

FIRST MIDTERM

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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 field at a distance of  $0.500 \times 10^{-10}$  m (about the size of an atom) from the center of a nucleus with a positive charge of  $+3e$ .

5 
$$E = k \frac{3e}{r^2} = 9 \cdot 10^9 \frac{N \cdot m^2}{C^2} \frac{3 \cdot 1.602 \cdot 10^{-19} C}{(0.5 \cdot 10^{-10} m)^2} = 1.73 \cdot 10^{14} \frac{N}{C}$$

- (b) If the mass of the sun is  $1.99 \times 10^{30}$  kg, calculate the period, in years, of an asteroid at a distance from the sun twice the distance of the earth from the sun. (Note: It is not necessary to do a lot of messy algebra to solve this.)

5 
$$\left(\frac{r}{1 \text{ AU}}\right)^3 = \left(\frac{T}{1 \text{ yr}}\right)^2 \implies T = T_E \left(\frac{r}{1 \text{ AU}}\right)^{3/2} = 1 \text{ yr} \cdot 2^{3/2} = 2.828 \text{ yrs}$$
  

$$(1.843 \cdot 10^8 \text{ s} - 1)$$

- (c) For the expression

$$\frac{1}{(x^2 - a^2)^{3/2}}$$

use the binomial expansion to calculate the term in  $a^6$ . Don't lose any pieces.

5 
$$\frac{1}{x^3} \left( 1 + \frac{3}{2} \frac{a^2}{x^2} + \frac{15}{8} \frac{a^4}{x^4} + \frac{5}{8} \frac{a^6}{x^6} + \dots \right) \implies -\frac{1}{x^3} \frac{15}{8} \frac{a^4}{x^4} = +2.19 \frac{1}{x^7}$$

- (d) Calculate the magnitude of the gravitational force between two students of mass 100 kg each if they are 10.0 m apart. (Approximate the students as spheres!)

5 
$$F = G \frac{m_1 m_2}{r^2} = 6.67 \cdot 10^{-11} \frac{N \cdot m^2}{kg^2} \frac{100^2 \text{ kg}}{10^2 \text{ m}^2} = 6.67 \cdot 10^{-9} \text{ N}$$

- (e) An electron is accelerated from rest by an electric field of  $1.00 \times 10^4$  N/C. What is its speed after traveling 10.0 cm?

5 
$$v = \frac{1}{2} a t^2 \implies v = \sqrt{2 a s} = \sqrt{2 \cdot 1.0 \cdot 10^4 \text{ N/C} \cdot 0.1 \text{ m}} = \sqrt{2 \cdot 10^3} = 44.7 \text{ m/s}$$
  

$$= 1.7 \cdot 10^8 \text{ m/s}$$