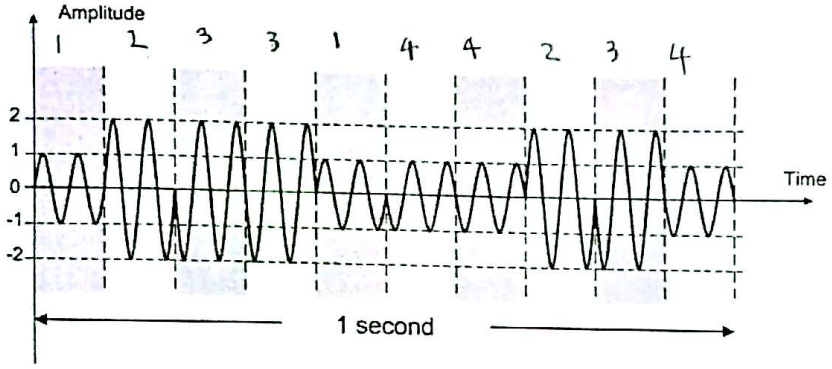
Part I: Multiple Choice

1. **[2 marks]** Consider the following digital-to-analog modulated signal.



Assume that all possible signal elements of the modulation scheme are depicted, determine the modulation scheme used to generate the signal.

A) BASK
B) 4-QAM
C) QFSK
D) QPSK
E) None of the above

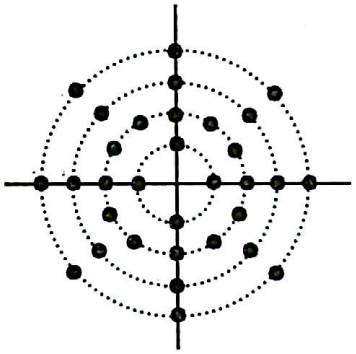
2. **[2 marks]** Suppose a client is downloading a 0.6 MBytes file from a server through a single communication link with a data rate of 30 Mbps. If the distance between the client and the server is 6000 km, determine the transmission delay, assuming that the propagation speed through the medium is 2×10^8 m/s.

A) 20 ms
B) 190 ms
C) 30 ms
D) 160 ms
E) None of the above

3. **[1 mark]** Suppose a file is being transmitted between two computers over a single-hop link. The propagation delay component of the overall delay experienced during the transmission can be reduced by:

A) Compressing the file
B) Partitioning the file into packets
C) Increasing the data rate
D) All of the above
E) None of the above

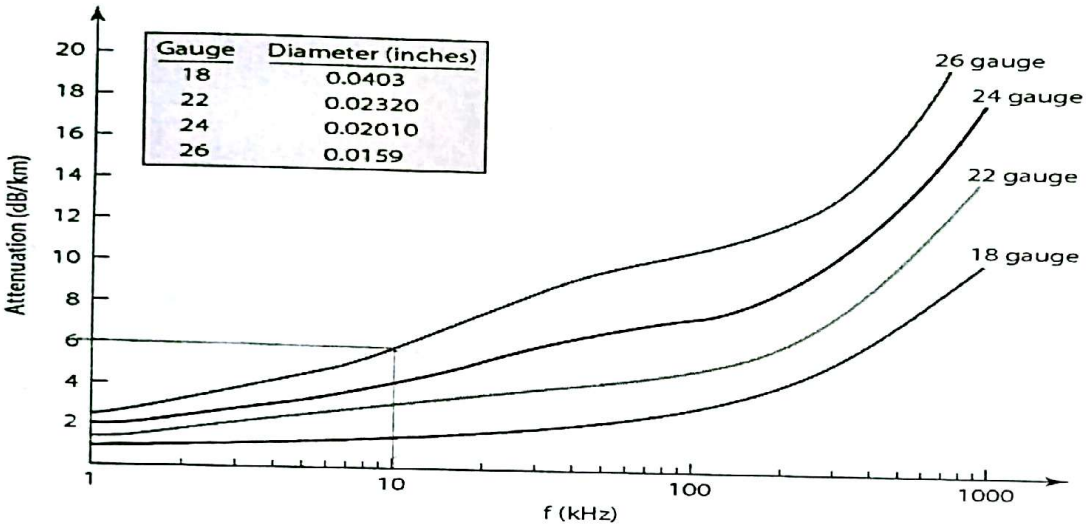
4. **[2 marks]** At what bit rate does a 9600 baud modem utilizing the following modulation scheme operate at?



