Course #: HUANG-COMP3721

Course Title: MIDTERM

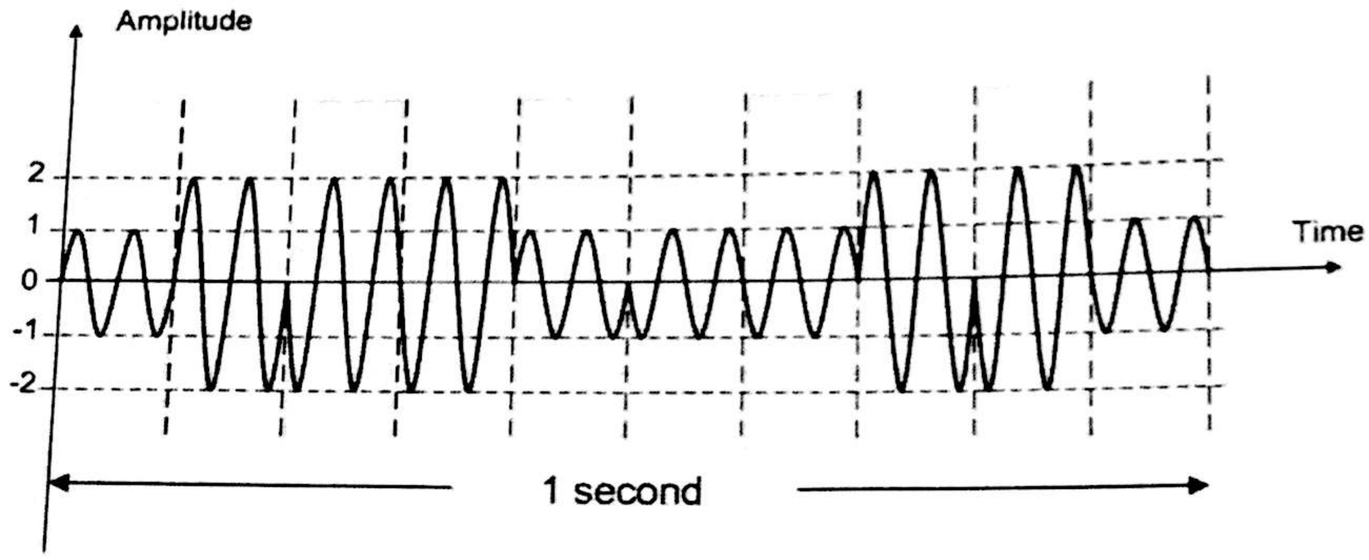
Day/Time: 02/26

Response Description:	<dash> correct <alphabet> student's incorrect response

Test Items:	1-5	6-10	11-12		
Test Key.	C,C,E,D,D	C,D,B,B,A	B,A		

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.

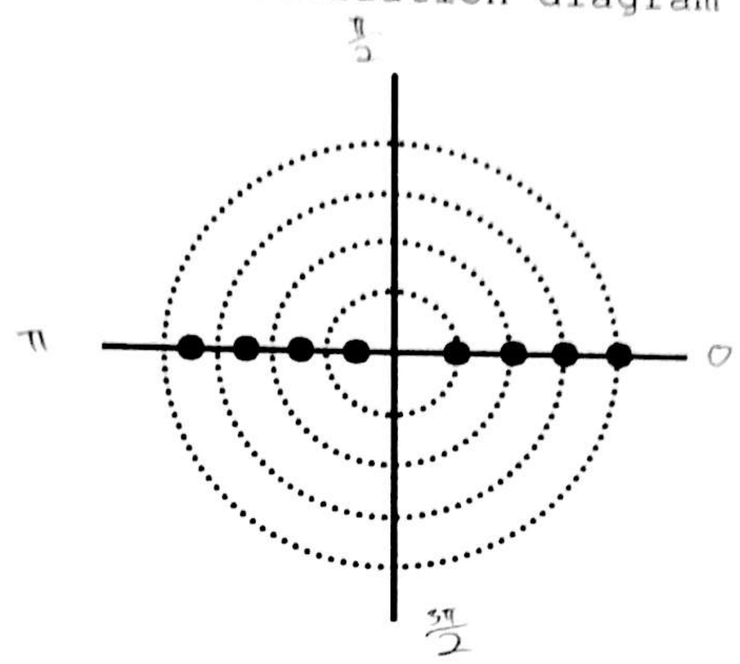
A) BASK
B) BFSK
C) 4-QAM
D) QPSK
E) None of the above

2. **[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

3. **[2 marks]** Consider the constellation diagram below.



