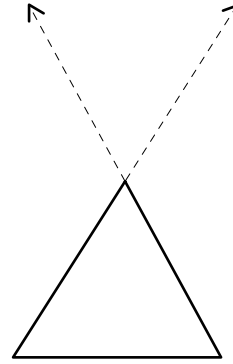


Chapter 16

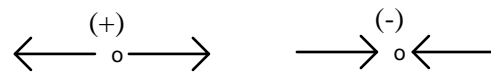
1. Change cm to m and μC to C. Use Coulomb's Law and solve for force.
2. Convert μC to Coulombs and then Coulombs to electrons using the charge of one electron given on page 482 as your conversion factor.
3. A charge of $+26 e$ means it is a positive charge that is 26 times stronger than the charge on one electron. Use that for your q_1 and the charge on 1 electron for your q_2 . You are also given distance. Plug your variables in to Coulomb's Law equation and solve for force.
4. The charge on each proton is 1.6×10^{-19} Coulombs. Use the distance given and Coulomb's Law to calculate force.
5. Change cm to m and μC to C. Use Coulomb's Law and solve for force.
6. The relationship between force and distance is $\frac{1}{r^2}$. If the distance decreases by $\frac{1}{2}$, the force will increase 4X; if the distance decreases by $\frac{1}{4}$, the force will increase 8X. If the distance increases by $\frac{1}{2}$, the force will be reduced 4X. Apply this information to the problem given.
8. First convert μC to coulombs, and then coulombs to electrons as in problem #1. Then find the mass of that many electrons if one electron weighs 9.11×10^{-31} kg.
9. Convert 1.0kg of H_2O to # atoms of H_2O . Multiply that times the number of electrons in one molecule of H_2O , and then by the charge on each electron.
12. This problem is long and will take some work. Leave yourself plenty of paper space. Using Coulomb's Law, find the force between each charge. **Example:** Find the force of $70\mu\text{C}$ on $48\mu\text{C}$, then the force of $70\mu\text{C}$ on $80\mu\text{C}$, then the force of $48\mu\text{C}$ on $80\mu\text{C}$. After you find the magnitude of the forces, decide whether the force of the first on the second is going to cause it to move right or left. If it will move left, the force is (-). If it will move right, the force is (+).

Now add these vectors for each charge. **Example:** If the force between charges 2 and 3 is -4.3N and the force between charges 1 and 3 is $+2.1\text{N}$, then the net charge on 3 is -2.2N .

13. Since this is an equilateral triangle and the charges are identical, the forces between any two charges is the same. Find the force between any two charges, place the vectors tip to tail and use vector addition to add them.



14. This is another vector problem. The forces between charges along the sides of the square will be the same because magnitudes and distances are identical. Forces between charges corner-to-corner will be smaller because the distance between them will be larger. The force on each charge will be the vector sum of the forces between that charge and each of the other three. Keep track of the directions of the forces, place the vectors tip to tail, and use vector addition to add them.
15. This problem is the same as #14, except two charges on opposite corners are negative, while the other two charges are positive. Keep track of the directions of the forces, place the vectors tip to tail, and use vector addition to add them. You will find a nice surprise.
20. Electric fields between the two charges add, so the only place to get them to cancel is outside. The positive charge is larger than the negative charge.



Let the distance to the test charge from the + charge be $(d + 0.25)$. Set the force of the (+) charge equal to the force of the (-) charge and solve for d .

23. See example 16-7 on page 451. Electric fields always point away from positive charges and toward negative charges. An electron will therefore always move in a direction opposite that which the field points. See equations 16-3 and 16-4a on page 450.
24. Use equation 16-5 on page 451 and the charge of a proton given on page 445.
25. See equations 16-3 and 16-4a on page 450.
26. Use equation 16-4a on page 450. Change cm to m.
27. See example 16-8 on page 452. Electric fields always point away from positive charges and toward negative charges. An electron will therefore always move in a direction opposite that which the field points.
Remember $F = ma$.

