Information Theory and Coding (CM303)

Midterm (40%) 28 May 2018

Instructor: Eng. Hosam Almqadim Time Allowed: 2 hours

Q1. (10 Marks) Consider the following information channel, the channel input **A** with symbols **a1, a2,** and **a3**, and probabilities **p(a1)=0.6**, **p(a2)=0.3**, and **p(a3)=0.1**. The channel output **B** with symbols **b1, b2,** and **b3**. The channel is fully specified by the following channel matrix

$$p(B/A) = \begin{bmatrix} ? & 0.5 & 0 \\ ? & 0 & 0.5 \\ 0 & 0.5 & ? \end{bmatrix}$$

a) Find the **missing probabilities** and **draw** the **schematic** of the channel? **(2 Marks)**
b) Obtain the output probabilities **p(b1)**, **p(b2)** and **p(b3)**? **(2 Marks)**
c) Find the Mutual Information **I(A;B)** and **Channel capacity C**? **(4 Marks)**
d) Find the **probabilities** and **entropy** of the **2nd order extension** $Z(A^2)$? **(2 Marks)**

Q2. (04 Marks) In a telegraph source having **two independent symbols** dot and dash, the **dot duration** is **1/3** of the **dash duration** and the total duration is **0.8 sec**. The probability of **dash occurrence is one third of dot occurrence** and the **time separation between symbols** is **0.1 sec**. Find the following:

A. The **information rate** of this telegraph. **(2 Marks)**
B. The **maximum possible information rate** with the same average symbol duration. **(2 Marks)**

Q3. (14 Marks) Consider a Discrete Memoryless Source with symbols **S ={a,b,c,d,e,f,g}** have probabilities ***P*(S)={3/14, 1/14, 1/7, 1/7, 2/7, 1/14, 1/14}** respectively.

0.214 0.071 0.143 0.28

1. Construct a **Huffman code** for the source? **(2 Marks)**
2. Compute the **average code length**, the **efficiency** and **redundancy** of the code? **(3 Marks)**
3. Is this code an **optimal code**? **(Justify your answer)** **(2 Marks)**
4. Find the **Information Rate** if the **DMS** generates **1 symbol** randomly **every 1µsec**? **(2 Marks)**
5. **Encode** the following message: **aabacaafggefad** **(2 Marks)**
6. Draw the **decision tree** of the code. **(1 Marks)**
7. **Decode** the following bit stream: **0101000110110000001101111100000001...** **(2 Marks)**

e e g b d f a e a d f e

Q4. (12 Marks) Given the following **code**

message	Code Word	message	Code Word	message	Code Word	message	Code Word
0000	000 0000	0100	110 0100	1000	101 1000	1100	011 1100
0001	110 0001	0101	000 0101	1001	011 1001	1101	101 1101
0010	011 0010	0110	101 0110	1010	110 1010	1110	000 1110
0011	101 0011	0111	011 0111	1011	000 1011	1111	110 1111

a) Find the **Generator matrix** of the code? **(4 Marks)**
b) Find the **error detection capability** and **error correction capability**? **(2 Marks)**
c) Find the **parity check matrix** of the code and its **Transpose**? **(2 Marks)**
d) Is this code a **linear code**? **(Justify your answer)** **(2 Marks)**
e) **Encode** the following bit stream **10110010000110111100.......** **(2 Marks)**

$\frac{bit}{sec}$. $\frac{Sym}{sec}$

Good luck

قســـم الاتصالات.   أسئلة الامتحان النهائي لمادة: نظرية المعلومات و الترميز

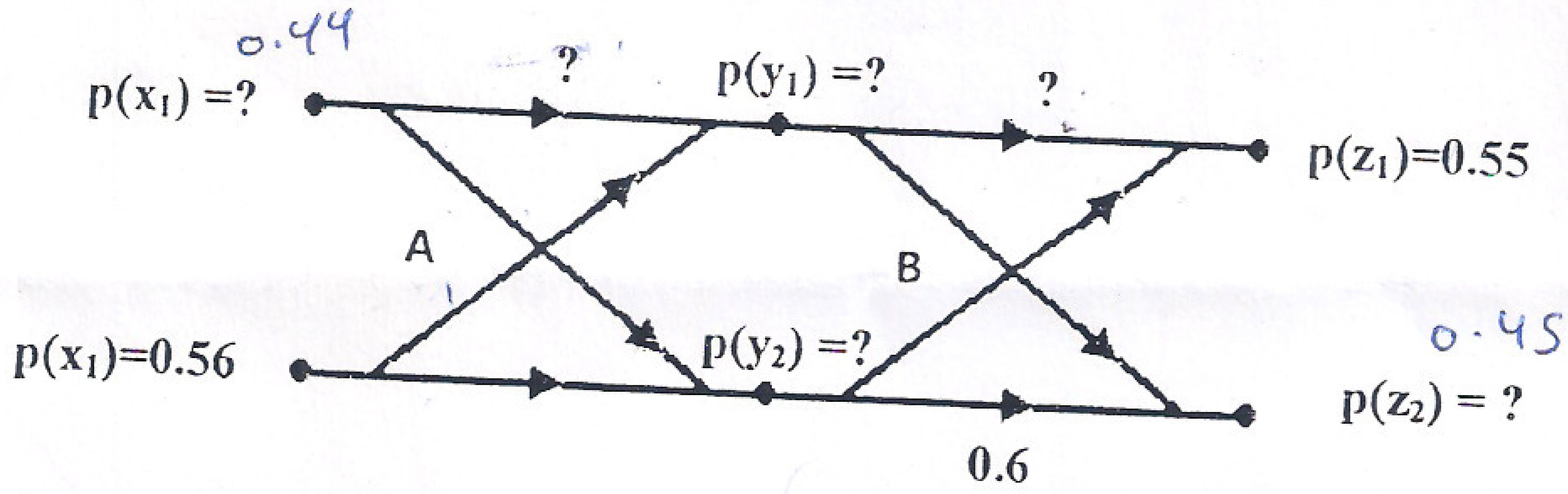
كلية التقنية الالكترونية
College of Electronic Technology - Tripoli

الفصل: السادس.   رمز المادة: CM 303.   التاريخ: 31 - 01 - 2018م

الفصل الدراسي: خريف 2017   اسم الأستاذ/المنسق: حسام الدين الهنشيري.   الزمن: ساعتان.

