Problem	Score	Out of
1		20
2		15
3		20
4		20
5		25
6		20
Total		120

Problem 1:

Write True or False. **Correct answer = 2, Wrong answer = -1, No answer =0.**

1	At the same signal to quantization noise ration (SNR), the transmission bandwidth of DPCM is larger compared to PCM	( )
2	At the same transmission bandwidth, Multi-level signaling (M-ary) is more power efficient than Polar binary signaling.	( )
3	In *M*-ary orthogonal signaling, the data rate is increased by a factor of $\log_2 M$ at a cost of increasing the transmission power.	( )
4	Carrier acquisition is needed for non-coherent detection.	( )
5	The power spectral density (PSD) of Bipolar signaling (line coding) has zero DC components.	( )
6	Quadrature Amplitude Modulation (QAM) allows the transmission of two analog signals at the same time and over the same channel	( )
7	An energy signal has zero average power	( )
8	Narrowband FM is more bandwidth efficient than Vestigial sideband modulation	( )
9	On reason to use modulation and filtering is to avoid interference with other communication systems.	( )
10	FM modulator is a linear system	( )

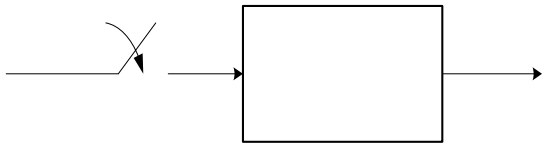
Problem 2:

Circle the correct answer (only one is correct):

1- A signal $g(t)$ is sampled at five times the Nyquist rate, quantized to L levels, and binary coded. To increase the SNR of the resulting PCM signal by more than 15 dB, we need to

a. Increase the number of bits representing each sample by around 5/3 bits
b. Using differential PCM to represent the samples of $g(t)$
c. Increase the number of quantizer levels to $8L$
d. Increase sampling rate 10 times

2- A signal $g(t)$ of bandwidth B is sampled at a rate $f_s = 1/T_s$ = 5B to produce the sequence $g(0T_s), g(T_s), g(2T_s), g(3T_s), \cdots, g(nT_s), \cdots$. Now, every odd sample of the sequence is dropped to produce the subsequence
$g(0T_s), g(2T_s), g(4T_s), \cdots, g(2nT_s), \cdots$.



The new sampling frequency is;

a. 10B
b. 5B
c. 15B
d. 2.5B

3- If a message signal $m(t)$ lies in the range $-15 < m(t) < 20$, the MINIMUM positive value for A that permits using an envelope detector to demodulate the AM signal $\phi_{AM}(t) = 3[A+m(t)]\cdot\cos(2\pi 20t)$ is:

a. A_{min} = 20 V,
b. A_{min} = 15 V,
c. A_{min} = 5 V,
d. A_{min} = 0.3333 V.

4- A message signal $m(t)$ is DSBSC modulated with a carrier frequency ω_c. When the DSBSC modulated signal is input to an envelope detector, the output of the envelope detector will be:

a. $m(t)$,
b. $|m(t)|$,
c. $m^2(t)$,
d. $-m^2(t)$

5- The local oscillator of a commercial superheterodyne AM receiver (with an IF frequency 455 kHz) is tuned to 1025 kHz. If each AM station has a bandwidth of 10 kHz, the station being demodulated by this AM receiver occupies the frequency band:

a. 1275 kHz to 1475 kHz
b. –5 kHz to 5 kHz
c. 565 kHz to 575 kHz
d. –10 kHz to 10 kHz

Problem 3:

1- Let the message signal be

$$m(t) = 3\cos 2\pi 10^3 t + 5\cos 20\pi 10^3 t$$

a. Sketch the spectrum of $m(t)$
b. what is the baseband bandwidth (B) of $m(t)$?
c. What is the power of $m(t)$?

1- The same signal m(t) modulates a carrier ($\cos(2\pi 10^6 t)$)

a. Write the expression of the double sideband amplitude modulated (DSB) signal in the time domain $\varphi_{DSB}(t)$.

b. Write expression of and sketch the frequency spectrum of the DSBSC modulated signal. Show the correct amplitudes and frequency values.

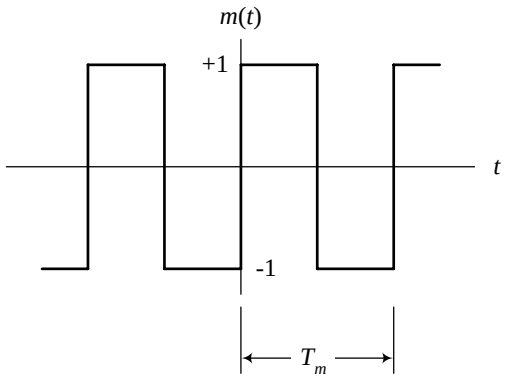
c. What is the transmission bandwidth?

d. Draw a block diagram of a coherent DSBSC demodulator using multipliers and filters. Specify filter characteristics.

e. For the same signal, sketch the spectrum of an upper sideband modulated signal $\left(\Phi_{USB}(\omega)\right)$. Write an expression of $\varphi_{DSB}(t)$ in the time domain. What is the transmission bandwidth in this case?

