10s is (neglect gravitation) **(2001E)**

1. 10 2. $5\sqrt{2}$ 3. $10\sqrt{2}$ 4. 20

Ans :3

Sol: $V_x = 10m/s$

$V_y = u_y + a_y t$ = $V_y = \frac{Eq}{m}\times t$ $\left[\sin ce\ u_y = 0,\ a_y = \frac{Eq}{m}\right]$

Resultant velocity $\Rightarrow V = \sqrt{V_x^2 + V_y^2} = 10\sqrt{2}m/s$

18. If the charge on a body is increased by 2C, the energy stored in it increases by 21%. The original charge on the body in coulombs is **(2001 E)**

1. 10 2. 20 3. 30 4. 40

Ans: 2

Sol: Energy stored $E = \frac{1}{2}CV^2 = \frac{q^2}{2C}$

$E \propto q^2$

$\Rightarrow \frac{E_1}{E_2} = \frac{q_1^2}{q_2^2}$ $\left[E_2 = E_1 + \frac{21E_1}{100} = \frac{121E_1}{100}\right]$

$\Rightarrow \frac{E_1}{\frac{121E_1}{100}} = \frac{q^2}{(q+2)^2}$

$\Rightarrow \frac{100}{121} = \left(\frac{q}{q+2}\right)^2$

$\Rightarrow \frac{10}{11} = \frac{q}{q+2} \Rightarrow 10q + 20 = 11q \Rightarrow q = 20C$

19. A 20F capacitor is charged to 5V and isolated. It is then connected in parallel with an uncharged 30F capacitor. The decrease in the energy of the system will be **(2001 E)**

1. 25J 2. 100J 3. 125J 4. 150J

Ans: 4

Sol: $\Delta W = \frac{1}{2}\frac{C_1C_2}{C_1+C_2}(V_1-V_2)^2$

$= \frac{1}{2}\frac{20\times30}{(20+30)}(5-0)^2 = 150J$

For an uncharged capacitor potential = 0

20. Two electric charges of $9\mu C$ and $-3\mu C$ are placed 0.16m apart in air. There will be a point P at which electric potential is zero on the line joining the two charges and in between them. The distance of P from $9\mu C$ charge is **(2001 E)**

1. 0.14m 2. 0.12m 3. 0.08m 4. 0.06m

Ans: 2

Sol: Let P be at distance x from the charge $9\mu C$. The distance of P from the charge -$3\mu C$ will be 0. 16-x

As $V_1 + V_2 = 0 \Rightarrow \frac{1}{4\pi \in_0}.\frac{9\times10^{-6}}{x} - \frac{3\times10^{-6}}{4\pi \in_0 (0.16-x)} = 0$

$\Rightarrow x = 0.12m$

21. An infinite no.of electric charges each equal to 5 nano coulombs are placed along X-axis at x = 1 cm, x = 2cm, x = 4cm, x=8cm,…. and so on. In this setup, if the consecutive charges have opposite sign, then the electric field in newton/coulomb at x = 0 is **(2001 E)**

1) 12×10^4 2) 24×10^4 3) 36×10^4 4) 48×10^4

Ans: 3

Sol: E = Resultant electric field = $E_1 + E_2 + E_3 + ...$

$= \frac{1}{4\pi t_0}\left[\frac{Q_1}{r_1^2} - \frac{Q_2}{r_2^2} + \frac{Q_3}{r_3^2} + ...\right]$

$= \frac{1}{4\pi t_0}\left[\frac{Q}{(1\times10^{-2})^2} - \frac{Q}{(2\times10^{-2})^2} + \frac{Q}{(4\times10^{-2})^2} + ...\right]$

$\therefore E = \frac{9\times10^9}{10^{-4}}\left[\frac{1}{1-\left(\frac{-1}{4}\right)}\right]\times5\times10^{-9}$

[Since $S_\infty = \frac{a}{1-r}$]

