PHYSICS

BOOKS - NN GHOSH PHYSICS (HINGLISH)

ELECTRIC FIELD AND POTENIAL

Examples

1. A point charge of $+3 \times 10^{-6}$ coulomb (C) is 12 cm apart from a second point chargeof

$-1.5 \times 10^{-6} C$. Calculate the force of attraction between them .

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2. Two small charged sphers repel each other with a force of $2 \times 10^{-3} N$. When taken 10 cm farther a part , the force $5 \times 10^{-4} N$. What are the charges and what was their original distance ?

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3. The work done in moving a charge of 2×10^{-9} C from a point of potential - 3000 V to another point P is $5 \times 10^{-5} J$. Find the potential at the point P.

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4. A charge of $20 \times 10^{-9} C$ is placed at a point . What work will be requried (a) to bring 1 C of positive charge from infinity to a distance of 10 cm from it ? (b) to carry a charge of 5 C

once compelety round it in a circle of radius 5 cm ? Given reasons .

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5. A hollow, spherical conductor of radius 10 cm is charged with $5 \times 10^{-9} C$. Find the potential (a) at a distance of 20 cm from the centre ,(b) at the surface of the sphere , (c) at a distance of 5 cm from centre.

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6. Two pith balls , of mass 10 mg, are suspended from the same point,each by a silk fibre 50 cm long . When equal and similar changes are given to them, they are repelled to a distance of 10 cm from each other. Calculate the chagre on either ball .

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7. ABCD is a square of side 4 cm. Charges of $16 \times 10^{-9}C, \ -16 \times 10^{-9}C$ and $32 \times 10^{-9}C$ are placed at the points A, C and

D, respectively. Determine the electric field at point B.

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8. The distance between charges $5.0 \times 10^{-11} C$ and $-2.7 \times 10^{-11} C$ is $0.2m$. The distance at which a third charge should be placed in order that it will not experience any force along the line joining the two charges is

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9. A charge of mass 50 mg and carrying $5 \times 10^{-9} C$ is approaching a fixed charge $10 \times 10^{-9} C$ with a velocity point $0.5 m/s$ .Find the maximum approch of the charge .

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10. A liquid drops hangs in equillibrium between two copper plates separated by a distacnce of 2cm and maintained at a potential difference of 600 volts. Calculate the charge on the drops if the radius of the drop

is 0.1mm and density of the liquid is $800kg/m^3$

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11. A charge of 60n C (nanocouloumb) is palced at the corner A of a square ABCD is side 10cm. Another charge of -10nc is located at the centre of the square. Find the work done in carrying a charge of +5 nC from the corner C to the corner B of square.

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12. The potential field depends on the x - and y - coordinates as $V = x^2 - y^2$. The corresponding electric field lines in x y plane are as.

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13. Two charges $-2Q$ abd Q are located at the points with coordinates $(-3a, 0)$ and $(+3a, 0)$ respectively in the x-y plane. (i) Show that all points in the x-y plane where the

electric potential due to the charges is zero, on a circle. Find its radius and the location of its centre (ii) Give the expression V(x) at a general point on the x-axis and sketch the function V(x) on the whole x-axis. (iii) If a particle of charge +q starts from rest at the centre of the circle, shown by a short quantitative argument that the particle eventually crosses the circule. Find its speed when it does so.

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14. Find the electric field potentail and strength at the centre of a hemisphere fo raidus R ahcged uniformly with the the surface density σ.

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15. Four identical charges i.e. q is placed at the corners of a square of side a. The charge Q that must be placed at the centre of the square such that the whole system of charges in equilibrium is

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Exercise

1. The force of attraction between two charges $+30 \times 10^{-9} C$ and $-20 \times 10^{-9} C$ seperated by a distance of 020m is found to be `5 xx 10^(-5)N. Find the relative permittivity of the medium.

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2. Two charges of $+4 \times 10^{-7} C$ and $-8 \times 10^{-7} C$ are 20cm apart. Find the resultant intensity at a pint P situated 20cm from either charge.

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3. A negative charge $q_1 = 50 \times 10^{-9} C$ and a positive charge $q_2 = 25 \times 10^{-9} C$ are fixed at a distance l=20cm. Where should a thrid charge q be placed on the line joining the charges so that they may be in equillibrium?

What is the nature of equillibrium with respect to its longitudenal displacement along the line joiing the two charges? Plot a grapgh showing dependence of this force on distance from $q_{\circ}$.