الاسم: .... رقم القيد: ....

Q1. (12 Marks) For the two Binary Symmetrical Channels (A & B) connected in cascade as shown below, Find the **input, output** and **channels forward probabilities.**



Q2. (8 Marks) Consider a DMS Source with symbols **Si, i=1,2,3,4.** Table below lists 6 possible binary codes

Table of Codes of the source S						
Si	Code 1	Code 2	Code 3	Code 4	Code 5	Code 6
S1	00	11	0	111	10	0
S2	01	00	1	10	100	1110
S3	01	10	00	110	1000	110
S4	00	01	11	0	1	10

$Y_1 = 0.44$

a) Find which of them **distinct** codes are? C2 C3 C4 C5 C6 (2 Marks)

b) Find which of them **prefix-free** codes are? C2 C4 C6 (2 Marks)

c) Find weather **instantaneous** codes are existence for these codes? (2 Marks)

d) Can you decide which code is **the best code** for this source, and why? (2 Marks)

Q3. (24 Marks, 3 each) Consider the **Systematic Linear Block Code** with the following **syndrome** look-up table.

Error Pattern (e)	Syndrome (S)
0000000	000
0000001	110
0000010	011
0000100	101
0001000	111
0010000	001
0100000	010
1000000	100

a) Find the **Generator matrix** of the code?

b) Find all the **Code Words** and the **Minimum Hamming Distance?**

c) Find **code bits, message bits, parity bits, code rate,** the **error-detection** and **error-correction capabilities** of the code?

d) Write down **the Parity Check Equations** and **draw the Encoder?**

e) Are the generator vectors **linearly independent?** (Justify your answer)

f) Is this code a **linear code?** (Justify your answer)

g) **Encode** the bit stream, **m= 11011110001001...?**

h) If **r1 = 1101011** and **r2= 0101101** were received, what are the **transmitted code-words** and **original messages?** (*clearly show the recovery steps*)

I 100 010 001 111 101 011 110

$r = \frac{k}{n}$ n = 9

Q4. (16 Marks) Given a Binary Convolutional Encoder with K=3, rate 1/3, and Impulse Response 101011010.

n = 9   101

v1 v2 v3
101
011
010

a) **Encode** the input sequence bits **m = 10101?** (5 Marks)

b) Draw the encoder? (show your answer) (6 Marks)

c) Draw the **Trills diagram** of the encoder? (5 Marks)

كيف!!

100 101
010 011
001 011

S00

1 1 0 1 0 0 0 0
1 0 1 1 0 1 0 0
1 1 0 0 0 0 1 0
0 0 0 1

1 0 1

$I_{k \times k}$ P^T $P_{n-k \times k}$

S = e H^T
S = r H^T

تمنياتي للجميع بالتوفيق
أ. حسام الدين الهنشيري

Information Theory and Coding (CM303)

Midterm (40%)

26 Dec 2017

Instructor: Eng. Hosam Almqadim

Time Allowed: 2 hours

Q1. (12 Marks) Consider the following information channel: the channel input A with symbols a1, a2, and a3, and probabilities **p(a1)=0.6**, **p(a2)=0.3**, and **p(a3)=0.1**. The channel output **B** with symbols **b1**, **b2**, and **b3**. The channel is fully specified by the following channel matrix

$$p(B/A)\quad \begin{array}{c|ccc} & b_1 & b_2 & b_3 \\ \hline a_1 & 0.5 & 0.5 & 0 \\ a_2 & 0.5 & 0 & 0.5 \\ a_3 & 0 & 0.5 & 0.5 \end{array}$$

a) **Draw the schematic** of the channel? **(2 Marks)**

b) Obtain the output probabilities **p(b1)**, **p(b2)** and **p(b3)**? **(3 Marks)**

c) Find the Mutual Information **I(A;B)**? **(5 Marks)**

d) Find the **probabilities** and **entropy** of the 2nd **order extension Z** of A? **(2 Marks)**

$H^2(S) = 2 \times H(S)$

$R_S\ H(S) \rightarrow \boxed{64 \propto \frac{1}{64}}$

Q2. (10 Marks) In a telegraph source having **two independent symbols** dot and dash, the **dot duration is 0.2 sec** and the **dash duration is 0.6 sec**. The probability of **dot occurrence is three times that of dash** and the **time separation between symbols** is 0.1 sec. Find the following:

RI

A) The **information rate** of this telegraph. **(5 Marks)**

B) The **maximum possible information rate** with the same average symbol duration. **(5 Marks)**

Q3. (18 Marks) Consider a Discrete Memoryless Source with symbols S ={a,b,c,d,e,f,g} have probabilities *P*(S)={2/7, 3/14, 1/7, 1/7, 1/14, 1/14, 1/14} respectively.

