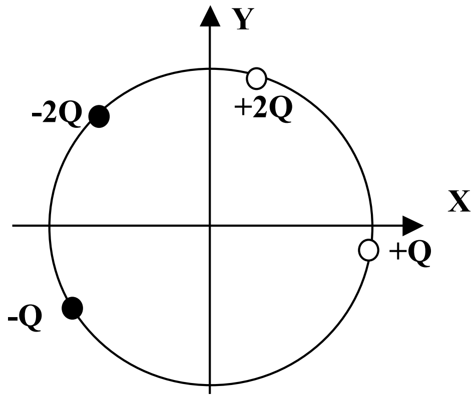
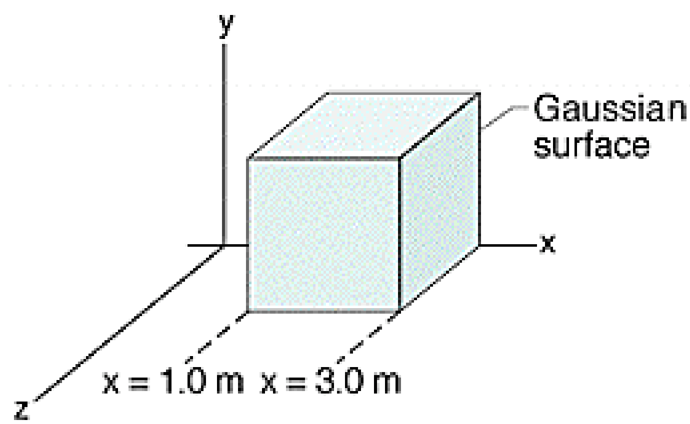
1. The figure below shows 4 point charges located on a circle centered about the origin. The exact locations of the charges on the circle are not given. What can you say about the electric potential created by these charges at the center of the circle?



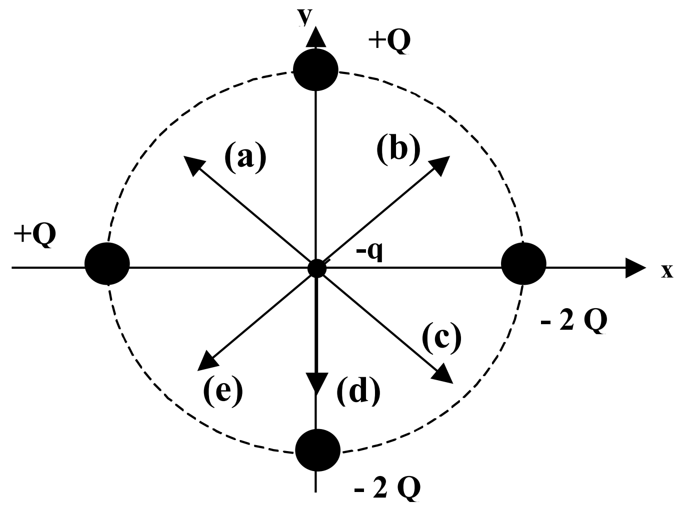
(a) The electric potential is 0 V.
(b) The electric potential is positive.
(c) The electric potential is negative.
(d) The electric potential may be either positive or negative, depending of the precise positions of the charges.
(e) Without knowing the positions of the charges, we cannot be precise about the electric potential.

2. An electric field given by **E** = 3 **i** - 3(y^2 + 7) **j** pierces the Gaussian CUBE of side **2 m** shown in the figure below. (*E* is in newtons per coulomb and *x* is in meters. The vectors **i** and **j** are unite vectors along the x and y directions as usual.) What is the electric flux through the top face?

(a) 672 N m^2/C
(b) –321 N m^2/C
(c) 105 N m^2/C
(d) –132 N m^2/C
(e) 251 N m^2/C



3. The adjacent figure shows 4 point charges located on a circle of radius **R**. A <u>negatively charged</u> particle of charge **- q** and mass **m** is released from rest at the center of the circle. Which of the arrows correctly indicates the direction of the instantaneous acceleration of this charge immediately upon release? (The vectors indicated by (a), (b), (c) and (e) all make a 45^0 angle with the x-axis.)



4. In Q3, what is the magnitude of the instantaneous acceleration of the charged particle immediately upon release? (In the equations below, $k = 1/4\pi\epsilon_0$)

(a) $\frac{kqQ}{mR}$

(b) $\frac{4.24kqQ}{mR^2}$

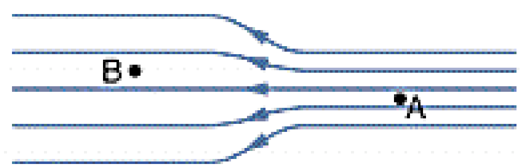
(c) $\frac{3kqQ}{R^2}$

(d) $\frac{3kQ}{mR^2}$

(e) $\frac{3kqQ}{mR^2}$

5. An electric dipole that is completely free to move (both rotation and translation) is placed in a region of uniform electric field. Which of the following statements is incorrect?
(a) The total force on the dipole is zero no matter what its orientation in the electric field.
(b) The total torque on the dipole is zero when the dipole moment points opposite to the electric field.
(c) The total torque on the dipole is a maximum when the dipole moment is perpendicular to the electric field.
(d) The total torque on the dipole is zero when the dipole moment points in the same direction as the electric field.
(e) The potential energy of the dipole is a maximum when the dipole moment points in the same direction as the electric field.

