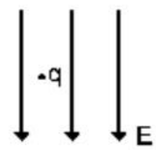
14. A particle of mass m and charge q is thrown at a speed u against a uniform electric field E. How much distance will it travel before coming to momentary rest ? Find out the time required till that moment. (Neglect gravity) .

15. A particle of mass m and charge +q is placed at rest in an uniform electric field as shown and released. The kinetic energy it attains after moving a distance y is(Neglect gravity) :



(A) $\frac{1}{2}qEy$ (B) qEy (C) qE^2y (D) $\frac{1}{2}m(qEy)$

16*. A particle of mass 2Kg and charge 1mC is projected vertically with a velocity $10ms^{-1}$. There is a uniform horizontal electric field of 10^4N/C.

(A) the horizontal range of the particle is 10m
(B) the time of flight of the particle is 2s
(C) the maximum height reached is 5m
(D) the horizontal range of the particle is 0.

17. A charged particle of charge q and mass m is released from rest in an uniform electric field E. Neglecting the effect of gravity, the kinetic energy of the charged particle after time 't' seconds is

(A) $\frac{Eqm}{t}$ (B) $\frac{E^2q^2t^2}{2m}$ (C) $\frac{2E^2t^2}{mq}$ (D) $\frac{Eq^2m}{2t^2}$

18. A proton and an electron are placed in an uniform electric field.

(A) The electric forces acting on them will be equal

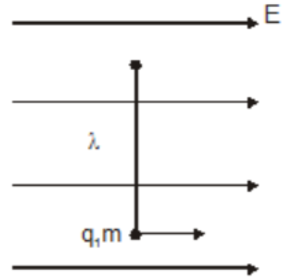
(B) The magnitudes of the forces will be equal

(C) Their acceleration will be equal

(D) The magnitudes of acceleration will be equal.

19. The bob of a simple pendulum has a mass of 40 g and a positive charge of 4.0×10^{-6} C. It makes 20 oscillations in 45 s. A vertical electric field pointing upward and of magnitude 2.5×10^{4} N/C is switched on. How much time will it now take to complete 20 oscillations ?

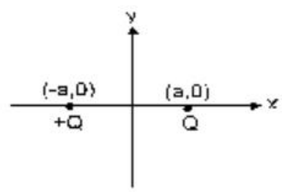
20. A simple pendulum has a length $2\sqrt{21}$, mass of bob m. The bob is given a charge q coulomb. The pendulum is suspended in a uniform horizontal electric field of strength E as shown in figure, then calculate the time period of oscillation when the bob is slightly displace from its mean position is :

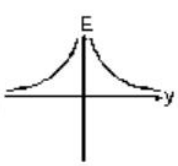


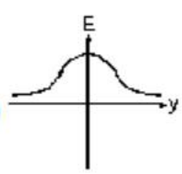
(A) $2\pi\sqrt{\frac{\lambda}{g}}$ (B) $2\pi\sqrt{\left[\frac{\lambda}{g+\frac{qE}{m}}\right]}$ (C) $2\pi\sqrt{\left[\frac{\lambda}{g-\frac{qE}{m}}\right]}$ (D) $2\pi\sqrt{\frac{\lambda}{\sqrt{g^2+\left(\frac{qE}{m}\right)^2}}}$

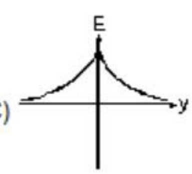
21. An electric charge $Q = 10^{-10}$C is placed at the point (1, 2, 3) cm. Find the electric field intensity due to it at the point (2,3,4) cm.

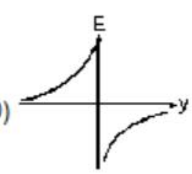
22. The variation of electric field on the y-axis as a function of 'y' is best represented by : [for the given figure]



(A) 

(B) 

(C) 

(D) 

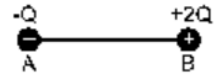
23. Two point particles A and B having charges of $+2.00 \times 10^{-6}$ C and of -4.00×10^{-6} C respectively are held at a separation of 20.0 cm. Locate the point(s) on the line AB or its extension where the electric field is zero

24. Three point charges q_0 are placed at three corners of square of side a. Find out electric field intensity at the fourth corner.

25. A point charge 50 μC is located in the x-y plane at the position vector $\vec{r}_0 = (2\hat{i} + 3\hat{j})$m. The electric field at the point of position vector $\vec{r} = (8\hat{i} - 5\hat{j})$ m, in vector from is equal to :

(A) $90(-3\hat{i} + 4\hat{j})$ V/m (B) $90(3\hat{i} - 4\hat{j})$ V/m (C) $900(-3\hat{i} + 4\hat{j})$ V/m (D) $900(3\hat{i} - 4\hat{j})$ V/m

26. Charge 2Q and –Q are placed as shown in figure. The point at which electric field intensity is zero will be:



(A) Somewhere between –Q and 2Q

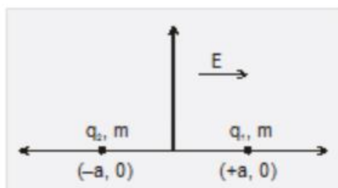
(B) Somewhere on the left of –Q

(C) Somewhere on the right of 2Q

(D) Somewhere on the right bisector of line joining –Q and 2Q

27. Two point charges 3μC and 2.5 μC are placed at point A (1, 1, 2)m and B (0, 3, –1)m respectively. Find out electric field intensity at point C(3, 3, 3)m.

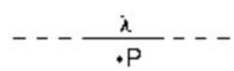
28. Two positively charged particles of charges q_1 and q_2 have mass m each. A uniform electric field having magnitude E exists in positive x direction as shown in figure. The given two charged particles are released from rest at t = 0 as shown in figure. If position of q_1 at t = 2 sec. is given by coordinate (+2a, 0) then the x-coordinate of q_2 at t = 2 sec is (neglect gravitational interaction between the particles) -



(A) $\frac{q_1+q_2}{m}E-2a$ (B) $\frac{q_1+q_2}{m}E-a$ (C) $2\left(\frac{q_1+q_2}{m}\right)E-2a$ (D) $2\left(\frac{q_1+q_2}{m}\right)E-a$

29. An infintely long line charge of linear charge density $\lambda = 2 \times 10^{-6}$ C/m is kept along y axis. Find out electric field intensity at a point which is situated on z axis at a distance 2 cm from origin.