32 symbols
5 bits

A) 0.3 kbps
B) 32.0 kbps
C) 48.0 kbps
D) 307.2 kbps
E) None of the above

5. **[2 marks]** Suppose the power at the beginning of a 26 gauge unshielded twisted pair (UTP) cable is 800 W, determine the power (rounded to the nearest W) at the end of a 2 km cable for a 10,000 Hz signal using the following attenuation vs. frequency plot.



A) 25 W
B) 50 W
C) 100 W
D) 788 W
E) None of the above

6 × 2 = -12dB

-12dB = $10\log_{10}\frac{P_2}{800W}$

6. **[2 marks]** A periodic analog composite signal is composed of simple sine waves with periods of 0.01 s, 0.02 s, 0.04 s and 0.25 s. Determine the maximum time interval between two consecutive samples such that the original analog signal can be accurately reproduced.

100Hz, 50Hz, 25Hz, 4Hz

200Hz

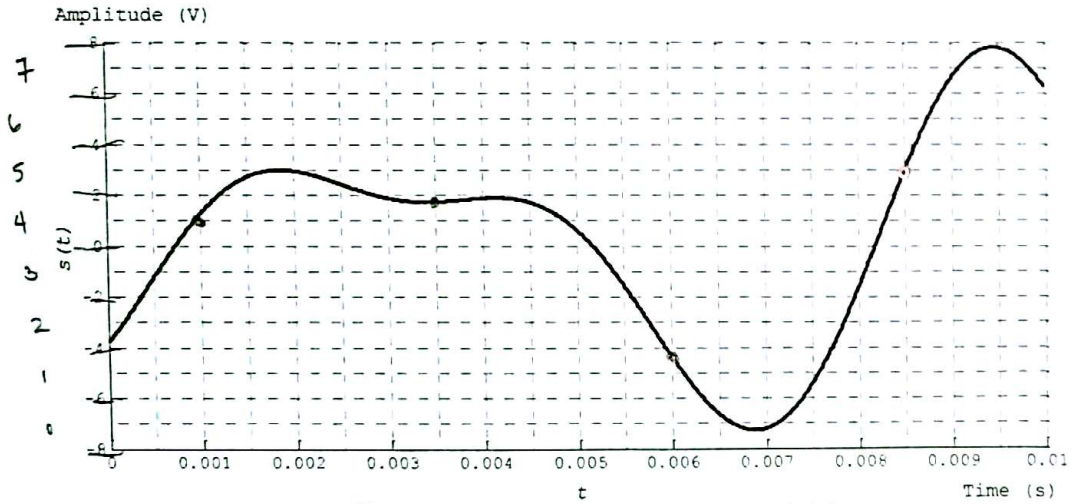
A) 0.005 s
B) 0.01 s
C) 0.125 s
D) 0.5 s
E) None of the above

7. **[2 marks]** Determine the value of x for the following:

$$\log_{b^2} 16 + \frac{1}{2}\log_b x^3 - \log_{b^2} x = \log_b 8$$

A) $\frac{1}{4}$
B) $\frac{1}{2}$
C) 2
D) 4
E) None of the above

8. **[2 marks]** Consider the following analog signal, $s(t)$, with minimum and maximum amplitudes of -8 V and +8 V, respectively. The signal, $s(t)$, is sampled for digital transmission using Pulse Code Modulation (PCM) with a sampling rate of 400 samples/s and 8 uniform quantization levels.



