Phys 451 **Winter 2026**

Worksheet #12

(Wednesday, February 4, 2026)

Name

Questions (5 pts):

Consider a hydrogen atom in an electric field $\mathcal{E}$. As we showed, the non-zero first-energy corrections to the unperturbed energies for the n = 2 state can be obtained by diagonalizing the following perturbation matrix (in the |200>, |210> basis):

$$\begin{pmatrix} 0 & -3e\mathcal{E}a_0 \\ -3e\mathcal{E}a_0 & 0 \end{pmatrix}$$

(a) Find the eigenvalues and eigenvectors of the perturbation matrix above. Write the eigenvectors in terms of the basis states.

(b) Sketch the new energy levels and indicate the new states resulting from the perturbation. Don't forget to include ones for which the energy correction is 0.

(c) **If you have time:** use symmetry arguments to find the first-order energy correction to the ground state (i.e. n =1).

(d) **If you have time:** Let's say you are a spectroscopist measuring emission from the n =2 to n = 1 transition. Sketch the transitions and the emission spectra for what you expect to see without and with the applied electric field.