(DMS)

1. Construct a **Huffman code** for the source? **(4 Marks)**
2. Compute the **average code length** of the code. **(2 Marks)**
3. Find the **efficiency** and the **redundancy** of the code? **(2 Marks)**
4. Is this code an **optimal code**? **(Justify your answer)** **(2 Marks)**
5. Find **RI** if the **DMS** generates **1 symbol** randomly **every 1µsec**? $\times 10^{6}$ **(2 Marks)**
6. **Encode** the following message: **aabacaafggefad** **(2 Marks)**
7. Draw the **decision tree** of the code. **(2 Marks)**
8. **Decode** the following bit stream: 010100011011001000011011111000000001.... **(2 Marks)**

a a g e d d c e b d f a

dot = 3dash

Good luck

[redacted]

Information Theory and Coding (CM303)
Midterm II (35%)
13 May 2017

Instructor: MEng. Hosam Almqadim **Time Allowed: 2 hours**

Q1. (9 Marks) Consider the following information channel, the channel input A with symbols **a1, a2,** and **a3**, and probabilities **p(a1)=0.6, p(a2)=0.3**, and **p(a3)=0.1**. The channel output **B** with symbols **b1, b2,** and **b3**. The channel is fully specified by the following channel matrix

$$
\begin{array}{cc}
 & \begin{array}{ccc} b_1 & b_2 & b_3 \end{array} \\
p(B/A) = & \begin{bmatrix} 0.5 & 0.5 & 0 \\ 0.5 & 0 & 0.5 \\ 0 & 0.5 & 0.5 \end{bmatrix}
\end{array}
\begin{array}{c} a_1 \\ a_2 \\ a_3 \end{array}
$$

$(b_1/a_1)(b_2/a_1)(b_3/a_1)$
$(b_1/a_2)(b_2/a_2)(b_3/a_2)$
$(b_1/a_3)(b_2/a_3)(b_3/a_3)$

a) **Draw** the schematic of the channel? **(3 Marks)**
b) Find the Mutual Information **I(A;B)**? **(6 Marks)**

Q2. (10 Marks) Consider a source with a six-symbol alphabet, X_1, X_2, X_3, X_4, X_5, and X_6, with probabilities $P_1 = 0.20$ $P_2 = 0.01$, $P_3 = 0.35$, $P_4 = 0.38$, $P_5 = 0.02$, and $P_6 = 0.04$, respectively.

A. Find a **Shannon-Fano code** for this source. step **(4 Marks)**
B. Compute the **average code length** of the code. $L = \sum P_i n_i$ **(2 Marks)**
C. Design a **decision tree** of the code? **(2 Marks)**
D. Is the code an **optimal code**? (**justify your answer**) **(2 Marks)**

Q3. (16 Marks) Given the following **code**

message	Code Word	message	Code Word
0000	000 0000	1000	101 1000
0001	110 0001	1001	011 1001
0010	011 0010	1010	110 1010
0011	101 0011	1011	000 1011
0100	110 0100	1100	011 1100
0101	000 0101	1101	101 1101
0110	101 0110	1110	000 1110
0111	011 0111	1111	110 1111

Aya MOHAMe

a) Find the **Generator matrix** of the code? $G[P_{k(n-k)} | I_k]$ **(4 Marks)**
b) Find the **error detection capability** and **error correction capability**? $e = d_{min} - 1$, $t = d_{min} - 1$ **(2 Marks)**
c) Find the **parity check matrix** of the code and its **Transpose**? **(2 Marks)**
d) Is this code a **linear code**? (**Justify your answer**) **(2 Marks)**
e) Are the generator vectors **linearly independent**? (**Justify your answer**) **(2 Marks)**
f) **Encode** the following bit stream 101100100001101111100...... **(2 Marks)**
g) **Draw** an encoder of the code? **(2 Marks)**

1011 → 000 1011
0010 → 011 0010

Good luck

$u = mG$

كلية التقنية الالكترونية

قســم الاتصالات. اسئلة الامتحان النهائي لمادة: نظرية المعلومات و الترميز

الفصل: السادس كلية/الاول استدراكي. رمز المادة: CM 303. التاريخ: 2017-01-21

الفصل الدراسي: خريف 2016 اسم الأستاذ/المنسق: حسام الدين الهنشيري. الزمن: ساعتان.

Q1. A discrete source transmits messages x_1, x_2, x_3 with probabilities $p(x_1) = 0.3$, $p(x_2) = 0.25$, $p(x_3) = 0.45$. The source is connected to the channel whose conditional probability matrix is