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4. Two pith balls„ each weighting 10mg are suspended from the sam point by silk threads, each of length 0.25m. When equal and similar charges are placed on them they repel each

other and are 10m apart. Find the charge on the each pith ball.

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5. A ball of mass $m = 0.5kg$ is suspended by a thread and a charge $q = 0.1\mu C$ is supplied when a ball with diameter $5cm$ and a like charge of same magnitude is brought close to the first ball but below it the tension decreases to $1/3$ of its initial value .The distance between centres of the balls is

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6. An α paritcle carrying an electric charge $3.2 \times 10^{-19} C$ is at a distance of $13.8 \times 10^{15} m$ from a gold nucleus (atomic number=79). Calculate the fore exertedby the gold nucleus on the α particle.

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7. A charges of $50 \times 10^{-9} C$ is placed at a point P. What amount of work will we done to

bring $2 \times 10^{-9} C$ from infinity to a point 5cm away from P? What work will be done to move a unit charge aroiund P in a circular of radius 8cm?

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8. A small uncharged sphere is placed in contact with an equal and similar charged sphere and then removed to a distance of 4 cm. The force of repulsion between them is

now 9×10^{-5}N. What was the original charges in the charged sphere?

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9. An electron is projected with an initial velocity of $10^{7} ms^{-1}$ into an electric field between two parallel plates 1 cm apart. The electron enters the field at a point midway between the plates. If the electron just misses the positivity charged plate as it emerges from the field, find the magnnitude of the electric

density between the plates. (Length of each plate is 2 cm, mass of electron=9×10^{-31}kg and charge of electron $= 1.6 \times 10^{-19}$C)

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10. A positive point charge $50\mu C$ is located in the plane xy at a point with radius vector $\vec{r}_0 = 2\hat{i} + 3\hat{j}$. The electric field vector $\vec{E}$ at a point with radius vector $\vec{r} = 8\hat{i} - 5\hat{j}$, where r_0 and r are expressed in meter, is

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11. Charges of $+q$, $+2q$, $+q$ and $-q$, are placed at the cornersof a square ABCD. Calculate the electric field at the intersection of the diagonals of the square when $q = \frac{5}{3} \times 10^{-9}$C and length of each side is 10 cm.

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12. Two small equal spheres carrying unlike and unequal charges are placed 8 cm apart

and attack each othwer with a force of 4×10^{-5}N. After they have been connected for a moment by a thin conducting wire, they repel each other with a force of 2×10^{-5}N. Calculate their original charges.

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13. Two small conducters 0.3 m apart carry 10×10^{-9}C and 20×10^{-9}C of electric charge. Find the potential and intensity of a point exactly midway between them.

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14. An electron of mass 9×10^{-31} kg carrying 1.6×10^{-19}C starts from rest from one point and reaches a second conductor with a velocity $10^{7} ms^{-1}$. Calculate the potential difference between the points.

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15. Calculate the radius of a drop of water which remains suspended in the eart's electric

field of 300 Vm^{-1} when charged with one electronic charge. (One electronic charge= 1.6×10^{-19}C)

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16. ABCD is a square of side 0.2 M. Positive charges $2 \times 10^{-9}C, 4 \times 10^{-9}$C and 8×10^{-9} C are placed at the points A,B and C. Calculate the work done to transfer one columb from D to the centre of the square.

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17. Two charges $+2 \times 10^{-9}$C and -8×10^{-9}C are placed 0.3 M apart in air. Find the point or p[oints where the electric field and potential is zero.

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18. Two charges 4 cm apart repel each other with a force of 2×10^{-2}N in air. When a dielectric slab of thickness 1 cm is placed between them, The force is reduced to

1.5×10^{-2}N. Calculate the permittivity of the dielectric.

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19. Charges of magnitude $\frac{1}{2}, \frac{2}{3}, \frac{3}{3}$ and $\frac{4}{3}$ nanocolumb are placed at the cornewrs A,B,C,D rwespectively of a square of side 2 cm. Find the work done in taking $\frac{5}{3}$ nanocolumb from the midpoint of AB to the midpoint CD.

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20. Four small spheres carrying $+\frac{5}{3}, +\frac{10}{3}, +\frac{5}{3}$ and $-\frac{5}{3}$nC are placed in order at the angular points of a sqare ABCD of 10 cm sides. Calculate the force on a charge of $+\frac{2}{3}$nC at the intersection O of the diagonal

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21. An electron is liberated from a hot filament and attracted by an anode at 1200 V. What is its speed when it strike the anode?(e= 1.6×10^{-19}C)

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Exercise B

1. A certain charge Q is divided into two parts q and $Q - q$, wheich are then separated by a cetain distance. What must q be in terms of Q to maximum the electrostatic repulsion between the two charges?