6. The electric field lines in some region of space are shown in the figure below. At B the spacing between the lines is twice that at A. If a proton placed at A experiences a force of magnitude 10 pN, what is the direction and magnitude of the force experienced by an electron at point B?



(a) 5 pN to the right.
(b) 5 pN to the left.
(c) 20 pN to the left.
(d) 20 pN to the right.
(e) 10 pN to the right.

7. Two point charges of equal magnitude but opposite sign are 1 □m apart from each other, forming an electric dipole. At a point *on the perpendicular bisector* of the dipole 1 mm away from the center of the dipole, the electric field is 27 N/C. What is the electric field *on the dipole axis* at a spot 3 mm away from the dipole center?

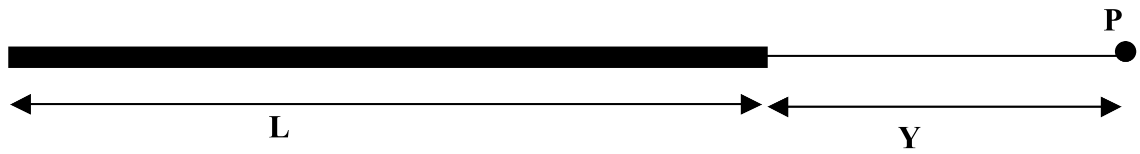
(a) There isn't enough information given to answer this.
(b) 27 N/C.
(c) 3 N/C.
(d) 2 N/C
(e) 1 N/C.

8. The electric field very close to the surface of a charged conductor is measured to be 8.85 x 10^6 V/m. What can you conclude from this measurement?

(a) The local charge density on the surface is non-uniform.
(b) The measurement must be wrong since this field is too large.
(c) The local charge density on a point on the surface close to where the measurement was made must be about 1 μC/m^2.
(d) The local charge density on a point on the surface close to where the measurement was made must be about 81 μC/m^2
(e) The local charge density on a point on the surface close to where the measurement was made must be about 0.5 μC/m^2.

9. A point charge placed 1 mm away from an infinitely large sheet of charge experiences a force of 10 N. What is the force experienced by this charge if you move it to a point that is 5 mm away from the sheet?
(a) 0.4 N.
(b) Finite, but extremely small.
(c) 50 N.
(d) 2 N.
(e) 10 N.

10. The figure below shows a thin, straight rod of length L over which a charge Q is uniformly distributed. Which of the expressions below gives the magnitude of the electric potential at point P located a distance Y away from the rod on a line that is collinear with the rod? Take the rod to lie along the x-axis, with x = 0 at the extreme left end of the rod.



(a) $\frac{Q}{4\pi\epsilon_0 L}\int_0^L \frac{dx}{(L - x + Y)}$

(b) $\frac{Q}{4\pi\epsilon_0 L}\int_0^L \frac{dx}{(x + L)^2}$

(c) $\frac{Q}{4\pi\epsilon_0 L}\int_0^Y \frac{dx}{(x + Y)}$

(d) $\frac{Q}{4\pi\epsilon_0 L}\int_0^L \frac{dx}{(x + Y)}$

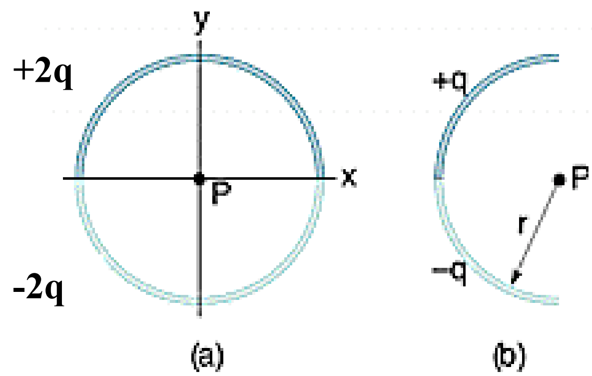
(e) $\frac{Q}{4\pi\epsilon_0 L}\int_0^L \frac{dx}{(L + Y - x)^2}$

11. A 1 F capacitor is fully charged using a 1.5 V battery. The capacitor is then discharged by connecting it across a light bulb. How much energy is dissipated in the light bulb during the discharge?

(a) 1.5 J
(b) 1 J.
(c) 1.125 J.
(d) 0.5 J.
(e) 2.25 J.

