Homework 6

1. **Nyquist Sampling** (20 points)
   The Fourier transform of $g_1(t)$ and $g_2(t)$ are shown in Fig. 1. Determine the Nyquist sampling rate and interval for each of the following signals: $g_1(t), g_2(t), g_1^2(t), g_2^m(t)$,$g_1(t)g_2(t)$, and $g_1^m(t)g_2^n(t)$.

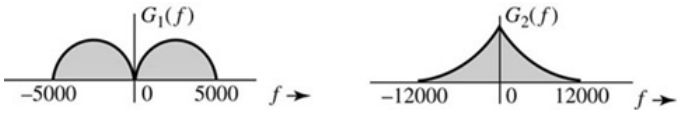

Figure 1: Problem 2

2. **Sampling** (20 points)
   The signals $m_1(t) = 10\cos 100\pi t$ and $m_2(t) = 10\cos 50\pi t$ are both sampled at frequency $f_s = 75$ Hz. Show that the two sequences of samples so obtained are identical. What are the Nyquist rates for these signals? What does this problem indicate about undersampling a signal?

3. **Sampling/Aliasing** (40 points)
   A signal $g(t) = \text{sinc}^2(5t)$ is sampled (using uniformly spaced impulses) at a rate of (i) 5 Hz; (ii) 10 Hz; (iii) 20 Hz. For each of the three cases:

   (a) Sketch the sampled signal.

   (b) Sketch the spectrum of the sampled signal.

   (c) Explain whether you can recover the signal $g(t)$ from the sampled signal.

   (d) If the sampled signal is passed through an ideal low-pass filter of bandwidth 5Hz, sketch the spectrum of the output signal.

4. **Aliasing** (10 points)
   A 4 kHz cosine is sampled at different rates given in the table below. In each case, what frequencies will we hear when we play the sinusoid back again? (fill in the table).

f_s	frequency we hear
9 kHz	
8 kHz	
7 kHz	
6 kHz	
5 kHz	
4.5 kHz	
4 kHz	
3.5 kHz	
3 kHz	
2.5 kHz	
2 kHz	

Hint: Refer to the lab instruction of *Lab 6: Sampling and Aliasing*. You basically need to find

$$f_{a,\min} = \min |f - \ell f_s| \qquad \ell \text{ is any integer}$$

and the answer should be below $f_s/2$.

5. **PCM** (20 points)
Twelve different message signals each with bandwidth of 10 kHz are to be multiplexed and transmitted. Determine the minimum bandwidth required for each method if the multiplexing/modulation method used is

   (a) FDM/SSB

   (b) TDM/PAM