Physics 400/506
Problem Set 4
Due Thursday, February 23, 2006 by the end of class

1. Griffiths 5.27

2. Griffiths 5.32

3. Prove that in the quark model, no meson has $J^{PC} = 1^{-+}$. (Hint: try to find a consistent set of ℓ and s values that can add to give $j = 1$ and give $P = -1$ and $C = +1$.)

4. A nucleon has a diameter of $\sim 10^{-15}$ m. Consider a model of the nucleon as three quarks trapped in a potential well with a diameter of $\sim 10^{-15}$ m.

A Use the uncertainty principle to do an order of magnitude estimate of the kinetic energy of each quark. Ignoring binding energy between the quarks, what would you estimate for the mass of a nucleon? How does your result compare to the true value?

B Not unexpectedly, elementary particles such as quarks and leptons seem to be even smaller. The size of an electron has been limited to be $<\sim 10^{-18}$ m, for example. Quark size limits are more difficult, but $< 10^{-16}$ m is not a bad guess. Suppose that quarks or leptons are composite particles. Use the uncertainty principled to estimate the kinetic energy of any sub-particle inside an up quark or inside an electron. Compare your result to the masses of these particles.

C Do you think your result is compatible with the idea that quarks and leptons have substructure? Why or why not?

5. Griffiths 4.32

6. What will the topic of your research paper be? (Remember that it is due on March 28!)

7. *Graduate students only:* Find the Λ_c^+ baryon (mass = 2285 MeV) in the Particle Data Booklet. Using the spin and flavour content of this baryon and Table 4.4 of Griffiths, calculate the expected mass of the Λ_c^+ using the methods of Section 5.10 of Griffiths. How well does your value agree with the actual mass?