Homework 7, Phys 230A, String Theory, Polchinski

Due 3/14/12.

1. In the IIB theory, we will consider a D1-brane at $X^2 \ldots, X^9 = 0$ and a Dp-brane at $X^{p+1}, \ldots, X^9 = 0$. There is zero distance between the branes, so no energy from stretching. We will look at all the cases $p = 3, 5, 7, 9$. Use light-cone quantization — consider α_n^i and ψ_n^i for $1 = 2, \ldots, 9$. You have seen that for such brane systems in the bosonic string, some X^i are integer moded and some are integer$+\frac{1}{2}$ moded. In the superstring, the rule is that in the R sector ψ^i has the same moding as X^i, for each i, and in the NS sector it has the opposite moding for each i. (This follows from the supersymmetric form of the conformal symmetry).

a) For each of $p = 3, 5, 7, 9$, find the lowest mass in the R and NS sectors by adding zero point energies using the heuristic rules.

b) For each of $p = 3, 5, 7, 9$, find the degeneracy of these lightest states in both the R and NS sectors.

c) First do parts a and b without making any GSO projection. Now discuss how this projection affects the answers. (It may not be obvious which half of the states to keep, in which case consider both cases.)

d) Which system or systems in c appear to be supersymmetric?

e) Now consider a more general situation, where there are four sets of directions: NN, in which both branes are extended; DD, in which neither is extended; ND, in which the first brane is extended and the other not; DN, in which the second is extended and the first not. (In the examples above, the set ND was empty). Show that your answer to part d depends only on the total number of ND + DN directions.