PHYSICS

BOOKS - NEW JYOTHI PHYSICS (TAMIL ENGLISH)

ELECTROSTATIC POTENTIAL AND CAPACITANCE

Solved Problems

1. Calculate the potential at a point P due to charge of $4 \times 10^{-7} C$ located 9 cm away. Hence obtain the

work done in bringing a charge of $2 \times 10^{-9} C$ from infinity to the point. P. Does the answer depend on the path along which the charge is brought?

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2. Two charge $3 \times 10^{-8} C$ and $-2 \times 10^{-8} C$ are located 15 cm apart. At what point on the line joining the two charges the electric potential zero? Take the potential at infinity to be zero.

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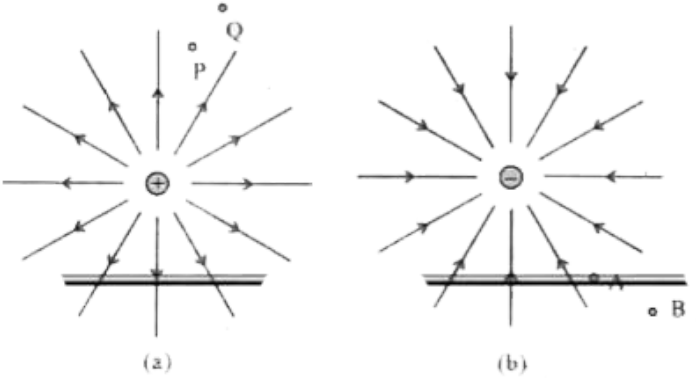
3. Figures (a) and (b) show the field lines of a positive and negative point charge respectively.



(a). Gives the sign of the potential difference $V_P - V_Q : V_B - V_A$

(b) Given the sign of the potential energy difference of a small negative charge between the points Q and P, A and b

(c) Give the sign of the work done by the field in moving a small positive charge from Q to P.

(d) Give the sign of the work done by external agencyin moving a small negative charge from B to A.

(e) Does the kinetic energy of a small negative charge increase or decrease in going from B to A?

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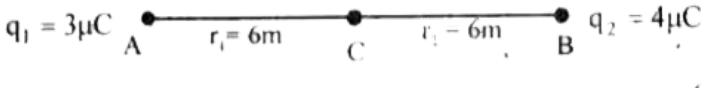
4. Two charges $+3\mu C$ and $+4\mu C$ are placed in free space 12m apart. What is the potential at the midpoint on the line joining these two charges?



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5. Calculate the electric potential at the surface of a gold nucleus of diameter 13 fermi. Atomic no. of gold is 79.

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6. In the Milikan oil drop experiment the drop carries 10 electronic charges charge and a mass of $4.4 \times 10^{-15} kg$. It is held almost stationary between two horizontal plate separated by 2cm. What is the potential between the plates?

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7. Two protons are relased when they are initially 2 fermi apart. Find their seepds when they are 4 fermi apart. Give the mass of a proton. $= 1.67 \times 10^{-27} kg$ and charge $= 1.6 \times 10^{-19} C$.

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8. The potential at the centre of a uniformly charged circular disc of radius 3 cm is 460V. What is the total charge on the disc?

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9. The ammonia molecule has a permanent electric dipole moment of 1.47 D where D is the debye unit and $1D = 3.34 \times 10^{-30} Cm$. Calculate the electric potential due to the ammonia molecule at a point distant 30 nm away along the dipole axis.

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10. Let us suppose that the earth had a net surface charge density of 1 electron per m^2. What would its potential be? Also what is the field just outside the earth's surface?

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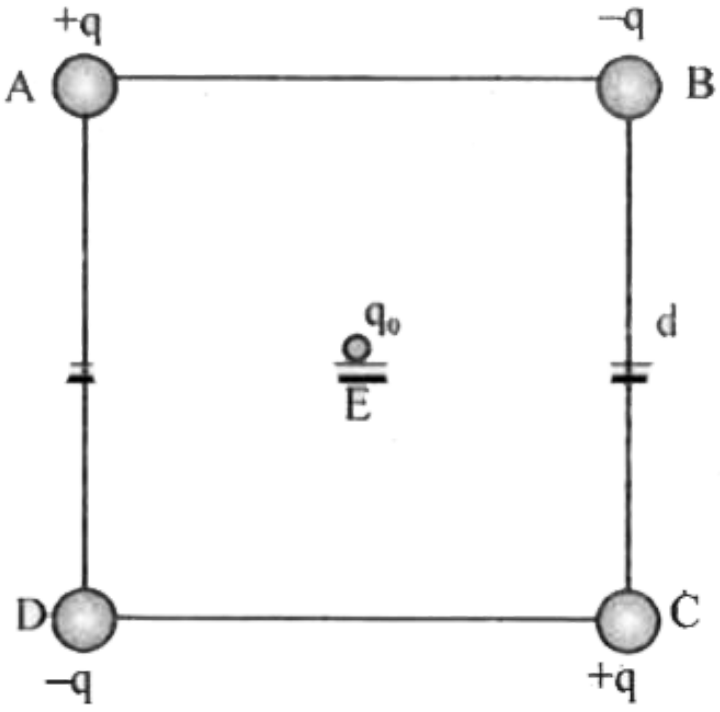
11. Four charges are arranged at the comers of a square ABCD of side d, as shown in Fig.

a. Find the work required to put together this arrangement

b. A charge q_0 is brought to the centre E of the square, the four charges being held fixed at its

corners. How much extra work is needed to do this?n



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12. a. Determine the electrostatic potential energy of a system consisting of two charges

$7\mu C$ and $-2\mu C$ (and with no external field) placed at (-9 cm, 0,0) and (9 cm, 0, 0) respectively.

b. How much work is required to separate the two charges infinitely away from each other?

c. Suppose that the same system of charges is now placed in an external electric field $E = A\left(\frac{1}{r^2}\right), A = 9 \times 10^5 Cm^{-2}$. What would the electrostatic energy of the configuration be?

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13. A molecule of a substance has a permanent electric dipole moment of magnitude $10^{-29} Cm$. A

mole of this substance is polarised (at low temperature) by applying a strong electrostatic field of magnitude $10^6 Vm^{-1}$. The direction of the field is suddenly changed by an angle of 60°. Estimate the heat released by the substance in aligning its dipoles along the new direction of the field. Assume 100% polarisation of the sample.

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14. Two points charges $20\mu C \text{ and } 10\mu C$ are separated by 1m in air. Find the work done to separate them two metre apart.

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15. Calculate the potential energy of the system of charges shown in the figure.

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16. a. A comb run through one's dry hair attracts small bits of paper. Why? What happens if the hair is wet or if it is a rainy day? (A paper does not conduct electricity.)

b. Ordinary rubber is an insulator. But special rubber tyres of aircraft are made slightly

conducting. Why is necessary?

c. Vehicles carrying inflammable materials usually have metallic ropes touching the ground during motion. Why?

d. A bird perches on a bare high power line, and nothing happens to the bird. A man standing on the ground touches the same line and gets a fatal shock. Why?