The modulation scheme represented by this constellation is best described by the following parameters:

A) 4 amplitudes, 1 phase shift, 8 bits/symbol
B) 8 amplitudes, 4 phase shifts, 3 bits/symbol
C) 4 amplitudes, 2 phase shifts, 4 bits/symbol
D) 8 amplitudes, 2 phase shifts, 8 bits/symbol
E) None of the above

4. **[1 mark]** The works of Shannon and Nyquist both provide us with a method of calculating an upper limit on the bit rate of the channel based on two different approaches. If we assume that the signal bandwidth is equal to the channel bandwidth, then the following statement(s) is(are) true:

A) Using Nyquist, the capacity is limited solely by the signaling levels and signal bandwidth
B) Using Shannon, the capacity is limited by the channel bandwidth and level of noise present on the channel
C) Using Shannon, we can determine the maximum data rate that can be achieved using a given signal bandwidth and signal power, in the presence of noise
D) All of the above
E) None of the above

5. **[2 marks]** Suppose the following analog composite signal has a bandwidth of 120 Hz and is sampled for digital transmission.

$$s(t) = \sin(4\pi ft) + 6\sin(6\pi ft) + 12\sin(12\pi ft)$$

Determine the minimum sampling rate such that the original analog signal can be accurately reproduced.

A) 24 Hz
B) 180 Hz
C) 240 Hz
D) 360 Hz
E) None of the above

$S = \frac{Al}{r}$ $\frac{\text{Bits}}{\text{sec}}$ $\frac{\text{Bits}}{\text{sample}}$ $\frac{\text{sample}}{\text{sec}}$

$2(f_{max}) = 240$

6. **[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 x 10^8 m/s.

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

0.6 M = 600,000 Bytes = 4.8 M bits

Data Rate = 30,000,000 bps

Distance = 6,000,000 m

$\frac{30M}{4.8M} = 6.25$

$S = \frac{dist}{time}$ $\frac{dist}{spd} = time$

7. **[1 mark]** Quantizing signal-to-noise is best defined as:

A) The ratio of the signal power to the noise power corrupting the signal
B) A comparison of the level of the described signal to the level of the noise
C) An error incurred in the PCM process when sampling and approximating a digital signal
D) An error incurred in the PCM process when sampling and approximating an analog signal
E) None of the above

FDM ≠

MSA ≠

8. **[1 mark]** Suppose we need to multiplex 10 channels, each requiring 0.002 MHz, using FDM. What is the minimum bandwidth required assuming guards bands of 0.1 kHz.

B

A) 2.1 kHz
B) 20.9 kHz
C) 21.0 MHz
D) 40.9 kHz
E) 41.0 MHz

2000 Hz channel × 10
100 Hz GBand × 9
} = 20,000 + 900
20 900 Hz
20.9 k Hz

9. **[2 marks]** Consider two sine waves A and B, with frequencies f_A and f_B respectively where $f_A = 4f_B$. What is the period, T_B, of signal B, in relation to the period, T_A, of signal A?

X

D

A) $T_B = 2T_A$
B) $T_B = 4T_A$
C) $T_B = T_A/2$
D) $T_B = T_A/4$
E) None of the above

$4f_B = \frac{1}{T_A}$

$T_B =$

10. **[2 marks]** Consider a synchronous time-division multiplexing (TDM) system with six digital sources A, B, C, D, E and F, each with a data rate of 240 bps. The TDM output frame rate is 12 frames/s. Determine the maximum number of frame synchronization bits that can be added to each output frame if the output link can support up to 1.505 kbps.