30. In the diagram shown P is a point negative charge. It's weight is balanced by the electric force due to the fixed very long wire. The equilibrium of the particle is



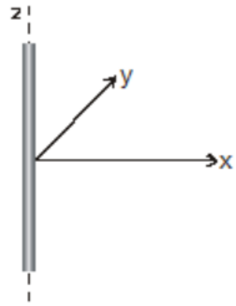
(A) stable, for vertical displacements

(B) neutral for vertical displacements

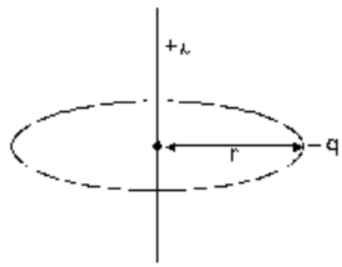
(C) stable for horizontal displacements (parallel to the wire)

(D) neutral for horizontal displacements (parallel to the wire)

31. An infinitely long wire is kept along z-axis from $z = -\infty$ to $z = +\infty$, having uniform linear charge density $\frac{10}{9}$ nC/m. Find the electric field $\vec{E}$ at point (6 cm, 8 cm, 10 cm).



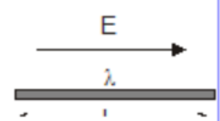
32. A particle of charge -q & mass *m* moves in a circle of radius *r* around an infinitely long line charge on linear charge density $+\lambda$. Then time period will be :



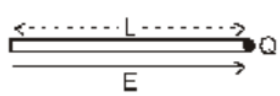
(A) $T = 2\pi r\sqrt{\frac{m}{2k\lambda q}}$ (B) $T^2 = \frac{4\pi^2 m}{2k\lambda q} r^3$ (C) $T = \frac{1}{2\pi r}\sqrt{\frac{2k\lambda q}{m}}$ (D) $T = \frac{1}{2\pi r}\sqrt{\frac{m}{2k\lambda q}}$

33.. A circular ring of radius a carries a total charge Q distributed uniformly over its length. A small length dL of the wire is cut off. Find the electric field at the centre due to the remaining wire.

34. A thin elastic rod (of uniform density) of natural length L and uniform cross-sectional area A and Young's modulus Y has uniform linear charge density λ (charge per unit length). The rod is placed in gravity free space having uniform electric field of magnitude E and directed parallel to length of the rod. Find the magnitude of extension in length of this rod ?

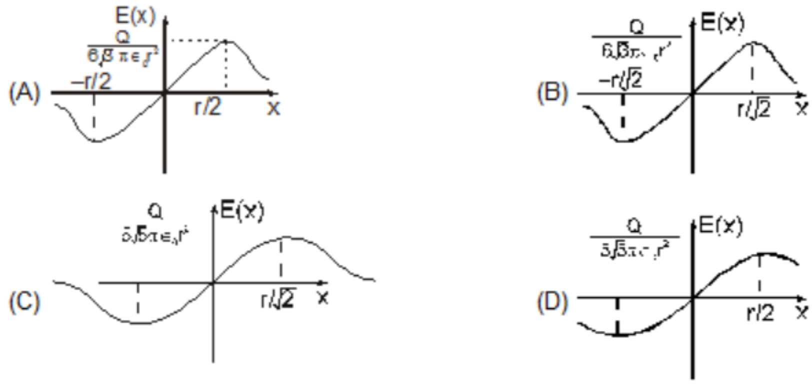


35. A light weight particle of charge Q is fixed at one end of an electrically insulated uniform elastic rod of natural length L, cross-sectional area A and Young's modulus Y. The rod is placed in space having uniform electric field of magnitude E and directed parallel to length of the rod as shown. Neglecting gravity, the magnitude of extension in this rod is

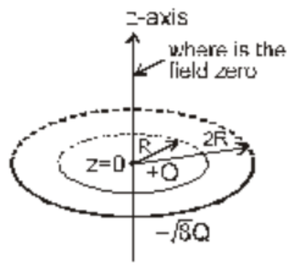


(A) $\frac{QEL}{YA}$ (B) $\frac{QEL}{2YA}$ (C) $\frac{QEL}{4YA}$ (D) None of these

36. Which of the following graphs shows the correct variation of electric field as a function of x along the axis of a uniformly and positively charged ring of radius R and charge Q.

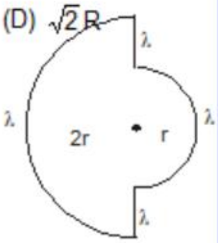


37. Two concentric rings, one of radius R and total charge +Q and the second of radius 2R and total charge $-\sqrt{8}\,Q$, lie in x-y plane (i.e., z = 0 plane). The common centre of rings lies at origin and the common axis coincides with z-axis. The charge is uniformly distributed on both rings. At what distance from origin is the net electric field on z-axis zero.



(A) $\frac{R}{2}$ (B) $\frac{R}{\sqrt{2}}$ (C) $\frac{R}{2\sqrt{2}}$ (D) $\sqrt{2}R$

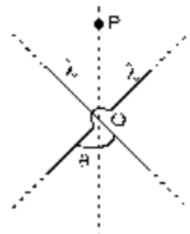
38. Two semicircular rings lying in same plane, of uniform linear charge density λ have radius r and 2r. They are joined using two straight uniformly charged wires of linear charge density λ and length r as shown in figure. Find the magnitude of electric field at common centre of semi circular rings is -



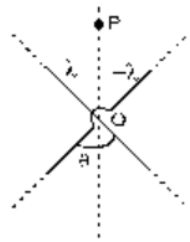
39. The maximum electric field intensity on the axis of a uniformly charged ring of charge q and radius R will be:

(A) $\frac{1}{4\pi\varepsilon_0}\frac{q}{3\sqrt{3}R^2}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3R^2}$ (C) $\frac{1}{4\pi\varepsilon_0}\frac{2q}{3\sqrt{3}R^2}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{3q}{2\sqrt{3}R^2}$

40. (i) Two infinitely long line charges each of linear charge density λ are placed at an angle θ as shown in figure, find out electric field intensity at a point P which is at a distance x from point O along angle bisector of line charges.



(ii) Repeat the above question if the line charge densities are λ and $-\lambda$.



