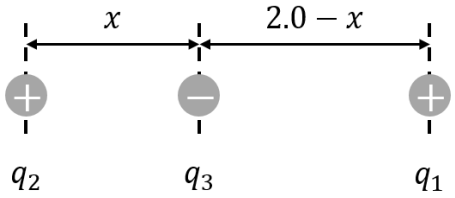
EP0605 Tutorial 6 – Static Electricity

Some useful constants: $m_{electron} = 9.11 \times 10^{-31}$ kg, $m_{proton} = 1.67 \times 10^{-27}$ kg, magnitude of charge of proton or electron = 1.6×10^{-19} C, $k = 9 \times 10^{9}$ Nm^2/C^2,

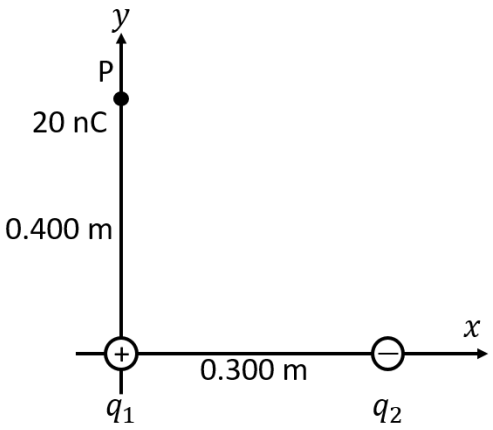
1. The electron and proton of a hydrogen atom are separated (on the average) by a distance of about 5.3×10^{-11} m. Find the magnitude of the electric force.

2. Three charges lies along the *x*-axis as shown. The positive charge $q_1 = 15\ \mu$C is at $x = 2.0$ m, and the positive charge $q_2 = 6.0\ \mu$C is at the origin. A negative charge q_3 is placed on the *x*-axis. Where should q_3 be located so that the resultant electric force on it is zero?



3. Charge $q_1 = 7.00\ \mu$C is at the origin, and $q_2 = -5.00\ \mu$C is on the *x*-axis, 0.300 m from the origin as shown. Find

   (a) the magnitude and direction of the electric field at point P, which has co-ordinates (0, 0.400) m.
   (b) the force on a charge of 2.00×10^{-8} C placed at P.

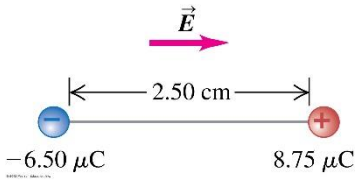


4. In an experiment in space, one proton is held fixed and another proton is released from rest a distance of 2.50 mm away. What is the initial acceleration of the proton after it is released?

5. A proton is travelling horizontally to the right at 4.50×10^{6} m/s.

   (a) Find the magnitude and direction of the weakest electric field that can bring the proton uniformly to rest over a distance of 3.20 cm.
   (b) How much time does it take the proton to stop after entering the field?
   (c) What minimum field (magnitude and direction) would be needed to stop an electron under the conditions of part (a)?

6. A point charge +8.75 μC is glued down on a horizontal frictionless table. It is tied to a point charge −6.50 μC by a light, nonconducting wire of length 2.50 cm. A uniform electric field of magnitude 1.85×10^8 N/C is directed parallel to the wire, as shown in the figure at right.



(a) Find the tension in the wire.
(b) What would the tension be if both charges were negative?

7. A point charge $q_1 = -4.00$ nC is at the point $x = 0.600$ m, $y = 0.800$ m and a second point charge $q_2 = +6.00$ nC is at the point $x = 0.600$ m, $y = 0$. Calculate the magnitude and direction of the net electric field at the origin due to these two point charges.

8. A point charge $q_1 = +2.40$ μC is held stationary at the origin. A second point charge $q_2 = -4.30$ μC moves from the point $x = 0.150$ m, $y = 0$ to the point $x = 0.250$ m, $y = 0.250$ m. How much work is done by the electric force on q_2?

9. A point charge q_1 is held stationary at the origin. A second charge q_2 is placed at point A and the electric potential energy of the pair of charges is $+5.4 \times 10^{-8}$ J. When the second charge is moved to point B, the electric force on the charge does -1.9×10^{-8} J of work. What is the electric potential energy of the pair of charges when the second charge is at point B?

10. Point charges $q_1 = +2.00\ \mu$C and $q_2 = -2.00\ \mu$C are placed at adjacent corners of a square for which the length of each side is 3.00 cm. Point A is at the center of the square, and point B is at the empty corner closest to q_2. Take the electric potential to be zero at a distance far from both charges.

(a) What is the electric potential at point a due to q_1 and q_2?
(b) What is the electric potential at point B?
(c) A point charge $q_3 = -5.00\ \mu$C moves from point A to point B. How much work is done on q_3 by the electric forces exerted by q_1 and q_2? Is this work positive or negative?

11. A positive charge $+q$ is located at the point $x = 0$, $y = -a$ and a negative charge $-q$ is located at the point $y = a$.

(a) Derive an expression for the potential V at points on the y-axis as a function of the coordinate y. Take V to be zero at an infinite distance from the charges.
(b) Find the potential at a point on the positive y-axis for the case $y > a$.
(c) What are the answers to parts (a) and (b) if the two charges are interchanged so that $+q$ is at $y = a$ and $-q$ is at $y = -a$?

Answers

1. $F_e = 8.2 \times 10^{-8}$ N
2. $x = 0.77$ m
3. $E = 2.71 \times 10^5$ N/C, $\phi = 66.6^o$, $F = 5.42 \times 10^{-3}$ N
4. $a = 2.2 \times 10^4$ m/s^2
5. a) 3.30×10^6 N/C to the left b) $t = 14.2$ ns c) 1.80×10^3 N/C
6. a) $T = 382$ N b) $T = 2.02 \times 10^3$ N
7. $E = 131.6$ N/C, 12.6^o above the –ve x-axis or 167.4^o counter clockwise from +ve x-axis.
8. $W = -0.356$ J
9. $W = 7.3 \times 10^{-8}$ J
10. a) $V = 0$ b) $V = -1.75 \times 10^5$ V c) $W = -0.875$ J
11. a) $V = k(-q/|y - a| + q/|y + a|)$ b) $V = -2kqa/(y^2)$ c) The potential is of the opposite sign.