

Exam Version 0

A00123456

Each exam is equally difficult.  
Answer your own exam.

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FINAL EXAMINATION  
8:00 – 11:00 AM  
May 20, 2015

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**Question 1** ( 5 marks)

- (a) A message source generates three possible messages with probabilities 0.8, 0.1, 0.1. What is the average entropy of the source in bits/message?
- (b) If a source generates one of these messages each second, what channel capacity is required to communicate these messages reliably?
- (c) You wish to transmit these messages over a channel with a bandwidth of 2 Hz. What is the minimum SNR required for reliable communication? Give your answer in dB.

**Question 2** ( 5 marks)

The following codewords form a  $(n, k)$  block code. The minimum distance is 3.

```
0 0 0 0 0 0 0
1 0 0 0 1 1 1
0 1 0 0 1 0 1
0 0 1 0 1 1 0
0 0 0 1 0 1 1
1 1 0 0 0 1 0
1 0 1 0 0 0 1
1 0 0 1 1 0 0
```

- (a) What are  $n$  and  $k$ ?
- (b) You receive the codeword 0000011. What codeword was most likely transmitted? Why? *Show your work or explain your reasoning.*
- (c) What is the Hamming distance between the most likely transmitted codeword and the received codeword?
- (d) What bit was most likely in error?

**Question 3 ( 4 marks)**

What is the UTF-8 encoding of a string composed of three characters: “P ω” (a capital ‘P’, a space, and the Greek lower-case letter omega)?

The following sections from the Unicode specification may be useful:

	000	001	002	003	004	005	006	007
0	NUL 0000	DLE 0010	SP 0020	0 0030	@ 0040	P 0050	` 0060	p 0070
1	SOH 0001	DC1 0011	! 0021	1 0031	A 0041	Q 0051	a 0061	q 0071

  

	U377	U3B7	U397	U3A7	U3B7	U3C7	U3D7	U3E7	U3F7
8		’E 0388	⊕ 0398	Ψ 03A8	θ 03B8	ψ 03C8	Ϟ 03D8	ϙ 03E8	ϐ 03F8
9		’H 0389	I 0399	Ω 03A9	ι 03B9	ω 03C9	ϙ 03D9	ϙ 03E9	C 03F9
A	˘ 037A	’I 038A	K 039A	Ï 03AA	κ 03BA	ï 03CA	Ϟ 03DA	ϙ 03EA	M 03FA

**Table 3-6. UTF-8 Bit Distribution**

Scalar Value	First Byte	Second Byte	Third Byte	Fourth Byte
00000000 0xxxxxxx	0xxxxxxx			
00000yyy yyxxxxxx	110yyyyy	10xxxxxx		
zzzyyyyy yyxxxxxx	1110zzzz	10yyyyyy	10xxxxxx	
000uuuuu zzzzyyyy yyxxxxxx	11110uuu	10uuzzzz	10yyyyyy	10xxxxxx

Give your answer as the hexadecimal values of the bytes. *Hints: SP is an abbreviation for space*  
*The answer requires more than 3 bytes.*

**Question 4 ( 5 marks)**

Draw the waveform that would be used to transmit the byte value 0xdb in LS-bit first order using MLT-3 encoding assuming the immediately preceding voltage level was a high (positive) level. Label the time and voltage axes assuming a 100BASE-TX Ethernet PHY. You do not need to apply 4B5B encoding or other processing to the bits.

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The following sequence of hexadecimal values appear at the beginning of an IP frame:

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45 00 00 30
00 20 00 00
FF 11 XX YY
10 00 00 01
FF FF FF FF
07 6D 07 6C
```

Answer the following questions:

- (a) What is the purpose of the bytes labelled XX and YY?
- (b) What are the values of XX and YY?
- (c) What protocol type does this packet carry? Give the numeric value of the protocol in decimal, not the name.
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**Question 6 ( 3 marks)**

A communication system using NRZ signalling has a noise margin of 2 V. Zero-mean additive Gaussian noise with an RMS voltage of 1 V is present. What is the approximate predicted bit error rate?

**Question 7 ( 3 marks)**

- (a) A communication system uses 4096-QAM with a symbol rate of 1 MHz. What is the bit rate?
- (b) Some old transmission lines used paper as a dielectric. The relative dielectric constant ( $\epsilon_r$ ) of paper is approximately 4. How fast do signals propagate along paper-insulated transmission lines?
- (c) You are testing an amplifier with a sine-wave input. You measure the output with a spectrum analyzer and find two harmonics that have levels -6 dB and -10 dB relative to the output at the input frequency. What is the amplifier’s THD in dB? *Hint: Assume the total harmonic power is the sum of the powers of the individual harmonic components.*

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Exam Version 1

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- (a) A message source generates three possible messages with probabilities 0.9, 0.05 and 0.05. What is the average entropy of the source in bits/message?
- (b) If a source generates one of these messages each second, what channel capacity is required to communicate these messages reliably?
- (c) You wish to transmit these messages over a channel with a bandwidth of 2 Hz. What is the minimum SNR required for reliable communication? Give your answer in dB.

**Question 2** ( 5 marks)

The following codewords form a  $(n, k)$  block code. The minimum distance is 3.

```
0 0 0 0 0 0 0
1 0 0 0 1 1 1
0 1 0 0 1 0 1
0 0 1 0 1 1 0
0 0 0 1 0 1 1
1 1 0 0 0 1 0
1 0 1 0 0 0 1
1 0 0 1 1 0 0
```

- (a) What are  $n$  and  $k$ ?
- (b) You receive the codeword 1100000. What codeword was most likely transmitted? Why? *Show your work or explain your reasoning.*
- (c) What is the Hamming distance between the most likely transmitted codeword and the received codeword?
- (d) What bit was most likely in error?

**Question 3 ( 4 marks)**

What is the UTF-8 encoding of a string composed of three characters: “P ω” (a capital ‘P’, a space, and the Greek lower-case letter omega)?

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Give your answer as the hexadecimal values of the bytes. *Hints: SP is an abbreviation for space*  
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Draw the waveform that would be used to transmit the byte value 0xdb in LS-bit first order using MLT-3 encoding assuming the immediately preceding voltage level was a high (positive) level. Label the time and voltage axes assuming a 100BASE-TX Ethernet PHY. You do not need to apply 4B5B encoding or other processing to the bits.

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Answer the following questions:

- (a) What is the purpose of the bytes labelled XX and YY?
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**Question 6 ( 3 marks)**

A communication system using NRZ signalling has a noise margin of 1 V. Zero-mean additive Gaussian noise with an RMS voltage of 0.5 V is present. What is the approximate predicted bit error rate?

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- (a) What are  $n$  and  $k$ ?
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