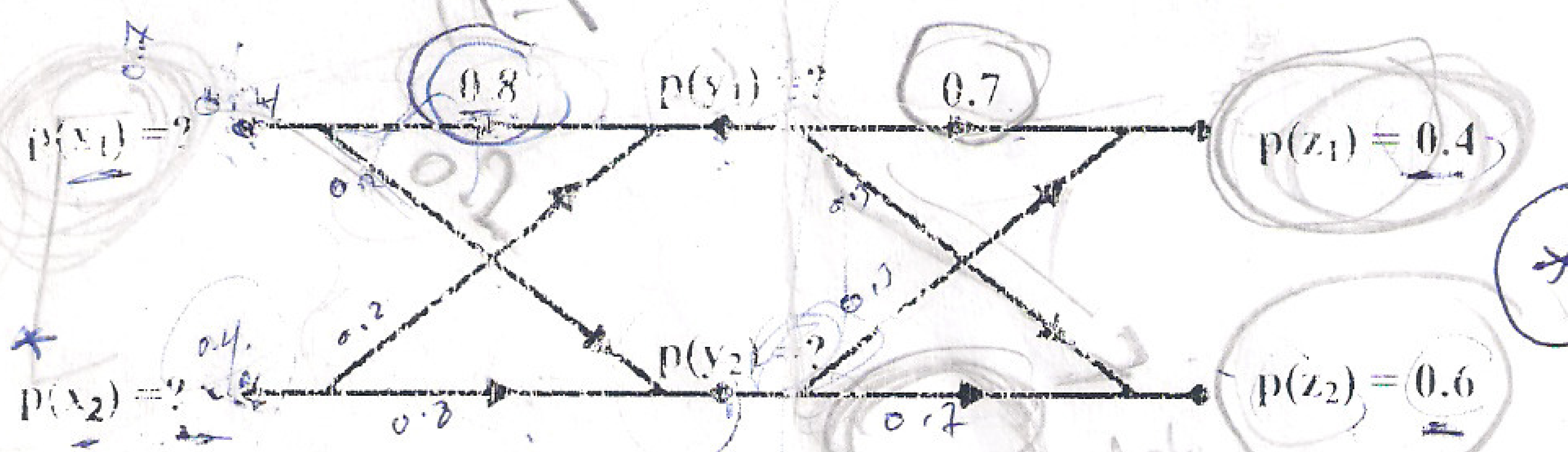
$$P(Y/X) = \begin{bmatrix} 0.9 & 0.1 & 0 \\ 0 & 0.8 & 0.2 \\ 0 & 0.3 & 0.7 \end{bmatrix}$$

$= P(e_j/a_i)\,p(a_i)$

A. Draw the channel schematic? And Obtain the joint probability matrix $P(X, Y)$? (4 Marks)

B. Obtain the probabilities $p(y_1)$, $p(y_2)$ and $p(y_3)$? (6 Marks)

Q2. Consider two binary symmetrical channels are connected in cascade as shown below:



A. Find the probabilities $p(x_1)$, $p(x_2)$, $p(y_1)$ and $p(y_2)$? (8 Marks)

Q3. (16 Marks) Consider a source with a six-symbol alphabet, X_1, X_2, X_3, X_4, X_5, and X_6, with probabilities $P_1 = 0.2$, $P_2 = 0.01$, $P_3 = 0.35$, $P_4 = 0.38$, $P_5 = 0.02$, and $P_6 = 0.04$, respectively.

A. Find a Shannon-Fano code for this source. (8 Marks)

B. Compute the average code length of the code. (8 Marks)

$t = \left\lfloor \frac{d_{min}-1}{2} \right\rfloor = 1$

Q4. (10 Marks) Consider the Systematic Linear Block Code with the following parity check matrix.

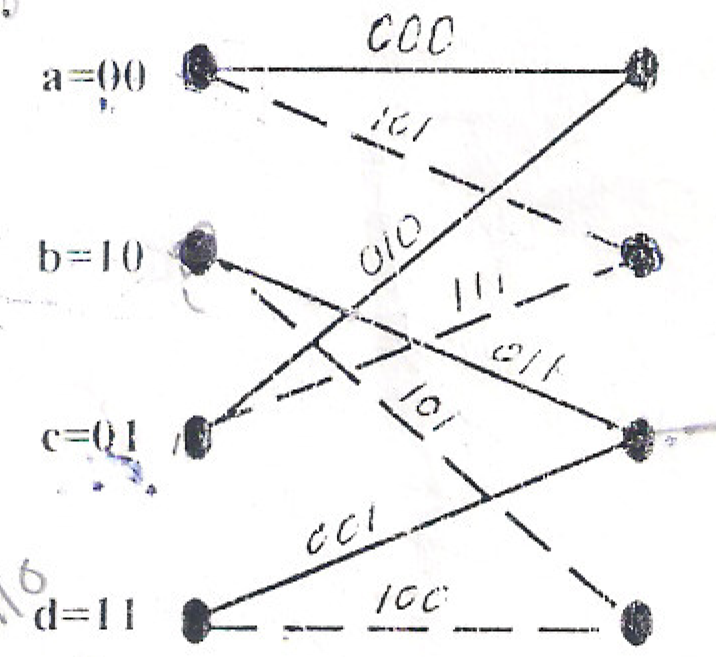
$u = mG$

$$H = \begin{bmatrix} 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{bmatrix}$$

A. If the code is a single error correction code, find the syndrome look-up table. (5 Marks)

B. For the received vectors r_1 and r_2, recover the transmitted code-word and the original message: $r_1 = 1101011$, $r_2 = 0101101$. (*clearly show the recovery steps*) (6 Marks)

Q5. (15 Marks) Given the following trellis diagram of a convolutional code.



A. Encode the input sequence bits m = 10101

B. Decode the received vector r using Viterbi Decoding.

R= 101 111 001 000 000.

C. How many errors are there in the received vector R (identify the error bits) and show the transmitted vector U

$S = eH^T$

تمنياتي للجميع بالتوفيق

استاذ المادة: أ. حسام الدين الهنشيري

Information Theory and Coding (CM303)

Midterm II (35%)

22 Nov 2016

Instructor: MEng. Hosam Almqadim Time Allowed: 2 hours

Q1. (5 marks) Given that the mutual Information $I(A;B)=H(A)-H(A/B)$, derive that $I(A;B)=I(B;A)$?

H(B) − H(B/A)

Q2. (10 marks) Consider a **DMS** Source with symbols **Si**. **i=1,2,3,4**. Table below lists 6 possible binary codes

	Table of Codes of the source S					
Si	**Code 1**	**Code 2**	**Code 3**	**Code 4**	**Code 5**	**Code 6**
S1	00	11	0	111	10	0
S2	01	00	1	10	100	1110
S3	01	10	00	110	1000	110
S4	00	01	11	0	1	10

a) Find which of them **distinct** codes are? 2, 3, 4, 5, 6

b) Find which of them **prefix-free** codes are? 2, 4, 6

c) Find weather **instantaneous** codes are existence for these codes? 4, 5

d) Can you decide which code is **the best code** for this source. and **why**?

