1. [25] 3.1 from Ziemer and Tranter.
Note: During the lecture, we focused on DSB demodulation assuming that the transmitter and receiver have exactly the same phase (phase coherent demodulation). The main objective of this problem is to illustrate the error that results from having different phases at both ends. The error $e(t)$ is defined as the difference between the desired message $m(t)$ and the demodulated signal. Mean-square error is the time average of the error-square over some time: $<e^2(t)>$, where $<.>$ means the time-average.

2. [20] In a DSB system the carrier is $x_c(t) = A\cos(2\pi f_c t)$ and the message signal is given by $m(t) = \sin c(t) + \sin c^2(t)$. Find the frequency domain representation and the bandwidth of the modulated signal.

3. [25] The message signal $m(t) = 2\cos(4000\pi t) + 5\cos(6000\pi t)$ is modulated by the carrier $x_c(t) = 100\cos(2\pi f_c t)$, where $f_c = 50\text{kHz}$.
   a) Using MATLAB, plot the modulated signal.
   b) Using MATLAB, compute and plot the amplitude and phase spectrum of the DSB signal.
   Hint: This is similar to the example on the web page.
   c) Compute the power of the DSB signal.

4. [30] You are asked to design a DSB modulator to generate a modulated signal $km(t)\cos(2\pi f_c t)$ where $m(t)$ is a signal band-limited to B Hz. The following figure shows a DSB modulator available in the stock room. The carrier generator available generates not $\cos(2\pi f_c t)$, but $\cos^3(2\pi f_c t)$. Explain whether you would be able to generate the desired signal using only this equipment. You may use any kind of filter you like.

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\begin{figure}
\centering
\begin{tikzpicture}
\node (input) [signal, input] {m(t)};
\node (filter) [right of=input, signal, node distance=2cm] {Filter};
\node (output) [right of=filter, signal, node distance=2cm] {km(t)\cos(2\pi f_c t)};
\draw [->] (input) -- (filter);
\draw [->] (filter) -- (output);
\node (cos3) [below of=filter, node distance=1cm] {\cos^3(2\pi f_c t)};
\end{tikzpicture}
\end{figure}
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a) What kind of filter is required?
b) Determine the signal spectra at the output of the multiplier and at the output of the filter?
c) Would this scheme work if the carrier generator output were \( \cos^2(2\pi f_t) \)? Explain.