**ENGR 3323: Signals and Systems**

**Final (7/25/2022)**

**Time:** 10:30 am – 12:30 pm **Name:**

**1)** The figure below shows the spectra of a periodic signal *x*(*t*).

a) By inspection, find the compact trigonometric Fourier series representing *x*(*t*).

b) Find the power of the signal *x*(*t*).

100

200

300

400

2

4

6

|Cn|

-π/8

θn

-π/4

-π/2

*f* (Hz)

100

200

300

400

*f* (Hz)

1. Find the fundamental frequency (first hormonic)
2. Find the output *y*(*t*) in a compact trigonometric format.
3. Find the power of the DC and first harmonic of the output *y*(*t*)

**3)**  A message signal is modulated by a carrier the modulated signal is

1. Find the Fourier transform *X*(jω) of the modulated signal *x*(*t*)
2. Build the block diagram of the receiver that will demodulate *x*(*t*) to recover the message signal *m*(*t*). You can assume the bandwidth of the signal *m*(*t*) is 15 rad/sec.

**4)** For the signal determine the essential bandwidth *B* (in hertz) of *x*(*t*) such that the energy contained in the spectral components of *x*(*t*) of frequencies below *B* Hz is 95% of the signal energy *Ex*.

**Hint:** you can find the energy in the time domain or in the frequency domain. Use the domain that simplify the integral.

**5)** An audio signal has a bandwidth of 10 kHz. This signal is sampled, quantized, and binary coded.

1. Determine the sampling rate if the signal is to be sampled at a rate 25% above the Nyquist rate.
2. If the samples are quantized into 300 levels, what number of binary pulses is required to encode each sample?
3. Determine the binary pulse rate (bits/s) of the binary-coded signal.
4. If the amplitude range of the audio signal is [-1, 1] volt, what is the maximum quantization error?

**Bonus Question**

For the signal *x*(*t*) = 2 + 2 cos(2π50*t*) + cos(2π55*t*) + cos(2π110*t*), a rectangular window is used to truncate the signal *x*(*t*) for transmission. What is the minimum time width of the window to maintain all frequencies on the spectra of the truncated window?