Q3. (10 marks) Consider a **DMS** source with symbols **Xi**. where i=1,2,3, and 4. with probability. **P(Xi)=** 0.2. 0.35. 0.05. and 0.4. respectively?

a) Construct a **Huffman code** for the source?

$R_I = R_s H$

b) Find the **information rate** if the source generates **one symbol** randomly every 1usec?

1.739 M bit/sec

Q4. (10 marks) Consider the **linear block code** with the codeword defined by

U = m1+m2+m4, m1+m3+m4, m1+m2+m3, m1, m2, m3, m4.

1. Find the **generator matrix** G
2. Find **all the codewords** U
3. Find the **parity-check matrix** H, HT
4. Find **code bits**, **message bits**, **parity bits**, **code rate**, **minimum distance**, **error detection capability** and error **correction capability**.

n k n−k $\frac{k}{n}$ dmin

k = 4, n = 8

Good luck

كلية التقنية الإلكترونية — قسم الاتصالات. اسئلة الامتحان النهائي لمادة: نظرية المعلومات و الترميز

الفصل: السادس كلية/الاول استدراكي. رمز المادة: CM 303. التاريخ: 2016-06-4

الفصل الدراسي: ربيع 2016 اسم الأستاذ/المنسق: حسام الدين الهنشيري. الزمن: ساعتان.

اسم الطالب:................................ رقم القيد:................................ المجموعة: ....

Q1. (16 Marks) In a telegraph source having **two independent symbols** dot and dash, the **dot duration** is 0.2 sec and the **dash duration is 0.6 sec**. The probability of **dot occurrence is three times that of dash** and the **time separation between symbols** is 0.1 sec. Find the following:

A. The **information** rate of this telegraph. (12 Marks)

B. The **maximum possible information rate** with the same average symbol duration. (4 Marks)

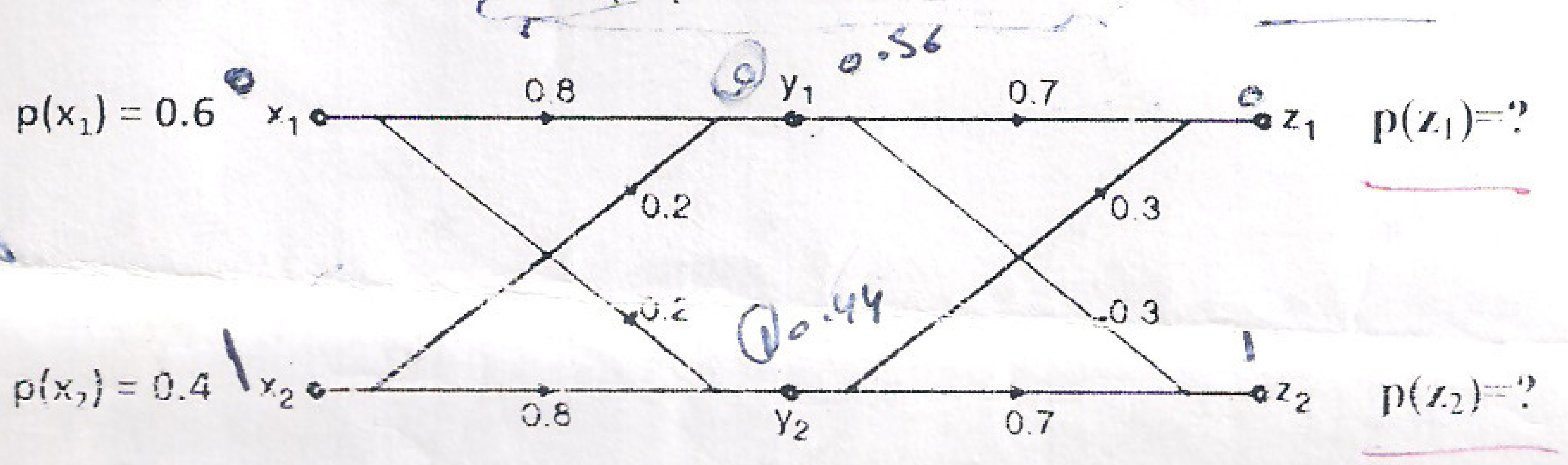
Q2. (16 Marks) Consider a source with a six-symbol alphabet, X_1, X_2, X_3, X_4, X_5, and X_6, with probabilities $P_1 = 0.2$, $P_2 = 0.01$, $P_3 = 0.35$, $P_4 = 0.38$, $P_5 = 0.02$, and $P_6 = 0.04$, respectively.

A. Find a **Shannon-Fano code** for this source. (8 Marks)

B. Compute the **average code length** of this Huffman code. (8 Marks)

حلول L ?