12. In the figure below, the arcs all have the same radius r and are uniformly charged as shown. In figure (a), the magnitude of the electric field at the origin is 2 N/C. What is the magnitude and direction of the electric field at the origin for the arrangement in figure (b)?

(a) 4 N/C, along the positive x-axis.
(b) 2 N/C along the negative y-axis.
(c) 1.414 N/C along the negative x-axis.
(d) 1.414 N/C along the negative y-axis.
(e) 1 N/C along the negative y-axis.



13. A <u>hollow conducting sphere</u> has some unknown amount of excess charge. It takes you 1 mJ of work to bring a 2 C charge from infinity to the surface of the sphere. What is the electric potential at the center of the sphere? Assume that the electric potential at infinity is 0 V.
(a) We cannot answer this without knowing the radius of the sphere.
(b) We cannot answer this without knowing both the charge on the sphere.
(c) The potential is 0 V since the sphere is a conductor.
(d) The potential is 0.5 mV since the sphere is a conductor.
(e) The potential is positive but we need to know the radius of the sphere to calculate a precise value.

14. In a given lightning flash, the potential difference between a cloud and the ground is 1.6 x 10^9 V and the quantity of charge transferred is 40 C. What is the change in energy of the transferred charge? ("G" = "giga" = 10^9, "M" = "mega" = 10^6)
(a) 64 GJ.
(b) 32 MJ.
(c) 26 GJ.
(d) 53 GJ.
(e) 46 MJ.

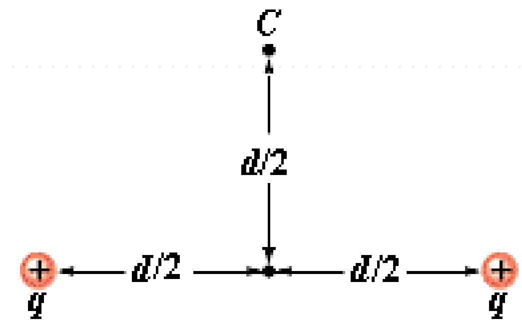
15. You are told that the total electric flux through the all faces of a regular tetrahedron (i.e. four equilateral triangles as faces) is -10 Nm^2/C. What can you conclude from this information?

(a) Each face of the solid must have a flux of -2.5 Nm^2/C.
(b) The tetrahedron probably contains a net negative charge, but we can't say how much.
(c) The tetrahedron probably contains a net positive charge, but we can't say how much.
(d) The tetrahedron contains -10 C of charge.
(e) The tetrahedron contains -8.85 x 10^{-11} C of charge.

16. You are located 5 m radially away from the axis of an extremely long uniformly charged cylinder of radius 1 mm. If you double your distance from the cylinder, what happens to the electric field?

(a) Remains the same.
(b) Decreases by a factor of 2.
(c) Decreases by a factor of 4.
(d) Decreases by a factor of 8.
(e) Increases by a factor of 4.

17. In the figure below, the two point charges each have a value q = +2 μC. The distance between the charges d = 2 m. You bring a third charge Q = +0.3 μC from infinity to the point C. How much work do you perform?

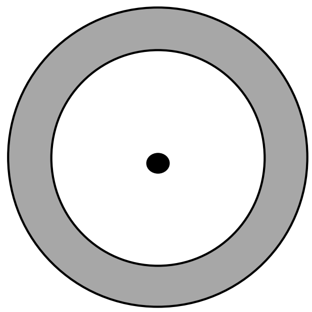


(a) 9.9 mJ.
(b) 1.26 mJ.
(c) 2.31 mJ.
(d) 7.63 mJ.
(e) 6.42 mJ.

18. A sphere of radius 3 cm has an unknown amount of charge uniformly distributed over its volume. If the electric field at a distance 10 cm from the center of the sphere is 3×10^{-3} N/C and points radially inward, what is the total charge on the sphere?

(a) -8.76×10^{-9} C
(b) -1.78×10^{-19} C
(c) -2.54×10^{-3} C
(d) $+1.26 \times 10^{-7}$ C
(e) -3.33×10^{-15} C

19. The figure below shows a spherical conducting shell surrounding a point charge Q = +1nC located at the center of the shell. If an excess charge of +1 nC is placed on the conducting shell, how does this charge distribute itself on the inner and outer surfaces of the shell?



Point charge at center = +1nC; surrounding shell carries excess charge of +1nC.

(a) 0 on the outside, -1 nC on the inside.
(b) +2 nC on the outside, -1 nC on the inside.
(c) +1 nC on the outside, -1 nC on the inside.
(d) –2 nC on the outside, +1 nC on the inside.
(e) +2 nC on the outside, 0 on the inside.

20. In the adjacent figure, the battery supplies 12 V. The values of the capacitors are $C_1 = C_2 = 10\ \mu F$, $C_3 = C_4 = 20\ \mu F$. If both switches S_1 and S_2 are closed, what is the charge on C_1?

(a) 80 μC
(b) 60 μC
(c) 40 μC
(d) 20 μC
(e) 10 μF