$\therefore E = \frac{45}{10^{-4}}\times\frac{4}{5} = 36\times10^4$ NC^{-1}

22. A charged particle of mass $5\times10^{-6}kg$ is held stationary in space by placing it in an electric field of strength $10^6 N/C$ directed vertically downwards. The charge on the particle is **(2000 E)**

1. $-20\times10^{-5}\mu C$ 2. $-5\times10^{-5}\mu C$ 3. $5\times10^{-5}\mu C$ 4. $20\times10^{-5}\mu C$

Ans: 2

Sol: As the particle is stationary net force = 0

$Eq + mg = 0$

$q = \frac{-mg}{E} = \frac{-\left(5\times10^{-6}\right)(10)}{10^{6}}$

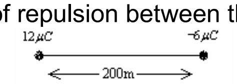
$= -5\times10^{-5}\,\mu C$

23. 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 lenth of each side 10 cm. The resultant force on the charge at C is $\left(\frac{1}{4\pi\epsilon_0} = 9\times10^{9}\,N - m^2/c^2\right)$ **(2000 E)**

1. 0.9N   2. 1.8N   3. 2.7N   4. 3.6N

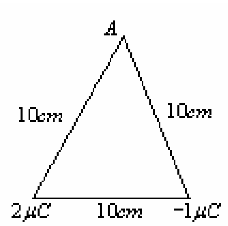
Ans: 2

Sol: From the figure, force of repulsion between the charges at A and C



$F_{rep} = \frac{1}{4\pi\varepsilon_0}\cdot\frac{q_1 q_2}{d^2}$

$= \frac{\left(9\times10^{9}\right)\left(2\times10^{-12}\right)}{(0.1)^2} = 1.8N$



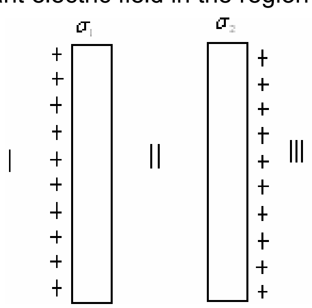
Force of attraction between the charges at B and C also has the same magnitude of 1.8N and the angle between force of attraction and repulsion is 120^0.

$\therefore$ Resultant force = $\sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos\theta}$

$\therefore\ F_R = F = 1.8N$

MEDICAL

24. Two parallel plane sheet 1 and 2 carry uniform charge densities σ_1 and σ_2, as shown in the figure. The magnitude of the resultant electric field in the region marked I is $(\sigma_1 > \sigma_2)$ **(2009 M)**



Sheet 1 Sheet 2

1) $\frac{\sigma_1}{2\epsilon_0}$ 2) $\frac{\sigma_2}{2\epsilon_0}$ 3) $\frac{\sigma_1+\sigma_2}{2\epsilon_0}$ 4) $\frac{\sigma_1-\sigma_2}{2\epsilon_0}$

Ans : 3

Sol: Applying Gauss law to the region I the Electric field intensity is

$$E = \frac{1}{2\epsilon_0}(\sigma_1 + \sigma_2)$$

Where σ_1 and σ_2 are the surface charge densities.

25. A parallel plate capacitor with air as dielectric is charged to a potential 'V' using a battery. Removing the battery, the charged capacitor is then connected across an identical uncharged parallel plate capacitor filled with wax of dielectric constant 'k'. The common potential of both the capacitor is **(2009 M)**

1) V volts 2) kV volts 3) (k+1) V volts 4) $\frac{V}{k+1}$ volts

Ans : 4

Sol: If the capacity of first capacitor is 'c' then the capacity of second capacitor is 'KC'.

