

FIRST EXAM

Name (print) MINI G Name (signed) \_\_\_\_\_

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

Discussion Section #: \_\_\_\_\_

**REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!**

Use the conversion constants and data given on the front page.

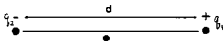
- (a) Calculate the magnitude of the electric force between two electrons that are  $0.72 \times 10^{-10}$  m apart.

$$|F| = k \frac{e^2}{r^2} = 9.00 \times 10^9 \times \frac{(1.6 \times 10^{-19})^2}{(0.72 \times 10^{-10})^2} = 4.44 \times 10^{-8} \text{ N}$$

- (b) What is the magnitude of the acceleration (in  $\text{m/s}^2$ ) of an electron in an electric field of magnitude 275 N/C?

$$|\vec{a}| = \frac{eE}{m} = \frac{1.6 \times 10^{-19} \times 275}{9.11 \times 10^{-31}} = 4.83 \times 10^{13} \text{ m/s}^2$$

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



$$|\vec{E}| = \left| k \frac{q_1}{(d/2)^2} + k \frac{q_2}{(d/2)^2} \right| = \frac{4k}{d^2} |q_2 - q_1| = \frac{4 \times 9.00 \times 10^9}{(1.75)^2} \times 13.0 \times 10^{-6} = 1.53 \times 10^5 \text{ N/C}$$

- (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 ( $e = 1.6 \times 10^{-19}$  C) in a cube 1000 m on a side, with its bottom at the earth's surface.

$$\Phi = 1000^2 \times (100 - 25), \quad Q = \epsilon_0 \oint \vec{E} \cdot d\vec{A} \quad \text{Number of charges} = \frac{Q}{e} = \frac{8.85 \times 10^{-12} \times 1000^2 \times (100 - 25)}{1.6 \times 10^{-19}} = 4.15 \times 10^{17}$$

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

$$(x^2 + a^2)^{-3/2} = x^{-3} \left( 1 + \frac{a^2}{x^2} \right)^{-3/2} = x^{-3} \left( 1 - \frac{3}{2} \frac{a^2}{x^2} + \frac{(-3/2)(-3/2+1)}{2} \frac{a^4}{x^4} - \dots \right)$$

$$a^4 \text{ term: } x^{-3} \cdot \frac{(-3/2)(-3/2+1)}{2} \cdot \frac{a^4}{x^4} = \frac{35}{8} \cdot \frac{a^4}{x^7}$$