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17. A parallel plate capacitor with air as dielectric between the plates has a separation of 5mm and

plate area $50cm^2$ is connected to a 200V source. Calculate

a. the charge on the plates.

(b) the charge on the plates if the space between the plates is filled with a dielectric K=5

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18. The area of each plate of a parallel capacitor is $100cm^2$ and the distance between them is 0.05 cm. It is filled with a dielectric and its capacitance becomes $3.54 \times 10^{-4}\mu F$. Find the dielectric constant of the substance.

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19. A slab of material of dielectric constant K has the same area as the plates of a parallel-plate capacitor but has a thickness $\left(\frac{3}{4}\right)d.$ where d is the separation of the plates. How is the capacitance changed when the slab is inserted between the plates?

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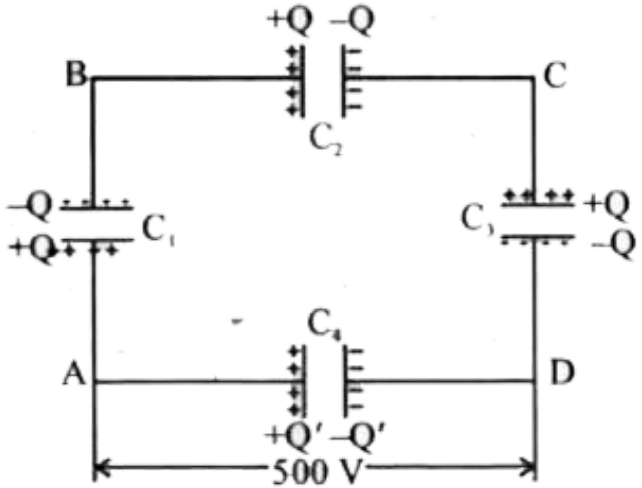
20. A network of four $10\mu F$ capacitors is connected to a 500 V supply, as shown in figure. Determine (a)

the equivalent capacitance of the network and (b) the charge on each capcitor.



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21. Three capacitors $2\mu F, 5\mu F$ and $10\mu F$ are joined in (a) series, (b) paralle. Find the equivalent capacitance.

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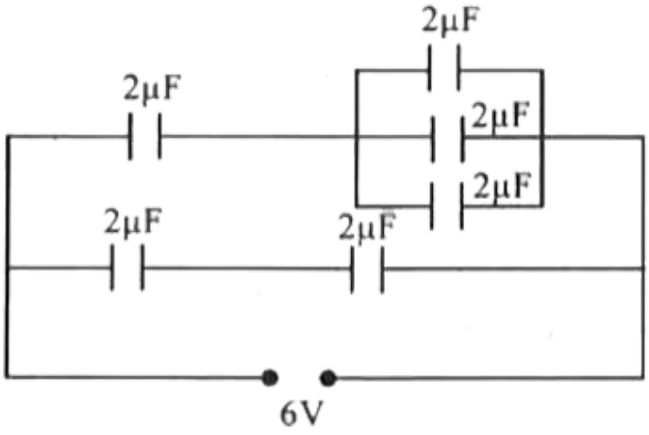
22. Find the effective capacity of the combination shown below :



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23. Two capacitors of capacities $100\mu F$ and $200\mu F$ are connected in sereis. A.p.d. of 90 V is applied across them. Calculate the p..d across each capacitor.

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24. A capacitor of $20\mu F$ and charged to 200V is connected parallel with parallel with another capacitor of $10\mu F$ and charged to 400V. Find the common potential.

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25. A storage capacitor on a RAM chip has a capacity 48fF. If the capacitor is charged to a potential of 4.6V, how many excess electrons are on its negative plate?

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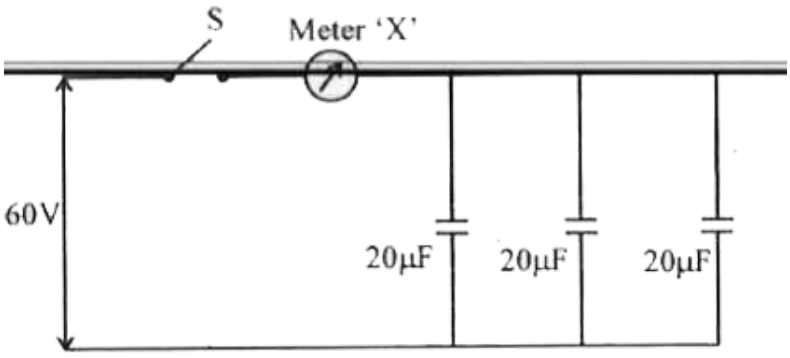
26. In the following figure, how many coulombs of charge pass through the meter X when the switch

S is closed.



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27. A parallel plate capacitor has a plate area $3m^2$, spaced by 3 dielectric slabs of dielectric constant 2,3,6 and of thickness 0.4mm, 0.6 mm and 1.2mm respectively. Find the effective capacity.

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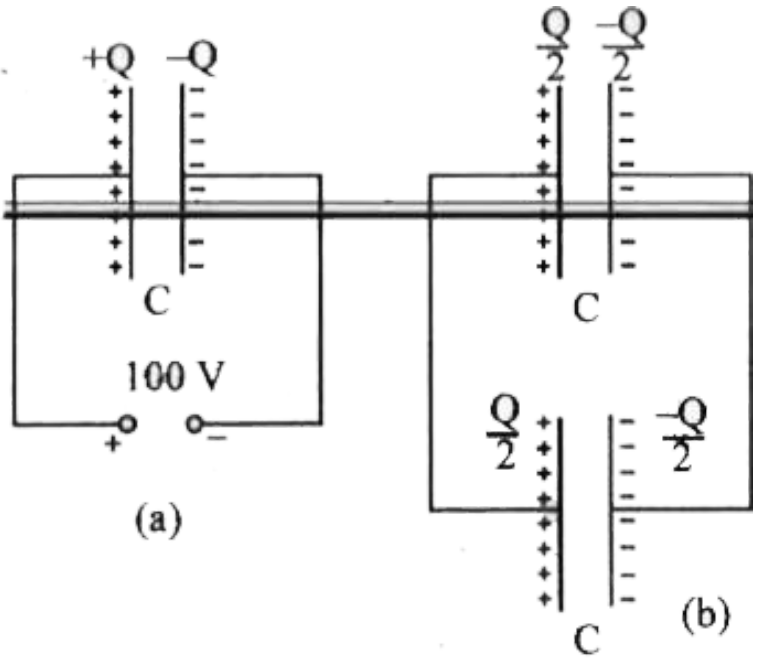
28. A 900pF capacitor is charged by 100 V battery as in figure (a). How much electrostatic energy is stored by the capacitor?