$\therefore$ common potential = $\frac{C_1V_1 + C_2V_2}{C_1 + C_2} = \frac{CV}{C + KC}$

$= \frac{V}{1+K}$ volt

26. A charge q is placed at the mid-point of the line joining two equal charges each of Q. If the whole system is in equilibrium, then the value of q is **(2008M)**

1) $-\frac{Q}{2}$ 2) $+\frac{Q}{2}$ 3) $-\frac{Q}{4}$ 4) $+\frac{Q}{4}$

Ans: 3

Sol: Potential energy of the system is equal to zero when the system is in equilibrium.

$$\frac{1}{4\pi\epsilon_0}\frac{Qq}{x} + \frac{1}{4\pi\epsilon_0}\frac{q(Q)}{x} + \frac{1}{4\pi\epsilon_0}\frac{Q^2}{2x} = 0$$

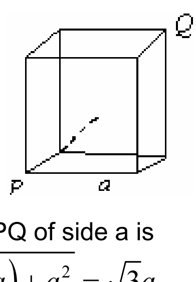
$$\frac{2(Q)(q)}{x} = \frac{-Q^2}{2x}$$

$$q = -\frac{Q}{4}$$

27. A charge 'Q' is placed at each corner of a cube of side 'a'. The potential at the centre of the cube is

1) $\frac{4Q}{3\epsilon_0 a}$ 2) $\frac{4Q}{\sqrt{3}\epsilon_0 a}$ 3) $\frac{4Q}{\sqrt{3}\pi\epsilon_0 a}$

Ans: 3

Sol: 

Length of the diagonal PQ of side a is

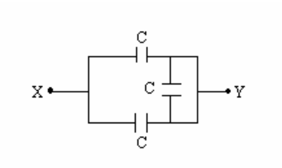
$$\sqrt{\left(\sqrt{2}a\right) + a^2} = \sqrt{\left(\sqrt{2}a\right) + a^2} = \sqrt{3}a$$

Distance of midpoint from each corner $= \frac{\sqrt{3}a}{2}$

As $V=\frac{1}{4\pi\in_0}\frac{Q}{r}\Rightarrow V=8\times\frac{1}{4\pi\in_0}\frac{Q}{\sqrt{3}a}\times 2$

$=\frac{4Q}{\sqrt{3}\pi\in_0 a}$

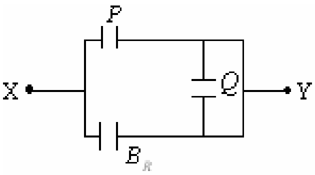
28. The equivalent capacity between the points X and Y in the circuit with $C=1\mu F$ **(2007M)**



1) $2\mu F$ 2) $3\mu F$ 3) $1\mu F$ 4) $0.5\mu F$

Ans: 1

Sol:



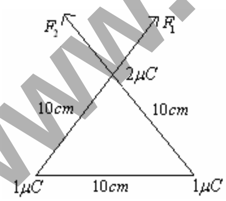
The capacitor Q is short circuited and P and R in parallel. So the resultant capacitance is equal to $2C=2\times1=2\mu F$

29. Three charges $1\mu C, 1\mu C$, and $2\mu C$ are kept at the vertices A, B and C of an equilateral triangle ABC of 10cm side, respectively. The resultant force on the charge at C is **(2007M)**

1) 0.9 N 2) 1.8 N 3) 2.72 N 4) 3.12 N

Ans : 4

Sol:



$F_1=F_2=\frac{1}{4\pi\in_0}\frac{10^{-6}\times2\times10^{-6}}{\left(10\times10^{-2}\right)}$

$=9\times10^9\times\frac{2\times10^{-12}}{10^{-2}}=1.8N$

The resultant force $F_R=\sqrt{F_1^2+2F_1F_2\cos\theta+F_2^2}$

$F_R=\sqrt{F_1^2+F_2^2+2F_1F_2\cos 60^0}$

$=\sqrt{(1.8)^2+(1.8)^2+2\times(1.8)(1.8)\frac{1}{2}}$

$=1.8\sqrt{3}=1.8\times1.732=3.12N$

30. The electrical potential on the surface of a sphere of radius 'r' due to a charge $3\times10^{-6}C$ is 500V. The intensity of electric field on the surface of the sphere is $\left[\frac{1}{4\pi\varepsilon_0}=9\times10^{9}Nm^2C^{-2}\right]\left(in\ NC^{-1}\right)$ **(2006M)**

