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PHZ4390
Aug. 21, 2013

Homework 1

Due Friday, Aug. 30 (see me for help or hints on any problem)

1. Do the following calculations.
   a. (5 pts) The decay width of the η meson is $\Gamma_\eta = 1.30$ keV. What is its lifetime in sec?
   b. (5 pts) The cross section for $e^+ + e^- \to \mu^+ + \mu^-$ is $\sigma = 4\pi\alpha^2 / 3E^2$, where E is the center of mass energy. Rewrite σ in dimensionally correct form by inserting appropriate factors of c and $\hbar$. What is σ in nb for $E = 30$ GeV? $1\text{ nb} = 10^{-33}\text{ cm}^2$.
2. A D^+ meson has a momentum of 2.0 GeV. Use the PDG tables to find its properties.
   a. (2 pts) What are its mass in GeV and lifetime in sec?
   b. (3 pts) What is the total energy E in GeV? What is the kinetic energy in GeV?
   c. (2 pts) What are β and γ?
   d. (3 pts) What is its average decay length in meters?
3. (10 pts) A beam of monoenergetic muons traveling at high velocity loses 25% of them over a distance of 1000 m. What is the momentum (GeV) and velocity (units of c) of each muon?
4. (10 pts) Cosmic rays are composed of energetic particles, mainly protons and heavier nuclei. Could long-lived unstable particles such as neutrons be cosmic ray components? One way of finding out is to determine whether neutrons could survive over (at least) interstellar distances of ~5 light years. What is the minimum energy (in GeV) needed by a neutron to allow a "reasonable" chance of survival after traveling a typical interstellar distance? How does this energy compare to that of most cosmic rays and what does this say about the likelihood of neutrons making up a significant cosmic ray component?

5. wxMaxima problems (you can see me for help)
    a. (4 pts) Find the coefficient of x^{10} in the taylor expansion of $\exp(\tan x)$.
    b. (3 pts) Use the sum command with the simpsum modifier to find $\sum_{n=1}^{\infty} \frac{1}{n^{14}}$.
    c. (3 pts) Use the diff function with the factor modifier to find the 9th derivative of $e^{-x^2/2}$.
    d. (3 pts bonus) Use the taylor function to show that the relativistic kinetic energy can be expanded as $\frac{1}{2}m\beta^2\left(1+a_1\beta^2+a_2\beta^4+\cdots\right)$ using energy units. Find a_1 and a_2. How small must β be to keep the non-relativistic kinetic energy formula accurate to 1%?
6. Python problems (you can see me for help). Please turn in your programs and their output.
    a. (5 pts) Write a program using a for loop that prints only the integers divisible by 7 from 7 to 424.
    b. (5 pts bonus) Write a program using strings and the count function that reports the number of occurrences of all letters of the alphabet in the string below (the string is the text between the quotation marks). Note that upper case and lower case letters are different. You might have to eliminate newline characters (\n) when you paste the text.

       "It is best to express the 4-momentum of the outgoing electron in terms of the other particles, then square it (getting rid of all its properties except for its mass). Please write down the 4-vectors of all other particles in the problem."