Q3. (8 Marks) Consider two **binary symmetrical channels** are connected in cascade as shown below:



A. Find the probabilities $p(z_1)$ and $p(z_2)$. (8 Marks)

Q4. (10 Marks) Consider the **Systematic Linear Block Code** with the following parity check matrix

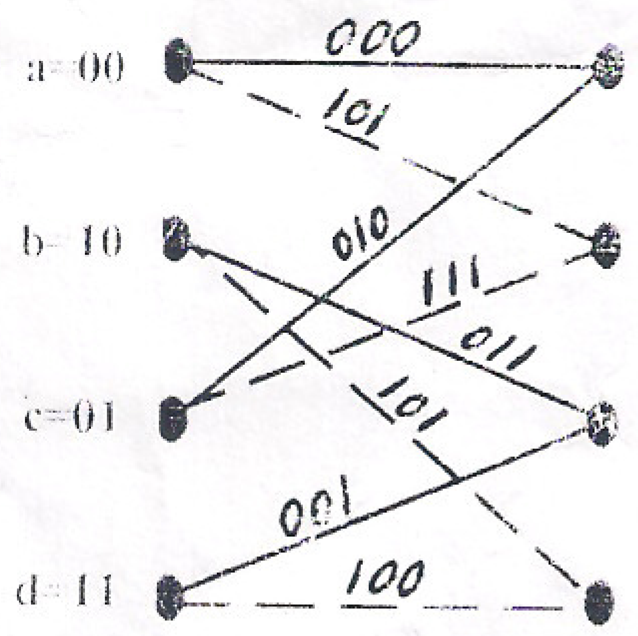
$$H = \begin{vmatrix} 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{vmatrix}_{6\times 3}$$

$H = [I_n \vdots P^T]$ $\quad$ $S = r H^T$ $\quad$ $K = 4$, $n = 8$

A. If the code is a **single error correction code**, find the **syndrome look-up table**. (5 Marks)

B. For the received vectors r_1 and r_2, **recover** the transmitted **code-word** and the **original message**. $r_1 = 1101011$, $r_2 = 0101101$. (*clearly show the recovery steps*) (5 Marks)

Q5. (10 Marks) Given the following **trellis diagram** of a **convolutional code**.



A. **Decode** the received vector r using **Viterbi Decoding**.

R= 101 111 111 100 001 011.

B. How many **errors** are there in the received vector **R** (**identify the error bits**) and show the transmitted vector **U**

$H = [I \vdots P^T]$

$H^T = \begin{bmatrix} I \\ P \end{bmatrix}$

bps $\quad$ RI

$G = [P \vdots I]$

تمنياتي للجميع بالتوفيق

استاذ المادة : م. حسام الدين الهنشيري

قســم الاتصالات.   أسئلة الامتحان النهائي لمادة: نظرية المعلومات و الترميز

الفصل: السادس كلية/الاول استراكي. رمز المادة: CM 303 . التاريخ: 4-06-2016

الفصل الدراسي: ربيع 2016   اسم الاستاذ/المنسق: حسام الدين الهنشيري.   الزمن: ساعتان.

اسم الطالب: ....   رقم القيد ....   المجموعة: ....

Q1. (16 Marks) In a telegraph source having **two independent symbols** dot and dash, the **dot duration** is 0.2 sec and the **dash duration is 0.6 sec**. The probability of **dot occurrence is three times** that of dash and the time separation between symbols is 0.1 sec. Find the following:

A. The **information rate** of this telegraph. (12 Marks)

B. The **maximum possible information rate** with the same average symbol duration. (4 Marks)

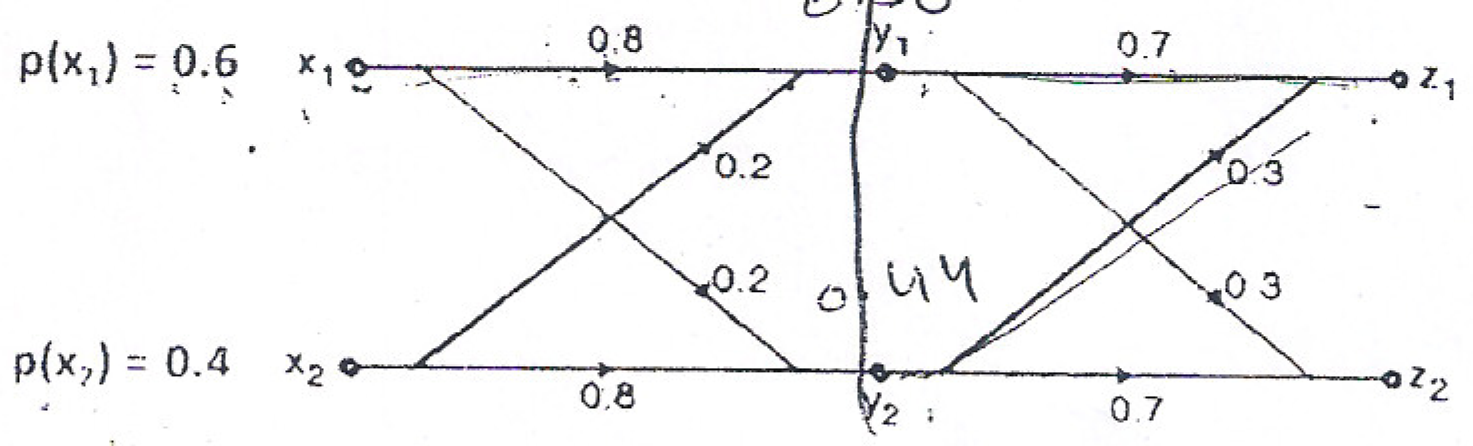
Q2. (16 Marks) Consider a source with a six-symbol alphabet, X_1, X_2, X_3, X_4, X_5, and X_6, with probabilities $P_1 = 0.2$, $P_2 = 0.01$, $P_3 = 0.35$, $P_4 = 0.38$, $P_5 = 0.02$, and $P_6 = 0.04$, respectively.

A. Find a **Shannon-Fano code** for this source. (8 Marks)

B. Compute the **average code length** of this Huffman code. L = 1.99 bit (8 Marks)

Q3. (8 Marks) Consider **two binary symmetrical channels** are connected in cascade as shown below

0.56



0.44

$p(z_1)=?$ 0.524

$p(z_2)=?$ 0.476

1

A. Find the probabilities $p(z_1)$ and $p(z_2)$. (8 Marks)

Q4. (10 Marks) Consider the **Systematic Linear Block Code** with the following parity check matrix.