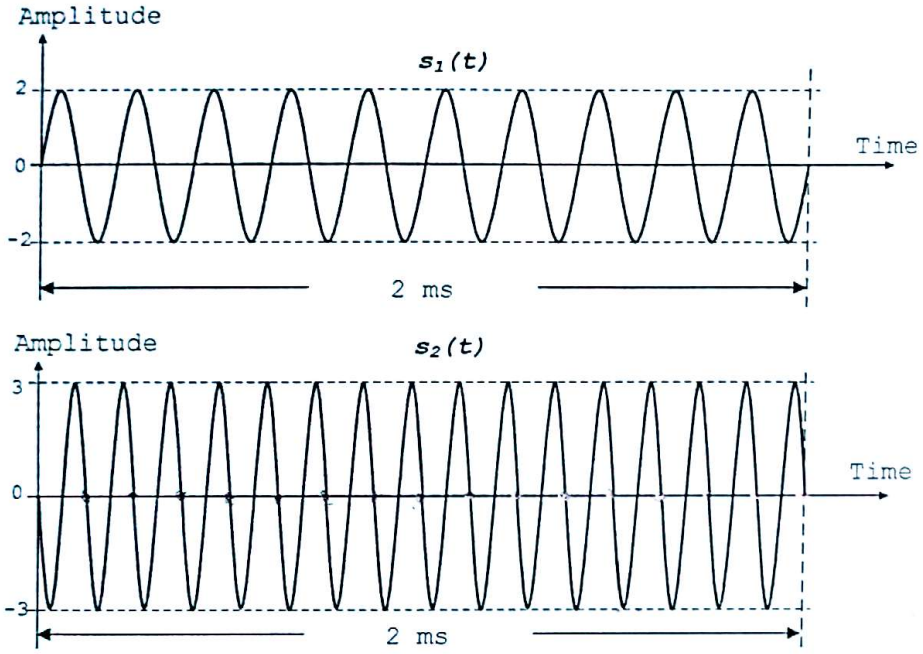
Assuming that the first sample is taken at 0.001 s, determine the resulting encoded words of the PCM signal for t = [0, 0.01] s.

A) 100100001101
B) 10100010
C) 010101100001111
D) 0110100011
E) None of the above

Part II: Short Answer

1. **[6 marks]** Suppose an analog composite signal is composed of the following two simple sinusoidal waves, $s_1(t)$ and $s_2(t)$, and is sampled for digital transmission using Pulse Code Modulation (PCM).

5½



a) **[2 marks]** Determine the minimum sampling rate such that the original analog composite signal can be accurately reproduced.

b) **[2 marks]** Using the sampling rate obtained in (a), determine the data rate (in bps) of the PCM signal if a quantizing SNR of above 30 dB is required.

c) **[2 marks]** Determine the SNR required (in dB) if the PCM signal obtained in (b) is to be transmitted over a noisy channel with a bandwidth of 12 kHz.

[Note: If you are unsure of your answer to part (a), you may use the value of 20000 to solve part (b).]

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a) S_2: $\frac{16 \text{ cycles}}{2 \text{ ms}} = 8000 \text{ Hz}$

Nyquist sampling rate: $2 \times 8000 \text{ Hz} = 16,000 \text{ Hz}$ ✓

b) $30\text{dB} \rightarrow 10 \log SNR_Q \rightarrow SNR_Q = 1000$ (-½). SNR_Q is in dB

$6n_b - 1.25 = 1000$

$n_b = 166.8$

$= 167$ bits to get $SNR_Q \geq 1000$ X.

bitrate $= 16,000 \text{ Hz} \times 167 \text{ bits}$

$= 2\,672\,000$ bps X

c) $2\,672\,000 = 12 \text{ kHz} \log_2(1 + SNR)$

$SNR = 1.06 \times 10^{67}$ X

$SNR_{dB} = 10 \log SNR = 670 \text{ dB}$ X

-½

2. **[6 marks]** Ernest, the CST student that created the autonomous drone in assignment #1, is developing a new digital-to-analog modulation scheme that combines FSK and ASK. The new modulation scheme, FASK, uses four different amplitudes: 1 V, 2 V, 3V and 4 V and two different frequencies: 2 Hz and 4 Hz.

