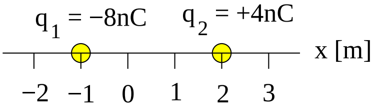
# Unit Exam I: Problem #1 (Fall '19)

Consider two point charges positioned on the $x$-axis as shown. Use $k = 9 \times 10^9 \mathrm{Nm^2C^{-2}}$.

(a) Find the electric potential at $x = 0$ and $x = 1\mathrm{m}$.

(b) Find magnitude and direction of the electric field at $x = 0$ and $x = 1\mathrm{m}$.

(c) Find magnitude and direction of the electric forces $\mathbf{F}_{21}$ acting on charge $q_1$ and $\mathbf{F}_{12}$ acting on charge $q_2$.



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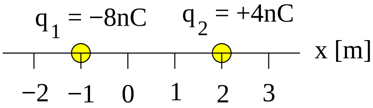



(a) $V_0 = k\dfrac{(-8\text{nC})}{1\text{m}} + k\dfrac{(4\text{nC})}{2\text{m}} = -54\text{V}, \qquad V_1 = k\dfrac{(-8\text{nC})}{2\text{m}} + k\dfrac{(4\text{nC})}{1\text{m}} = 0\text{V}.$

(b) $\mathbf{E}_0 = -k\dfrac{|-8\text{nC}|}{(1\text{m})^2}\hat{\mathbf{i}} - k\dfrac{|4\text{nC}|}{(2\text{m})^2}\hat{\mathbf{i}} = -81\text{N/C}\hat{\mathbf{i}}, \qquad \mathbf{E}_1 = -k\dfrac{|-8\text{nC}|}{(2\text{m})^2}\hat{\mathbf{i}} - k\dfrac{|4\text{nC}|}{(1\text{m})^2}\hat{\mathbf{i}} = -54\text{N/C}\hat{\mathbf{i}}.$

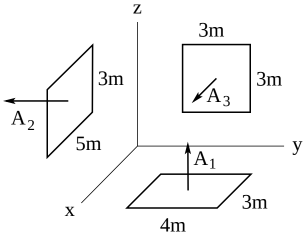
(c) $\mathbf{F}_{21} = k\dfrac{|(-8\text{nC})(4\text{nC})|}{(3\text{m})^2}\hat{\mathbf{i}} = 32\text{nN}\hat{\mathbf{i}}, \qquad \mathbf{F}_{12} = -\mathbf{F}_{21} = -32\text{nN}\hat{\mathbf{i}}.$

Consider plane, rectangular surfaces with area vectors $\mathbf{A}_1$ (in positive $z$-direction), $\mathbf{A}_2$ (in negative $y$-direction), and $\mathbf{A}_3$ (in positive $x$-direction) as shown.

The region is filled with a uniform electric field, $\mathbf{E} = (-5\hat{\mathbf{i}} + 6\hat{\mathbf{j}} + 7\hat{\mathbf{k}})$N/C [$\mathbf{E} = (6\hat{\mathbf{i}} + 7\hat{\mathbf{j}} - 8\hat{\mathbf{k}})$N/C].

(a) State the area vectors $\mathbf{A}_1$, $\mathbf{A}_2$, $\mathbf{A}_3$.

(b) Find the electric flux $\Phi_E^{(1)}$, $\Phi_E^{(2)}$, $\Phi_E^{(3)}$ through each surface.



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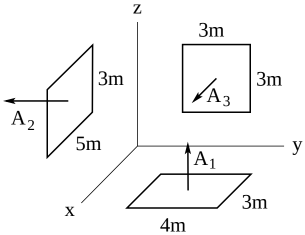



(a) $\mathbf{A}_1 = 12\text{m}^2\hat{\mathbf{k}}, \quad \mathbf{A}_2 = -15\text{m}^2\hat{\mathbf{j}}, \quad \mathbf{A}_3 = 9\text{m}^2\hat{\mathbf{i}}.$