31. You are given the charge, the mass and the acceleration of the electron. Use that information to find the force on the electron and the magnitude of the electric field.
32. See equations 16-3 and 16-4a on page 450. Use the information given (remember the electric field is being recorded halfway between the two charges – so use $\frac{1}{2}$ the distance between them) to calculate either one of the charges.
33. You'll have to calculate the distance from each charge to the center of the square, and use those distances to calculate the electric field due to each at the center point. Remember they are vectors so you'll have to keep track of the (+)'s and the (-)'s.
34. You'll have to determine the distance of each charge from one designated corner of the square. Then use those distances to calculate the electric field at that point due to each of the 3 charges on the other three corners. As in problem #31, don't forget to keep track of (+)'s and (-)s.
52. Convert $42 \mu\text{C}$ to # electrons. That is how many electrons the penny lost. Now find out how many electrons a 3.0g copper would have if it had them all. To find the fraction lost, divide the smaller number by the larger number. That's it.
53. Convert $42 \mu\text{C}$ to # electrons. That is how many electrons the penny lost. Now find out how many electrons a 3.0g copper would have if it had them all. To find the fraction lost, divide the smaller number by the larger number. That's it.

54. The force on the proton due to the electric field must be equal in magnitude but opposite in direction for the proton to continue hovering.
Set the two equations equal and solve for the force on the proton due to the electric field.
Then you'll know the force and the charge so you can find the electric field.



64. This problem will take 3 steps.
- Use the tangent function to find the distance from either charge to the midpoint. Use that to find the distance and then the force between the two charges.
 - Gravitational force on the point charges causes the vertical force and the electric force is horizontal. The charges are identical, solve for Q.

63. Find the angular frequency, ω , using $\omega = \sqrt{\frac{k}{m}}$. Remember, the distance from equilibrium for any simple harmonic oscillator at any time $t = A \cos \omega t$. Use $E = k \frac{Q}{r^2}$ and set $r = 0.15 - 0.050 \cos \omega t$.

67. This problem will take 3 steps.
- i) You're given the length of the string (L) and (indirectly) the length of the adjacent side of the triangle formed when the charge is in an electric field. Use this information to find Θ .
 - ii) Gravitational force on the point charge causes a vertical force and the electric force is horizontal. Using trigonometry and the angle Θ you found in part (a), calculate the electric force on the charge.
 - iii) You know the electric field and the force, solve for the charge. If the charge moves in the same direction as the electric force, what must it be?

Chapter 17

1. See page 471. Assume the ground to be $V_a = 0$.
2. Use $\text{Work} = Q\Delta V$ and watch your signs.
3. The charge on an electron (q or q_e) = 1.6×10^{-19} C. Work = energy.
4. You have KE and mass (it is an electron). Find v .
5. See equations 17-4a and 17-4b page 474.
6. Change mm to meters. See equations 17-4a and 17-4b page 474.
List your variables and solve for V .
7. See equations 17-4a and 17-4b page 474. List your variables and solve for distance.
8. $\text{KE} = \text{work}$ in this case. A charge of $2e$ means it has twice the charge of one electron.
You're given work in keV. Convert to Joules and solve for potential (Volts).
9. This is a unit problem. Solve for meters.
10. The total work done is equal to the potential energy + kinetic energy. You're given the total work and the kinetic energy. First find the potential energy. Use that and the given charge to solve for potential difference.
11. Change eV to Joules. Joules measure energy and work. You're given mass (it is an electron) and KE, solve for velocity.
12. Change eV to Joules. Joules measure energy and work. You're given mass (it is a proton) and KE, solve for velocity.
13. A charge of $+2e$ means $q = 2(1.6 \times 10^{-19}$ C), but for this problem, it is irrelevant.
MeV = mega electron volts. Change them to eV and then to Joules. Now you have KE and mass, find velocity.
14. and 15. See section 17-5 page 476.
18. a) Use the Coulomb's Law derivation of the equation for electric field (pg. 450). The charge on a proton is 1.6×10^{-19} C. You now know electric field, distance and charge.
Solve for V .
b) Electric potential energy is Volts. Use the Coulomb's Law derivation equation for voltage.

