Physics 25 Practice Problems Chapter 18

1. What is the electric force on an up quark in a proton due to the other up quark, assuming their separation is 1.0×10^{-15} m?

2. What is the electric force of attraction (in nano-newtons, nN) between a Ca^{++} ion in $CaCl_2$, and either one of the two chloride ions (Cl^-), assuming the separation between the calcium ion and the chloride ions is one angstrom (1.0×10^{-10} m) ?

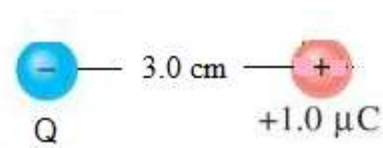
3. Suppose the electric force between two equal charges is 640 pico-newtons (pN) (640×10^{-12} N). What would be the new force if the separation between the charges is doubled?

4. Two protons are placed at opposite vertices of a square, and an electron is placed at another vertex. The side length of the square is 5.0×10^{-11} m. At the center of the square is a third proton. What is the net force on the center proton?

5. What would have to be the separation in meters between two objects, each having the same charge, 6×10^{-5} C, in order that the repulsive force each exerts on the other be 7.2 N?

6. An object having a charge $q_1 = 3$ C is on the x-axis. A second object having a charge $q_2 = 4$ C is also on the x-axis, 7 meters to the right of q_1. How far to the right of q_1 may a charge q_o be placed without it experiencing a net electric force?

7. The charge of the object on the right below is 1.0 μC; the separation between this charge and the unknown charge Q is 3.0 cm. The electric force 1.0 μC charge exerts on the unknown charge Q is 12.0 newtons. What is the absolute value of the charge Q (in μC)?



8. What would have to be the charge of each of two identical charges separated by 1.8 m in order that the repulsive force each exerts on the other be 8.0 N?

9. The force between two charged objects is 100 N. What would be the new force between the objects if the charge on one object were quadrupled, the charge on the other reduced to one-half, and the separation between the objects reduced to a quarter of its previous value?

10. Two protons are at adjacent vertices of a square whose side-length is L =2.0 Å. What is the net force (in nano-newtons, nN) on an electron placed at one of the other vertices?

Solutions

1. Up quarks: $Q = (2/3)\ e$ $= (2/3)\ 1.6 \times 10^{-19}$ $= 1.07 \times 10^{-19}$ C $r = 1.0 \times 10^{-15}$ m $F = kQ^2/r^2$ $= 102.4$ N	**2.** Ca++ Cl^{-} $F = 9 \times 10^9\ (2 \times 1.6 \times 10^{-19})(1.6 \times 10^{-19})/(1.0 \times 10^{-10})^2$ $= 4.6 \times 10^{-8}$ N $= 46 \times 10^{-9}$ N $= 46$ nN

<table>
<tr><td rowspan="2">3. $F_1 = kQ^2/r_1^2$
$= 640$ pN
$r_2 = 2r_1$
$F_2 = kQ^2/r_2^2$
$= k\ Q^2/(2r_1)^2$
$= (1/4)\ kQ^2/r_1^2$
$= (1/4)\ 640$
$= 160$ pN

Faster:
Doubling r quadruples r^2, which quarters the force to 160 pN.</td>
<td>4.
The pushes by the protons at the opposite vertices cancel. The pull by the electron is $F = ke^2/r^2$, where r is the half-diagonal distance, ½ √2 L, is $2\ ke^2/L^2$</td></tr>
<tr><td>5.
$9 \times 10^9\ (6 \times 10^{-5})^2\ /r^2 = 7.2$
$r = 2.12$ m</td></tr>
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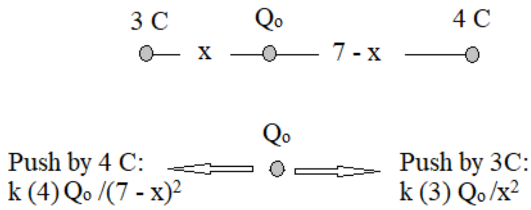
6.

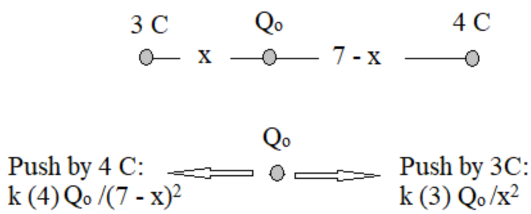


Sum of forces = 0:

$k(3)Q_o/x^2 - k(4)Q_o/(7 - x)^2 = 0$

Divide equation by kQ_o and solve for x:
x = 3.25 m

Note: Q_o is closer to the smaller charge, than to the larger one, as expected.



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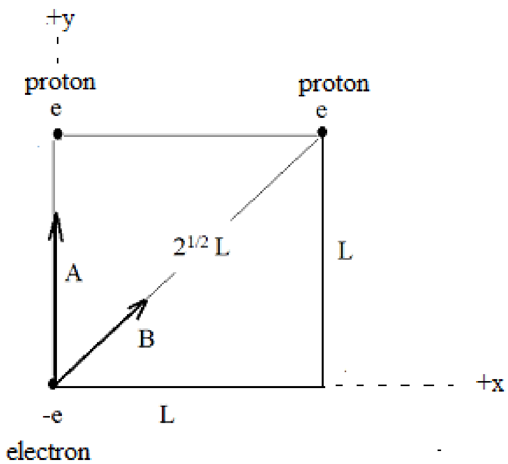
7.
$9 \times 10^9 (1 \times 10^{-6})Q / 0.03^2 = 12$
$Q = 1.2 \times 10^{-6}$ C
$= 1.2\ \mu C$

8.
$(9 \times 10^9)\ Q^2/1.8^2 = 8.0$
$Q = 5.37 \times 10^{-5}$ C

9.
$F = kQ_1Q_2/r^2$
$= 100$ N

-Quadrupling Q_1 quadruples F to 400 N.
-Halving Q_2 halves F to 200 N.
-Quartering r decreases r^2 to $1/16^{th}$ of its previous value, which increases F to 16 times its previous value to 3200 N.

10.



$L = 2.0 \times 10^{-10}$ m

C = A + B
$C_x = A_x + B_x$
$= 0 + (ke^2/2L^2) \cos 45$
$= 2.04 \times 10^{-9}$ N

$C_y = ke^2/L^2 + (ke^2/2L^2) \sin 45$
$= 7.80 \times 10^{-9}$ N

$C = (C_x^2 + C_y^2)^{1/2}$
$= 8.06 \times 10^{-9}$ N
$= 8.06$ nN