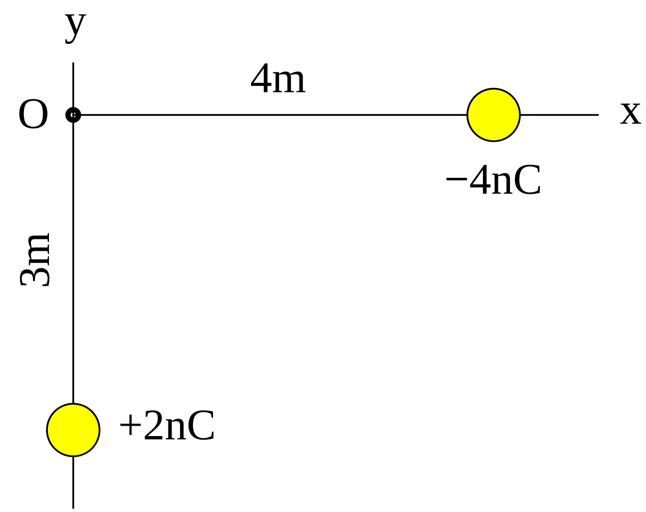
Unit Exam I: Problem #1 (Spring ’19)

Consider two point charges positioned as shown. Use $k = 9 \times 10^9\,\mathrm{Nm^2/C^2}$.

(a) Find the electric field $\mathbf{E} = E_x\,\hat{\mathbf{i}} + E_y\,\hat{\mathbf{j}}$ at point O.

(b) Find the electric potential V at point O.

(c) Find the magnitude F of the force between the two charges.



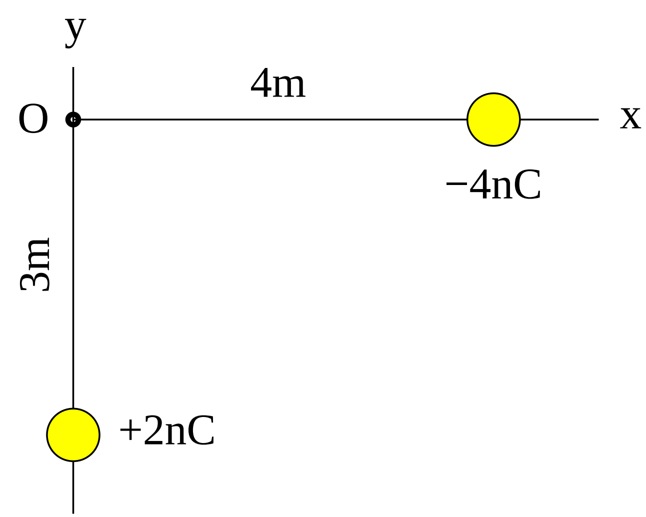
Unit Exam I: Problem #1 (Spring ’19)

Consider two point charges positioned as shown. Use $k = 9 \times 10^9\,\mathrm{Nm^2/C^2}$.

(a) Find the electric field $\mathbf{E} = E_x\,\hat{\mathbf{i}} + E_y\,\hat{\mathbf{j}}$ at point O.

(b) Find the electric potential V at point O.

(c) Find the magnitude F of the force between the two charges.



Solution:

(a) $E_x = k\dfrac{|-4\mathrm{nC}|}{(4\mathrm{m})^2} = \dfrac{9}{4}\,\mathrm{N/C} = 2.25\,\mathrm{N/C}, \quad E_y = k\dfrac{|2\mathrm{nC}|}{(3\mathrm{m})^2} = 2\,\mathrm{N/C}.$

(b) $V = k\dfrac{(-4\mathrm{nC})}{4\mathrm{m}} + k\dfrac{2\mathrm{nC}}{3\mathrm{m}} = -9\mathrm{V} + 6\mathrm{V} = -3\mathrm{V}.$

(c) $F = k\dfrac{|(-4\mathrm{nC})(2\mathrm{nC})|}{(5\mathrm{m})^2} = \dfrac{72}{25}\mathrm{nN} = 2.88\mathrm{nN}$

