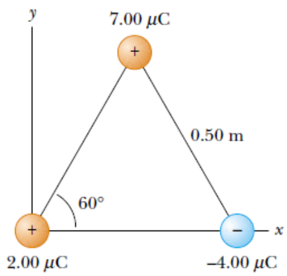
EXERCISES 10.B

Section 1: Coulomb's Law

1. Two protons in an atomic nucleus are typically separated by a distance of 2×10^{-15}m. The electric repulsion force between the protons is huge, but the attractive nuclear force is even stronger and keeps the nucleus from bursting apart. What is the magnitude of the electric force between two protons separated by 2×10^{-15}m ?
2.a) Two protons in a molecule are separated by 3.8×10^{-10}m. Find the electric force exerted by one proton on the other.
b) How does the magnitude of this force compare to the magnitude of the gravitational force between the two protons?
c) What If? What must be the charge to mass ratio of a particle if the magnitude of the gravitational force between two of these particles equals the magnitude of electric force between them?
3.Three point charges are located at the corners of an equilateral triangle as shown in Figure. Calculate the resultant electric force on the 7μC charge.



This figure is for question and

4. Two identical conducting small spheres are placed with their centers 0.3m apart. One is given a charge of 12nC and the other a charge of -18nC. a) Find the electric force exerted by one sphere on the other.
b) What If? The spheres are connected by a conducting wire. Find the electric force between the two after they have come to equilibrium.

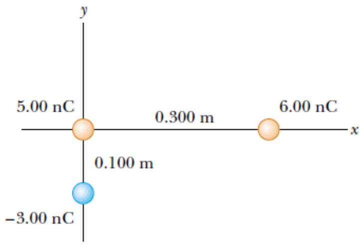
Section 2 : The Electric Field

5.What are the magnitude and direction of the electric field that will balance the weight of (a) an electron and (b) a proton?

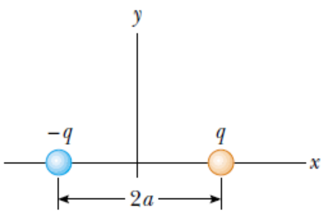
Charge and Mass of the Electron, Proton, and Neutron

Particle	Charge (C)	Mass (kg)
Electron (e)	$-1.602\,191\,7 \times 10^{-19}$	$9.109\,5 \times 10^{-31}$
Proton (p)	$+1.602\,191\,7 \times 10^{-19}$	$1.672\,61 \times 10^{-27}$
Neutron (n)	0	$1.674\,92 \times 10^{-27}$

6. An object having a net charge of 24μC is placed in a uniform electric field of 610 N/C directed vertically. What is the mass of this object if it "floats'' in the field?
7. An airplane is flying through a thundercloud at a height of 2000 m. (This is a very dangerous thing to do because of updrafts, turbulence, and the possibility of electric discharge) If a charge concentration of +40C is above the plane at a height of 3000 m within the cloud and a charge concentration of-40C is at height 1000 m, what is the electric field at the aircraft?
8. Two point charges are located on the x axis. The first is a charge $+Q$ at $x = -a$. The second is an unknown charge located at $x = -3a$. The net electric field these charges produce at the origin has a magnitude of $2keQ/a2$. What are the two possible values of the unknown charge?
9. Three charges are at the corners of an equilateral triangle as shown in Figure.
a) Calculate the electric field at the position of the 2μC charge due to the 7μC and -4μC charges.
b) Use your answer to part (a) to determine the force on the 2μC charge.
10. Three point charges are arranged as shown in Figure.
a) Find the vector electric field that the 6nC and -3nC charges together create at the origin.
b) Find the vector force on the 5nC charge.

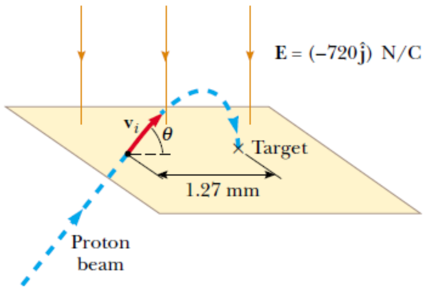


11. Two 2 μC point charges are located on the x axis. One is at x =1m, and the other is at x=-1.00 m.
a) Determine the electric field on the y axis at y =0.5m.
b) Calculate the electric force on a -3μC charge placed on the y axis at y= 0.5 m.
12.Consider the electric dipole shown in Figure. Show that the electric field at a *distant* point on the +x axis is $E_x \approx 4k_e qa/x^3$.

