SECOND MIDTERM

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

(a) Calculate the work needed to assemble 3 protons (q = +1.60 × 10^{-19} C) into an equilateral triangle 1.00 × 10^{-10} m on a side.

\[ W = W_1 + W_2 + W_3 = 2 \times \frac{k q^2}{r} + 2 \times \frac{k q^2}{r} \]
\[ = 3 \times \frac{9.00 \times 10^{-19} \times 1.60 \times 10^{-19}}{1.00 \times 10^{-10}} \]
\[ = 6.91 \times 10^{-19} \text{ N.m} \]

(b) A satellite is in orbit about the earth 20,000 km above its surface. If the period of the satellite is 13.0 hours, find the mass of the earth from this data (not the true value).

\[ T = 4\pi^2 \frac{r^3}{GM} \Rightarrow M_e = \frac{4\pi^2 r^3}{GT^2} = \frac{4\pi^2 (6.38 \times 10^6 - 2\times10^7)^3}{6.67 \times 10^{-11} \times \frac{4}{3} \times 3600} \]
\[ = 5.97 \times 10^{24} \text{ kg} \]

(c) If 15.0 coulomb of charge is uniformly distributed along a wire 2.00 km long, calculate the electric field at the mid point of the wire and 1.50 cm from the center of the wire and perpendicular to the wire.

\[ \Phi = \frac{q}{\varepsilon_0} \Rightarrow E = \frac{\Phi}{2 \pi \varepsilon_0 r} \]
\[ E = \frac{2 \pi \varepsilon_0}{2 \pi \varepsilon_0} = 8.99 \times 10^9 \frac{9 \times 10^9}{2} \]
\[ = 8.99 \times 10^9 \text{ N.m}^2/C^2 \]

(d) Calculate the term in \( a^6 \) for the expression given below. \( a \ll x \).

\[ (1+x)^n = 1 + nx + \frac{n(n-1)}{2} x^2 - \frac{n(n-1)(n-2)}{6} x^3 \]
\[ a \ll x \Rightarrow \]
\[ T_3 = \frac{7x^1x^1}{x^2x^3x^4x^4} \]
\[ = 3.01 x \frac{a^6}{x^6} \]

(e) An electric potential is given by \( V = Ax^5 (1 - z^2) \). Find the y component of the electric field at the point \( x = 1.00, y = 2.00, z = 5.00 \).

\[ E_y = -\frac{\partial V}{\partial y} \]
\[ = -3Ax^5 y^2 (1 - z^2) \]
\[ = -3Ax^5 y^2 (1 - z^2) \times 3A \times 1.00 \times 2.00 \times (1 - 25.00) \]
\[ = 3A \times 1.00 \times 2.00 = 288 \text{ A} \]