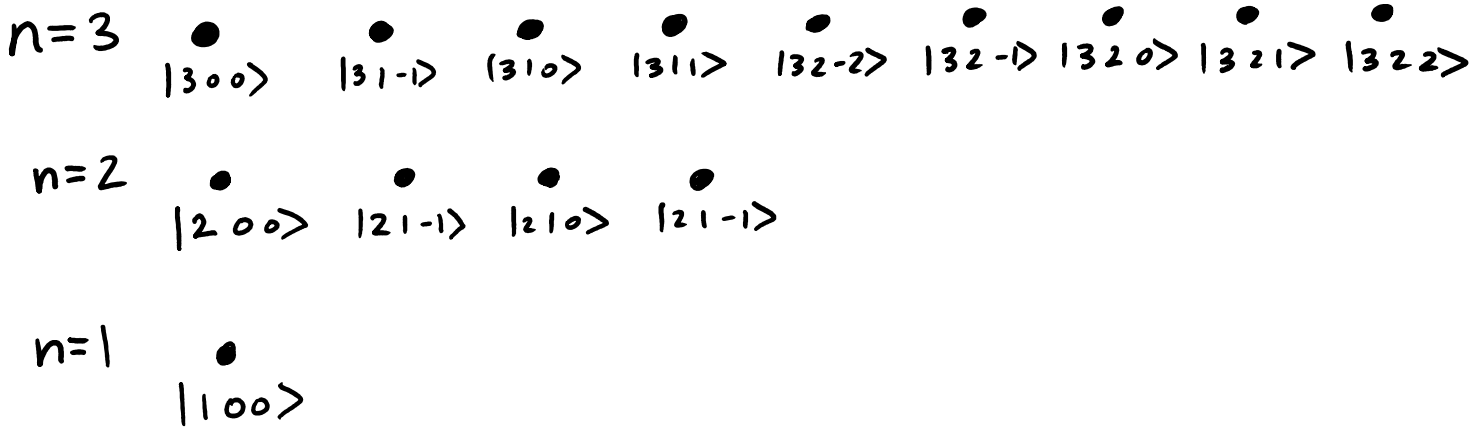
PHYSICS 402 WORKSHEET

① The following chart shows some low-energy states of the hydrogen atom (before considering the electron spin) in the $|n\ \ell\ m\rangle$ notation. Show how L_+ and L_- act on each of the states by drawing $\xrightarrow{+}$ and $\xrightarrow{-}$ arrows. Circle the groups that can be transformed into one another by rotations.



② Write the results of the following:

a) $L_z|2\ 1\ 1\rangle =$

b) $L^2|2\ 1\ 1\rangle =$

c) $L_+|2\ 1\ 1\rangle =$

d) $L_-|2\ 1\ 1\rangle =$

e) $L_x|2\ 1\ 1\rangle =$

extra: $L_xL_y|2\ 1\ 0\rangle$

③ For states of a spin 1 particle of the form

$$\sum_M c_M |M\rangle ,$$

which are physically unchanged after a rotation about the z axis?

What about the x-axis?