Schwartz Chapter 17: Problems 1*

Problem 1*

(0) There is only one diagram. The internal lines form a triangle with two smuon lines and a photino line.
The calculation of the diagram involves the following steps:
1. Draw the diagram, labeling the momenta and Lorentz indices.
2. Write down the mathematical expression for the vertex $-ie\Gamma^\mu(p', p)$ using the Feynman rules.
3. Combine the denominators using a Feynman parameter.
4. Shift the loop momentum k^μ so the denominator is a function of k^2.
5. Average the numerator over the "angles" of k^μ.
6. Set the incoming and outgoing muons on their mass-shells: $p^2 = p'^2 = m_\mu^2$.
7. Sandwich the vertex function between muon spinors, $\bar{u}(p')\Gamma^\mu(p', p)u(p)$, and use the Dirac equation to simplify the expression.
8. Use the Gordon decomposition to express it in the form

$$\bar{u}(p')\Gamma^\mu(p', p)u(p) = \bar{u}(p')\big[F_1(q^2)\gamma^\mu + F_2(q^2)(i/2m_\mu)\sigma^{\mu\nu}q_\nu\big].$$

7. Evaluate the loop integral for $F_2(q^2)$. (It does not need any regularization.)

(a) You can get the contribution to the anomalous magnetic moment of the muon from $F_2(q^2 = 0)$. Neglect the muon mass m_μ compared to the smuon mass $m_{\tilde{\mu}}$ and the photino mass $m_{\tilde{A}}$. The Feynman parameter integral can then be evaluated analytically.

(b) Determine the deviation between experiment and the Standard Model by taking the difference and adding the errors in quadrature. You can obtain constraints on the masses of SUSY particles by requiring their contribution to $g - 2$ to be less than the deviation between experiment and the Standard Model. Consider the two extreme possibilities: $m_{\tilde{\mu}} \ll m_{\tilde{A}}$ and $m_{\tilde{\mu}} \gg m_{\tilde{A}}$. In one limit, the result does not depend on $m_{\tilde{\mu}}$, so put a constraint on $m_{\tilde{A}}$. In the other limit, the result depends on a combination of $m_{\tilde{\mu}}$ and $m_{\tilde{A}}$, so put a constraint on that combination.

(c) Set $m_{\tilde{A}} = m_{\tilde{\mu}} = M_{\text{susy}}$. Put a constraint on M_{susy}.