FIRST MIDTERM

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REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!
Use the conversion constants and data given on the front page.

Two charges of equal magnitude, +Q and -Q are a distance a apart on the x-axis. Take x = 0 at the midpoint between the two charges.

(a) Write a general expression for the electric field at point P at the coordinate x.
(b) Using the binomial expansion, calculate the electric field at P, keeping the first two non-zero terms involving a.
(c) If a/x is 0.10, what fractional error is introduced by ignoring the last term in part (b). (That is, what fraction of the total answer is this last term?)

\[ E = 0.4 \frac{Q}{\varepsilon_0} \left[ \frac{1}{(x+a)^2} - \frac{1}{(x-a)^2} \right] \]

\[ E = 0.4 \frac{Q}{\varepsilon_0} \left[ \left(1 + \frac{a}{x} \right)^{-2} - \left(1 - \frac{a}{x} \right)^{-2} \right] \]

\[ \frac{1}{(1 + \frac{a}{x})^2} = 1 + (-2)\left(\frac{a}{x}\right) + (-2)(-3)\left(\frac{a}{x}\right)^2 + \ldots \]

\[ \frac{1}{(1 - \frac{a}{x})^2} = 1 + (-2)(-\frac{a}{x}) + (-2)(-3)(-\frac{a}{x})^2 + \ldots \]

\[ E = -0.4 \frac{Q}{\varepsilon_0} \left( \frac{2a}{x} + \frac{a^3}{x^3} \right) \]

\[ \text{Fractional error} = \frac{0.001}{2.01} \]

\[ \text{Fractional error} = 0.005 \]