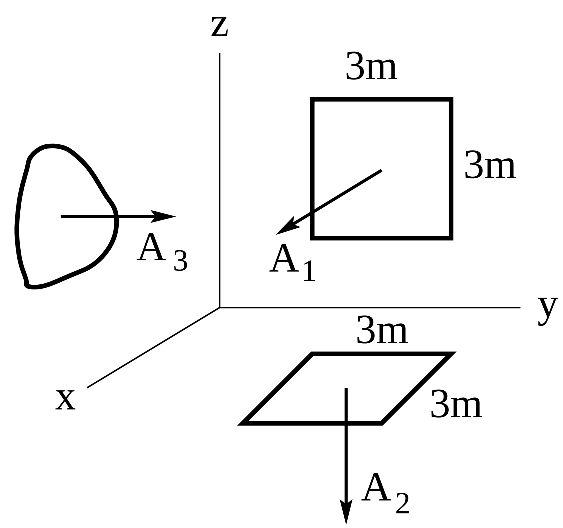
Unit Exam I: Problem #2 (Spring ’19)

Consider three plane surfaces (two squares, one odd shape) with area vectors $\mathbf{A}_1$ (in positive x-direction), $\mathbf{A}_2$ (in negative z-direction), and $\mathbf{A}_3$ (in positive y-direction). The region is filled with a uniform electric field $\mathbf{E} = (2\hat{\mathbf{i}} + 3\hat{\mathbf{j}} + 4\hat{\mathbf{k}})$N/C. The electric flux through surface 3 is $\Phi_E^{(3)} = 21\mathrm{Nm}^2/\mathrm{C}$.

(a) Find the electric flux $\Phi_E^{(1)}$ through surface 1.

(b) Find the electric flux $\Phi_E^{(2)}$ through surface 2.

(c) Find the area vector $\mathbf{A}_3$ of surface 3.

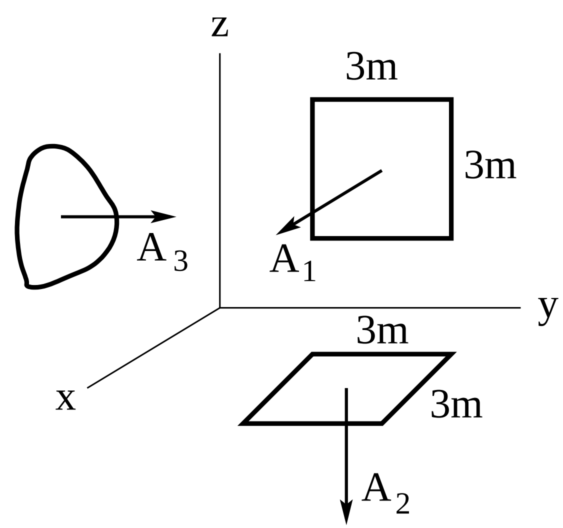


Consider three plane surfaces (two squares, one odd shape) with area vectors $\mathbf{A}_1$ (in positive x-direction), $\mathbf{A}_2$ (in negative z-direction), and $\mathbf{A}_3$ (in positive y-direction). The region is filled with a uniform electric field $\mathbf{E} = (2\hat{\mathbf{i}} + 3\hat{\mathbf{j}} + 4\hat{\mathbf{k}})$N/C. The electric flux through surface 3 is $\Phi_E^{(3)} = 21\mathrm{Nm}^2/\mathrm{C}$.

(a) Find the electric flux $\Phi_E^{(1)}$ through surface 1.

(b) Find the electric flux $\Phi_E^{(2)}$ through surface 2.

(c) Find the area vector $\mathbf{A}_3$ of surface 3.



Solution:

(a) $\mathbf{A}_1 = 9\mathrm{m}^2\,\hat{\mathbf{i}}, \quad \Phi_E^{(1)} = \mathbf{E}\cdot\mathbf{A}_1 = (2\mathrm{N/C})(9\mathrm{m}^2) = 18\mathrm{Nm}^2/\mathrm{C}.$

(b) $\mathbf{A}_2 = -9\mathrm{m}^2\,\hat{\mathbf{k}}, \quad \Phi_E^{(2)} = \mathbf{E}\cdot\mathbf{A}_2 = -(4\mathrm{N/C})(9\mathrm{m}^2) = -36\mathrm{Nm}^2/\mathrm{C}.$

(c) $\mathbf{A}_3 = A_3\,\hat{\mathbf{j}}, \quad \Phi_E^{(3)} = A_3(3\mathrm{N/C}) = 21\mathrm{Nm}^2/\mathrm{C} \quad \Rightarrow \quad A_3 = 7\mathrm{m}^2.$