(b). The capacitor is disconnected from the battery and connected to another 900pF capacitor as in figure (b). What is the electrostatic energy stored

by the system?



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29. A capacitor is charged with $9\mu C$ and has a 100V p.d. between the plates. Calculate its capacity

and energy stored in it, if air is trapped between the plates.

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30. If A 250V capacitors of $C_1 = 2\mu F = 2 \times 10^{-6} F$ $C_2 = 5\mu F = 5 \times 10^{-6} F$ then find charge and energy stored in each capacitor.

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31. A certain capacitor is charged to a potential V. By what percentage the potential to be increased, so that energy increases by 10%?

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32. A $4\mu F$ capacitor is charged to a potential 10V using a battery. The battery is then removed and then this capacitor is connected parallel to an unchanged capacitor of capacity $6\mu F$. What is the common potential?

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Solution To Exercises From Ncert Texation

1. Two charges $5 \times 10^{-8} C$ and $-3 \times 10^{-8} C$ are located 16 cm apart. At what point(s) on the line joining the two charges is the electric potential zero ? Take the potential at the infinity to be zero.

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2. A regular hexagon of side 10cm has a charge $5 \mu C$ at each of its vertices. Calculation the potential at the centre of the hexagon.

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3. Two charges $2\mu C$ and $-2\mu C$ are placed at points A and B 6cm apart.

a. Identify an equipotential surface of the given system.

(b) What is the direction of the electric field at every point on this surface?

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4. A spherical coductor of radius 12cm has a charge of $1.6 \times 10^{-7} C$ distributed uniformly on its

surface. What is the electric field (a) inside (b) just outside the sphere (c), at a point 18cm from the centre of the sphere ?

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5. A parallel plate capacitor with air between the plates has a capacitor of 8pF $\left(1\text{pF}=10^{-12}F\right)$. What will be the capacitance if the distance if the distance between the plates is reduced by, half and the space between them is filled with a substance of dielectric constant 5?

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6. Three capacitors each of capacitance 9pF are connected in seris

a. What is the total capacitance of the combination?

(b). What is the potential difference across each capacitor if the combination is connected a 120V supply?

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7. Three capacitors of capacitances 2pF, 3pF and 4pF are connected in parallel.

(a) What is the toal capacitance of the combination.

(b) Determine the charge on each capacitor if the combination is connected to a 100V supply.

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8. In a parallel plate capacitor with air between the plates, each plate has an area of $6 \times 10^{-3} m^2$ and the distance between the plates is 3mm. Calculate the capcitance of the capacitor. If this capacitor is connected to a 100V supply, what is the charge on each plate of hte capacitor?

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9. Explain what would happen if in the capacitor gives in Exercise 8, a 3 mm thick mic sheet (of dielectric constant =6) were inserted between the plates,

a. while the voltage remain connected.

b. after the supply was disconnected.

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10. A 12pF capacitor is connected to a 50V battery. How much electrostatic energy stored in the

capacitor?

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11. A 600pF capacitor is charged a 200V supply. It is then disconnnected from the supply and is connected to another uncharged 600pF capacitor. How much electro static energy is lost in the process.

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12. A charge of 8mC is located at the origin. Calculate the work done in taking a small charge of $-2 \times 10^{-9} C$ from a point P (0,0,3 cm) to a point Q(0,4cm,0), via a point F (0.6 cm, 9cm).

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13. A cube of side 'b' has a charge 'q' at each of its vertices. Determine the potential and electric field due to this charge array at the centre of the cube.

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14. Two tiny spheres carrying charges 1.5μ and $2.5\mu C$ are located 30 cm apart. Find the potential and electric field.

a. at the mid-point of the line joining the two charges, and

b. at a point 10 cm from the midpoint in a plane normal to the line and passing through the mid-point.

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15. A spherical conducting shell of inner radius r_1 and outer radius r_2 has a charge Q.

a. A charge 'q' is placed at the centre of the shell. What is the surface charge density on the inner and outer of the shell?

b. Is the electric field inside a cavity (with not charge) zero, even if the shell is not spherical, but has any irregular shape? Explain.

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16. What is the electric field in between the plates of the capacitor, if σ is the surface charge density?

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17. A long charged cylinder of linear charge density λ is surrounded by a hollow co-axial conducting cylinder. What is electric field in the space between the two cylinders?

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18. The potential energy of a system increases, if work is done

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19. If one of the two electrons of a H_2 molecule is removed, we get a hydrogen molecular ion H_2^+. In the ground state of an H_2^+, the two protons are separated by roughly 1.5Å, and the electron is roughly 1Å from each proton. Determine the potential energy of the system. Specific your choice of the zero of potential energy.

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20. Two charged conducting spheres of radii a and b are connected to each other by a wire. What is the ratio of electric fields at the surfaces of the two

spheres? Use the result obtained to explain why charge density on the sharp and pointed ends of a conductor is higher than on its flatter portions.

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21. Two charges -q and +q are located at points (0,0,-a) and (0,0,a) respectively.

a. What is the electrostatic potential at the points (0,0,z) and (x,y,0)?

b. Obtain the dependence of potential on the distance r of a point from the origin which $\frac{r}{a} > > 1$.

c. How much work is done in making a small test charge from the point (5,0,0), (-7,0,0) along the x-axis? Does the answer change if the path of hte test charge between the same points is not along the x-axis?

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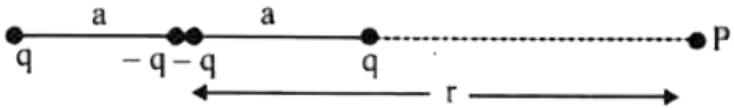
22. Figure shows a charge array known as an electric quadrupole. For a point on the axis of the quadrupole, obtain the dependence of potential on 'r' for $\frac{r}{a} > > 1$, and contrast your result with that due to an electric dipole, and an electric monopole

(i.e, a single charge)



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23. An electrical technican requires a capacitance fo $2\mu F$ in a circuit across a potential difference of 1kV. A large number $1\mu F$ capacitor are available to him each of which can withstand a potential difference of not more than 400V. Suggest a possible arrangement that requires the minimum number of capacitors.

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24. What is the area of plates of 2F parallel capacitor, given that the separation between the plates is 0.5 cm? [You will realise from your answer why ordinary capacitors are in the range of μF or less. However, electrolytic capacitors do have a much larger capacitance (0.1F) because of very minute separation between the conductors.