41. A flat circular fixed disc has a charge +Q uniformly distributed on the disc. A charge +q is thrown with kinetic energy K, towards the disc along its axis. The charge q

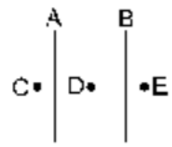
(A) may hit the disc at the centre

(B) may return back along its path after touching the disc

(C) may return back along its path without touching the disc

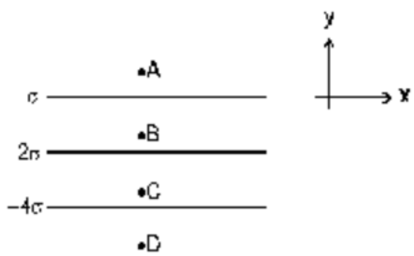
(D) any of the above three situations is possible depending on the magnitude of K

42*. Two infinite plane sheets A and B are shown in the figure. The surface charge densities on A and B are $(2/\pi) \times 10^{-9}$ C/m² and $(-1/\pi) \times 10^{-9}$ C/m² respectively. C, D, E are three points where electric fields (in N/C) are E_C, E_D and E_E respectively.



(A) E_C = 18, towards right
(B) E_D = 54, towards right
(C) E_D = 18, towards right
(D) E_E = 18, towards right

43. If three infinite charged sheets of uniform surface charge densities σ, 2σ and –4σ are placed as shown in figure, then find out electric field intensities at points A, B, C and D.



44. An infinitely large non-conducting plane of positive charge having a uniform surface charge density σ is kept vertical. A small ball B of mass m and charge q is attached to a thread and tied to a point A on the sheet. Find the angle θ which AB makes with the plane in equilibrium.

45. A α particle is released from rest 10 cm from a large sheet carrying a surface charge density of -2.21×10^{-9} C/m². Find the time after which it shall strike the sheet.. ($\epsilon_0 = 8.84 \times 10^{-12}$ C²/Nm²)

46. Find out electric field intensity due to uniformly charged solid nonconducting sphere of volume charge density ρ and radius R at following points :

(i) At a distance r from surface of sphere (inside)

(ii) At a distance r from the surface (outside)

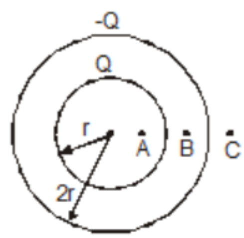
47. Repeat the question if sphere is a hollow nonconducting sphere of radius R and uniform surface charge density σ.

48*. A non-conducting solid sphere of radius R is uniformly charged. The magnitude of the electric field due to the sphere at a distance r from its centre.

(A) increase as r increase, for $r \leq R$ (B) decrease as r increases, for $0 < r < \infty$.

(C) decrease as r increases, for $R < r < \infty$. (D) is discontinuous at r = R

49. consider two thin uniformly charged concentric shells of radii r and 2r having charges Q and – Q respectively, as shown. Three points A, B and C are marked at distances $\frac{r}{2}, \frac{3r}{2}$ and $\frac{5r}{2}$ respectively from their common centre. If E_A, E_B and E_C are magnitudes of the electric fields at points A, B and C respectively then



(A) $E_A > E_B > E_C$ (B) $E_C > E_B > E_A$ (C) $E_B > E_A = E_C$ (D) $E_B > E_A > E_C$

50. Consider a solid uniformly charged sphere. There are two points A (inside) and B (outside) where the electric fields are same. The ratio of distance of A to the distance of B from the surface is :

(A) 1: 1 (B) 2: 1 (C) 1: 2 (D) having many values

ELECTRIC POTENTIAL AND POTENTIAL DIFFERENCE

51. What is the potential at origin if two equal point charges 'q' are placed at (a, 0) and (–a, 0)?

52. Two particles A and B having charges of $+ 2.00 \times 10^{-6}$ C and $- 4.00 \times 10^{-6}$ C respectively are held fixed at a separation of 20.0 cm. Locate the point(s) on the line AB where the electric potential is zero.

53. Six equal point charges 'q_0' are placed at six corners of a regular hexagon of side 'a'. Find out work required to take a point charge 'q'

(i) From infinity to the centre of hexagon.

(ii) From infinity to a point on the axis which is at a distance '$\sqrt{3}$ a ' from the centre

(iii) Does your answer to part (i) and (ii) depends on the path followed by the charge.

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54. The dimensional formula of potential is

(A) $ML^2T^{-3}A^{-1}$ (B) $MLT^{-3}A^{-1}$ (C) $MT^{-4}A^{-2}$ (D) $ML^2T^{-2}A^{-1}$

55. At a certain distance from a point charge the electric field is 500 V/m and the potential is 3000 V. What is the distance ?

(A) 6 m (B) 12 m (C) 36 m (D) 144 m

56. Two equal and opposite charges each 1 μC are placed at a distance of 1 metre from each other. The potential at a point midway between the two point charges will be :

(A) zero (B) 3.6×10^{-3} V (C) 3.6×10^{-4} V (D) 4×10^{-6} V

57. 12 J of work has to be done against an existing electric field to take a charge of 0.01 C from A to B. How much is the potential difference $V_B - V_A$?

58. A charge of 8 mC is located at the origin. Calculate the work done by external agent in taking a small charge of -2×10^{-9} C from a point A(0, 0, 0.03 m) to a point B(0, 0.04 m, 0) via a point C(0, 0.06 m, 0.09 m).

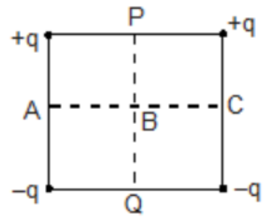
59. In front of a uniformly charged infinite nonconducting sheet of surface charge density σ, a point charge q_0 is shifted slowly from a distance a to b (b > a). If work done by external agent is W then find out relation between the given parameters.

60. An electric field of 30 N/C exists along the negative x-axis in space. Calculate the potential difference $V_B - V_A$ where the points A and B are given by,

(a) A = (0, 0) ; B = (0, 2m)

(b) A = (4m, 2m) ; B = (6m, 5m)

61. Figure represents a square carrying charges +q, +q, –q, –q at its four corners as shown. Then the potential will be zero at points



(A) A, B, C, P and Q (B) A, B and C (C) A, P, C and Q (D) P, B and Q

62. Two equal positive charges are kept at points A and B. The electric potential at the points between A and B (excluding these points) is studied while moving from A to B. The potential

(A) continuously increases (B) continuously decreases

(C) increases then decreases (D) decreases than increases

63. Ten charges (5 of them are +q each & other five are –q each) are placed randomly on the circumference of a circle. The radius of the circle is R. The electric potential at the centre of this circle due to these charges will be

(A) 0 (B) 10Kq/R (C) 5Kq/R

(D) cannot be calculated unless the positions of the charges on the circle are specified.