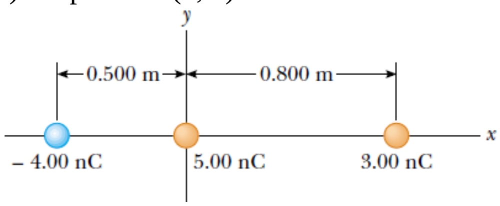


Section 3 : Motion of Charged Particles in a Uniform Electric Field

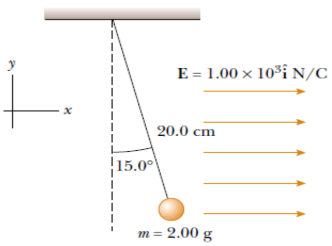
13. An electron and a proton are each placed at rest in an electric field of 520 N/C. Calculate the speed of each particle 48ns after being released.
14.A proton accelerates from rest in a uniform electric field of 640 N/C. At some later time, its speed is 1.2×10^6 m/s (nonrelativistic, because v is much less than the speed of light).
a) Find the acceleration of the proton.
b) How long does it take the proton to reach this speed?
c) How far has it moved in this time?
d) What is its kinetic energy at this time?
15. A proton is projected in the positive x direction into a region of a uniform electric field $E=-6\times10^5\vec{i}$ N/C at t=0. The proton travels 7cm before coming to rest. Determine:
a) the acceleration of the proton b) its initial speed c) the time at which the proton comes to rest.
16.The electrons in a particle beam each have a kinetic energy K. What are the magnitude and direction of the electric field that will stop these electrons in a distance d ?
17. A positively charged bead having a mass of 1g falls from rest in a vacuum from a height of 5m in a uniform vertical electric field with a magnitude of 1×10^4 N/C. The bead hits the ground at a speed of 21m/s.
Determine: a) the direction of the electric field (up or down),
b) the charge on the bead.
18.A proton moves at 4.5×10^5 m/s in the horizontal direction. It enters a uniform vertical electric field with a magnitude of 9.6×10^3N/C. Ignoring any gravitational effects, find:
a) the time interval required for the proton to travel 5cm horizontally,
b) its vertical displacement during the time interval in which it travels 5cm horizontally,
c) the horizontal and vertical components of its velocity after it has traveled 5cm horizontally.
19. Protons are projected with an initial speed v_i=9.55×10^3m/s into a region where a uniform electric field $E=-720\vec{j}$ N/C is present, as shown in Figure. The protons are to hit a target that lies at a horizontal distance of 1.27mm from the point where the protons cross the plane and enter the electric field in Figure
Find: a) the two projection angles + that will result in a hit and
b) the total time of flight (the time interval during which the proton is above the plane in Figure for each trajectory.



20.Three point charges are aligned along the x axis as shown in Figure. Find the electric field at:
a) the position (2, 0) b) the position (0, 2).

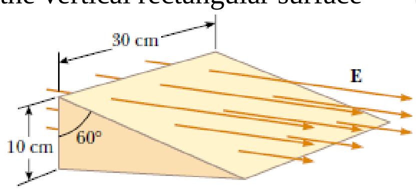


21. A small, 2g plastic ball is suspended by a 20cm long string in a uniform electric field as shown in Figure. If the ball is in equilibrium when the string makes a 15° angle with the vertical, what is the net charge on the ball?



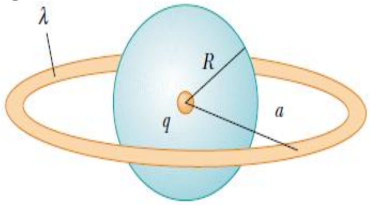
Section 4 : Electric Flux

22. An electric field with a magnitude of 3.50 kN/C is applied along the x axis. Calculate the electric flux through a rectangular
plane 0.350 m wide and 0.700 m long assuming that:
a) the plane is parallel to the yz plane;
b) the plane is parallel to the xy plane;
c) the plane contains the y axis, and its normal makes an angle of 40° with the x axis.
23. A vertical electric field of magnitude 2×10^4N/C exists above the Earth's surface on a day when a thunderstorm is brewing. A car with a rectangular size of 6m by 3m is traveling along a roadway sloping downward at 10°. Determine the electric flux through the bottom of the car. A 40cm diameter loop is rotated in a uniform electric field until the position of maximum electric flux is found. The flux in this position is measured to be 5.2×10^5 Nm^2/C. What is the magnitude of the electric field?
24. Consider a closed triangular box resting within a horizontal shown in Figure. Calculate the electric flux through
a) the vertical rectangular surface b) the slanted surface c) the entire surface of the box.



