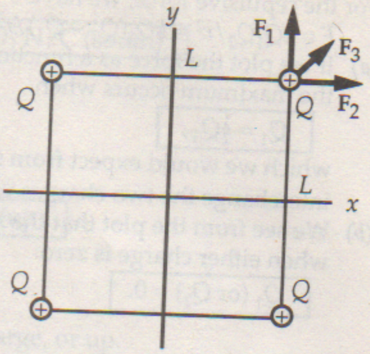
13. We find the magnitudes of the individual forces on the charge at the upper right corner:

$F_1 = F_2 = kQQ/L^2 = kQ^2/L^2$
$= (9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2})(6.00 \times 10^{-3}\ \mathrm{C})^2/(1.00\ \mathrm{m})^2$
$= 3.24 \times 10^5\ \mathrm{N}.$

$F_3 = kQQ/(L\sqrt{2})^2 = kQ^2/2L^2$
$= (9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2})(6.00 \times 10^{-3}\ \mathrm{C})^2/2(1.00\ \mathrm{m})^2$
$= 1.62 \times 10^5\ \mathrm{N}.$



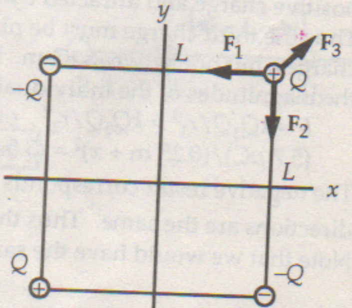
The directions of the forces are determined from the signs of the charges and are indicated on the diagram.
For the forces on the top charge, we see that the net force will be along the diagonal. For the net force, we have

$F = F_1 \cos 45° + F_2 \cos 45° + F_3$
$= 2(3.24 \times 10^5\ \mathrm{N}) \cos 45° + 1.62 \times 10^5\ \mathrm{N}$
$= 6.20 \times 10^5\ \mathrm{N}$ along the diagonal, or away from the center of the square.

From the symmetry, each of the other forces will have the same magnitude and a direction away from the center: The net force on each charge is **6.20 ×10⁵ N away from the center of the square.**
Note that the sum for the three charges is zero.

14. Because the magnitudes of the charges and the distances have not changed, we have the same magnitudes of the individual forces on the charge at the upper right corner:

$F_1 = F_2 = kQQ/L^2 = 3.24 \times 10^5\ \mathrm{N}.$
$F_3 = kQ^2/2L^2 = 1.62 \times 10^5\ \mathrm{N}.$



The directions of the forces are determined from the signs of the charges and are indicated on the diagram.
For the forces on the top charge, we see that the net force will be along the diagonal. For the net force, we have

$F = -F_1 \cos 45° - F_2 \cos 45° + F_3$
$= -2(3.24 \times 10^5\ \mathrm{N}) \cos 45° + 1.62 \times 10^5\ \mathrm{N}$
$= -2.96 \times 10^5\ \mathrm{N}$ along the diagonal, or toward the center of the square.

From the symmetry, each of the other forces will have the same magnitude and a direction toward the center: The net force on each charge is **2.96 ×10⁵ N toward the center of the square.**
Note that the sum for the three charges is zero.

15. For the two forces, we have

$F_{\mathrm{electric}} = kq_1q_2/r_{12}^2 = ke^2/r^2$
$= (9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2})(1.6 \times 10^{-19}\ \mathrm{C})^2/(0.53 \times 10^{-10}\ \mathrm{m})^2 = \boxed{8.2 \times 10^{-8}\ \mathrm{N}.}$

$F_{\mathrm{gravitational}} = Gm_1m_2/r^2$
$= (6.67 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2})(9.11 \times 10^{-31}\ \mathrm{kg})(1.67 \times 10^{-27}\ \mathrm{kg})/(0.53 \times 10^{-10}\ \mathrm{m})^2$
$= \boxed{3.6 \times 10^{-47}\ \mathrm{N}.}$

The ratio of the forces is

$F_{\mathrm{electric}}/F_{\mathrm{gravitational}} = (8.2 \times 10^{-8}\ \mathrm{N})/(3.6 \times 10^{-47}\ \mathrm{N}) = \boxed{2.3 \times 10^{39}.}$

16. Because the electrical attraction must provide the same force as the gravitational attraction, we equate the two forces:

$kQQ/r^2 = Gm_1m_2/r^2;$
$(9.0 \times 10^9\ \mathrm{N \cdot m^2/C^2})Q^2 = (6.67 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2})(5.97 \times 10^{24}\ \mathrm{kg})(7.35 \times 10^{22}\ \mathrm{kg})$, which gives
$Q = \boxed{5.71 \times 10^{13}\ \mathrm{C}.}$