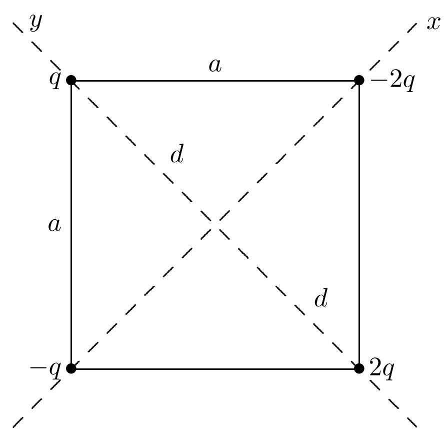
5. Since the magnitude of the electric field produced by a point charge q is given by $E = |q|/4\pi\varepsilon_0 r^2$, where r is the distance from the charge to the point where the field has magnitude E, the magnitude of the charge is

$$|q| = 4\pi\varepsilon_0 r^2 E = \frac{(0.50\,\mathrm{m})^2(2.0\,\mathrm{N/C})}{8.99 \times 10^9\,\mathrm{N\cdot m^2/C^2}} = 5.6 \times 10^{-11}\ \mathrm{C}\ .$$

13. We choose the coordinate axes as shown on the diagram below. At the center of the square, the electric fields produced by the charges at the lower left and upper right corners are both along the x axis and each points away from the center and toward the charge that produces it. Since each charge is a distance $d = \sqrt{2}a/2 = a/\sqrt{2}$ away from the center, the net field due to these two charges is

$$\begin{aligned} E_x &= \frac{1}{4\pi\varepsilon_0}\left(\frac{2q}{a^2/2} - \frac{q}{a^2/2}\right) = \frac{1}{4\pi\varepsilon_0}\frac{q}{a^2/2} \\ &= \frac{\left(8.99 \times 10^9\,\mathrm{N\cdot m^2/C^2}\right)\left(1.0 \times 10^{-8}\,\mathrm{C}\right)}{(0.050\,\mathrm{m})^2/2} = 7.19 \times 10^4\ \mathrm{N/C}\ . \end{aligned}$$



At the center of the square, the field produced by the charges at the upper left and lower right corners are both along the y axis and each points away from the charge that produces it. The net field produced at the center by these charges is

$$E_y = \frac{1}{4\pi\varepsilon_0}\left[\frac{2q}{a^2/2} - \frac{q}{a^2/2}\right] = \frac{1}{4\pi\varepsilon_0}\frac{q}{a^2/2} = 7.19 \times 10^4\ \mathrm{N/C}\ .$$

The magnitude of the field is

$$E = \sqrt{E_x^2 + E_y^2} = \sqrt{2(7.19 \times 10^4\,\mathrm{N/C})^2} = 1.02 \times 10^5\,\mathrm{N/C}$$

and the angle it makes with the x axis is

$$\theta = \tan^{-1}\frac{E_y}{E_x} = \tan^{-1}(1) = 45^\circ\ .$$

It is upward in the diagram, from the center of the square toward the center of the upper side.

30. Vertical equilibrium of forces leads to the equality

$$q\left|\vec{E}\right| = mg \implies \left|\vec{E}\right| = \frac{mg}{2e} .$$

Using the mass given in the problem, we obtain $\left|\vec{E}\right| = 2.03 \times 10^{-7}$ N/C. Since the force of gravity is downward, then $q\vec{E}$ must point upward. Since $q > 0$ in this situation, this implies $\vec{E}$ must itself point upward.

40. We assume there are no forces or force-components along the x direction. We combine Eq. 23-28 with Newton's second law, then use Eq. 4-21 to determine time t followed by Eq. 4-23 to determine the final velocity (with $-g$ replaced by the a_y of this problem); for these purposes, the velocity components *given* in the problem statement are re-labeled as v_{0x} and v_{0y} respectively.

(a) We have $\vec{a} = \frac{q\vec{E}}{m} = -\left(\frac{e}{m}\right)\vec{E}$ which leads to

$$\vec{a} = -\left(\frac{1.60 \times 10^{-19}\,\mathrm{C}}{9.11 \times 10^{-31}\,\mathrm{kg}}\right)\left(120\ \frac{\mathrm{N}}{\mathrm{C}}\right)\hat{\jmath} = -2.1 \times 10^{13}\,\mathrm{m/s^2}\ \hat{\jmath}\ .$$

(b) Since $v_x = v_{0x}$ in this problem (that is, $a_x = 0$), we obtain

$$\begin{aligned} t &= \frac{\Delta x}{v_{0x}} = \frac{0.020\,\mathrm{m}}{1.5 \times 10^5\,\mathrm{m/s}} = 1.3 \times 10^{-7}\ \mathrm{s} \\ v_y &= v_{0y} + a_y t = 3.0 \times 10^3\,\mathrm{m/s} + \left(-2.1 \times 10^{13}\,\mathrm{m/s^2}\right)\left(1.3 \times 10^{-7}\,\mathrm{s}\right) \end{aligned}$$

which leads to $v_y = -2.8 \times 10^6$ m/s. Therefore, in unit vector notation (with SI units understood) the final velocity is

$$\vec{v} = 1.5 \times 10^5\,\hat{\imath} - 2.8 \times 10^6\,\hat{\jmath}\ .$$

44. (a) The magnitude of the dipole moment is

$$p = qd = \left(1.50 \times 10^{-9}\,\text{C}\right)\left(6.20 \times 10^{-6}\,\text{m}\right) = 9.30 \times 10^{-15}\ \text{C}\cdot\text{m}\ .$$

(b) Following the solution to part (c) of Sample Problem 23-5, we find

$$U(180^\circ) - U(0) = 2pE = 2\left(9.30 \times 10^{-15}\right)(1100) = 2.05 \times 10^{-11}\ \text{J}\ .$$