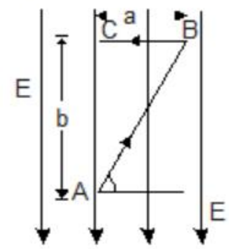
64. A charge of 5 C is given a displacement of 0.5 m, the work done by electric force in the process is 10 J. The potential difference between the two points will be :

(A) 2 V (B) 0.25 V (C) 1 V (D) 25 V

65. The kinetic energy which an electron acquires when accelerated (from rest) through a potential difference of 1 volt is called :

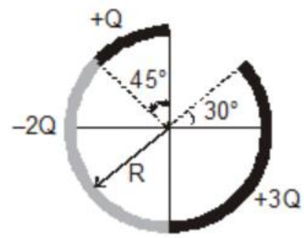
(A) 1 joule (B) 1 electron volt (C) 1 erg (D) 1 watt

66. The potential difference between points A and B in the given uniform electric field is :



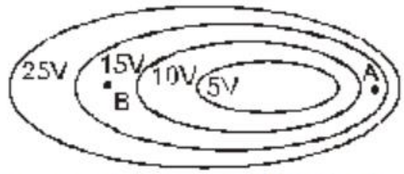
(A) Ea (B) $E\sqrt{(a^2 + b^2)}$ (C) Eb (D) $(Eb/\sqrt{2})$

67. Figure shows three circular arcs, each of radius R and total charge as indicated. The net electric potential at the centre of curvature is :



(A) $\frac{Q}{2\pi\varepsilon_0 R}$ (B) $\frac{Q}{4\pi\varepsilon_0 R}$ (C) $\frac{2Q}{\pi\varepsilon_0 R}$ (D) $\frac{Q}{\pi\varepsilon_0 R}$

68. The figure shows several equipotential lines. Comparing between points A and B, pick up the best possible statement



(A) the electric field has a greater magnitude at point A and is directed to left.

(B) the electric field has a greater magnitude at point A and is directed to right.

(C) the electric field has a greater magnitude at point B and is directed to left.

(D) the electric field has a greater magnitude at point B and is directed to right.

69. A particle of charge Q and mass m travels through a potential difference V from rest. The final momentum of the particle is :

(A) $\frac{mV}{Q}$ (B) $2Q\sqrt{mV}$ (C) $\sqrt{2m\ QV}$ (D) $\sqrt{\frac{2QV}{m}}$

70. A mercury drop of water has potential 'V' on its surface. 1000 such drops combine to form a new drop. Find the potential on the surface of the new drop.

(A) V (B) 10V (C) 100V (D) 1000V

71. If a uniformly charged spherical shell of radius 10 cm has a potential V at a point distant 5 cm from its centre, then the potential at a point distant 15 cm from the centre will be :

(A) $\frac{V}{3}$ (B) $\frac{2V}{3}$ (C) $\frac{3}{2}V$ (D) 3V

72. A hollow sphere is uniformly charged. Inside the sphere

(A) The potential is zero but the electric field is non–zero

(B) The electric field is zero but the potential is non–zero

(C) Both the electric field and the potential are non–zero

(D) Both the electric field and the potential are zero

73. Two conducting spheres of radii 4 m and 5 m are charged to the same potential. If σ_1 and σ_2 are the respective values of the surface charge densities on the two conductors, then the ratio $\frac{\sigma_1}{\sigma_2}$ is :

(A) $\frac{5}{4}$ (B) $\frac{4}{5}$ (C) $\frac{25}{16}$ (D) $\frac{16}{25}$

POTENTIAL ENERGY OF A SYSTEM OF POINT CHARGES

74. Find the potential energy of a charge q_0 placed at the centre of regular hexagon of side a, if q charge is placed at each vertex of regular hexagon?

75. Two identical charges 5 μC each are fixed at a distance 8cm and between them a charged particle of mass 9×10^{-6} kg and charge – 10 μC is placed at a distance 5 cm from each of them and is released. Find the speed of the particle when it is nearest to the two charges.

76. If a charge is shifted from a low potential region to high potential region. the electrical potential energy:

(A) Increases (B) Decreases

(C) Remains constant (D) May increase or decrease.

77. A particle of mass 2 g and charge 1μC is held at rest on a frictionless horizontal surface at a distance of 1 m from a fixed charge 1 mC. If the particle is released it will be repelled. The speed of the particle when it is at distance of 10 m from the fixed charge is:

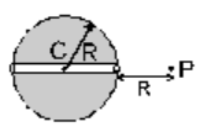
(A) 100 m/s (B) 90 m/s (C) 60 m/s (D) 45 m/s

78. A particle of mass m, charge q > 0 and initial kinetic energy K is projected from infinity toward a heavy nucleus of charge Q assumed to have a fixed position.

(a) If the aim is perfect, how close to the centre of the nucleus is the particle when it comes instantaneously to rest?

(b) With a particular imperfect aim the particle's closest approach to nucleus is twice the distance determined in (a). Determine speed of particle at the closest distance of approach.

79. A solid uniformly charged fixed non-conducting sphere of total charge Q and radius R contains a tunnel of negligible diameter. If a point charge –q of mass 'm' is released at rest from point P as shown in figure then find out its velocity at following points

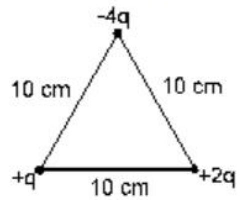


(i) At the surface of sphere (ii) At the centre of the sphere

80. Two positive point charges 15 μC and 10 μC are 30 cm apart. Calculate the work done in bringing them closer to each other by 15 cm.

81. Three point charges are arranged at the three vertices of a triangle as shown in Figure.

Given: $q = 10^{-7}$ C. Calculate the electrostatic potential energy of the system.



