Ave. = 15.1

FIRST EXAM

Name (print) __________________________ Name (signed) __________________________

Discussion Instructor (circle one): Emerson Gaughan Iguchi Stoops Zhang

Discussion Section #: __________

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

(a) Calculate the magnitude of the electric force between two electrons that are 0.72 × 10^-10 m apart.

\[ F = k \frac{q_1 q_2}{d^2} = 9 \times 10^9 \times \left( \frac{1.6 \times 10^{-19}}{0.72 \times 10^{-10}} \right)^2 = 4.4 \times 10^{-6} \text{ N} \]

(b) What is the magnitude of the acceleration (in m/s^2) of an electron in an electric field of magnitude 275 N/C?

\[ a = \frac{F}{m} = \frac{9 \times 10^9 \times 2.75}{9.1 \times 10^{-31}} = 4.83 \times 10^{13} \text{ m/s}^2 \]

(c) Calculate the magnitude of the electric field at a point midway between two charges, one of +5.5 × 10^-6 C and the other of -7.5 × 10^-6 C. The distance d is 1.75 m.

\[ E = \left| \frac{k q_2}{(d_2)^2} + k \frac{q_1}{(d_1)^2} \right| = \frac{4k}{d^2} \left| \frac{q_2}{(1.75)^2} + \frac{q_1}{(1.75)^2} \right| = 1.53 \times 10^5 \text{ N/C} \]

(d) If the electric field at the surface of the earth is found to be 100 N/C, and pointed downward, and at 1000 m above the surface of the earth it is 25 N/C also pointed downward, calculate the number of elementary charges \((e = 1.6 \times 10^{-19} \text{ C})\) in a cube 1000 m on a side, with its bottom at the earth's surface.

\[ \Phi = 1000^2 \times (100 - 25) \text{ N/C} \text{m} \]
\[ Q = \varepsilon_0 \frac{\Phi}{C} \text{ Number of charges} = \frac{Q}{c} = \frac{8.85 \times 10^{-12} \times 1000^2 \times (100 - 25)}{1.6 \times 10^{-19}} = 4.15 \times 10^7 \]

(e) In the binomial expansion of \((x^2 + a^2)^{-3/2}\), calculate completely the term in \(a^4\).

\[ (x^2 + a^2)^{-3/2} = x^{-3} \left( 1 + \frac{a^2}{x^2} \right)^{-3/2} = x^{-3} \left( 1 - \frac{3}{2} \frac{a^2}{x^2} + \frac{\left( -\frac{3}{2} \right) \left( -\frac{3}{2} - 1 \right)}{2} \frac{a^4}{x^4} + \ldots \right) \]
\[ a^4 \text{ term: } x^{-3} \left( -\frac{3}{2} \times \frac{3}{2} \times \frac{1}{2} \right) \frac{a^4}{x^4} = \frac{35}{8} \frac{a^4}{x^4} \]