Assigned on Thursday, March 10, 2016.

Remember, you can volunteer to explain any of these at the board. You don't need to work them all out, these are the problems most closely related to the recent lectures.

Problems in Jackson's 3rd edition:

11.19 π-meson decay and detection
11.20 Λ-baryon decay and detection
11.21 Decays of a parent particle into daughter particles
11.23 Center of mass frame in high-energy collisions
11.24 Threshold kinetic energies for particle production by collisions
11.25 Colliding beam experiments

Other Problems:

W9. Light is emitted from a rapidly rotating star of radius R, angular speed Ω, mass M. Consider light emitted at frequency ω_0 in the rest frame of the emitting atoms.

a) Assuming that the gravitational red-shift is negligible ($GM/c^2R \ll 1$), determine the range of frequencies observed by an astronomer far from the star.

b) How do you think these results would be modified by effects due to gravity? What would be a simple model or formula for the gravitational red-shift on the observed photons?

W10. Consider the 4-momentum p for photons, the quanta of light. In the following questions, employ the basic assumption that light travels at speed c in all reference frames.

a) Use the energy-momentum dispersion relation $E^2 = m^2c^4 + \vec{p}c \cdot \vec{p}c$ and the definition of wave (or particle) group velocity to show that photons can be considered as particles with zero rest mass.

b) The 4-momentum for photons is defined as $p = (\frac{\hbar\omega}{c}, \vec{p})$, where $\vec{p} = \hbar\vec{k}$. What is the invariant "length squared" for this 4-vector?

c) A photon of 4-momentum p is detected by some "device" with 4-momentum $p_d = (\gamma mc, \vec{p}_d)$. Show that the photon energy detected by the device is given by the scalar product of the 4-vectors,

$$\hbar\omega_d = \frac{1}{m}\, p \circ p_d.$$