25. A uniform electric field $a\vec{i} + b\vec{j}$ intersects a surface of area A. What is the flux through this area if the surface lies
a) in the yz plane? b) in the xz plane? c) in the xy plane?
26. A point charge q is located at the center of a uniform ring having linear charge density 3 and radius a, as shown in

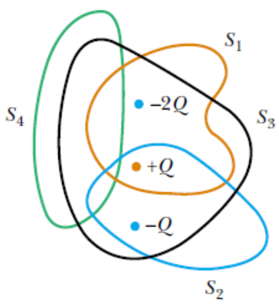
Figure. Determine the total electric flux through a sphere centered at the point charge and having radius R, where $R < a$.



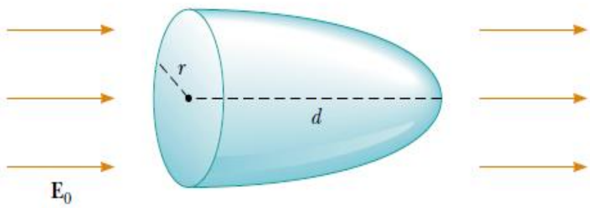
27. A pyramid with horizontal square base, 6m on each side, and a height of 4m is placed in a vertical electric field of 52N/C. Calculate the total electric flux through the pyramid's four slanted surfaces.

Section 5 : Gauss's Law

28.The following charges are located inside a submarine:5μC, -9μC, 27μC, and -84μC.
a) Calculate the net electric flux through the hull of the submarine.
b) Is the number of electric field lines leaving the submarine greater than, equal to, or less than the number entering it?
29. The electric field everywhere on the surface of a thin spherical shell of radius 0.75m is measured to be 890 N/C and points radially toward the center of the sphere.
a) What is the net charge within the sphere's surface?
b) What can you conclude about the nature and distribution of the charge inside the spherical shell?
30. Four closed surfaces, $S1$ through $S4$, together with the charges -2Q, Q, and -Q are sketched in Figure. (The colored lines are the intersections of the surfaces with the page.) Find the electric flux through each surface.



31.Calculate the total electric flux through the paraboloidal surface due to a uniform electric field of magnitude E_0 in the direction shown in Figure.



32. A point charge of 12μC is placed at the center of a spherical shell of radius 22cm. What is the total electric flux through:
a) the surface of the shell
b) any hemispherical surface of the shell?
c) Do the results depend on the radius? Explain.
33. An uncharged non conducting hollow sphere of radius 10cm surrounds a 10μC charge located at the origin of a cartesian coordinate system. A drill with a radius of 1mm is aligned along the z axis, and a hole is drilled in the sphere. Calculate the electric flux through the hole.
34. A charge of 170μC is at the center of a cube of edge 80cm.
a) Find the total flux through each face of the cube.
b) Find the flux through the whole surface of the cube.
c) What If? Would your answers to parts (a) or (b) change if the charge were not at the center? Explain.

Section 6 : Application of Gauss's Law to Various Charge Distributions

35. Determine the magnitude of the electric field at the surface of a lead-208 nucleus, which contains 82 protons and 126 neutrons. Assume the lead nucleus has a volume 208 times that of one proton, and consider a proton to be a sphere of radius 1.2×10^{-15} m.
36. A solid sphere of radius 40cm has a total positive charge of 26µC uniformly distributed throughout its volume. Calculate the magnitude of the electric field: a) 0cm b) 10cm c) 40cm d) 60cm from the center of the sphere.
37. A 10g piece of Styrofoam carries a net charge of -0.7µC and floats above the center of a large horizontal sheet of plastic that has a uniform charge density on its surface. What is the charge per unit area on the plastic sheet?
38. A cylindrical shell of radius 7cm and length 240 cm has its charge uniformly distributed on its curved surface. The magnitude of the electric field at a point 19.0 cm radially outward from its axis (measured from the midpoint of the shell) is 36kN/C. Find: a) the net charge on the shell
b) the electric field at a point 4cm from the axis, measured radially outward from the midpoint of the shell.
39. Fill two rubber balloons with air. Suspend both of them from the same point and let them hang down on strings of equal length. Rub each with wool or on your hair, so that they hang apart with a noticeable separation from each other. Make order-of-magnitude estimates of: a) the force on each,
b) the charge on each,
c) the field each creates at the center of the other,
d) the total flux of electric field created by each balloon. In your solution state the quantities you take as data and the values you measure or estimate for them.
40. A uniformly charged, straight filament 7m in length has a total positive charge of 2µC. An uncharged cardboard cylinder 2cm in length and 10cm in radius surrounds the filament at its center, with the filament as the axis of the cylinder. Using reasonable approximations, find:
a) the electric field at the surface of the cylinder b) the total electric flux through the cylinder.
41. An insulating sphere is 8cm in diameter and carries a 5.7µC charge uniformly distributed throughout its interior volume. Calculate the charge enclosed by a concentric spherical surface with radius: a) r =2cm b) r =6cm.
42. A large flat horizontal sheet of charge has a charge per unit area of $9\mu C/m^2$. Find the electric field just above the middle of the sheet.