X

E

A) 5 bits
B) 6 bits
C) 7 bits
D) 65 bits
E) None of the above

240×6 = 1440

$1440 \frac{bits}{s} = 12 \frac{frames}{sec} \times X \frac{bits}{frame}$

$\frac{1440}{12} = 120$ bits

11. **[2 marks]** Determine the signal-to-noise ratio required, in dB, to achieve a data rate of 30 Mbps given a channel that spans from 60 MHz to 65 MHz in the radio spectrum.

C

A) 8.5 dB
B) 18 dB
C) 63 dB
D) 64 dB
E) None of the above

$BW = 5$

$N = 30$ Mbps

$30 = 5 \times \log_2(1 + SNR)$

$6 = \log 2(1 + SNR)$

$2^6 = 1 + SNR$

12. **[1 mark]** Which of the following shows the correct terminology of encapsulation in each layer?

A

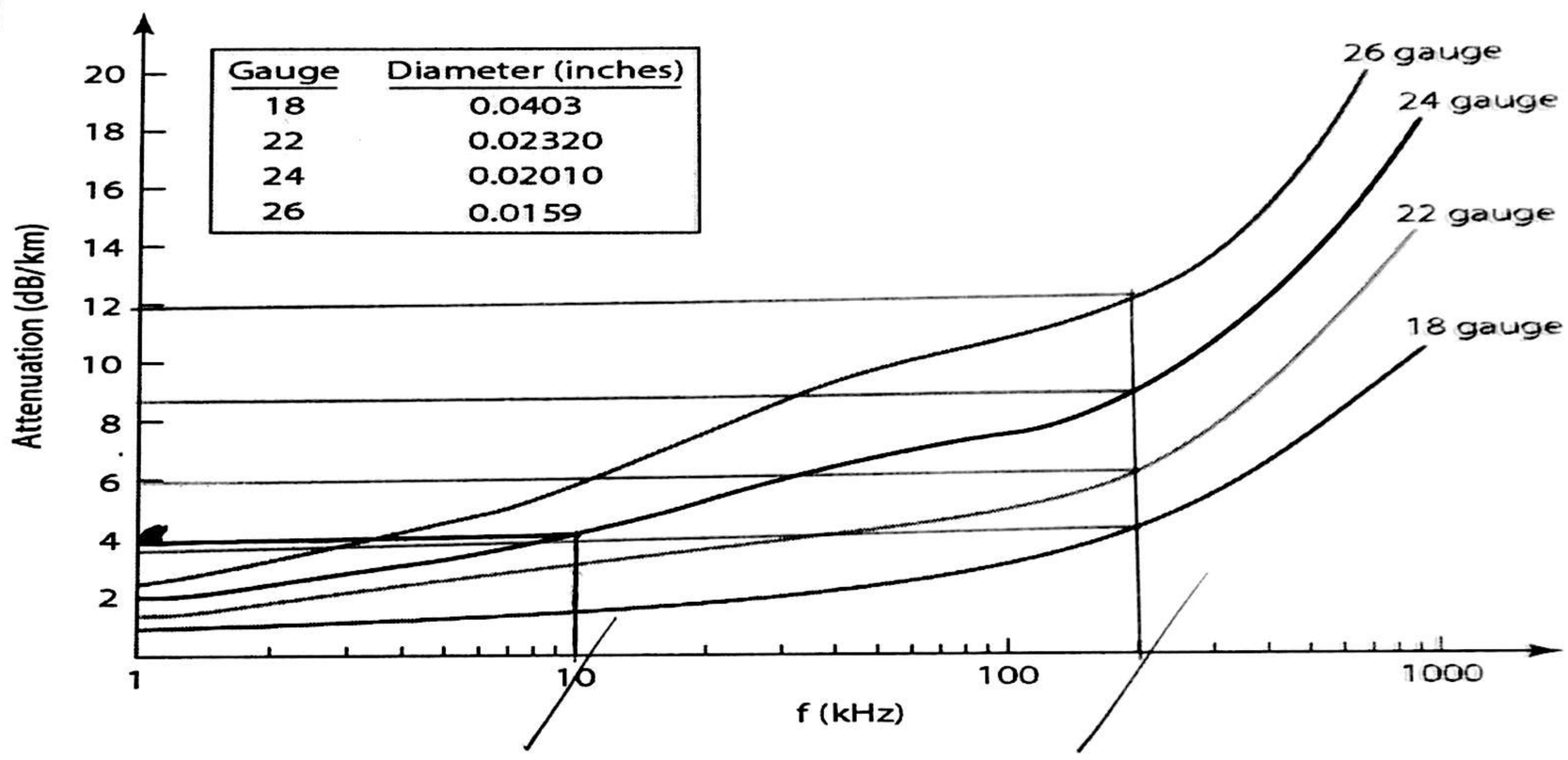
A) Application: message, Transport: segment, Network: datagram, Data Link: frame, Physical: bit
B) Application: frame, Transport: segment, Network: datagram, Data Link: message, Physical: bit
X C) Application: message, Transport: frame, Network: datagram, Data Link: segment, Physical: bit
X D) Application: bit, Transport: segment, Network: datagram, Data Link: frame, Physical: message