1) <10 2) >20 3) Between 10 and 20 4) <5

Ans: 1

Sol: Potential on the surface of sphere

$$V=\frac{1}{4\pi\in_0}\frac{q}{R}=500$$

$$E=\frac{\left(\frac{1}{4\pi\in_0}\frac{q}{R}\right)^2}{\frac{1}{4\pi\in_0}q}$$

$$=\frac{500\times500}{9\times10^{9}\times3\times10^{-6}}$$

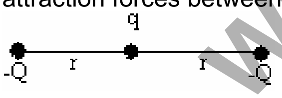
$$=\frac{25\times10^{4}}{27\times10^{3}}=\frac{250}{27}<10$$

31. Two unit negative charges are placed on a straight line. A positive charge 'q' is placed exactly at the mid-point between these unit charges. If the system of three charges is in equilibrium the value of 'q' (in C) is **(2006M)**

1) 1.0 2) 0.75 3) 0.5 4) 0.25

Ans :4

Sol: If the system of these three charges is in equilibrium if repulsive force between –Q and –Q is balanced by attraction forces between q and -Q



$$=F_1+F_2=0\Rightarrow F_1=-F_2$$

$$=\frac{1}{4\pi\in_0}\frac{(-Q)(-Q)}{(2r)^2}=\frac{1}{4\pi\in_0}\left[\frac{q(-Q)}{r^2}\right]$$

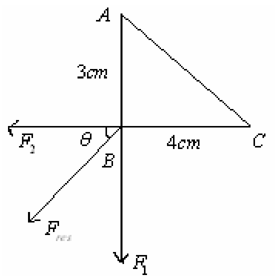
On solving $q=\frac{Q}{4}=0.25$

32 Three identical charges of magnitude $2\mu C$ are placed at the corners of a right angled triangle ABC whose base BC and height BA are respectively 4cm and 3cm. Forces on the charge at the right angled corner 'B' due to the charges at 'A' and 'C' are respectively F_1 and F_2. The angle between their resultant force and F_2 is **(2005 M)**

1) $Tan^{-1}\left(\frac{9}{16}\right)$ 2) $Tan^{-1}\left(\frac{16}{9}\right)$ 3) $Sin^{-1}\left(\frac{16}{9}\right)$ 4) $Cos^{-1}\left(\frac{16}{9}\right)$

Ans : 2

Sol : Angle made by the resultant $f_{resul\tan t}$ with f_2 is $(i.e)\tan\alpha = \frac{b\sin\theta}{a+b\cos\theta}$



$\theta = \tan^{-1}\frac{F_1}{F_2}$

$$\frac{F_1}{F_2} = \frac{\frac{1}{4\pi\in_0}\frac{q^2}{3^2}}{\frac{1}{4\pi\in_0}\frac{q^2}{4^2}} = \frac{16}{9}$$

$\theta = \tan^{-1}\frac{16}{9}$

33. Energy 'E' is stored in a parallel plate capacitor 'C_1'. An identical uncharged capacitor 'C_2' is connected to it, kept in contact with it for a while and then disconnected, the energy stored in C_2 is **(2005 M)**

1) $\frac{E}{2}$ 2) $\frac{E}{3}$ 3) $\frac{E}{4}$ 4) Zero

Ans :3

Sol : Energy stored in the 1st capacitor

$E = \frac{1}{2}CV^2$

If second similar capacitor is in contact with the 1st one the potential on the second capacitor is V/2.

