Exercises SUSY

0) What happens to a (non-hydrogen) atom in an exactly susy world? (No chemistry!)

sect. 3.1

1) $Q := i\left(\frac{\partial}{\partial\bar\theta} + i\gamma^\mu\theta\partial_\mu\right)$, $\bar{Q} := i\left(-\frac{\partial}{\partial\theta} - i\bar\theta\gamma^\mu\partial_\mu\right)$

check $\{Q_\alpha, \bar{Q}_\beta\} = 2\gamma^\mu_{\alpha\beta} P_\mu$

sect. 3.2

2) Convert 4-spinor $\longrightarrow$ Weyl-spinor expressions

$m\bar\Psi\Psi$, $\bar\Psi\gamma^\mu i\partial_\mu\Psi$, $\bar\Psi\gamma^\mu P_L i\partial_\mu\Psi$

3) Prove, using Weyl spinors (anticommuting)

$\theta^\alpha\psi_\alpha = \psi^\alpha\theta_\alpha$, $\bar\psi_L i\bar\sigma^\mu\partial_\mu\psi_L = \psi_L i\sigma^\mu\partial_\mu\bar\psi_L$

4) Compute $\left(x^\mu + i\bar\theta\gamma^\mu\xi - i\,\overline{\theta_R - \xi_R}\,\gamma^\mu(\theta_R - \xi_R)\right)$ using Weyl spinors and show: $\bar{D}^{\dot\alpha}\Phi := \left(\partial/\partial\bar\theta_{\dot\alpha} - i^{\dot\alpha}(\bar\sigma^\mu\theta)\partial_\mu\right)\Phi = 0$ for any chiral s.f.

sect. 4.1

5) Compute $\Phi_1\,\Phi_2\,\Phi_3$

6) Work out superpotential terms from $W = y_t\, \Phi_H\, \Phi_L\, \bar{\Phi}_R$

(part of MSSM); components : H , $\tilde{H}_\alpha$
A_L , $\psi_{L\,\alpha}$
A_R , $\psi_{R\,\alpha}$

for $H \equiv v = \text{const}$ derive mass terms and derive interaction Feynman rules

sect. 4.4

7) Derive the D-term contributions in general $\mathcal{L}$ and solve/insert eq. of motion for D.

8) Sketch the Feynman rules of general theory

sect. 4.5

9) Derive the Feynman rules for SUSY-QED in 4-spinors; define SUSY-QCD and derive the gluino Feynman rules

Diagrams for gluino pair production at LHC?

sect. 5.2

10) Prove : $\hat{H}_u\, \hat{Q}\, \hat{U}$ is $SU(2)_L \times U(1)_Y$ gauge invariant

11) Suppose there is only one Higgs doublet $\hat{H}_d$ in the MSSM.
What's wrong with the terms:

$$\int d^2\theta_L \quad \hat{H}_d \; \hat{Q} \; \hat{U}$$

$$\int d^2\theta_L \quad \hat{H}_d^\dagger \; \hat{Q} \; \hat{U}$$

$$\int d^4\theta \quad \hat{H}_d^\dagger \; \hat{Q} \; \hat{U} \qquad ?$$

12) Why does R-parity imply that the lightest susy particle is stable? Which of the susy particles could be dark matter candidates?

13) Write explicitly the W(A)-terms relevant for selectrons, expanding SU(2)-products.
Compute $\partial W(A)/\partial H_d^0$, $\partial W(A)/\partial \tilde{e}_L$, $\partial W(A)/\partial \tilde{e}_R^\dagger$
and write the selectron mass terms as $(\tilde{e}_L^\dagger \; \tilde{e}_R^\dagger)(\text{matrix})\begin{pmatrix}\tilde{e}_L \\ \tilde{e}_R\end{pmatrix}$.