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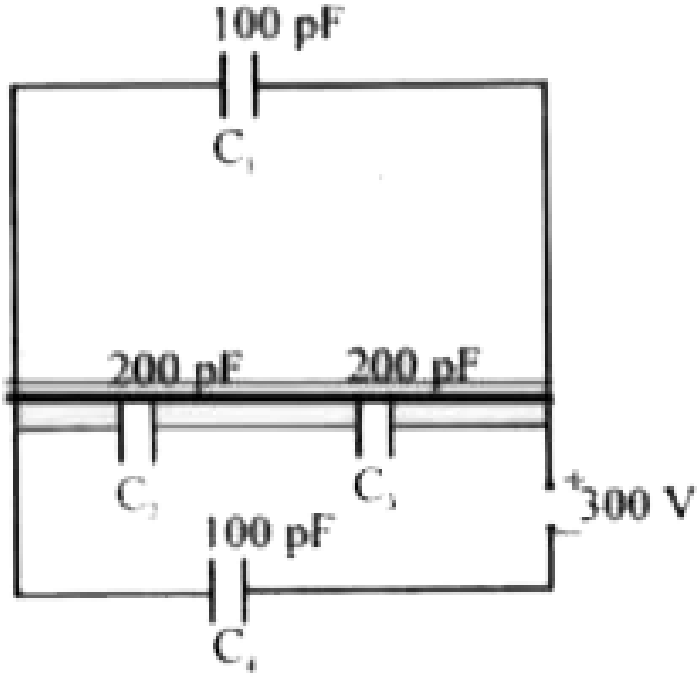
25. Obtain the equivalent capacitance of the network in figure below. For a 300V supply determine the charge and voltage across each



capacitor.

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26. The plates of a parallel plate capacitor have an area of $90cm^2$ each and are separated by 2.5mm. The capacitor is charged by connecting it to a 400V supply.

a. How much electrostatic energy is stored by the capacitor?

b. View this energy as stored in hte electrostatic field between the plates, and obtain the energy per unit volume u. Hence arrive at a relation between u and the magnitude of electric field E between the plates.

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27. A $4\mu F$ capacitor is charged by a 200V supply. It is then disconnected from the supply and is connected to another uncharged $2\mu F$ capacitor. How much electrostatic energy of the first capacitor is lost in the form of heat and electrostatic radiation?

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28. Show that the force on each plate of a parallel plate capacitor has a magnitude equal to $\left(\frac{1}{2}\right)QE$, where Q is the charge on the capacitor, and E is

the magnitude of electric field between the plates. Explain the origin of the factor $\frac{1}{2}$.

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29. A spherical capacitor has an inner sphere of radius 12cm and an outer sphere of radius 13cm. The outer sphre is earthed the inner sphere is given a charge of $2.5\mu C$. The space between the concentric spheres is filled with a liquid of dielectric constant 32.

a. Determine hte capacitance of the capacitor.

b. What is the potential of hte inner sphere?

c. Compare the capacitance of this capacitor with that of an isolated sphere of radius 12cm. Explain why the latter is much smaller.

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30. Two large conducting spheres carrying charges $Q_1,$ and $Q_2,$ are brought close to each other. Is the magnitude of electrostatic force between theme exactly given by $\frac{Q_1Q_2}{4\pi\varepsilon_0 r^2}$, where r is the distance between their centres?

b. If Coulomb's law involved $\frac{1}{r^3}$ dependence $\left(\text{instead of } \frac{1}{r^2}\right)$, would Gauss law be still true?

c. A small test charge is released at rest at a point in an electrostatic field configuration. Will it travel along the field line passing through that point?

d. What is the work done by the field of a nucleus in a complete circular orbit of the electron? What if the orbit is elliptical?

e. We know that electric field is discontinuous across the surface of a charged conductor. Is electric potential also discontinuous there?

f. What meaning would you give to the capacitance of a single conductor?

g. Guess a possible reason why water has a much greater dielectric constant (=80) than say, mica (= 6).

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31. A cylindrical capacitor has two co-axial cylinders of length 15 cm and radii 1.5 cm and 1.4 cm. The outer cylinder is earthed and the inner cylinder is given a charge or 3.5 μC. Determine the capacitance of the system and the potential of the inner cylinder. Neglect end effects (i.e., bending of field lines at the ends).

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32. A parallel plate capacitor is to be designed with a voltage rating 1kV, using a maeterial of dielectric constant 3 and dielectric strength about $10^7 Vm^{-1}$, (Dielectric strength is the maximum electric field a material can tolerate without breakdown, i.e, without starting to conduct electricity through partial ionisation.) For safety, we should like the field never to exceed say 10% of the dielectric strength. What minimum area of the plates is required to have a capacitance of 50pF?

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33. Describe schematically the equipotential surfaces corresponding to

a. a constant electric field in the z-direction.

b. a field that uniformly increases in magnitude but remains in a constant (say,z) direction.

c. a single positive charge at the origin, and

d. a uniform grid consisting of long equally spaced parallel charged wires in a plane.

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34. In a Van de Graaff type generator, a spherical metal shell is to be a $15 \times 10^6 V$ electrode. The

dielectric strength of the gas surrounding the electrode is $5 \times 10^7 Vm^{-1}$. What is the minimum radius of the spherical shell required? (You will learn from this exercise why one cannot build an electrostatic generator using a very small shell which requires a small charge to acquire a high potential.)

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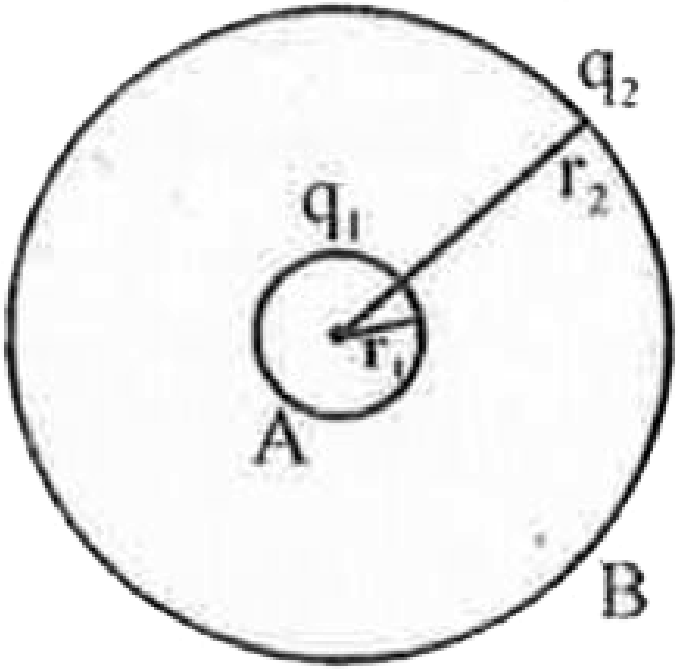
35. A small sphere of radius r_1 and charge q_1 is enclosed by a spherical shell of radius r_2 and charge q_2. Show that if q_1 is positive, charge will

necessarily flow from the sphere to the shell (when the two are connected by a wire) no matter what the charge q_2, on the shell is.