(b) $\Phi_E^{(1)} = \mathbf{E}\cdot\mathbf{A}_1 = (7\text{N/C})(12\text{m}^2) = 84\text{Nm}^2/\text{C} \qquad [\Phi_E^{(1)} = \mathbf{E}\cdot\mathbf{A}_1 = (-8\text{N/C})(12\text{m}^2) = -96\text{Nm}^2/\text{C}].$

$\Phi_E^{(2)} = \mathbf{E}\cdot\mathbf{A}_2 = (6\text{N/C})(-15\text{m}^2) = -90\text{Nm}^2/\text{C} \qquad [\Phi_E^{(2)} = \mathbf{E}\cdot\mathbf{A}_2 = (7\text{N/C})(-15\text{m}^2) = -105\text{Nm}^2/\text{C}].$

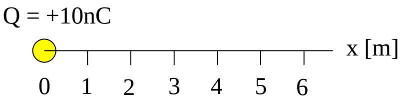
$\Phi_E^{(3)} = \mathbf{E}\cdot\mathbf{A}_3 = (-5\text{N/C})(9\text{m}^2) = -45\text{Nm}^2/\text{C} \qquad [\Phi_E^{(3)} = \mathbf{E}\cdot\mathbf{A}_3 = (6\text{N/C})(9\text{m}^2) = 54\text{Nm}^2/\text{C}].$

The point charge $Q = 10\text{nC}$ is fixed at $x = 0$. It generates an electric field and an electric potential everywhere. A charged particle (not shown) with mass $m = 5\text{kg}$ and charge $q = 2\text{nC}$ is released from rest at $x = 2\text{m}$ [$x = 3\text{m}$]. Use $k = 9 \times 10^9 \text{Nm}^2\text{C}^{-2}$.

(a) Find the potential energy $U_2$ [$U_3$] of the particle at $x = 2\text{m}$ [$x = 3\text{m}$].

(b) Find the acceleration $a_2$ [$a_3$] of the particle at $x = 2\text{m}$ [$x = 3\text{m}$].

(c) Find the kinetic energy $K_6$ of the particle when it has arrived at $x = 6\text{m}$.



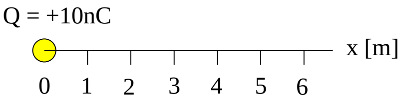
# Unit Exam I: Problem #3 (Fall '19)

The point charge $Q = 10\text{nC}$ is fixed at $x = 0$. It generates an electric field and an electric potential everywhere. A charged particle (not shown) with mass $m = 5\text{kg}$ and charge $q = 2\text{nC}$ is released from rest at $x = 2\text{m}$ [$x = 3\text{m}$]. Use $k = 9 \times 10^9 \text{Nm}^2\text{C}^{-2}$.

(a) Find the potential energy $U_2$ [$U_3$] of the particle at $x = 2\text{m}$ [$x = 3\text{m}$].

(b) Find the acceleration $a_2$ [$a_3$] of the particle at $x = 2\text{m}$ [$x = 3\text{m}$].

(c) Find the kinetic energy $K_6$ of the particle when it has arrived at $x = 6\text{m}$.




(a) $U_2 = k\dfrac{(10\text{nC})(2\text{nC})}{2\text{m}} = 90\text{nJ} \quad \left[U_3 = k\dfrac{(10\text{nC})(2\text{nC})}{3\text{m}} = 60\text{nJ}\right].$

(b) $a_2 = \dfrac{F_2}{m} = k\dfrac{(10\text{nC})(2\text{nC})}{(4\text{m}^2)(5\text{kg})} = 9\text{nm/s}^2 \quad \left[a_3 = \dfrac{F_3}{m} = k\dfrac{(10\text{nC})(2\text{nC})}{(9\text{m}^2)(5\text{kg})} = 4\text{nm/s}^2\right].$

(c) $K_6 = U_2 - k\dfrac{(10\text{nC})(2\text{nC})}{6\text{m}} = 90\text{nJ} - 30\text{nJ} = 60\text{nJ} \quad \left[K_6 = U_3 - k\dfrac{(10\text{nC})(2\text{nC})}{6\text{m}} = 60\text{nJ} - 30\text{nJ} = 30\text{nJ}\right].$