



### Question 1

Two signal,  $g_1(t)$  and  $g_2(t)$ , whose Fourier transform is shown in Fig. 1. Determine the Nyquist interval and the Nyquist rate for the following signals:

- 1)  $g_1(t)$
- 2)  $g_2(t)$
- 3)  $g_1(t) * g_2(t)$
- 4)  $g_1(t) \times g_2(t)$
- 5)  $[g_1(t)]^2$
- 6)  $[g_2(t)]^m$

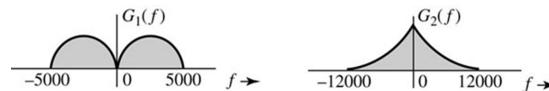


Fig. 1

### Question 2

Determine the Nyquist rate for the following signals:

- 1)  $\text{sinc}(100\pi t)$
- 2)  $\text{sinc}^2(100\pi t)$
- 3)  $\text{sinc}(100\pi t) + \text{sinc}(200\pi t)$
- 4)  $\text{sinc}(100\pi t) \times \text{sinc}(500\pi t)$

### Question 3

In a PCM system, an input signal  $m(t) = 8 \cos(2\pi t)$  volts. It is required to design a uniform quantizer with a maximum quantization error of 0.4 volts.

- 1) What is the minimum number of bits required to characterize the output levels?
- 2) What is the **actual** maximum quantization error if that minimum number of bits are fully utilized?
- 3) Assume that the zero volt value is a mid-point between two levels. Assume also a sampling rate that is double the Nyquist rate, with the first samples taken at  $t = 0$  seconds. Sketch the quantizer output waveform for one complete cycle of the input.

### Question 4

A signal  $m(t)$  is defined as

$$m(t) = \text{sinc}^2(5t)$$

The signal  $m(t)$  is sampled using uniformly spaced impulses at a rate of (a) 5 Hz, (b) 10 Hz, (c) 20 Hz. For each of the three cases:

- 1) Sketch the sampled signal
- 2) Sketch the spectrum of the sampled signal
- 3) Can you recover the signal  $m(t)$  from the sampled signal
- 4) If the sampled signal is passed through an ideal low-pass filter of bandwidth 5 Hz, sketch the spectrum of the output signal, and write its expression in time-domain.



**Undergraduate Program**  
**Communications Engineering (ELC 325A)**  
Computer Engineering Department  
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**Problem Set - Sampling, PM, PCM Systems**



**Question 5**

Four telemetry signals of bandwidths 0.5 KHz, 1 KHz, 2 KHz and 4 KHz. TDM is used and these signals are transmitted simultaneously by binary PCM.

Each signal must be sampled at least 25% above the Nyquist rate.

The maximum tolerable error in sample amplitudes is 0.5% of the peak signal amplitude.

- 1) What is the sampling rate of each signal?
- 2) What is the minimum number of levels of the Quantizer?
- 3) What is the minimum possible data rate of the multiplexed signal?
- 4) What is the minimum bandwidth required for transmission? (Assume channel efficiency of 1.5 bps/Hz)