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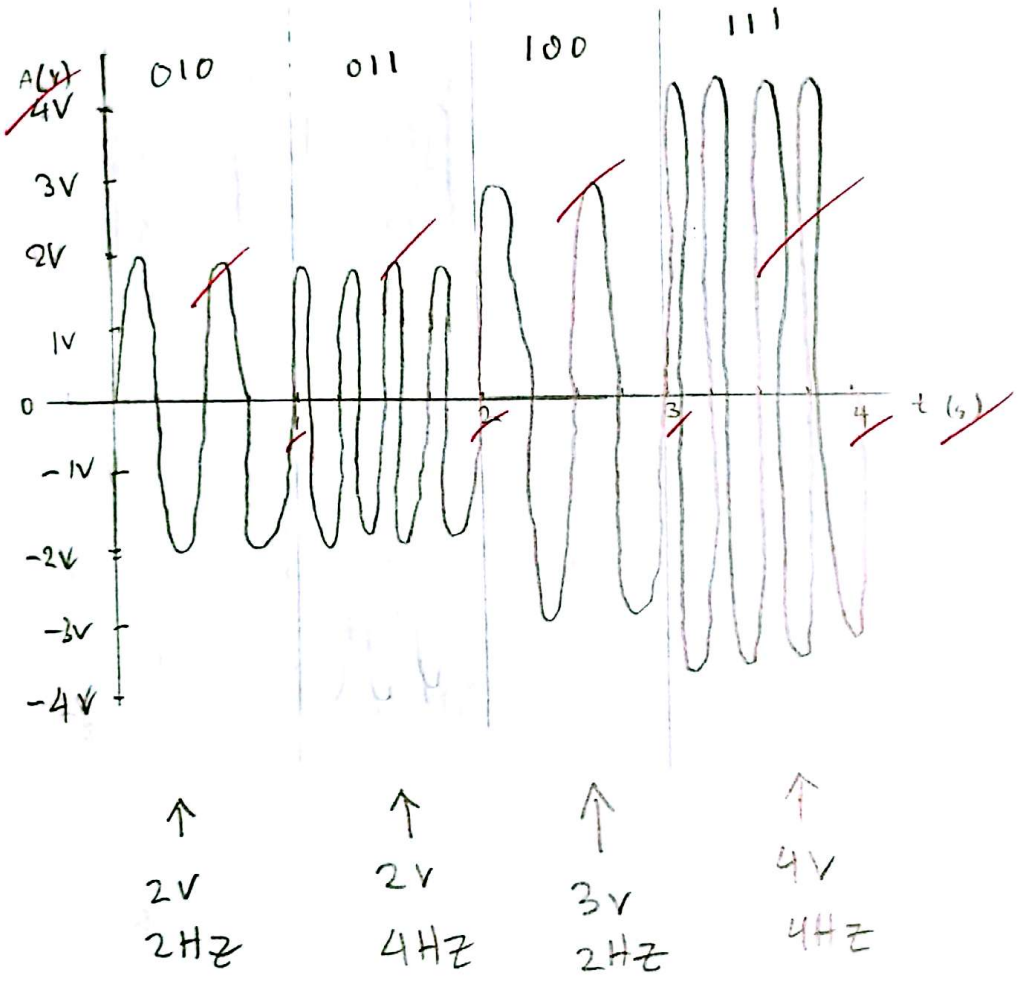
a) **[3 marks]** Using the table below, devise a mapping of bit values to signal elements that uses all possible combinations of amplitudes and frequencies in FASK.

Bit value	Amplitude	Frequency
000	1V	2Hz
001	1V	4Hz
010	2V	2Hz
011	2V	4Hz
100	3V	2Hz
101	3V	4Hz
110	4V	2Hz
111	4V	4Hz

b) **[3 marks]** Suppose Ernest wants to transmit the following data stream, 010011100111, using FASK. Plot the modulated signal using the mapping devised in (a), assuming a baud rate of 1 symbols/s. Label the axes and clearly indicate the beginning and the end of each symbol as well as the associated bit values in the plot.



Good!

3. **[8 marks]** Consider a synchronous time-division multiplexing system with five digital sources A, B, C, D and E, each with a data rate of 10 kbps. For synchronization, 4 bits are added to each TDM output frame.

a) **[4 marks]** Determine the minimum number of bits the TDM output frame needs to carry from each digital source such that the output link data rate is no more than 58 kbps.

b) **[4 marks]** Ignoring the output link data rate constraint in (a), determine the maximum TDM output frame rate such that the overhead of the synchronization bits is no more than 5% of the TDM output frame size.

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a) $(((\text{input frame size}) \times 5) + 4 \text{ bits}) \times \frac{10 \text{ Kbps}}{\text{input frame size}} = 58 \text{Kbps}$

$(5x + 4)\left(\frac{10K}{x}\right) = 58K$

$\frac{50Kx}{x} + \frac{40K}{x} = 58K$

5 bits from each source

Good!

b) $(((\text{input frame size}) \times 5) + 4 \text{ bits}) \times \frac{10 \text{ kbps}}{\text{input frame size}} = ?$

$(((16 \text{ bits}) \times 5) + 4 \text{ bits}) \times \frac{10 \text{kbps}}{16 \text{ bits}}$

$\frac{4}{0.05} = 80$

$\frac{80-4}{5} = 15.2 \rightarrow 16$

$= 52{,}500 \text{ bps}$

$\frac{52{,}500}{80+4} = 625 \text{ frames/sec}$

$\frac{10\,000}{16} = 625 \text{ frames/sec}$

-2

-2