∴ Energy stored in second capacitor

$= \frac{1}{2}C\left(\frac{V}{2}\right)^2 = \frac{E}{4}$

34. Capacitance of a capacitor becomes $\frac{7}{6}$ times its original value if a dielectric slab of thickness, t=$\frac{2}{3}d$ is introduced in between the plates. 'd' is the separation between the plates. The dielectric constant of the dielectric slab is **(2004 M)**

1) $\frac{14}{11}$ 2) $\frac{11}{14}$ 3) $\frac{7}{11}$ 4) $\frac{11}{7}$

Ans : 4

Sol. $C_0 = \frac{\in_0 A}{d}$ ……….(1)

$C = \frac{7}{6}C_0$ ………..(2)

$$C = \frac{\in_0 A}{d - t\left(1 - \frac{1}{K}\right)} = \frac{\in_0 A/d}{1 - \frac{t}{d}\left(1 - \frac{1}{K}\right)}$$

$$\frac{C_0}{1 - \frac{2}{3}\left(1 - \frac{1}{K}\right)} = \frac{3KC_0}{2+K} \text{.........(3)}$$

Dividing (1) and (3)

$$\Rightarrow \frac{C}{C_0} = \frac{3K}{K+2} = \frac{7}{6}$$

$$\Rightarrow K = \frac{14}{11}$$

35. A parallel plate capacitor filled with a material of dielectric constant K is charged to a certain voltage. The dielectric material is removed. Then **(2004M)**

a) The capacitance decreases by a factor K

b) The electric field reduces by a factor K

c) The voltage across the capacitor increases by a factor K

d) The charge stored in the capacitor increases by a factor K

1) a and b are true 2) a and c are true

3) b and c are true 4) b and d are true

Ans :2

Sol: i) Electric field increases by a factor K

ii) Charge decreases by a factor K

36. Between the plates of a parallel plate capacitor of capacity C, two parallel plates of the same material and area same as the plate of original capacitor, are placed. If the thickness of these plates is equal to $\frac{1}{5}$th of the distance between the plates of the original capacitor, then the capacity of the new capacitor is **(2003 M)**

1) $\frac{5}{3}C$ 2) $\frac{3}{5}C$ 3) $\frac{3}{10}C$ 4) $\left(\frac{10}{3}\right)C$

Ans :1

Sol: $C = \frac{\in_0 A}{d}$

After insertion of metal plates, the effective distance of separation becomes d- t

$$\therefore\ d - 2 \times \frac{d}{2} = \frac{3d}{5}$$

$$C' = \frac{\in_0 A}{\frac{3d}{5}} = \frac{5}{3}\frac{\in_0 A}{d} = \frac{5}{3}C$$

37. A charged sphere of diameter 4cm has a charge density of $10^{-4} C/cm^2$. The work done in joules when a charge of 40nano-coulombs is moved from infinite to a point, which is at a distance of 2cm from the surface of the sphere is **(2003 M)**

1) 14.4π 2) 28.8π 3) 144π 4) 288π

Ans :1

Sol: $\sigma = \frac{q}{4\pi R^2} \Rightarrow q = 4\pi R^2 \sigma$ ....(1)

Work done = potential energy at the given distance r = 2+2 = 4cm from the centre of the sphere.

$W = \frac{qq'}{4\pi \in_0 r} = \frac{4\pi R^2 \sigma q'}{4\pi \in_0 r}$ ....(2)

Sub. (1) in (2)

$$= \frac{4\pi \times \left(2\times10^{-2}\right)^2 \times 1 \times \left(40\times10^{-9}\right) \times \left(9\times10^{8}\right)}{4\times10^{-2}}$$

= 14.4 πJ

38. The capacities of three capacities are in the ratio 1 : 2 : 3. Their equivalent capacity when connected in parallel is $\frac{60}{11}\mu F$ more than that when connected in series. The individual capacities are ..... in μF .

1. 4, 6, 7 2. 1, 2, 3 3. 2, 3, 4 4. 1, 3, 6 **[2002 M]**

Ans :2

Sol: $C_1 = C_0, C_2 = 2C_0, C_3 = 3C_0$

In parallel, $C = C_1 + C_2 + C_3 = C_0 + 2C_0 + 3C_0 = 6C_0$

In series, $C' = \frac{C_1C_2C_3}{C_1C_2 + C_2C_3 + C_3C_1}$

$$= \frac{(C_0)(2C_0)(3C_0)}{(C_0)(2C_0) + (2C_0)(3C_0) + (3C_0)(C_0)} = \frac{6}{11}C_0$$

