(1) The Hamiltonian for negatively-charged particle in a magnetic field is $H = -\gamma \vec{S} \cdot \vec{B}$. Section 1.6 of the course notes discusses the precession of a negatively-charged spin-1/2 particle when the magnetic field is $\vec{B} = B_0 \hat{\mathrm{k}}$. In this activity, you'll explore the precession of a negatively-charged spin-1 particle under the same conditions.

(a) Consider a negatively-charged spin-1 particle in state

$$|\Psi_1\rangle = \frac{1}{\sqrt{2}}\Big(|+1_z\rangle - |-1_z\rangle\Big).$$

Find the time evolution of this state if the magnetic field is $\vec{B} = B_0 \hat{\mathrm{k}}$. Express your answer in terms of the Larmor frequency $\Omega_0 = |\gamma B_0|$.

(b) Calculate $\mathcal{P}_{+1_x}(t)$ for this particle (the probability that a measurement of spin along the x axis have a result of $+\hbar$).

(c) Suppose instead that the initial state of the particle is

$$|\Psi_2\rangle = \frac{1}{\sqrt{2}}\Big(|+1_z\rangle + |-1_z\rangle\Big).$$

Find the time evolution of this state given the same magnetic field, and calculate $\mathcal{P}_{+1_x}(t)$ for this state.

(d) Suppose instead that the initial state of the particle is

$$|\Psi_3\rangle = \frac{1}{\sqrt{3}}\Big(|+1_z\rangle + |0_z\rangle + |-1_z\rangle\Big).$$

Find the time evolution of this state given the same magnetic field, and calculate $\mathcal{P}_{+1_x}(t)$ for this state.

(e) Compare your answers for $\mathcal{P}_{+1_x}(t)$ for these three states. How are they similar? How do they differ?