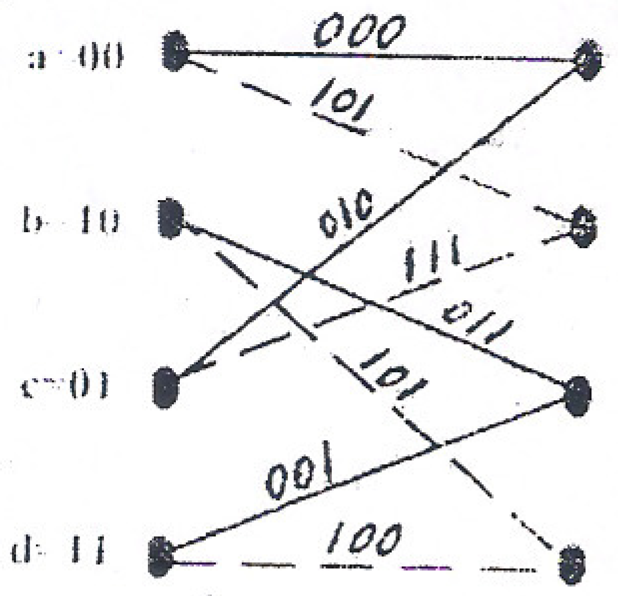
$$H=\begin{vmatrix} 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 & 1 & 1 & 0 \end{vmatrix}$$

A. If the code is a **single error correction code**, find the **syndrome look-up table**. (5 Marks)

B. For the received vectors r_1 and r_2, **recover** the transmitted code-word and the **original** message.

r_1 = **1101011**, r_2= **0101101**. (*clearly show the recovery steps*) (5 Marks)

Q5. (10 Marks) Given the following **trellis diagram** of a **convolutional code**.



A. ~~**Decode the received vector r using Viterbi Decoding.**~~

R= 101 111 111 100 001 011.

B. How many **errors** are there in the received vector R (**identify the error bits**) and **show the transmitted vector U**

7es

تمنياتي للجميع بالتوفيق

استاذ المادة : م. حسام الدين الهنشيري

Information Theory and Coding (CM303)
Midterm II (40%)
14 May 2016

Instructor: MEng. Hosam Almqadim — Time Allowed: 2 hours

Q1: (5 points) Consider a **DMS S** with symbols Si, i = 1,2,3,4. Table below lists 6 possible binary codes

Table of Codes of the source S

Si	Code 1	Code 2	Code 3	Code 4	Code 5	Code 6
S1	00	11	0	111	10	0
S2	01	00	1	10	100	1110
S3	01	10	00	110	1000	110
S4	00	01	11	0	1	10

a) Find which of them **distinct** codes are?

b) Find which of them **prefix-free** codes are?

Q2: (20 points) Consider a (7,4) linear block code with generator matrix **G**

$$G = \begin{bmatrix} 1 & 1 & 1 & 1 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \quad 4\times7$$

$P_{k(n-k)}$ $\quad I_{(k\times k)}$

A. Find all the **codewords** of the code?

B. Find the **parity-check matrix**? H

C. Find **code bits**, **message bits**, **parity bits**, **code rate**, **minimum distance**, **error detection capability** and **error correction capability**?

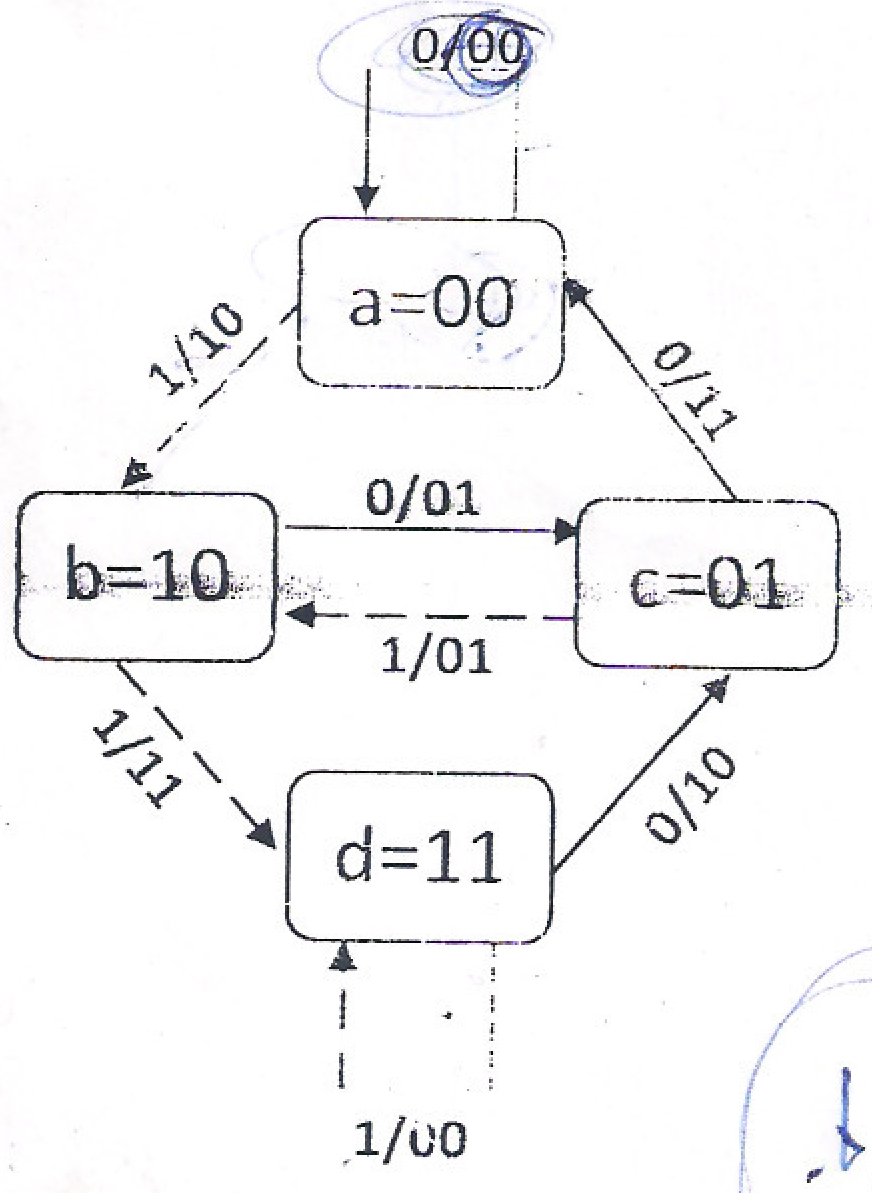
D. Compute the **syndrome** for the received vector 1101101. Is this a valid code vector?