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36. a. The top of the atmosphere is at about 400 kV with respectto the surface of the earth, corresponding to an electric field that decreases with altitude. Near the surface of the earth, the field is about $100Vm^{-1}$. Why then do we not get a electric shock as we step out of our house into the openy (Assume the house to be a steel cage so there is no field inside!)

b. A man fixes outside his house one evening a two metre high insulating slab carrying on its top a large aluminium sheet of area $1m^2$. Will he get an electric shock if he touches the metal sheet next morning?

c. The discharging current in the atmosphere due to the small conductivity of air is known to be 1800A on an average over the globe. Why then does the atmosphere not discharge itself completely in due course and become electrically neutral? In other words, what keeps the atmosphere charged?

d. What are the forms of energy into which the electrical energy of the atmosphere is dissipated during a lightning? (Hint: The earth has an electric field of about $100 Vm^{-1}$ at its surface in the downward direction, corresponding to a surface charge density $= -10^{-9} Cm^{-2}$?.

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Practice Problems For Self Assessment

1. Calculating the work done in eV in carrying a charge +e Coulomb through a potential rise of 100 volts. $\left(1.0eV = 1.6 \times 10^{-19}\text{joules}\right)$

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2. Four charges, each of value q, are placed at the four corners of a square of side a. What is the potential at the centre of the square

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3. A proton of charge $1.6 \times 10^{-19} C$ and mass $1.67 \times 10^{-27} kg$ is accelerated from rest in air through a p.d. of 1000 volts. Calculate its final speed.

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4. 64 charged water droplets each with a diameter 1 mm and charge $2 \times 10^{-12} C$ coalesce to form a single group. Calculate the potential of the bigger drop.

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5. Two charges $6\mu C$ and $3\mu C$ are kept 9 cm apart in free space. Calculate the work done to move $3\mu C$ by $3cm$ towards $9\mu C$.

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6. n' small drops of same size are charged to a potential V. The drops caolesce to form a bigger drop. Calculate the potential of the bigger drop.

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7. Three charges $6\mu C$ are fixed at the three vertices of an equilateral triangle of side 9cm. Find the potential at the mid point of the base of the triangle.

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8. Potential at a point by the relation $V = 4x^2 + 5y^2 + 6z^2$. Calculate the magnitude of field of components at (1,-2,2)

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9. Assuming the Earth to be a spherical conductor of radius 6380 km, calculate its capacity.

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10. Three capacitors of capacity $2\mu F, 4\mu F$ and $6\mu F$ are connected first in series and then in parallel. Find the ratio of equivalent capacities in the two combination.

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11. Three capacitors each of capacity $10\mu F$ are connected in parallel. This combination is connected to a capacitor of capacity C in series so that the effective capacity is $12\mu F$. Find the value of C.

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12. A p.d. of 280V is applied to $2\mu F$ and $5\mu F$ capacitors in series. Find the p.d. across each capacitors.

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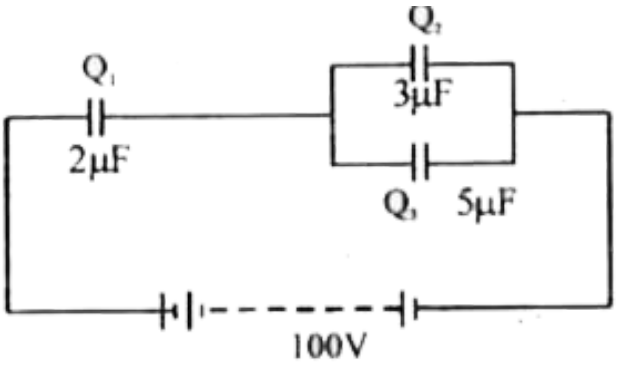
13. Calculate the charge on each capacitors shown in figure below.



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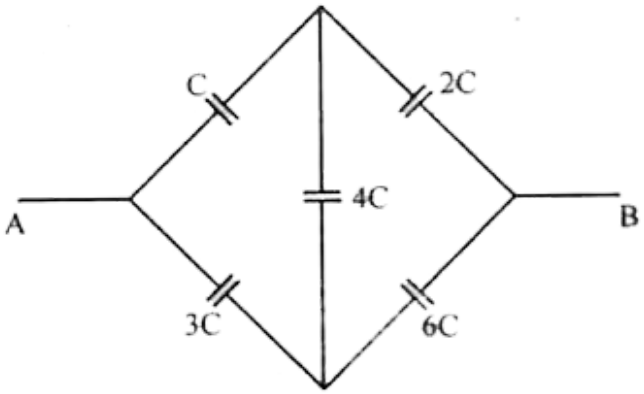

14.

Calculate the effective capacitance between A and B.

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15. Two metal plates $50cm \times 50cm$ have a separation of 2cm. The metal plates are separated by 2 dielectric material constant 4 and 6 and of

thickness 0.8 cm and 1.2 cm respectively. Find the effective capacity.

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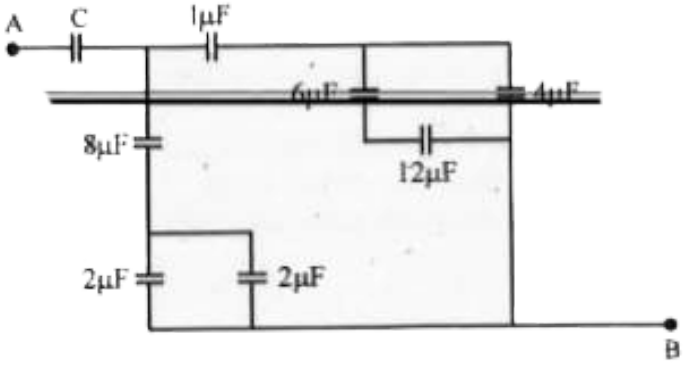
16. Find the capacitane value of C if the equivalent capacity between A and B in the given figure is $1\mu F$



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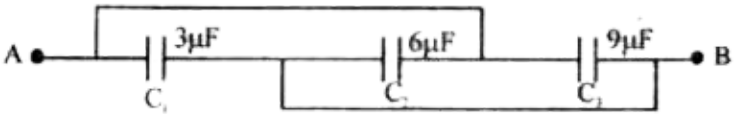
17. Calculate the effective capacitance combination given below:



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18. Match the following

A	B	C
i. γ ray	Sun burn	Photon emission by fast moving electrons
ii. X-ray	Remote sensing	Electronic de-excitation
iii. UV ray	Diagnosis	Oscillating current
iv. Microwave	Radioactivity	Nucleus

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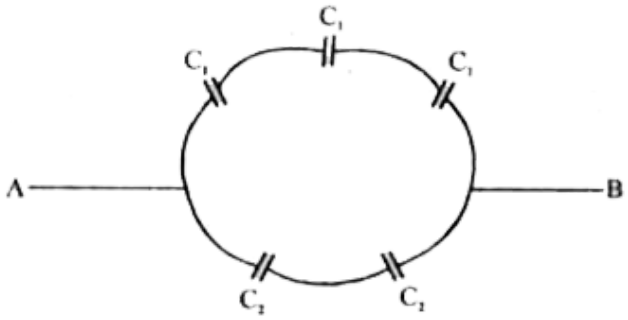
19. Calculate the effective capacity in the following combination. Given $C_1 = 3\mu F$ and $C_2 = 2\mu F$



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20. An isolated conducting sphere of radius 6cm has a charge of $1.5\mu C$. Calculate the energy stored in the field of this charged conductor and the energy density at the surface of the sphere.