Given that $C - C' = 6C_0 - \frac{6C_0}{11} = \frac{60}{11}$

$\Rightarrow C_0 = 1\mu F$

$C_1 = 1\mu F, C_2 = 2\mu F, C_3 = 3\mu F$

39. A capacitor of capacity 10μF is charged to 40 V and a second capacitor of capacity 15μF is charged to 30 V if the capactors are connected in parallel, the amount at change that flows from the smaller capacitor to higher capacitor in μC is........ **[2002 M]**

1. 30 2. 60 3. 200 4. 250

Ans :2

Sol: Common potential $= \frac{C_1V_1 + C_2V_2}{C_1 + C_2}$

$= \frac{10\times40 + 15\times30}{10+15}$ = 34V

Amount of charge flowing = $10\times 40-10\times 34$

=60μC

40. A parallel plate capacitor of capacity $5\mu F$ and plate separation 6cm is connected to a 1V battery and is charged. A dielectric of dielectric constant 4 and thickness 4 cm is introduced into the capacitor. The additional charge that flows into the capacitor from the battery is **[2001 M]**

1. $2\mu C$ 2. $3\mu C$ 3. $5\mu C$ 4. $10\mu C$

Ans : 3

Sol: $C_{air}=\frac{\in_0 A}{d}$, $C_{medium}=\frac{\in_0 A}{d-t+\frac{t}{k}}$

$$\Rightarrow \frac{C_{medium}}{C_{air}}=\frac{d}{d-t+\frac{t}{k}}=\frac{6}{6-4+\frac{4}{4}}=2$$

$\therefore\ C_m=2\left(C_{air}\right)=10\mu F$

Charge q = CV = 10 x 1 = - 1μC

Additional charge = Final charge – Initial charge

= 10μC – 5μC

= 5μC

41. Two capacitors of capacity $4\mu F$ and $6\mu F$ are connected in series and a battery is connected to the combination. The energy stored is E_1. If they are connected in parallel and if the same battery is connected to this combination the energy is . The ratio $E_1:E_2$ is **[2001 M]**

1. 4:9 2. 9:14 3. 6:25 4. 7:12

Ans: 3

Sol: As the capacitors are connected in series

$$E_{series}=E_1=\frac{1}{2}\left(\frac{C_1C_2}{C_1+C_2}\right)V^2$$

As the capacitors are connected in parallel

$$E_{parallel}=E_2=\frac{1}{2}\left(C_1+C_2\right)V^2$$

$$\therefore\ \frac{E_1}{E_2}=\frac{C_1C_2}{\left(C_1+C_2\right)}=\frac{6\times 4}{\left(6+4\right)^2}$$

$$\Rightarrow E_1:E_2=6:25$$

42. In a parallel plate capacitor, the capacitance **[2001 M]**

1. increases with increase in the distance between the plates
2. decreases if a dielectric material is put between the plates
3. increases with decrease in the distance between the plates
4. increases with decrease in the area of the plates

Ans : 3

Sol: From the relation $C = \frac{\in_0 A}{d} \Rightarrow C \propto \frac{1}{d}$

$\therefore$ Capacity increases with decrease in distance

43. Two charges of $4\mu C$ each are placed at the corners of A and B of an equilateral triangle ABC of side length 0.2m in air. The electric potential at C is $\left(\frac{1}{4\pi \in_0} = 9\times10^9\right)$ **[2000 M]**

1. $9\times10^4 V$ 2. $18\times10^4 V$ 3. $36\times10^4 V$ 4. $72\times10^4 V$

Ans : 3

Sol: Electric potential of C $\Rightarrow V = V_1 + V_2$

$$V = \frac{1}{4\pi\varepsilon_0}.\frac{q_1}{r} + \frac{1}{4\pi\varepsilon_0}.\frac{q_2}{r} = 0$$

$$= 2\left[\frac{1}{4\pi \in_0}\right].\frac{q}{r} = 36\times10^4 V$$