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2. A uniform electric field exists in the region between toe oppositely charged plane parallel plates. An electron is released from rest at the surface of the negatively charged plate and strikes the surface of the opposition plate 2 cm away from the first in an intercval of $1.5 \times 10^{-8} s$. Find (a) the electric intensity ,(b) the velocity of the electron when it strikes the second plate.

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3. Two brass plates are arranged horizontally , one 2 cm above the other. The plates are charged to a potential differnece of 6600 V. Now very fine liquid drops are sprayed into the space between the plates . Big drops collect at the bottom plate some drops go up and some remain statinary . How do you explain this ? If the radius of the stationary drops is 2×10^{-6} m and density of liquid 800 kgm^{-3} , calculate the charge carried by the stationary drops. Does this result confirm quantisation of charge?

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4. Three charges $-1\mu C, 2\mu C \text{and} 3\nu C$ are placed respectively at the corners A, B, C of an equiliateral triangle of sides 2m. Calculate the potential and electric field at the midpoint of the side BC.

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5. Three small balls, each of mass 10 g , are suspended from a common point by 1-m silk threads . The balls are identically charged and hung at the corners of an equiliteral triangle of 0.1 m. What is the charge on each ball ?

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6. In the Bohr model of the hydrogen atom, an electron revolves in a circular orbit around the nucleus of a single proton. IF the radius of the

orbit is 5.28×10^{-11} m, find the number of revolutions of the electrons per second. (Charge on electron $=1.6 \times 10^{-19}$C and charge on proton is same as on electron but positive.) (Hint: Coulomb's force of attraction $= \omega^2 r$)

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7. Two equal positive point charges are sperated by a distance of 2a. A point test charge is located in a plane which is normal to the line joining these charge and midway

between them. Calculate the radius r of the circle of symmetry in this plane for which the force on the test charge has the maximum value.

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8. An alpha particle of velocity $1.6 \times 10^{7} ms^{-1}$ approaches a gold nucleus (Z=79). Calculate the distance of the closest approach. Mass of an alpha particle is 6.6×10^{-27} kg. What is the significance of this closest approach?

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9. Three charges -q, +q and -q are placed along a st. line at equal distance , say a. Calculated the potential energy of this system of charges (i) when +q charge is in the middle and (ii) when this charge is at one end.

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10. Two concentric spherical shells of conducting material and of radii a and b

$(b > a)$ are given charges q_1 and q_2, respectively. Find the potential at a point at a distance r form the centre, (i) outside the two shells, (ii) between the two shells. What is the potential difference between the two shells and what will happen if they are joined by a wire?

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11. Two equal charges, +Q each, are at a distance r from each other. A third charge is

placed on the line joining the above two charges such that all these charges are in equilibrium. Find q, in terms of Q.

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12. An infinite number of charges, each equal to q are arranged in a line at distance 1,2,4,8,16,.....from a fixed point on the line. Find the potential and field at that fixed point. What will be the potential and electric field if,

in the above set up, the consecutive charges have opposite signs?

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13. Four charges +q,+2q,+3q and +4q are placed at the four corners ABCD of a square of side a. Calculate the field and potential at the centre of the square.

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14. Two identical positive charges are placed at the diagonally opposite corners of a square and two more identical but negative charges are placed at the remaining two corners. What is the work done in putting all charges together at the centre if q is the magnitude of each charge and 2a is the length of each side of the square?

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15. A charge Q is placed at each of the two opposite corners of a square of side a.A charge is placed at each of the other two corners. (a) if the reultant electrical force system of charges? What is the signification of its negative potential energy?

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16. A thin copper ring of radius a is charged with q units of electricity. Calculate the electric

field at a point at a distance x from the centre and on the axis of the ring. Use the result to find the electirc field due to a charged disc of surface density of charge ε.

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17. A an electron is placed at the centre of the copper ring of problem 37. Show that if the electron is displaced a little, it will perform simple harmonic motion with a frequency $f = \frac{1}{2\Pi}\sqrt{\frac{eq}{4\pi\varepsilon_0 ma^3}}$

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18. A thin half- ring of radiusb 20 cm is uniformly charged with a total charge of $0.7nC$. Find the magnitude of the electric field at the centre of the centre of the half-ring.