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21. Two capacitors $3\mu F$ and $6\mu F$ are first connected in series with a battery of emf 240V. The connection is broken and then connected in parallel. Find the final charges on the two capacitors.

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22. A parallel plate capacitor having plate area $50cm^2$ and separated by a distance 2mm with dielectric material has a capacity of 100pF. The

plates are charged to p.d. of 240V. Calculate the charge stored in it and the dielectic constant.

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23. A parallel plate capacitor is charged to $50\mu C$ at 150V. It is then connected to another capacitor of capacity four times of first capacitor. Calculate the energy loss.

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Evaluation Questions And Answers

1. Fill up.

Electric dipole of charge 15 C	Distance of separation = ... (i)	Dipole moment = 15×10^{-12} cm
Two plane parallel sheets of charge	Equal and opposite charge density	Electric field between the plates is = ... (ii) .....
..... (iii)	Unit of energy	Energy = 1.6×10^{-19} J
The effective capacitance is less than the least among the combination	Charge on each capacitor is ..... (iv)	Potential on each capacitor is ..... (v) .....
Conducting sphere of radius 10 cm having charge 1 C	Potential at the centre = ... (vi)	Electric field at the centre is zero

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2. Match the following

i. Electric field	Work done per positive charge	Farad
ii. Electric potential	Charge per unit potential difference	ampere
iii. Capacitance	Force per unit positive charge	JC^{-1}
	Charge per unit time	NC^{-1}

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3. What happens to a conductor when some charges are given to it?

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4. a. Are potential difference and potential energy the same?

b. If they are not the same, then define them

c. Also state how they are related.

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5. A proton und un electron move between two ports having a potential difference V.

a. Which gains more energy

b. Define electron volt.

c. How is 1e V and 1 MeV related to joule?

d. Write the dimensional formula of electrostatic potential.

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6. Work is done on the charge'. What do you understand by this?

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7. Three charges q, q_2 and q_3 are placed in such a way that the distance q_1 and q_2 is r_{12}, q_2 and $q_3 isr_{23}$ and $q_2 isr_{31}$.

a. What is the potential energy of the system?

b. In the above question if there are 'N' point charges, then what is thenet potential energy of the system? Give the expression.

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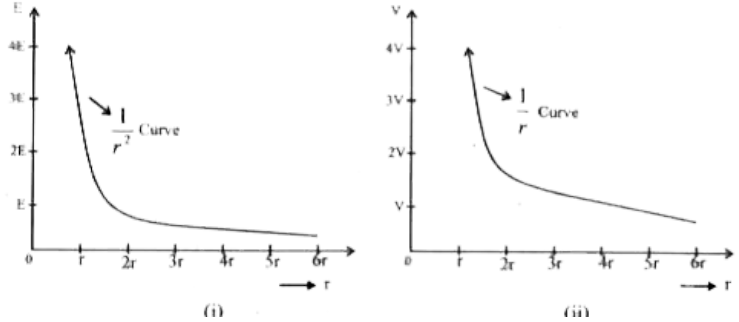
8. You are given two graphs. What conclusion do you draw from the graphs?



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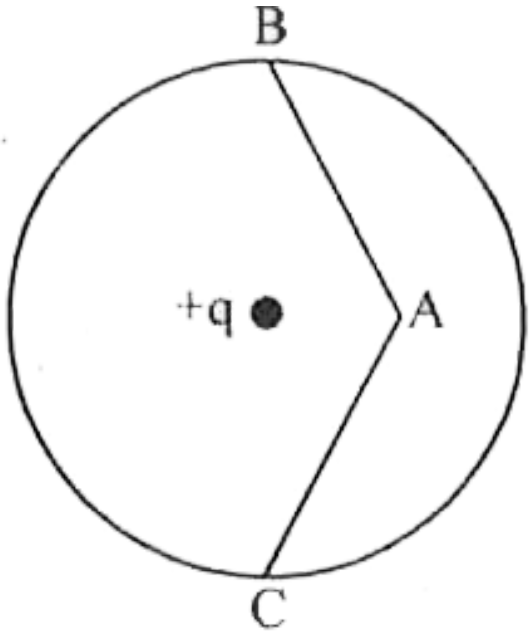
9. A circle is drawn with centre as charge +q.

a. What is the work done in moving a charge +q from B to C along the circumference of the circle?

If the charge +q is first taken from B to A and then

from A to C, on which path work done will be more?



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10. What is the potential difference between the surface and interior point of charged conductor?

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11. What happens when an uncharged conductor is placed near to a conductor?

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12. What is the relation between potential difference and electric field intensity?

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13. How can we increase the capacitance of a conductor?

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14. Potential of a conductor changes on charging.

a. How is charge related to the potential?

b. What is the ratio called?

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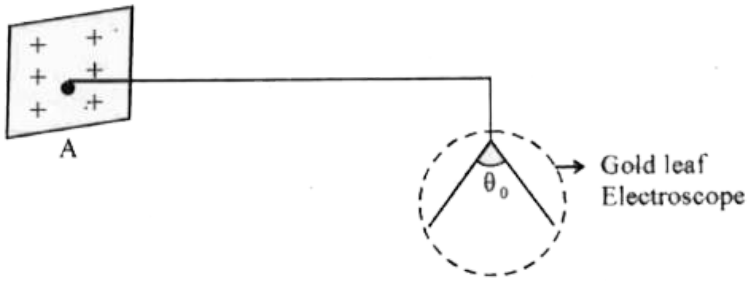

15.

In the above figure an uncharged conducting plate B is brought near A (left side of A)

What will happen to plate B?

b. What will happen to the deflection θ_0

c. If the plate B is earthed, what will happen to the potential and capacitance of plate A?

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16. In an experiment with a capacitor, the charge which was stored is measured for different values of changing p.d. The results are tabulated as follows:

Charge stored/μC	7.5	30	60	75	90
pd/V	1	4	8	10	12

a. Plot a graph with charge on Y - axis and p.d. on X axis. Using the graph, calculate the capacitance of the capacitor.

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17. A pair of capacitors is connected in parallel while another identical pair in series. Which pair would be more dange rous to handle after being connected to the same voltage source?

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18. If p.d. across a capacitor is doubled b. halved, by what factor does the energy stored change in each case?

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19. If you were asked to design a capacitor of small size and large capacitance, what factors would be imperiant in your design?

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20. In series combination, what is the charge on each plate of the capacitors?

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21. How will the applied voltage be divided among the capacitors?

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22. What is the work done in increasing the charge from Q_1 to $Q_1 + \delta_1 + \delta Q_1$, if the potential difference between the plates is V?

