Homework 3

1. **AM Modulation** (Haykin and Moher, Problem 3.7)
   The AM signal:
   $$s(t) = A_c[1 + k_a m(t)]\cos(2\pi f_c t)$$
   is applied to the system shown in Fig. 1. Assuming that $|k_a m(t)| < 1$ for all t and the message signal $m(t)$ is limited to the interval $-W \leq f \leq W$, and that the carrier frequency $f_c > 2W$, show that $m(t)$ can be obtained from the square-rooter output $v_3(t)$.

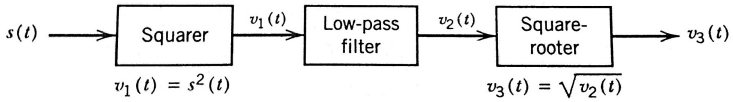

Figure 1: Problem 1

2. **DSB-SC Modulation** (Haykin and Moher, Problem 3.8)
   Consider a message signal $m(t)$ with the spectrum shown in Fig. 2. The message bandwidth is $W = 1$ kHz. This signal is applied to a product modulator, together with a carrier wave $A_c \cos \omega_c t$ producing the DSB-SC modulated wave $s(t)$. This modulated wave is next applied to a *coherent detector*. Assuming perfect synchronism between the carrier waves in the modulator and detector, determine the spectrum of the detector output when:
   (a) the carrier frequency $f_c = 1.25$ kHz, and
   (b) the carrier frequency $f_c = 0.75$ kHz.
   What is the lowest carrier frequency for which each component of the modulated wave $s(t)$ is uniquely determined by $m(t)$?

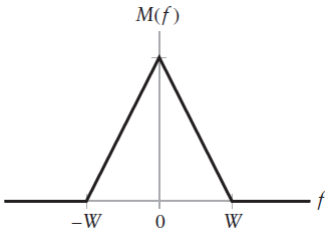

Figure 2: Problem 2

3. **DSB-SC Modulation** (Parts d and e are optional, 4 points bonus if you solve)
You are asked to design a DSB-SC modulator to generate a modulated signal $km(t)\cos(\omega_c t+\theta)$, where $m(t)$ is a signal bandlimited to W Hz as shown in Fig. 3 (b). The figure shows a DSB-SC modulator available in the stockroom. The carrier generator available generates not $\cos\omega_c t$ but $\cos^3\omega_c t$. Explain whether you would be able to generate the design using only this equipment. You may use any kind of filter you like.

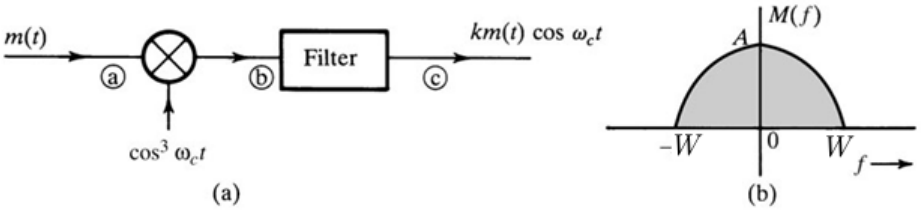

Figure 3: Problem 3

(a) What kind of filter is required in the figure?
(b) Determine the signal spectra at points b and c, and indicate the frequency bands occupied by these spectra.
(c) What is the minimum usable value of ω_c?
(d) Would this scheme work in the carrier generator output were $\sin^3\omega_c t$? Explain.
(e) Would this scheme work in the carrier generator output were $\cos^n\omega_c t$ for any integer $n \geq 2$?