University of Toronto PHY357S

Problem Set 2

due Monday, 11 February 2002

(Late penalty is 10% per day, and no problem set is accepted after February 13.)

Each problem is of equal weight, but **not all problems may be marked**.

These problems are primarily based on Chapters 1-7 of Martin and Shaw and on the lectures notes up to January 23; Appendices A, B and E and the inside back cover of M&S may also be helpful. If you have any questions, ask me or Stan, preferably before the last lecture prior to the due date.

1) The "whole body dose" is the radiation dose absorbed by a person averaged over their whole body. A typical transatlantic flight will give you an additional whole body radiation dose of about 30 μSv due to cosmic rays.
   a) Almost very time a ^{60}Co ("Cobalt-60") atom decays it produces two gamma rays: one at 1173KeV and one at 1333KeV. If a typical undergraduate lab 40 KBq ^{60}Co source is 1m away from a student for 6 three hour lab periods, approximately what whole body radiation dose will the student receive from the source?
   b) When a ^{90}Sr ("Strontium-90") atom decays, it produces beta decay electrons with a average total energy of about 1MeV. If a beta electron enters your body it is absorbed. If student accidentally (and stupidly) puts a 40 KBq ^{60}Sr source in their pocket next to their skin and forgets about it for 3 days until the next lab period, what whole body radiation dose will the student receive from the source?

2)
   a) Consider the one particle Hamiltonian in three dimensions:
   $$H = -\frac{1}{2m}\nabla^2 + k_x x^{a_x} + k_y y^{a_y} + k_z z^{a_z}$$
   where $k_x, a_x, k_y, a_y, k_z, a_z$ are real constants. For example, $k_x = k_y = k_z \neq 0,\ a_x = a_y = a_z = 2$ would be a three dimensional harmonic oscillator. Are there any constraints on $k_x, a_x, k_y, a_y, k_z, a_z$ if we require that three momentum, $\vec{\mathbf{p}} = \left(p_x, p_y, p_z\right)$, must be conserved, and if so, what are they?
   b) The 1993 Nobel prize in Physics was given for observations of a binary pulsar which strongly indicate that gravitational radiation must exist. The graviational force is presumably mediated by bosons called "gravitons", and gravitational radiation presumably consists of these gravitons. Infer the parity (P) and charge conjugation (C) of the graviton from the behaviour of the classical Newtonian gravitational field.

3)
   a) Do the masses of all the hadrons given in Appendix E.4 and E.5 indicate a consistant mass difference between the u and d quarks?
   b) Estimate the mass differences between the Δ^-, Δ^0, Δ^+, and Δ^{++} baryons.

4) Martin and Shaw Problem 7.3