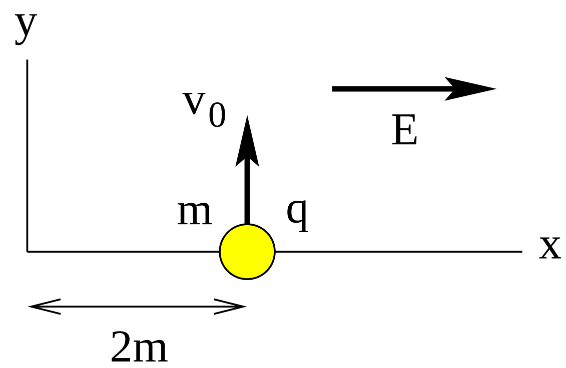
Unit Exam I: Problem #3 (Spring '19)

Consider a region of uniform electric field $\mathbf{E} = 3\mathrm{N/C}\,\hat{\mathbf{i}}$. A charged particle $(m = 2\mathrm{kg},\ q = 4\mathrm{C})$ is projected at time $t = 0$ with initial velocity $\mathbf{v}_0 = 5\mathrm{m/s}\,\hat{\mathbf{j}}$ from the position shown.

(a) Find the acceleration $\mathbf{a} = a_x\,\hat{\mathbf{i}} + a_y\,\hat{\mathbf{j}}$ of the particle at time $t = 3$s.

(b) Find its velocity $\mathbf{v} = v_x\,\hat{\mathbf{i}} + v_y\,\hat{\mathbf{j}}$ at time $t = 3$s.

(c) Find its position $\mathbf{r} = x\,\hat{\mathbf{i}} + y\,\hat{\mathbf{j}}$ at time $t = 3$s.

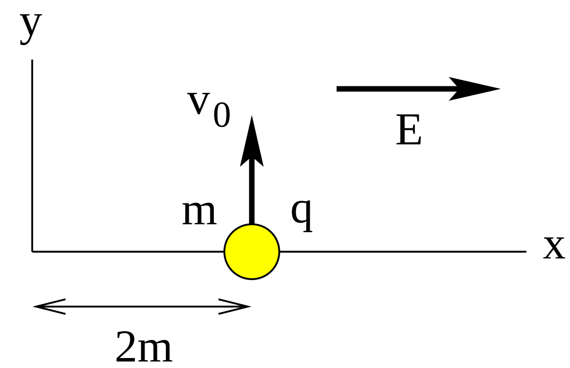


Consider a region of uniform electric field $\mathbf{E} = 3\mathrm{N/C}\,\hat{\mathbf{i}}$. A charged particle $(m = 2\mathrm{kg},\ q = 4\mathrm{C})$ is projected at time $t = 0$ with initial velocity $\mathbf{v}_0 = 5\mathrm{m/s}\,\hat{\mathbf{j}}$ from the position shown.

(a) Find the acceleration $\mathbf{a} = a_x\,\hat{\mathbf{i}} + a_y\,\hat{\mathbf{j}}$ of the particle at time $t = 3$s.

(b) Find its velocity $\mathbf{v} = v_x\,\hat{\mathbf{i}} + v_y\,\hat{\mathbf{j}}$ at time $t = 3$s.

(c) Find its position $\mathbf{r} = x\,\hat{\mathbf{i}} + y\,\hat{\mathbf{j}}$ at time $t = 3$s.



Solution:

(a) $a_x = \dfrac{q}{m}E = \dfrac{4\mathrm{C}}{2\mathrm{kg}}(3\mathrm{N/C}) = 6\mathrm{m/s}^2, \quad a_y = 0.$

(b) $v_x = a_x t = (6\mathrm{m/s}^2)(3\mathrm{s}) = 18\mathrm{m/s}, \quad v_y = v_0 = 5\mathrm{m/s}.$

(c) $x = x_0 + \dfrac{1}{2}a_x t^2 = 2\mathrm{m} + 0.5(6\mathrm{m/s}^2)(3\mathrm{s})^2 = 29\mathrm{m}, \quad y = v_0 t = (5\mathrm{m/s})(3\mathrm{s}) = 15\mathrm{m}.$