82. Eight equal point charges each of charge 'q' and mass 'm' are placed at eight corners of a cube of side 'a'.

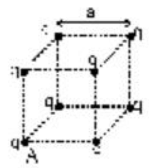
(i) Find out potential energy of charge system

(ii) Find out work done by external agent against electrostatic forces and by electrostatic forces to increase all sides of cube from a to 2a.

(iii) If all the charges are released at rest then find out their speed when they are at the corners of cube of side 2a.

(iv) If keeping all other charges fix , charge of corner 'A' is released then find out its speed when it is at infinite distance?

(v) If all charges are released at rest then find out their speed when they are at a very large distance from each other.



83. In bringing an electron towards another electron, electrostatic potential energy of the system :

(A) Deceases (B) Increases

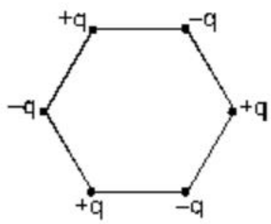
(C) Becomes zero (D) Remains same

84. When the separation between two charges is increased, the electric potential energy of the charges

(A) increases (B) decreases

(C) remains the same (D) may increase or decrease

85. Six charges of magnitude + q and –q are fixed at the corners of a regular hexagon of edge length a as shown in the figure. The electrostatic potential energy of the system of charged particles is :



(A) $\frac{q^2}{\pi \epsilon_0 a}\left[\frac{\sqrt{3}}{8}-\frac{15}{4}\right]$ (B) $\frac{q^2}{\pi \epsilon_0 a}\left[\frac{\sqrt{3}}{2}-\frac{9}{4}\right]$ (C) $\frac{q^2}{\pi \epsilon_0 a}\left[\frac{\sqrt{3}}{4}-\frac{15}{2}\right]$ (D) $\frac{q^2}{\pi \epsilon_0 a}\left[\frac{\sqrt{3}}{2}-\frac{15}{8}\right]$

86. You are given an arrangement of three point charges q, 2q and xq separated by equal finite distances so that electric potential energy of the system is zero. Then the value of x is :

(A) $-\frac{2}{3}$ (B) $-\frac{1}{3}$ (C) $\frac{2}{3}$ (D) $\frac{3}{2}$

87*. Which of the following quantities do not depend on the choice of zero potential or zero potential energy

(A) potential at a point

(B) potential difference between two points

(C) potential energy of a two - charge system

(D) change in potential energy of a two-charge system

SELF ENERGY AND ENERGY DENSITY

88. A spherical shell of radius R with a uniform charge q has point charge q_0 at its centre. Find the work performed by the electric forces during the shell expansion slowly from radius R to 2R. Also find out work done by external agent against electric forces.

89. Two identical nonconducting spherical shells having equal charge Q are placed at a distance d apart. When they are released find out kinetic energy of each sphere when they are at a large distance.

90. In a solid uniformly charged sphere of total charge Q and radius R if energy stored out side the sphere is U_0 joules then find out self energy of sphere in term of U_0?

91. A sphere of radius 1 cm has potential of 8000 V. The energy density near the surface of sphere will be:
(A) 64×10^5 J/m^3 (B) 8×10^3 J/m^3 (C) 32 J/m^3 (D) 2.83 J/m^3

92. If 'n' identical water drops assumed spherical each charged to a potential energy U coalesce to a single drop, the potential energy of the single drop is(Assume that drops are uniformly charged):
(A) $n^{1/3}$ U (B) $n^{2/3}$ U (C) $n^{4/3}$ U (D) $n^{5/3}$ U

QUESTIONS BASED ON RELATION BETWEEN $\vec{E}$ AND V :

93. If $V = x^2y + y^2z$ then find $\vec{E}(x, y, z)$

94. If $V = 2r^2$ then find out (i) $\vec{E}$ (1, 0, –2) (ii) $\vec{E}(r = 2)$

95. An electric field $\vec{E} = (20\hat{i} + 30\hat{j})$ N/C exists in the space. If the potential at the origin is taken to be zero, find the potential at (2m, 2m).

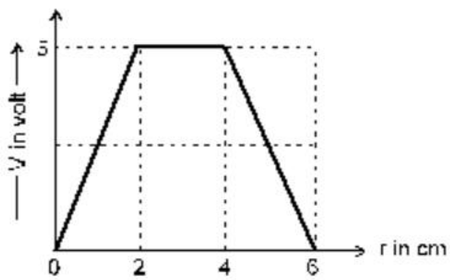
96. An electric field $\vec{E} = Ax\hat{i}$ exists in the space, where A = 10 V/m^2. Take the potential at (10 m, 20 m) to be zero. Find the potential at the origin.

97. If $E = 2r^2$ then find V(r)

98. If $\vec{E} = 2x^2\,\hat{i} - 3y^2\hat{j}$ then find v(x, y, z)

99*. The electric field intensity at a point in space is equal in magnitude to :
(A) Magnitude of the potential gradient there
(B) The electric charge there
(C) The magnitude of the electric force, a unit charge would experience there
(D) The force, an electron would experience there

100. The variation of potential with distance r from a fixed point is shown in Figure. The magnitude of electric field at r = 5 cm, is :



(A) (2.5) V/cm (B) (5) V/cm (C) (2/5) V/cm (D) (3/5) V/cm

101. The electric potential V as a function of distance x (in metre) is given by

$$V = (5x^2 + 10x - 9) \text{ volt}$$

The value of electric field at x = 1 m would be :

(A) – 20 volt/m (B) 6 volt/m (C) 11 volt/m (D) –23 volt/m

102. In the above question the electric force acting on a point charge of 2 C placed at the origin will be :

(A) 2 N (B) 6 N (C) –8 N (D) – 20 N

103. A uniform electric field having a magnitude E_0 and direction along positive X-axis exists. If the electric potential V is zero at x = 0, then its value at x = +x will be :

(A) $V_x = xE_0$ (B) $V_x = -xE_0$ (C) $V_x = x^2E_0$ (D) $V_x = -x^2 E_0$

104. The electric field and the electric potential at a point are E and V respectively

(A) If E = 0, V must be zero

(B) If V = 0, E must be zero

(C) If $E \neq 0$, V cannot be zero

(D) None of these

105. The electric potential decreases uniformly from 120 V to 80 V as one moves on the X-axis from x = – 1 cm to x = + 1 cm. The electric field at the origin

(A) must be equal to 20V/cm

(B) may be equal to 20V/cm

(C) may be greater than 20V/cm

(D) may be less than 20V/cm

106. The electric field in a region is directed outward and is proportional to the distance r from the origin. Taking the electric potential at the origin to be zero, the electric potential at a distance r :

(A) is uniform in the region

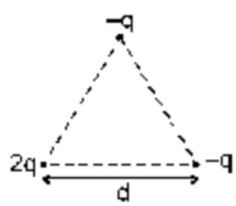
(B) is proportional to r

(C) is proportional to r^2

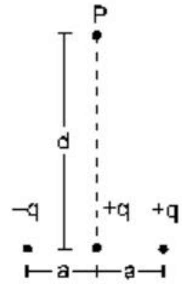
(D) increases as one goes away from the origin.