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23. In which form and where is the energy of the capacitor stored?

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24. What is the electric field in between the plates of a capacitor in the presence of adielectric medium?

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25. A capacitor of capacitance C is connected to a voltage source of p.d. V. The capacitor gets charged.

a. What happens to the voltage across the capacitor as charge increases?

b. What is the net work done when the capacitor is fully charged?

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26. What happens when a non polar molecule is placed in an external electric field?

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27. What is the difference between a hydrogen molecule and HCI molecule?

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28. If the positive centre of charge coincides with negative centre of charge, what is its dipole moment?

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29. Classify the following molecules into Polar and non-polar.

$(H_2O, H_2, NH_3, N_2, CO_2, CO, HCI, O_2)$

b. Define polar and non-polar molecules.

c. Whar is meant by dielectric polarization?

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30. What is the electric field in between the plates of the capacitor, if σ is the surface charge density?

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31. A conducting spherical shell of radius R has a charge Q. A small sphere of radius $r_0(r_0 < R)$ currying a charge g is introduced inside the large shell. What is the potential

i. at a point r $(r > r_0)$ due to inner sphere

ii. it at a point r=R

iii. at a point $r = r_0$

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32. Two copper spheres of radii, one hollow and the other solid are charged to the same potential.

a. Which of the two will hold was charge?

b. Can a metal sphere a radius 1 cm hold a charge of 1 C?

c. What is your justification?

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33. Two capacitors when connected in series the effective capacity is $2\mu F$ and when in parallel is

$9\mu F$. Calculate the value of each capacitors.

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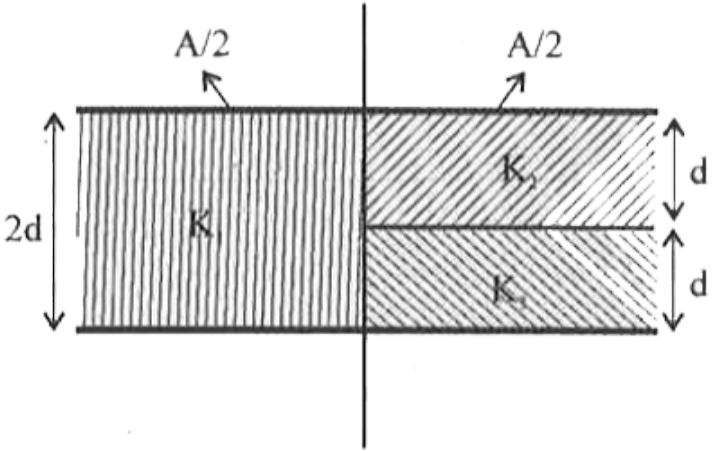
34. What is the capacity having a plate area A of the figure given below?



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35. Keeping the voltage of the charging source constant, what would be the percentage change in the energy stored in a parallel plate capacitor if the separation between its plates is decreased by 10%?

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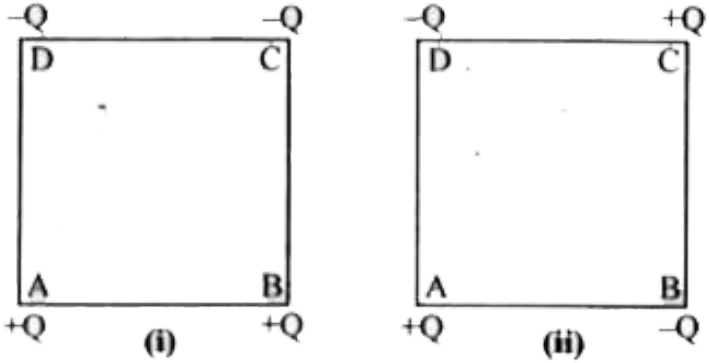
36. Four point charges are placed at the four corners of a square in the two ways (i) and (ii) as shown below: Will the

i. electric field

ii. electric potential, at the centre of the square, be

the same or different in the two configurations and



why?

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37. How much work is done in moving a $500\mu C$ charge between two points on an equipotential surface?

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38. Two dielectric slabs of dielectric constants K_1 and K_2 are filled in between the two plates, eachof area A of the parallel plate capacitor as shown in the figure. Find the net capacitance of the capacitor.

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39. An infinite number of charges, each of charge q, are located along the x-axis at x=1, x=2 x=4, x=8 and so on. Find the potential at x=0.

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40. Derive an expression for field intensity due to a uniformly charged ring at a point on the axis.

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41. Two parallel plate capacitors X and Y have the same area of plates and same separation between them. X has air between the plates while Y contains a dielectric medium of $\varepsilon_r = 4$. (i) Calculate capacitance of each capacitor if equivalent capacitance of the combination is 4 μF. (ii) Calculate the potential difference between the

plates of X and Y. (iii) Estimate the ratio of electrostatic energy stored in X and Y.

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Previous Year Questions

1. A. A device to store electrical charge is called

a. Transformer

b. Capacitor

c. Resistor d. Inductor

B. What is meant by energy density of a parallel plate capacitor?

C. Derive an expression for the energy stored in a parallel plate capacitor.

D. What is the area of the plates of a $0.1\mu F$ parallel plate air capacitor, given that the separation between the plates is 0.1 mm.

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2. A. Potentiometer measures the potential difference more accurately than a voltmeter, because the potentiometer

a. does not draw current from external circuit.

b. has a wire of high resistance.

c. draws a heavy current from external circuit.

d. has a wire of low resistance.

B. With the help of a diagram explain the principle of a potentiometer.

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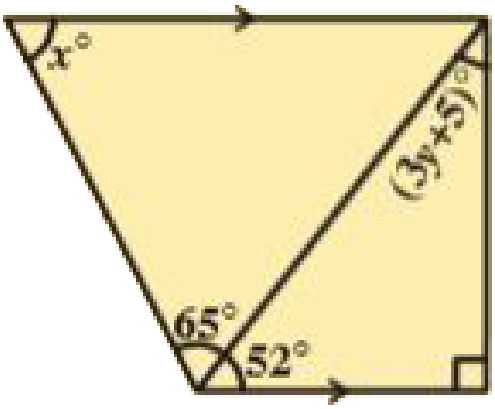
Competitive Exam Corner

1. From the figure find x and y.



A. 2V

B. 1V

C. 3V

D. 1.5V

Answer: A

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2. Two point charges $+5\mu C$ and $-2\mu C$ are kept at a distance of 1m in free space. The distance between the two zero potential points on the line joining the charge is

A. a. $\frac{2}{7}m$

B. b. $\frac{2}{3}m$

C. c. $\frac{22}{21}m$

D. d. $\frac{20}{21}m$

Answer: D

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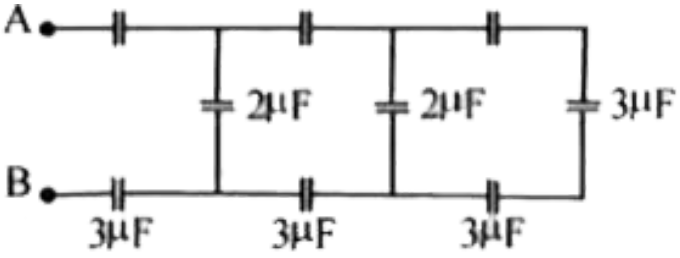
3. The equivalent capacitance betweeen A and B is $(\text{in } \mu F)$



A. a. 25

B. b. $\frac{84}{25}$

C. c. 9

D. d. 1

Answer:

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4. Identify the false statement.