Problem 4:

Consider an FM signal $\phi_{FM}(t)$ generated by modulating a message signal $m(t)$ given by a rectangular periodic pulse train with amplitude $A_m = \pm 1$ and period $T_m = 1$ second.



a) Give the expression of the signal $\phi_{FM}(t)$. You can assume the carrier amplitude A_c = 1 V, carrier frequency f_c = 1000 Hz, and FM sensitivity factor k_f = 200π Hz/V.
Note: you don't need to compute the integral of $m(t)$. Just state the formula!

b) Give the expression of the instantaneous frequency of the signal. Show that it has two possible values only. What are these values?

c) Use Carson's rule to approximate the bandwidth of the FM signal $\phi_{FM}(t)$. Notice that you need to estimate the bandwidth of the message signal $m(t)$. For this, you can simply assume it is equal to the frequency of the 3rd harmonic of the Fourier series of $m(t)$.

d) If the amplitude of the message signal m(t) is doubled, find the new FM bandwidth.

e) Explain whether this analog FM modulation is similar to a digital modulation scheme (like ASK, PSK or FSK)? State which of these is similar to the above FM signal and give reasons explaining your answer?

Problem 5:

The signal m(t) = $8[1+\cos(20\pi t)\cos(100\pi t)]$ (t is in seconds) is sampled using an ideal sampling function at the rate of 150 samples/sec. Each sample is encoded using a 16-level quantizer.

a. Calculate the bandwidth of the signal m(t).

b. Is sampling done at, below or above Nyquist rate? Show your work.

c. Determine the rate of transmission.

d. Find the signal-to-quantization noise ratio.

e. Sketch the amplitude spectrum of the sampled function in the range $-80 \text{ Hz} < f < 380 \text{ Hz}$. Label all amplitudes and frequencies.

f. If we have a system that is capable of transmitting 15 kbit/sec, how many signals, identical to m(t) and sampled at the same rate of 150 samples/sec, can be transmitted using TDM.

g. How much storage space is required to store a 20-second file of m(t) generated the method above.

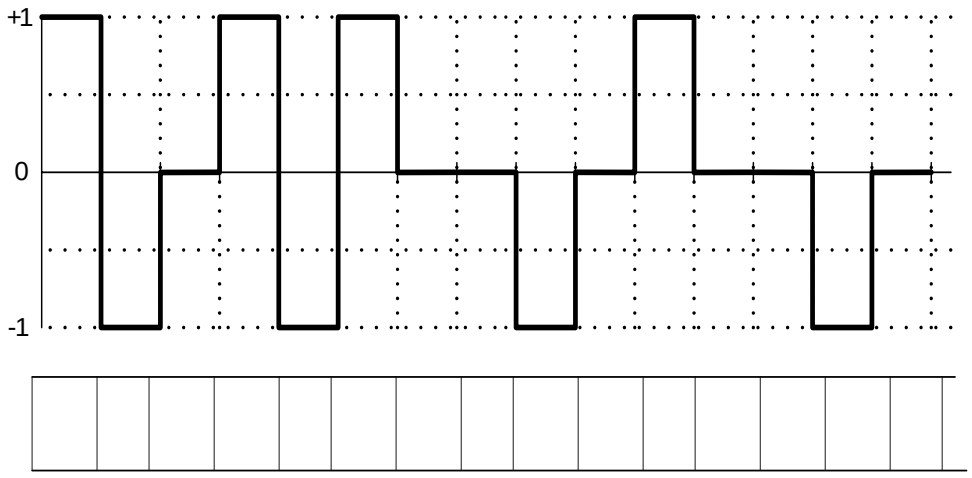
h. If the file in (g) is to be downloaded from the internet using a DSL link of 256Kbps transmission rate. Find the download time in seconds.

i. If Delta modulation is used instead of PCM with a sampling rate that is 4 times the Nyquist rate. Find the transmission rate.

Problem 6:

1- The figure shows a PCM signal represented by a Bi-Polar (RZ) line code.

(a) Find the sequence of 15 bits represented by this waveform



(b) Name two advantages and two disadvantages of this line code

2- A file of size 900 kbits is to be transmitted over a channel of bandwidth BW = 50 kHz.

(a) Determine the minimum time and resulting bit rate required to send this file assuming binary (two-level) signaling.

(b) Determine the minimum time required to send this file if we decide instead to send the file using a raised-cosine pulse with a roll factor of $r = 0.25$

(c) We now decide to use multilevel signaling. Determine the time required to send the file and the resulting bit rate using an 8-ary (8-level) raised cosine pulse with a roll off factor of $r = 0.6$

(d) We would like to transmit the file in exactly 2.7 seconds while minimizing the ISI (inter-symbol interference) as much as possible. To do so we use *M*-ary (multi-level signaling). Determine the number of levels *M* for this to happen and the roll-off factor *r* of the pulse shape.