Physics 460—Practice S–1 (Due Apr 16, 1 pm) Name: Timothy Holmes

S–1: I can analyze systems with intrinsic angular momentum (spin).	
Unsatisfactory Progressing Acceptable Polished	

In the z basis the spin operators are, for the case $s = 1$,

$$S_z \leftrightarrow \hbar\begin{bmatrix}1&0&0\\0&0&0\\0&0&-1\end{bmatrix}, \quad S_x \leftrightarrow \frac{\hbar}{\sqrt{2}}\begin{bmatrix}0&1&0\\1&0&1\\0&1&0\end{bmatrix}, \quad S_y \leftrightarrow \frac{\hbar}{\sqrt{2}}\begin{bmatrix}0&-\mathrm{i}&0\\\mathrm{i}&0&-\mathrm{i}\\0&\mathrm{i}&0\end{bmatrix},$$

and the eigenstates of S_x and S_y are

$$|{+1_x}\rangle \leftrightarrow \frac{1}{2}\begin{bmatrix}1\\\sqrt{2}\\1\end{bmatrix}, \qquad |0_x\rangle \leftrightarrow \frac{1}{\sqrt{2}}\begin{bmatrix}1\\0\\-1\end{bmatrix}, \qquad |{-1_x}\rangle \leftrightarrow \frac{1}{2}\begin{bmatrix}1\\-\sqrt{2}\\1\end{bmatrix},$$

$$|{+1_y}\rangle \leftrightarrow \frac{1}{2}\begin{bmatrix}1\\\sqrt{2}\mathrm{i}\\-1\end{bmatrix}, \qquad |0_y\rangle \leftrightarrow \frac{1}{\sqrt{2}}\begin{bmatrix}1\\0\\1\end{bmatrix}, \qquad |{-1_y}\rangle \leftrightarrow \frac{1}{2}\begin{bmatrix}1\\-\sqrt{2}\mathrm{i}\\-1\end{bmatrix}.$$

(1) A spin 1 particle in state $|0_z\rangle$ is placed in a magnetic field $\vec{B} = B_0\,\hat{\jmath}$. The Hamiltonian for the particle is then $H = -\gamma\vec{S}\cdot\vec{B}$, where γ is a constant.

$H = -\gamma B_0 S_y \rightarrow \Omega_0 S_y$

(a) If you measure the energy of the particle at time $t = 0$, what values can you obtain and with what probability?

(b) For each possible value of the energy that you might obtain through measurement, find a time t for which you would be assured of measuring that value. If you believe that there is no such time t for some value(s) of the energy, explain why.

(a) $|\psi(t)\rangle = e^{-iHt/\hbar}|\psi_0\rangle = e^{-iHt/\hbar}/\sqrt{2}\,\left[|{+1_z}\rangle + |0_z\rangle + |{-1_z}\rangle\right]$

$t=0 \quad \langle 0_z|\psi\rangle = \frac{1}{\sqrt{2}}\left[\cancel{\langle 0_z|{+1_z}\rangle}^{0} + \cancel{\langle 0_z|0_z\rangle}^{1} + \cancel{\langle 0_z|{-1_z}\rangle}^{0}\right]\cdot\frac{1}{\sqrt{2}}$

$= \left|\frac{1}{\sqrt{2}}\frac{1}{\sqrt{2}}\right| = \boxed{\frac{1}{2}}$

(B) $\cos\frac{\Omega_0 t}{2}$?