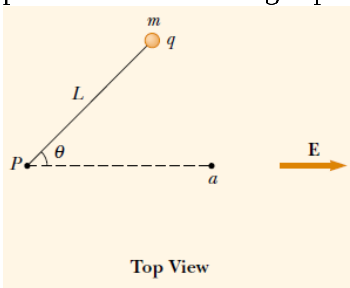
Section 7 : Potential Difference and Electric Potential

43. How much work is done (by a battery, generator, or some other source of potential difference) in moving Avogadro's number of electrons from an initial point where the electric potential is 9V to a point where the potential is -5V? (The potential in each case is measured relative to a common reference point.)
44. An ion accelerated through a potential difference of 115 V experiences an increase in kinetic energy of 7.37×10^{-17} J. Calculate the charge on the ion.
45. a) Calculate the speed of a proton that is accelerated from rest through a potential difference of 120 V.
b) Calculate the speed of an electron that is accelerated through the same potential difference.
46. What potential difference is needed to stop an electron having an initial speed of 4.2×10^5 m/s?

Section 8: Potential Differences in a Uniform Electric Field

47. The difference in potential between the accelerating plates in the electron gun of a TV picture tube is about 25 000 V. If the distance between these plates is 1.50 cm, what is the magnitude of the uniform electric field in this region?
48. An electron moving parallel to the x axis has an initial speed of 3.7×10^6 m/s at the origin. Its speed is reduced to 1.4×10^5 m/s at the point x =2cm. Calculate the potential difference between the origin and that point. Which point is at the higher potential?
49. Suppose an electron is released from rest in a uniform electric field whose magnitude is 5.9×10^3 V/m.
a) Through what potential difference will it have passed after moving 1.00 cm?
b) How fast will the electron be moving after it has traveled 1.00 cm?

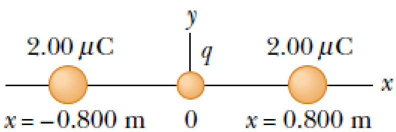
50. A particle having charge q =2μC and mass m =0.01kg is connected to a string that is L=1.50 m long and is tied to the pivot point P in Figure. The particle, string and pivot point all lie on a frictionless horizontal table. The particle is released from rest when the string makes an angle α=60° with a uniform electric field of magnitude E =300 V/m. Determine the speed of the particle when the string is parallel to the electric field (point a in Fig).



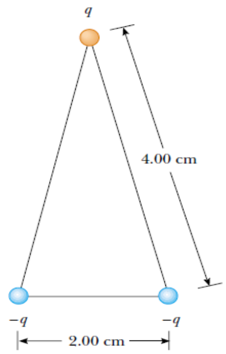
Section 9 : Electric Potential and Potential Energy Due to Point Charges

51. a) Find the potential at a distance of 1cm from a proton.
b) What is the potential difference between two points that are 1cm and 2.00 cm from a proton?
c) What If? Repeat parts (a) and (b) for an electron.

52. Given two 2μC charges, as shown in Figure and a positive test charge q=1.28×10^{-18} C at the origin,
a) what is the net force exerted by the two 2μC charges on the test charge q?
b) What is the electric field at the origin due to the two 2μC charges?
c) What is the electric potential at the origin due to the two 2μC charges?



53. The three charges in Figure are at the vertices of an isosceles triangle. Calculate the electric potential at the midpoint of the base, taking q=7C.



54. Two point charges, Q_1 =+5nC and Q_2=-3nC, are separated by 35cm.
a) What is the potential energy of the pair? What is the significance of the algebraic sign of your answer?
b) What is the electric potential at a point midway between the charges?