Network : Datagram / Packet

Part II: Short Answer

1. **[7 marks]** Use the following attenuation versus frequency and distance plot for the unshielded twisted pair (UTP) cable to answer part (a) and part (b).

7



a) **[4 marks]** Determine the power at the end of a 6 km 24 gauge UTP cable for a 10 kHz signal given the power at the beginning of the cable is 500 W.

b) **[3 marks]** List the gauge(s) of the UTP cable that can be used to transmit a 100 kHz signal over a distance of 10 km if the maximum attenuation allowed is 100 dB.

a) Att: $4\,dB/Km \rightarrow 24\,dB/6Km$ Attenuation

$-24\,dB = 10 \log_{10} \frac{P2}{P1}$

$-24\,dB = 10 \log_{10} \frac{P2}{500}$

$\frac{-24}{10} = \frac{P2}{500}$

$10^{-2.4} = \frac{P2}{500}$

$(0.00398)500 = P2$

$2W = P2$

End of Cable

b) 100 KHz
10 Km

18 : $4 \frac{dB}{Km}$ ▷ $40\,dB/10Km$

22 : $6 \frac{dB}{Km}$ ▷ 60

24 : $9 \frac{dB}{Km}$ ▷ 90

26 : $12 \frac{dB}{Km}$ ▷ 120 X

Only 18, 22, 24 Gauge

2. **[8 marks]** Joe, the CST student that created the autonomous drone in assignment #1, has been asked to setup a webcast for the school concert orchestra with live audio streaming. The musical ensemble consist of the following instruments: cello, trumpet, violin, cymbals and trombone, with the frequency ranges of each instrument listed as follows:

Instrument	Frequency Range (Hz)
Cello	65 - 988 BW = 923
Trumpet	165 - 988 BW = 823
Violin	196 - 3120 BW = 2924
Cymbals	200 - 10567 BW = 10 367
Trombone	82 - 494 BW = 412

The composite analog audio signal is sampled for digital transmission using Pulse Code Modulation (PCM).

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

b) **[4 marks]** Determine the maximum number of uniform quantization levels that can be used if the upload link has a bandwidth of 256 kbps.

c) **[2 marks]** Determine the signal strength in relation to the quantization error, in dB, of the PCM signal.

a) $2(f_{max}) = 2(10567) = 21134 \frac{\text{Samples}}{\text{sec}}$ [Min]

b) $\text{BitRate} = f_s \times n_B$

$\frac{\text{BitRate}}{f_s} = n_B \approx \frac{256{,}000 \frac{\text{Bits}}{\text{sec}}}{21134 \frac{\text{samples}}{\text{sec}}} = 12.1 \frac{\text{Bits}}{\text{Sample}}$

Maximum $\therefore$ 12.1 bits → ~~13 bits~~ (-½)

$\log_2 L = 13$

$L = 2^{13}$

$L = 8192$ Levels (-½)

c) $SNR_Q = 6 n_B - 1.25$

$SNR_Q = 6(\text{XX}) 1.25$

$SNR_Q = 76.75$ dB

NYQ = 256,000