

FIRST MIDTERM

Name (print) _____ Name (signed) _____

Discussion Instructor (circle one): Baselgia Morrill Reeve Stoops Zhang

Discussion Section # _____

REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!

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

- (a) If a satellite circles the Earth in a circular orbit 500 km above the surface of the Earth in exactly 90 min, what is the mass of the Earth (not quite the same as on the data sheet)?

$6.61 \times 10^{24} \text{ kg}$

$$M = \frac{4\pi^2}{T^2 G} r^3 \quad r = R_E + h = 6.88 \times 10^3 \text{ km} \quad T = 90 \times 60 = 5400 \text{ sec.}$$

- (b) Calculate the total energy of the Earth in its orbit around the Sun. Assume the radius of the orbit is 1.48×10^8 km.

$-2.68 \times 10^{33} \text{ J}$

$$T_K = \frac{1}{2} m v^2 \quad \text{since } m \frac{v^2}{r} = G \frac{Mm}{r^2} \quad T_K = \frac{1}{2} G \frac{Mm}{r} \quad T_P = -G \frac{Mm}{r}$$

$$T_{\text{total}} = T_K + T_P = -\frac{1}{2} G \frac{Mm}{r} = -\frac{1}{2} \times 6.67 \times 10^{-11} \times \frac{1.97 \times 10^{30} \times 5.98 \times 10^{24}}{1.48 \times 10^{11}}$$

- (c) Calculate the magnitude of the electric force between two electrons that are 0.2×10^{-10} m apart.

$5.76 \times 10^{-7} \text{ N}$

$$F = k \frac{e^2}{r^2} = 9.00 \times 10^9 \times \frac{(-1.6 \times 10^{-19})^2}{(0.2 \times 10^{-10})^2}$$

- (d) Using the binomial expansion on $(1 + x^2)^{-4/3}$ where $x \ll 1$, calculate the coefficient of the term in x^6 .

-1.73

$$(1+x^2)^{-4/3} = 1 + \left(-\frac{4}{3}\right)x^2 + \frac{1}{2!} \left(-\frac{4}{3}\right)\left(-\frac{4}{3}-1\right)x^4 + \frac{1}{3!} \left(-\frac{4}{3}\right)\left(-\frac{4}{3}-1\right)\left(-\frac{4}{3}-2\right)x^6 + \dots$$

- (e) If a cube has a total charge inside of +3.20 nC, calculate the total electric flux, with units, crossing the faces of the cube.

$3.62 \times 10^{12} \text{ Nm}^2/\text{C}$

$$\Phi = \frac{Q}{\epsilon_0} = \frac{3.20 \times 10^{-9}}{8.85 \times 10^{-12}} = 3.62 \times 10^{12}$$