16.7: Direct Calculation of Electrical Quantities from Charge Distributions (Answers)

Note: Answers are provided for only the odd-numbered questions.

Conceptual Questions

Calculating Electric Potential of Charge Distributions

13. The second has 1/4 the dipole moment of the first.

15. The region outside of the sphere will have a potential indistinguishable from a point charge; the interior of the sphere will have a different potential.

Problems

Electric Dipoles

105. $E_x = 0, E_y = \frac{1}{4\pi\varepsilon_0}[\frac{2q}{(x^2+a^2}) \frac{a}{\sqrt{(x^2+a^2)}} \Rightarrow x \gg a \Rightarrow \frac{1}{2\pi\varepsilon_0}\frac{qa}{x^3}$

$E_y = \frac{q}{4\pi\varepsilon_0}[\frac{2ya+2ya}{(y-a)^2(y+a)^2}] \Rightarrow y \gg a \Rightarrow \frac{1}{\pi\varepsilon_0}\frac{qa}{y^3}$

107. The net dipole moment of the molecule is the vector sum of the individual dipole moments between the two O-H. The separation O-H is 0.9578 angstroms:

$\vec{p} = 1.889 \times 10^{-29} Cm\hat{i}$

Calculating Electric Fields of Charge Distributions

83. $dE = \frac{1}{4\pi\varepsilon_0}\frac{\lambda dx}{(x+a)^2}, E = \frac{\lambda}{4\pi\varepsilon_0}[\frac{1}{l+a} - \frac{1}{a}]$

87. At $P_1 : \vec{E}(y) = \frac{1}{4\pi\varepsilon_0}\frac{\lambda L}{y\sqrt{y^2+\frac{L^2}{4}}}\hat{j} \Rightarrow \frac{1}{4\pi\varepsilon_0}\frac{q}{\frac{a}{2}\sqrt{(\frac{a}{2})^2+\frac{L^2}{4}}}\hat{j} = \frac{1}{\pi\varepsilon_0}\frac{q}{a\sqrt{a^2+L^2}}\hat{j}$

At P_2: Put the origin at the end of **L**.

$dE = \frac{1}{4\pi\varepsilon_0}\frac{\lambda dx}{(x+a)^2}, \vec{E} = -\frac{q}{4\pi\varepsilon_0 l}[\frac{1}{l+a} - \frac{1}{a}]\hat{i}$

97. circular arc $dE_x(-\hat{i}) = \frac{1}{4\pi\varepsilon_0}\frac{\lambda ds}{r^2} cos\theta(-\hat{i}$,

$\vec{E}_x = \frac{\lambda}{4\pi\varepsilon_0 r}(-\hat{i}),$

$dEy(-\hat{i}\,\hat{}\,) = \frac{1}{4\pi\varepsilon_0}\frac{\lambda ds}{r^2} sin\theta(-\hat{j}),$

$\vec{E}_y = \frac{\lambda}{4\pi\varepsilon_0 r}(-\hat{j});$

y-axis: $\vec{E}_x = \frac{\lambda}{4\pi\varepsilon_0 r}(-\hat{i});$

x-axis: $\vec{E}_y = \frac{\lambda}{4\pi\varepsilon_0 r}(-\hat{j}),$

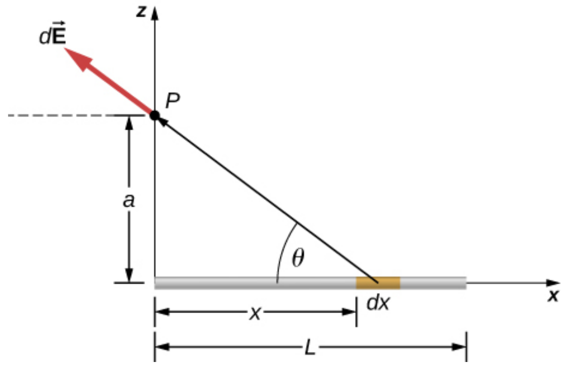
$\vec{E} = \frac{\lambda}{2\pi\varepsilon_0 r}(-\hat{i}) + \frac{\lambda}{2\pi\varepsilon_0 r}(-\hat{j})$

Additional Problems

121. Electric field of wire at **x**: $\vec{E}(x) = \frac{1}{4\pi\varepsilon_0}\frac{2\lambda_y}{x}\hat{i},$

$$dF = \frac{\lambda_y \lambda_x}{2\pi\varepsilon_0}(lnb - lna)$$

123.



$$dEx = \frac{1}{4\pi\varepsilon_0}\frac{\lambda dx}{(x^2+a^2)}\frac{x}{\sqrt{x^2+a^2}},$$

$$\vec{E}_x = \frac{\lambda}{4\pi\varepsilon_0}[\frac{1}{\sqrt{L^2+a^2}} - \frac{1}{a}]\hat{i},$$

$$dE_z = \frac{1}{4\pi\varepsilon_0}\frac{\lambda dx}{(x^2+a^2)}\frac{a}{\sqrt{x^2+a^2}},$$

$$\vec{E}_z = \frac{\lambda}{4\pi\varepsilon_0 a}\frac{L}{\sqrt{L^2+a^2}}\hat{k},$$

Substituting z for a, we have:

$$\vec{E}(z) = \frac{\lambda}{4\pi\varepsilon_0}[\frac{1}{\sqrt{L^2+z^2}} - \frac{1}{z}]\hat{i} + \frac{\lambda}{4\pi\varepsilon_0 z}\frac{L}{\sqrt{L^2+z^2}}\hat{k}$$

125. There is a net force only in the **y**-direction. Let θ be the angle the vector from **dx** to **q** makes with the **x**-axis. The components along the **x**-axis cancel due to symmetry, leaving the **y**-component of the force.

$$dF_y = \frac{1}{4\pi\varepsilon_0}\frac{aq\lambda dx}{(x^2+a^2)^{3/2}},$$

$$Fy = \frac{1}{2\pi\varepsilon_0}\frac{q\lambda}{a}[\frac{l/2}{((l/2)^2+a^2)^{1/2}}]$$

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