1. C-TDL Ch. X problem 1

2. C-TDL Ch. X problem 3

3. Show, using a plane wave as your original eigenstate, that the momentum operator “generates” a translation in space. Prove that a unitary operator $U$ may be written in terms of a Hermitian operator $G$, where $U = \exp(i\theta G)$, where $\theta$ is arbitrary.

4. “Adding” $l = 1$ with $s = 1/2$: Use raising and lowering operators as well as orthogonality to express the combined basis states in terms of the individual basis states $|l = 1, m_l, s = 1/2, m_s\rangle$.

5. Sakurai Ch. 3 Problem 8 (Sakurai is on reserve in the library if you want to see the problems in their original form. If that is inconvenient, they are reproduced here):

Consider a sequence of Euler rotations represented by

$$D^{1/2}(\alpha, \beta, \gamma) = \exp(-i\sigma_3\alpha/2)\exp(-i\sigma_2\beta/2)\exp(-i\sigma_3\gamma/2).$$

[The (1/2) superscript on $D$ means that we are in a spin 1/2 system, so the matrices are the Pauli matrices.]

Because of the group properties of rotations, we expect that this sequence of operations is equivalent to a single rotation about some axis by an angle $\theta$. Find $\theta$.

7. Sakurai Ch. 3 Problem 17:

Suppose a half–integer $l$ value, say $1/2$, were allowed for orbital angular momentum. From

$$L_+ Y_{1/2, 1/2}(\theta, \phi) = 0,$$

we may deduce, as usual,

$$Y_{1/2, 1/2}(\theta, \phi) \sim e^{i\phi/2}\sqrt{\sin\theta}.$$

Now try to construct $Y_{1/2, -1/2}(\theta, \phi)$ by (a) applying $L_-$ to $Y_{1/2, 1/2}(\theta, \phi)$; and (b) using $L_-Y_{1/2, -1/2}(\theta, \phi) = 0$. Show that the two procedures lead to contradictory results. (This gives an argument against half–integer $l$ values for orbital angular momentum.)

8. In class we found the linear Stark for the $n=2$ level of hydrogen. Now find it for the $n=3$ level of hydrogen. The matrix will be quite sparse so order the levels judiciously. Choose the perturbation to be $W_S = -qE_z$. (You can determine which matrix elements will be nonzero by noting that $\langle l'm'|Y_{m'}|l'm''\rangle$ is nonzero only if the $(lm)$ quantum numbers can be “added” to the $(l'm')$ quantum numbers to yield the $(l'm'')$ quantum numbers).