$$
\begin{aligned}
s_1 &= x_1 + x_2 \\
s_2 &= x_2 - x_1
\end{aligned}
$$

$$
\begin{aligned}
s_1(t) &= A_1 \cos(\omega_1 t + \phi_1) \\
s_2(t) &= A_2 \cos(\omega_2 t + \phi_2)
\end{aligned}
$$

$$
\begin{aligned}
s_1(t) &= L \cos(\omega_1 t) \\
s_2(t) &= L \cos(\omega_2 t)
\end{aligned}
$$

$$
s_1 - s_2 = (x_1 + x_2) - (x_2 - x_1) = 2x_1
$$

$$
x_1 = \frac{1}{2}(s_1 - s_2)
$$

$$
x_2 = \frac{1}{2}(s_1 + s_2)
$$

$$
\begin{aligned}
x_1(t) &= \frac{1}{2} L \left[\cos(\omega_1 t) - \cos(\omega_2 t)\right] \\
&= \frac{1}{2} L \left[\cos\left(\sqrt{\frac{k}{m}} t\right) - \cos\left(\sqrt{\frac{3k}{m}} t\right)\right]
\end{aligned}
$$

$$
\begin{aligned}
x_2(t) &= \frac{1}{2} L \left[\cos(\omega_1 t) + \cos(\omega_2 t)\right] \\
&= \frac{1}{2} L \left[\cos\left(\sqrt{\frac{k}{m}} t\right) + \cos\left(\sqrt{\frac{3k}{m}} t\right)\right]
\end{aligned}
$$