Problem 1 (50 points)

Prob. 6.7 of Thomson

Problem 2 (30 points)

Prob. 6.10 of Thomson

Problem 3 (20 points)

In a recent lecture, we showed that the $1 + \cos^2 \theta$ angular distribution in the center-of-mass frame for the $e^- + e^+ \rightarrow \mu^- + \mu^+$ reaction at high energy can be obtained from the consideration of helicity conservation.

a) If the $e^-$ beam and the $e^+$ beam both have positive helicity, what would the angular distribution be?

b) Now consider the $\nu_\mu + \bar{\nu}_\mu \rightarrow \nu_e + \bar{\nu}_e$ reaction, which proceeds via $\nu_\mu + \bar{\nu}_\mu \rightarrow Z^0 \rightarrow \nu_e + \bar{\nu}_e$, what would the angular distribution be? Note that $\nu$ has negative helicity and $\bar{\nu}$ has positive helicity at high energies.

Note the following values for the rotation matrices:

$$d_{11}^1(\theta) = d_{-1-1}^{-1}(\theta) = (1 + \cos \theta)/2; \quad d_{-11}^1(\theta) = d_{1-1}^{-1}(\theta) = (1 - \cos \theta)/2$$