Assignment #2
Elementary Particle Physics: Phys 4602/5602
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Due January 23$^{\text{th}}$, 2012

Students registered in 4602 and 5602 do all the problems

1. Two experimental groups claim to have discovered weak neutral current (*i.e.* coupling of charged leptons to the Z^0 boson). The first claims to have seen:

   (1) $\nu_\mu + e^- \rightarrow \nu_\mu + e^-$

   while the second group claims evidence for

   (2) $\nu_e + e^- \rightarrow \nu_e + e^-$

   Draw the Feynman diagrams for these processes. Quite apart from experimental details, which of those two processes is more unequivocal demonstration of weak neutral currents? Why?

2. State which of the following reactions are allowed by the conservation laws and which are forbidden. Give the reason in either case.

   a) $\nu_\mu + p \rightarrow \mu^+ + n$

   b) $\Sigma^0 \rightarrow \pi^+ + e^- + \bar{\nu}_e$

   c) $\pi^0 \rightarrow \gamma + \gamma$

   d) $p \rightarrow n + e^+ + \nu_e$

   e) $\tau^+ \rightarrow e^+ + e^- + e^+$

   f) $p + \bar{p} \rightarrow \pi^+ + \pi^- + \pi^0$

   g) $\pi^+ \rightarrow e^+ + \nu_e$

   h) $K^+ \rightarrow \pi^+ + \pi^- + \gamma$

i) $\nu_e + \bar{\nu}_e \rightarrow g$

j) $Z^0 \rightarrow t + \bar{t}$

3. Draw the Feynman diagram for the process $e^+e^- \rightarrow \mu^+\mu^-$. (a) Draw the arrows in the diagram according to the Feynman-Stückelberg prescription. Estimate the distance between the vertices at collision energy much larger than the masses of any of the particles in (b) the rest mass of the electron, (c) the centre-of-mass frame. Check the consistency of these estimates by considering the Lorentz contraction in going from the rest frame, in which the electron is stationary, to the centre-of-mass frame.