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19. A thin nonconducting ring of radius r has a linear charge density $q = q_0 \cos\theta$, where q_0 is a constant and θ is the angle at the centre

from the diameter of maximum charge density in the anticlockwise direction. Find the electric field at the centre of the ring.

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20. A thin wire ring of radius r has an electric charge q. What is the tension of the wire if a point charge q_0 is placed at the ring's centre?

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21. A charge +Q is uniformly distributed over a thin ring of a radius R. Find the velocity of a negative point charge -Q at the moment it passes through the centre of the ring if it was initially at rest at infinity on the axis of the ring. The mass of the charge-Q is equal to m.

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22. Three identical particals, each of charge Q=0.5 μ C and mass $m = 7.5 \times 10^{-10}$ kg are

placed at the verticle of an equilateral triangle of side r_0=1m and released. The particle repel each other by coulomb forces to larger equilateral triangle. Find the relative velocity between any two of them when the triangle has grown to a side length of r=2m.

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23. Two small similar balls of mass m are hung by silk threads of length l from the same point , a small angle apart and carry similar charges

q. They lose charge and draw closer quasistatically .Calculate the rate of loss of charge if the relative velocity varies as $v = \frac{k}{\sqrt{x}}$ where k is a constant.

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24. Calculate the field due to a uniformly charged straight conductor of length 2j at a distance d along its perpendicular bisector. The charge on the conductor is q.

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25. Two positive charges q_1 and q_2 are located at points with radius vectors $\overrightarrow{r}_1$ and $\overrightarrow{r}_2$. Find the negative charge and its radius vector which would make the force on all the charges zero.

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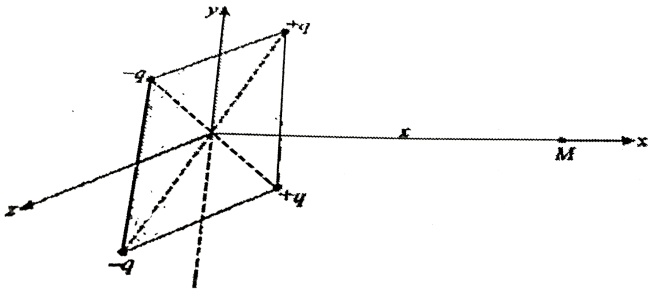
26. Point charges q and -q located at the vertices of a square with diagonals 2l as shown in figure. Find the magnitude of the

electric field at a point located symmetrically with respect to the vertices of the square at a distance x from its centre. Consider $x > > l_0$

$$\left[-\frac{ql}{\sqrt{2}\pi\varepsilon_0 x^3} \right]$$



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27. Two co-axisal rings, each of radius R, are separated by a small distance l(ltltR) and carry

charges q and -q.Find the electric potential and field at a point on the axis at a distance x from the midpoint between the rings,

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28. Find the potential ϕ of an electric field given by $\vec{E} = a\left(y\hat{i} + x\hat{j}\right)$ where a is a constant .

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29. Calculate the potential at a point on the perpendicular bisector of uniformly charged thin rod (linear density of charge $=\lambda$) of length 2l at a distance a from the centre of the rod.

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30. A ring of radius R carries a charge q uniformly distribited over it. A long thin wire carrying charge λper unit length of it is held along its axis with one end coinciding with the

centre of the ring. Find the interaction force between the ring and the thread.

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31. Electric charge q is uniformly distributed in a spherical space from which a cavity of diameter equal to the radius R of the spherical space has been removed. Calculate the potential and field at a point P lying on the diameter of the cavity at a distance $r > r/2$ but lt R from the centre of the sphere.

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32. A copper rod AB of length l is rotated about one end A with a constant angular velocity ω. Calculate the electric field at a distance x from the axis of rotation. Also determine PD between A and B.

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33. A metal rectangular parallelipiped is moved parallel to itself with constant acceleration a .

Find the electric field developed inside the metal and surface density of charges produced.

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34. Three small identical netural balls are the verstices of an equilateral triangle . The balls are connected to a large charged sphere held above the plane of the plane of the triangle symmerticaly with repect to the balls . The first and the second balls acquire charge q_1 and q_2

respectively . How much is q_3 ?.The connecting wires are thin.

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35. Eight equal charged are placed at the eight corners of a cubewhich is a on each side . Calculate the force experienced by each charge q.

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