Problem set #7

1) Enhanced gauge groups in Type I'
a) Find all enhanced simple gauge groups in Type I' (simple here means the gauge group in the vector multiplet is simple).
b) Using the equation for the sources of the string coupling in Type I' find the values of the scalar vev's that lead to the enhanced gauge groups found in part a).
c) Find all enhanced gauge groups G of the form G=G_1*G_2, where G_1 and G_2 are simple. For each case, specify the range that the ranks of the groups G_1 and G_2 can take.
d) For each case that you find in part c) find the values of the scalar vev's that lead to this particular enhanced gauge group.

2) W bosons and root systems
Using the set of roots you found in problem 5 of problem set 6, match each root to a given BPS W boson which becomes massless at the enhanced E_n point. In particular specify which W bosons arise from one D0 brane, which arise from anti D0 branes and which W bosons arise from 2 D0 branes, etc.
b) Make an attempt to explain the reason why the D0 branes transform in the spinor representation of the SO(2n-2) group.
Remember that these states are still in the vector multiplet of the supersymmetry algebra and therefore there are gauge fields, fermions and scalar, all of which transform in the spinor representation of the gauge group SO(2n-2).

3) Orientifolds in compact backgrounds.
a) Using a compact Orientifold background with 16 supercharges and O6 planes find all possible connected moduli spaces of vacua. Consider cases with O6+ and O6- only with no other types of orientifold planes. Find the number of vector multiplets and write down the scalar manifold for each case.
Do not forget to include the scalar in the gravity multiplet.
b) Find the maximal rank Sp gauge group in each of the cases you found in a).

4) 5d SYM with 16 supercharges & (0,2) theories in 6 dimensions
a) Identify the W boson, 't Hooft Polaykov monopole and the instanton for an SU(2) gauge theory that lives on the world volume of D4 branes in Type IIA.
b) Write down their mass or tension formulas in terms of the parameters and vevs of the 5d gauge theory.
c) Write down the results of b) in terms of the Type IIA string parameters.
d) Using S duality between Type IIA and M theory write down the results of c) in terms of the parameters and vevs of M theory.
e) Identify the BPS branes that you found in d) in terms of the (0,2) world volume theory living on the M5 brane. Remember that this is a theory of tensionless strings and that there are no BPS particles for this theory in 6 dimensions.