Physics 2220
Spring 2000
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FIRST MIDTERM

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

(a) A lithium-7 nucleus has 3 protons and 4 neutrons. Calculate the force between a lithium nucleus and an electron 3.00×10^{-11} m apart.

$F = \frac{k q_1 q_2}{r^2}$; $q_1 = 3e$; $q_2 = -e$; $F = -\frac{9 \cdot 10^9 \cdot 3 \cdot (1.6 \cdot 10^{-19})^2}{(3 \cdot 10^{-11})^2} = -7.68 \cdot 10^{-7}$ N

(attractive)

(b) Calculate the electric field (in N/C) at a distance of 4.00×10^{-9} m from a lithium nucleus.

$E = \frac{kq}{r^2} = \frac{9 \cdot 10^9 \cdot 3 \cdot 1.6 \cdot 10^{-19}}{(4 \cdot 10^{-9})^2} = 2.70 \cdot 10^8 \ \frac{N}{C}$

(c) A conducting sphere of radius 1.50×10^{-2} m has a positive charge of 1.75×10^{-11} C. Determine the electric field at a distance of 3.30 m from the center of the sphere.

$d > R \Rightarrow E = \frac{kq}{d^2} = \frac{9 \cdot 10^9 \cdot 1.75 \cdot 10^{-11}}{(3.3)^2} = 1.45 \cdot 10^{-2} \ \frac{N}{C}$

(d) For the expression $1/(x-a)^{5/2}$, where $a \ll x$, calculate completely the term in a^3 using the binomial expansion.

$(x-a)^{-5/2} = x^{-5/2}\left(1 - \frac{a}{x}\right)^{-5/2} = x^{-5/2}\left(1 - \frac{5}{2}\frac{a}{x} + \frac{5}{2}\cdot\frac{7}{2}\cdot\frac{1}{2!}\frac{a^2}{x^2} - \frac{5}{2}\cdot\frac{7}{2}\cdot\frac{9}{2}\cdot\frac{1}{3!}\frac{a^3}{x^3} + \ldots\right)$

term in a^3: $\left(-\frac{5}{2}\cdot\frac{7}{2}\cdot\frac{9}{2}\cdot\frac{1}{3!}\frac{a^3}{x^3}\right)x^{-5/2} = -6.56\frac{a^3}{x^{11/2}}$

(e) An electron is accelerated from rest in a uniform electric field of 4.67 N/C. Find the speed of the electron after it has traveled 3.25 cm.

$F = ma = qE \quad a = \frac{qE}{m} ; \quad v^2 = 2ad$

$v = (2ad)^{1/2} = \left(\frac{2qEd}{m}\right)^{1/2} = \left(\frac{2 \cdot 1.6 \cdot 10^{-19} \cdot 4.67 \cdot 0.0325}{9.11 \cdot 10^{-31}}\right)^{1/2} = 2.31 \cdot 10^5 \ \frac{m}{s}$