DIPOLE

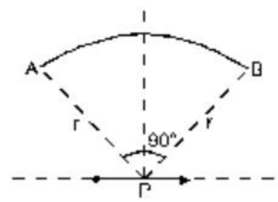
107. Three charges are arranged on the vertices of an equilateral triangle as shown in figure. Find the dipole moment of the combination.



108. Find the magnitude of the electric field at the point P in the configuration shown in figure for d >> a. Take 2qa = p.

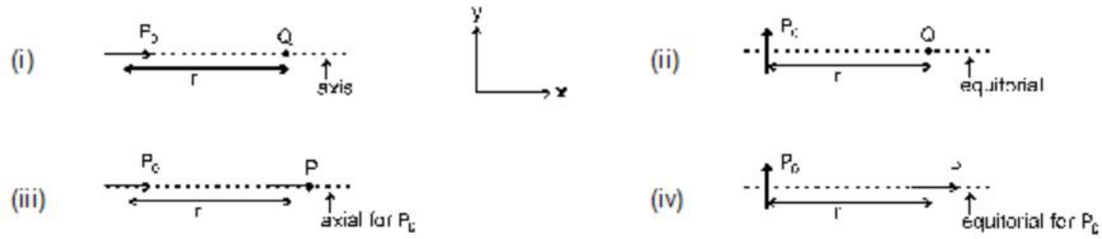


109. A charge 'q' is carries slowly from a point A (r, 135°) to point B (r, 45°) following a path which is a quadrant of circle of radius 'r'. If the dipole moment is $\vec{P}$, then find out the work done by external agent?



110. Find out force and torque experienced by short dipole $\vec{P}_0$ in following different arrangements as shown in figures.

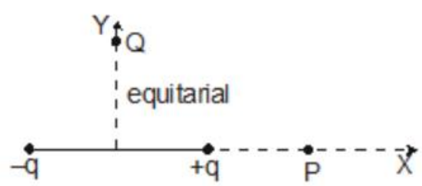
[Assume point charge is Q, $\vec{P}_0 = q_0(2a)$ and $\vec{p} = q(2a)$]



111. Find out the magnitude of electric field intensity at point (2, 0, 0) due to a dipole of dipole moment, $\vec{P} = \hat{i} + \sqrt{3}\,\hat{j}$ kept at origin? Also find out the potential at that point.

112 . A molecule of a substance has permanent electric dipole moment equal to 10^{-29} C-m. 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. For simplicity, assume 100% polarisation to the sample.

113. Due to an electric dipole shown in fig., the electric field intensity is parallel to dipole axis :



(A) at P only (B) at Q only (C) both at P and at Q (D) neither at P nor at Q

114. An electric dipole of moment $\vec{p}$ is placed at the origin along the x-axis. The angle made by electric field with x-axis at a point P, whose position vector makes an angle θ with x-axis, is (where $\tan\alpha = \frac{1}{2}\tan\theta$)

(A) α (B) θ (C) $\theta + \alpha$ (D) $\theta + 2\alpha$

115. An electric dipole consists of two opposite charges each of magnitude 1.0 μC separated by a distance of 2.0 cm. The dipole is placed in an external field of 1.0×10^5 N/C. The maximum torque on the dipole is :

(A) 0.2×10^{-3} N-m (B) 1.0×10^{-3} N-m (C) 2.0×10^{-3} N-m (D) 4.0×10^{-3} N-m

116. A dipole of electric dipole moment P is placed in a uniform electric field of strength E. If θ is the angle between positive directions of P and E, then the potential energy of the electric dipole is largest when θ is :

(A) zero (B) $\pi/2$ (C) π (D) $\pi/4$

117. An electric dipole is placed (not at infinity) in an electric field generated by a point charge

(A) The net electric force on the dipole must be zero

(B) The net electric force on the dipole may be zero

(C) The torque on the dipole due to the field must be zero

(D) The torque on the dipole due to the field may be zero

118. Two opposite and equal charges 4×10^{-8} coulomb when placed 2×10^{-2} cm apart form a dipole. If this dipole is placed in an external electric field 4×10^8 N/C, the value of maximum torque and the work required in rotating it through 180º from its initial orientation which is along electric field will be (Assume rotation of dipole about an axis passing through centre of the dipole):

(A) 64×10^{-4} N-m and 44×10^{-4} J (B) 32×10^{-4} N-m and 32×10^{-4} J

(C) 64×10^{-4} N-m and 32×10^{-4} J (D) 32×10^{-4} N-m and 64×10^{-4} J

119. At a point on the axis (but not inside the dipole and not at infinity) of an electric dipole

(A) the electric field is zero

(B) the electric potential is zero

(C) neither the electric field nor the electric potential is zero

(D) the electric field is directed perpendicular to the axis of the dipole

120*. The force between two short electric dipoles separated by a distance r is directly proportional to :

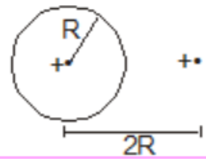
(A) r^2 (B) r^4 (C) r^{-2} (D) r^{-4}

FLUX CALCULATION AND GAUSS'S LAW

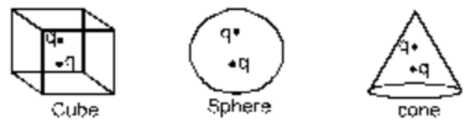
121. Find out the electric flux through an area 10 m² lying in XY plane due to an electric field $\vec{E} = 2\hat{i} - 10\hat{j} + 5\hat{k}$.

122. In a uniform electric field E if we consider an imaginary cubical close gaussian surface of side a , then find the net flux through the cube ?

