

## Advanced Quantum Mechanics A – Problem Set 5

1. Find the energies and eigenfunctions of the Dirac equation describing an electron moving in the  $x-y$  plane in the presence of a constant magnetic field  $B$  along the  $z$  direction. Hint: Show that in two dimensions one can use the following representation of the Dirac matrices:  $\alpha_x = \sigma_x$ ,  $\alpha_y = \sigma_y$ ,  $\beta = \sigma_z$ , where  $\sigma_{x,y,z}$  are the Pauli matrices.

Write the wavefunction as a spinor  $\psi = \begin{pmatrix} \psi_1 \\ \psi_2 \end{pmatrix}$  and derive separate equations for  $\psi_1$  and  $\psi_2$ . Discuss the non-relativistic limit of the results.

2. Calculate the fine structure of the hydrogen atom spectrum. Do it within first order perturbation theory in the relativistic corrections, which we obtained in class for the Schrodinger Hamiltonian.