3) \[ P_\text{=} \frac{1}{4} \quad \sin^2 \theta = \frac{1}{4} \quad \sin \theta = \frac{1}{2} \quad \theta = 30^\circ \]

half height in at 20 kHz \quad w_1 = 10 kHz \quad B_0 = 30 kHz

\[ B_1 = \frac{1}{3} B_0 \]

when \ Probability = \frac{1}{4} \]

\[ \frac{w_1^2}{w_1^2 + (w - w_0)^2} = \frac{1}{4} \]

\[ (w - w_0)^2 = 3 w_1^2 \]

\[ w - w_0 = \pm \sqrt{3} w_1 \]

\[ w = w_0 - \sqrt{3} w_1 \]

\[ w = w_0 - \frac{\sqrt{3}}{3} w_0 \]

\[ w = w_0 (1 - \frac{\sqrt{3}}{3}) \]

\[ w = 30 \text{ KHz} \left( 0.42 \right) = 12.6 \text{ kHz} \]

\[ \sin \theta = \frac{1}{2} = \frac{B_1}{B_0} \]

\[ B_{eff} = 2 B_1 = \frac{2}{3} B_0 \]
One procedure is to invert the magnetization with a 180 degree pulse. Then the magnetic moments will relax with a time $T_1$ to the field direction. Then a 90 degree pulse (after various time delays) will rotate the spins into the $xy$ plane so the size the magnetization can be observed (by induction in a pickup coil).

2a) The pulse width certainly has to be narrower than $T_1$ or else the spins would begin to reorient in the $z$ direction. Similarly it must be less than $T_2$ or else the spins will begin to get out of phase before they reach the $xy$ plane. Since the width must be smaller than these times the magnitude must be large enough to produce the 90 degree rotation in this short time.

b) The delay should be much less than $T_1$. It should be long enough for the dephasing due to the inhomogeneous fields to take place but it should also be short compared to the random spin-spin dephasing $T_2$. 

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Figure 12: Two pulse sequence showing inversion recovery of $M_z$. The FID signal produced by the $\pi/2$ ($90^\circ$) pulse has an initial amplitude related to the value of $M_z$ at the end of the interval TI. Taken from reference [5].

Figure 16: Multipulse spin echo sequence. Later $180^\circ$ (\(\pi\)) pulses refocus the spins to produce additional spin echoes following on the first echo. The envelope of the decay follows and exponential in terms of $T_2$. From reference [5].
\[ 1^4 \gamma = 10,000 = \frac{1}{\lambda^2} \left( 1+\gamma - 1-\gamma \right) \]

\[ s_2 = s_1^2 + s_2^2 + 2s_1 s_2 - s_1 - s_2 \]

\[ s_2 \left( 1+\gamma - 1-\gamma \right) = \frac{1}{\lambda^2} \left( \begin{align*}
1 & (1+\gamma - 1-\gamma) \\
0 & (1+\gamma - 1-\gamma)
\end{align*} \right) \]

\[ s_2 / 1+\gamma - 1-\gamma = 0 \quad \text{Eigenvalue in zero} \]

\[ s_1 = s_2 \frac{h^2}{\lambda^2} \left( 1+\gamma - 1-\gamma \right) = \frac{1}{\lambda^2} \left( \begin{align*}
1 & h^2 (1+\gamma - 1-\gamma) \\
0 & h^2 (1+\gamma - 1-\gamma)
\end{align*} \right) \]

\[ s_1 = s_2 \frac{h^2}{\lambda^2} \left( 1+\gamma - 1-\gamma \right) = -\frac{h^2}{\lambda^2} \quad \text{Eigenvalue} \]

\[ \begin{align*}
\text{Sum} = & -\frac{h^2}{\lambda^2} (1+\gamma + 1-\gamma) = -\frac{h^2}{\lambda^2} \left( 1+\gamma - 1-\gamma \right) \end{align*} \]

\[ \text{a) } \gamma = \frac{1}{\lambda^2} \left( 1+\gamma + 1-\gamma \right) \quad 1-\gamma = \frac{1}{\lambda^2} (1+\gamma - 1-\gamma) \]

\[ \begin{align*}
1+\gamma = & \frac{1}{\lambda^2} \left( 1+\gamma + 1-\gamma \right) \\
1-\gamma = & \frac{1}{\lambda^2} (1+\gamma - 1-\gamma) \end{align*} \]

\[ \begin{align*}
\gamma = & \frac{h^2}{\lambda^2} \left( 1+\gamma + 1-\gamma \right) \\
\gamma = & \frac{h^2}{\lambda^2} \left( 1+\gamma - 1-\gamma \right) \end{align*} \]

b) The system has total angular momentum \( \hbar \)

so we expect that all directions in space to be equivalent.