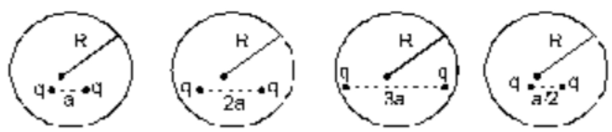
123. Find the flux of the electric field through a spherical surface of radius R due to a charge of 8.85×10^{-8}C at the centre and another equal charge at a point 2R away from the centre



124. Two point charges are placed at a certain distance (as shown in figures) inside a cube , sphere and a cone. Arrange the order of flux through the closed surfaces.



125. In which of the following case the flux is maximum through close spherical gaussian surface of radius R ?



126. A charge Q is placed at the centre of an imaginary hemispherical surface. Using symmetry arguments and the Gauss's law, find the flux of the electric field due to this charge through the surface of the hemisphere

127. What do you predict by the given statement about the nature of charge (positive or negative) enclosed by the close surface. "In a close surface lines which are leaving the surface are double then the lines which are entering in it".

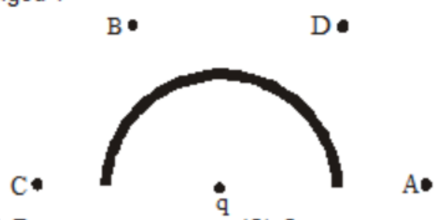
126. A charge Q is placed at the centre of an imaginary hemispherical surface. Using symmetry arguments and the Gauss's law, find the flux of the electric field due to this charge through the surface of the hemisphere

127. What do you predict by the given statement about the nature of charge (positive or negative) enclosed by the close surface. "In a close surface lines which are leaving the surface are double then the lines which are entering in it".

128. A square of side 'a' is lying in xy plane such that two of its sides are lying on the axis. If an electric field $\vec{E} = E_0 x\hat{k}$ is applied on the square. The flux passing through the square is –

(A) E_0a^3 (B) $\frac{E_0a^3}{2}$ (C) $\frac{E_0a^3}{3}$ (D) $\frac{E_0a^2}{2}$

129. Figure shows a charge q placed at the centre of a hemisphere. A second charge Q is placed at one of the positions A, B, C and D. In which position(s) of this second charge, the flux of the electric field through the hemisphere remains unchanged ?

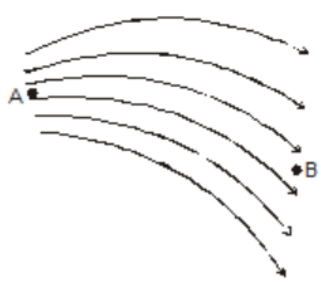


(A) A (B) B (C) C (D) D

130. If electric field is uniform, then the electric lines of forces are

(A) divergent (B) convergent (C) circular (D) parallel

131. The figure shows the electric lines of force emerging from a charged body. If the magnitude of electric fields at A and B are E_A and E_B respectively and if the distance between A and B is r, then



(A) $E_A < E_B$ (B) $E_A > E_B$ (C) $E_A = \frac{E_B}{r}$ (D) $E_A = \frac{E_B}{r^2}$

132. Select the correct statement :

(A) The electric lines of force are always closed curves

(B) Electric line of force is parallel to equipotential surface

(C) Electric line of force is perpendicular to equipotential surface

(D) Electric line of force is always the path of a positively charged particle.

133. If the electric flux entering and leaving a closed surface are respectively of magnitude ϕ_1 and ϕ_2, then the electric charge inside the surface will be :

(A) $\frac{\phi_2 - \phi_1}{\varepsilon_0}$ (B) $(\phi_1 - \phi_2)\varepsilon_0$ (C) $\varepsilon_0(\phi_2 - \phi_1)$ (D) $\varepsilon_0(\phi_2 + \phi_1)$

134*. An electric dipole is placed at the centre of a sphere, Mark the correct options.

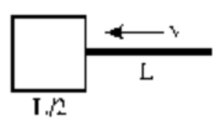
(A) The flux of the electric field through the sphere is zero

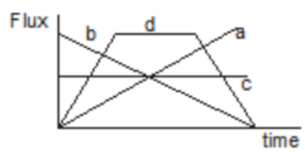
(B) The electric field is zero at every point of the sphere

(C) The electric field is not zero anywhere on the sphere

(D) The electric field is zero on a circle on the sphere.

135. Figure (a) shows an imaginary cube of edge L/2. A uniformly charged rod of length L moves towards left at a small but constant speed v. At t = 0, the left end just touches the centre of the face of the cube opposite it. Which of the graphs shown in fig.(b) represents the flux of the electric filed through the cube as the rod goes through it ?

(a) 

(b) 

(A) a (B) b (C) c (D) d

136. Electric charges are distributed in a small volume. The flux of the electric field through a spherical surface of radius 10cm surrounding the total charge is 25 V-m. The flux over a concentric sphere of radius 20cm will be

(A) 25 V-m (B) 50 V-m (C) 100 V-m (D) 200 V-m

137. Mark the correct options :

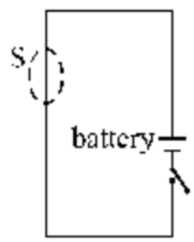
(A) Gausss's law is valid only for symmetrical charge distributions

(B) Gauss's law is valid only for charges placed in vacuum

(C) The electric field calculated by Gauss's law is the field due to the charges inside the Gaussian surface

(D) The flux of the electric field through a closed surface due to all the charge is equal to the flux due to the charges enclosed by the surface.

138*. A closed surface S is constructed around a neutral conducting wire connected to a battery and a switch as shown in figure. As the switch is closed, the free electrons in the wire start moving along the wire. In any time interval, the number of electrons entering the closed surface S is equal to the number of electrons leaving it. On closing the switch, the flux of the electric field through the closed surface.