20. Using the derivation of Coulomb's Law for potential, find voltage. You know the charge on an electron. Use Energy = KE = qV and solve for velocity.
23. It takes no work to move the 1st e^- because it is not working against another potential. The second e^- works against the potential of the first, and the 3rd e^- works against the potentials of the first 2 electrons. Add them together.
27. a) Find the potential (V) of the proton at 0.53×10^{-10} m.
 b) The Fe on the electron provides centripetal force. Set these two equations equal to each other and solve for velocity. Solve for the KE and convert to eV.
 c) The total energy = KE + PE. You found KE in part (b). Find PE using $U = qV$, remembering that the potential from an electron is (-). Keep your units in eV.
 d) The ionization energy is (-) the total energy.
28. See equation 17-6a on page 459. The dipole moment is the product of the magnitude of one of the charges times the separation distance.
31. The charge on each capacitor plate is always equal in magnitude but opposite in sign to the other plate. So $Q = 2500 \mu\text{C}$. Change that to coulombs and solve for Capacitance.
32. Change pF to F. Solve for V.
33. Charge is Q, measured in coulombs. Change pC to Coulombs. Solve for Capacitance.
34. You are given potential (voltage) and capacitance. Change μF to F and solve for charge.
35. See equation 17-8 on page 481.
36. See Example 17-9 on page 483. In this case, no dielectric is inserted, but capacitance remains constant.
37. Change 2.45 mm to meters. List your variables and solve for charge. Solve equation 17-7 (pg. 480) for capacitance and set it equal to equation 17-8. Solve for charge.
38. You know $Q = CV$, $V = Ed$ and $C = k\epsilon_0 \frac{A}{d}$. You can derive an equation for area in terms of what is given in two steps. First substitute $V = Ed$ for V in $Q = CV$ and solve for C. Then substitute this for C in $C = k\epsilon_0 \frac{A}{d}$. Cancel your distances and solve for A. Now substitute variables and solve for the area of the two plates.
39. Use $Q = CV$ and $V = Ed$ to derive an equation for E in terms of charge, distance and capacitance. Substitute variables and solve for electric field.
42. See equation 17-9 on page 482, and Table 17-3 on page 483.

43. Look up the dielectric constant of mica in Table 17-3 on page 483. You're given the radius of each plate so you can calculate the area. Use equation 17-8 on page 481 and solve for capacitance.
46. See section 17-9 page 484. There are three equations (17-20) for energy storage on a capacitor.
47. See section 17-9 page 484. There are three equations for energy storage on a capacitor. Substitute variables and solve for capacitance.
49. You are given distance, potential and (indirectly) area.
- Find an equation for capacitance on page 481, and assume this is an air-gap capacitor. Solve for capacitance.
 - Combine $Q = CV$ and $C = k\epsilon_0 \frac{A}{d}$ to derive an equation for charge in terms of the variables given. Substitute variables and solve for charge.
 - Too easy. $V = Ed$. Remember you're calculating the field at a point $\frac{1}{2}$ way between the plates.
 - See section 17-9 page 484. There are three equations for energy storage on a capacitor. Substitute variables and solve for stored energy
 - See Conceptual Example 17-9 on page 483.
56. a) Change MJ (megajoules) to joules. You now have energy and charge - solve for V.
b) Assuming all those MJ of energy become heat, use the heat equation to calculate the mass of water that can be brought from 20°C to boiling.
57. See equation 17-9 on page 584.
58. The acceleration is provided by the electric force. The acceleration has to be larger than g for the electrons to be able to move. To find the potential necessary to keep the electrons stationary, set $mg = Fe$. Solve for V.
59. This problem takes 2 steps. First calculate the energy necessary to heat that much water from 20° to the temperature given. Now use one of the energy storage equations and solve for potential difference.
61. See homework problem #37 in this chapter.