A. Inside a charged or neutral conductor electrostatic field is zero

B. The electrostatic field at the surface of the charged conductor must be tangential to the surface at any point

C. There is no net charge at any point inside the conductor

D. Electrostatic potential is constant throughout the volume of the conductor

Answer: B

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5. Two conducting spheres of radii 3 cm and 1 cm are separated by a distance of 10 cm in free space. If the spheres are charged to same potential of 10

V each, the force of repulsion between them is density

A. $\left(\frac{1}{3}\right) \times 10^{-9} N$

B. $\left(\frac{2}{9}\right) \times 10^{-9} N$

C. $\left(\frac{1}{9}\right) \times 10^{-9} N$

D. $\left(\frac{4}{3}\right) \times 10^{-9} N$

Answer: A

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6. The work done in carrying a charge 'a' once round a circle of radius 'a' with a charge Q at its centre is

A. $\frac{qQ}{4\pi\varepsilon_0 a}$

B. $\frac{qQ}{4\pi\varepsilon_0 a^2}$

C. $\frac{q}{4\pi\varepsilon_0 a}$

D. zero

Answer:

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7. A parallel plate capacitor is charged to a potential difference of V volts. After disconnecting the charging battery the distance between the plates of the capacitor is increased using an insulating handle. As a result the potential difference between the plates

A. charge and potential difference

B. charge and capacitance

C. capacitance and potential difference

D. energy stored and potential difference

Answer:

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8. Two particles A and B having equal charges +6 C, after being accelerated through the same potential difference, enter a region of uniform magnetic field and describe circular paths of radii 2 cm and 3cm respecitevely. The ratio of mass A to that of B is

A. a. $\frac{4}{9}$

B. b. $\frac{9}{5}$

C. c. $\frac{1}{2}$

D. d. $\frac{1}{3}$

Answer: A

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9. Two identical thin rings, each of radius 10 cm carrying charges 10 C and 5 C are coaxially placed at a distance 10 cm apart. The work done in moving a charge q from the centre of the first ring to that of the second is

A. a. $\frac{q}{\frac{\sqrt{2}+1}{\sqrt{2}}}$

B. b. $\frac{q}{8\pi\varepsilon_0}\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$

C. c. $\frac{q}{4\pi\varepsilon_0}\left(\frac{\sqrt{2}+1}{\sqrt{2}}\right)$

D. d. $\frac{q}{4\pi\varepsilon_0}\left(\frac{\sqrt{2}-1}{\sqrt{2}}\right)$

Answer: B

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10. The electric potential V at any point (x, y, z) in space is given by $V = 3x^2$ where x, y, z are all in metre. The electric field at the point (1 m, 0,2 m) is

A. a. $6Vm^{-1}$ along negative x-axis

B. b. $6Vm^{-1}$ m along positive x-axis

C. c. 12 Vm^{-1} makong negative x-axis

D. d. 12 Vm^{-1} along positive r-axis

Answer: A

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11. Choose the correct statement.

A. a. Polar molecules have permanent electric dipole moment

B. b. CO_2 molecule is a polar molecule

C. c. H_2O is a non-polar molecule

D. d. The dipole field at large distances falls of as

Answer: A

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12. In a parallel plate capacitor, if the intervening medium of permittivity & between the plates is replaced by another medium of permittivity $\frac{\varepsilon}{2}$, then its capacitance is

A. halved

B. doubled

C. unchanged

D. quadruped

Answer: A

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13. The percentage error in measuring resistance with a metre bridge can be minimized by adjusting the balancing point close to

A. a. 0 cm

B. b. 20cm

C. c. 50cm

D. d. 80cm

Answer: C

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14. An uncharged parallel plate capacitor filled with a dielectric of dielectric constant K is connected to an air filled identical parallel capacitor charged to potential V_1.If the common potential is V_2. the value of K is

A. $\frac{V_1 - V_2}{V_1}$

B. $\frac{V_1}{V_1 - V_2}$

C. $\frac{V_2}{V_1 - V_2}$

D. $\frac{V_1 - V_2}{V_2}$

Answer: D

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15. Choose the wrong statement about equipotential surfaces.

A. It is a surface over which the potential is constant

B. The electric field is parallel to the equipotential surface

C. The electric field is perpendicular to the equipotential surface

D. The electric field is in the direction of steepest decrease of potential

Answer: B

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16. Three capacitors connected in series have an effective capacitance of $4\mu F$. If one of the capacitance is removed, the net capacitance of the capacitor increases to $6\mu F$. The removed capacitor has a capacitance

A. a. $2\mu F$

B. b. $4\mu F$

C. c. $10\mu F$

D. d. $12\mu F$

Answer: D

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17. A soap bubble is charged to a potential 12 V. If its radius is doubled, the potential of the bubble becomes

A. a. 12V

B. b. 24V

C. c. 3V

D. d. 6V

Answer: D

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18. The energy stored in a capacitor of capacitance

Chaving a charge Q under a potential V is

A. a. $\frac{1}{2}Q^2V$

B. b. $\frac{1}{2}C^2V$

C. c. $\frac{1}{2}\frac{Q^2}{V}$

D. d. $\frac{1}{2}QV$

Answer: D

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19. A point charge of 2 C experiences a constant force of 1000 N when moved between two points separated by a distance of 2 cm in a uniform electric field. The potential difference between the two points is

A. a. 12V

B. b. 8V

C. c. 10V

D. d. 16V

Answer: C

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20. A charge Q is distributed over two concentric hollow spheres of radii r and R $(R > r)$, so that the surface charge densities are equal. The potential at the common centre is $\frac{1}{4\pi\varepsilon_0}$ times

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21. The velocity acquired by a charged particle of mass m and charge Q accelerated from rest by a potential of V is

A. a. $\frac{QV}{m}$

B. b. $\sqrt{\frac{m}{QV}}$

C. c. $\sqrt{mQV}$

D. d. $\frac{\sqrt{(2QV)}}{m}$

Answer:

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22. A $5\mu F$ capacitor is fully charged by a 12V battery and then disconnected. If it is connected now parallel to an uncharged capacitor, the voltage across it is 3V. Then the capacitance of the uncharged capacitor is

A. a. $5\mu F$

B. b. $15\mu F$

C. c. $50\mu F$

D. d. $10\mu F$

Answer: B

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