(A) is increased (B) is decreased (C) remains unchanged (D) remains zero

14. $\frac{mu^2}{2qE}$, $\frac{mu}{qE}$ 15. B 16. ABC

17. B 18. B 19. $30\sqrt{3}$ = 52 s

20. D 21. $\vec{E}=\frac{Q}{4\pi\epsilon_0 r^3}\vec{r}$ and $\vec{r}=\hat{i}+\hat{j}+\hat{k}$

22. B 23. $\frac{20}{\sqrt{2}-1}$ = 48.3 cm from A along BA

24. $\left(\sqrt{2}+\frac{1}{2}\right)\frac{Kq_0}{a^2}$ 25. D 26. B

27. $2540\hat{i}+2000\hat{j}+1720\hat{k}$ N/C. 28. C

29. $\frac{2K\lambda}{r}$ = 18 × 10^5 N/C 30. D

31. (120 i + 160 j) N/C 32. A 33. $\frac{QdL}{8\pi^2\epsilon_0 a^3}$

34. zero 35. B 36. B

37. D 38. $\frac{1}{4\pi\epsilon_0}\frac{\lambda}{r}$ 39. C

40. (i) $\frac{4K\lambda}{x}$; along OP,

(ii) $\frac{4K\lambda}{x}\cot\frac{\theta}{2}$; Perpendicular to OP.

41. D 42. BD

43. $E_A = \frac{-\sigma}{2\epsilon_0}\hat{j}$, $E_B = \frac{-3\sigma}{2\epsilon_0}\hat{j}$,

$E_C = \frac{-7\sigma}{2\epsilon_0}\hat{j}$, $E_D = \frac{\sigma}{2\epsilon_0}\hat{j}$,

53. (i) $\frac{6Kqq_0}{a}$ (ii) $\frac{3Kqq_0}{a}$ (iii) No

54. A 55. A 56. A

57. 1200 volts 58. $W = Kqq_0\left(\frac{1}{r_B}-\frac{1}{r_A}\right)$ = 1.2 J

59. $\frac{W}{q_0} = -\frac{\sigma}{2\epsilon_0}(b-a)$ 60. (a) 0, (b) E.d = 60

61. B 62. D 63. A

64. A 65. B 66. C

67. A 68. A 69. C

70. C 71. B 72. B

73. A 74. $\frac{6Kqq_0}{a}$ 75. 10^3 m/s

76. D 77. B

78. (a) $\frac{Qq}{4\pi\epsilon_0 K}$ (b) $\sqrt{\frac{K}{m}}$

79. $v_{surface} = \sqrt{\frac{qQ}{4\pi\epsilon_0 mR}}$ (ii) $v_{centre} = \sqrt{\frac{qQ}{2\pi\epsilon_0 mR}}$

80. 4.5 J 81. -9.0×10^{-3} J.

82. *(i)* $\frac{4Kq^2}{a}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right]$ *(ii)* $W_{ext} = -\frac{2Kq^2}{a}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right]$, $W_{el} = \frac{2Kq^2}{a}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right]$

(iii) $\sqrt{\frac{Kq^2}{2ma}\left[3+\frac{3}{\sqrt{2}}+\frac{1}{\sqrt{3}}\right]}$

(iv) $\sqrt{\dfrac{2Kq^2}{ma}\left[3+\dfrac{3}{\sqrt{2}}+\dfrac{1}{\sqrt{3}}\right]}$

(v) $\sqrt{\dfrac{Kq^2}{ma}\left[3+\dfrac{3}{\sqrt{2}}+\dfrac{1}{\sqrt{3}}\right]}$

83. B 84. D 85. D

85. A **86. A 87. BD**

88. $W_{el} = \dfrac{q(q_0 + q/2)}{8\pi\varepsilon_0 R}$, $W_{ext} = -\dfrac{q(q_0 + q/2)}{8\pi\varepsilon_0 R}$

89. $K.E. = \dfrac{1}{2}\dfrac{Q^2}{4\pi\varepsilon_0 d}$ 90. $\dfrac{6U_0}{5}$ Joules

91. D 92. D

93. $-2xy\,\hat{i} - (x^2 + 2yz)\,\hat{j} - y^2\hat{k}$

94. (i) $-4(\hat{i} - 2\hat{k})$ (ii) $\vec{E} = -8\hat{r}$

95. $V = -\int_0^2 20dx - \int_0^2 30dy = -100$ V

96. 500 V 97. $\dfrac{-2r^3}{3} + C$

98. $-\dfrac{2x^3}{3} + y^2 + C$ 99. AC 100. A

101. A 102. D 103. B

104. D 105. BC 106. C

125. Same in all cases. 126. $Q/(2\varepsilon_0)$

127. There is net positive charge in the close surface.

128. B 129. AC 130. D

131. B 132. C 133. C

134. AC 135. D 136. A

137. D 138. D 139. C

140. A 141. C

142. (a) $\dfrac{Q}{2A}$ (b) $\dfrac{Q}{2A\varepsilon_0}$ towards left

(c) $\dfrac{Q}{2A\varepsilon_0}$ towards right (d) $\dfrac{Q}{2A\varepsilon_0}$ towards right

143. $-\dfrac{Q}{2}$

144. (a) zero (b) σ/ε_0, Towards left (c) zero

145. (i) $\dfrac{Q'_1}{Q'_2} = \dfrac{2}{3}$ (ii) $\dfrac{2}{5}\times 30 = 12\ \mu C$,

$\dfrac{3}{5}\times 30 = 18\ \mu C$ (iii) $\dfrac{\sigma'_1}{\sigma'_2} = \dfrac{3}{2}$

(iv) $2\pi\varepsilon_0\left(\dfrac{r_1 r_2}{r_1 + r_2}\right)(v_1 - v_2)^2 = 1.49$ Joules

146. (i) on inner shell = 0, on outer shell = $Q_a + Q_b$

107. $qd\sqrt{3}$, along the bisector of the angle at 2q, away from the triangle

108. $\frac{1}{4\pi\varepsilon_0 d^3}\sqrt{q^2d^2 + p^2}$

109. $\frac{\sqrt{2}\, qP}{4\pi\varepsilon_0 r^2}$

110. (i) $\frac{2KP_0Q}{r^3}(-\hat{i})$ (ii) $\frac{KP_0Q}{r^3}\hat{j}$

(iii) $\frac{6KP_0P}{r^4}\hat{i}$ (iv) $\frac{3KP_0P}{r^4}(-\hat{j})$

111. $|E| = \frac{\sqrt{7}K}{8}$, $V = \frac{K}{4}$ [where $K = 1/4\pi\epsilon_0$]

112.	3 J	113.	C	114.	C
115.	C	116.	C	117.	D
118.	D	119.	C	120.	D

121. 50 Nm^2/C.

122. 0

123. $10^4 \frac{N-m^2}{C}$

124. $\phi_{cube} = \phi_{sphere} = \phi_{cone} = \frac{2q}{\varepsilon_0}$.