Q3: (15 points) For the following state diagram.

a) **Draw the encoder** using shift registers, modulo-2 adders, and a commutator?

b) Find the **generator polynomial** of the encoder? g(x)

c) **Encode** the input sequence bits **m** = 10101?



$S = VH^T =$

$u_1 \quad u_2$

000 $\quad$ 0 $\quad$ 0

001 $\quad$ 1 $\quad$ 1

010

~~100~~

~~010~~

~~101~~

$g_1 = 1 + x^2$

$g_2 = x + x^2$

Good luck

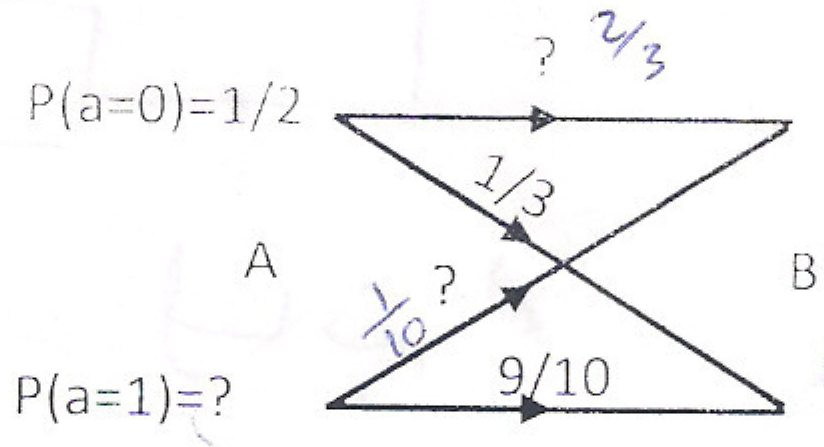
3

Information Theory and Coding (CM303)

Midterm Exam (40%)
16 April, 2016

Instructor: MEng. Hosam Almqadim   Time Allowed: 2h 15min

Q1. (10 Marks) Consider the following binary information channel



$P(b=0) = (\frac{1}{2} \times \frac{2}{3}) + (\frac{1}{2} \times \frac{1}{10}) = \frac{23}{60}$

$P(b=1) = \frac{37}{60}$

Determine **H (A)**, **H (A/B)**, **H (B/A)** and mutual information **I (A; B)** ?

$= 1$ $\quad = 0.733$ $\quad =$ $\quad = 0.2667$

Q2. (15 Marks) In a PCM system the voice signal is quantized in **16 levels** with the following probabilities:

P1 = P2 = P3 = P4 = 0.1   **P5 = P6 = P7 = P8 = 0.05**

P9 = P10 = P11 = P12 = 0.075   **P13 = P14 = P15 = P16 = 0.025**

a) Calculate the **entropy**.

b) Calculate the **Information rate**. Assume f_m = 4 kHz.

c) Calculate the entropy of the **third order extension** of this source **H(z=s^3)**.

Q3. (15 Marks) Consider a Discrete Memoryless Source with symbols **Si** = **1,2,3,4,5,6,7** have probabilities **P(Si)={2/7, 3/14, 1/7, 1/7, 1/14, 1/14, 1/14}** respectively.

0.286 0.2143 0.14286 0.07143

a) Construct a Huffman code for the source?

b) Find the efficiency and the redundancy of the code?

c) Is this code an optimal code? (**Justify your answer**)

موجود حلها

كلية التقنية الالكترونية طرابلس
College of Electronic Technology - Tripoli

قسم الاتصالات. أسئلة الامتحان النهائي لمادة : نظرية المعلومات و الترميز
لطلبة الفصل: السادس. رمز المادة: CM 303 . التاريخ: 2016-01-05

الفصل الدراسي : خريف 2015-2016 اسم الأستاذ/المنسق : حسام الدين الهنشيري. الزمن: ساعتان

اسم الطالب :........................ رقم القيد .... المجموعة : ....

Q1: In a telegraph source having two independent symbols **dot** and **dash**, the **dot duration** is **0.1s** and the **dash duration** is **0.5s**. The probability of dot occurrence is **four times** that of dash and the **time separation** between symbols is **0.1s**. Find the information rate of this telegraph source? **(16 Marks)**

Q2: Consider a **DMS** S with symbols s_i, $i=1,2,3,4,5,6$ and with probabilities $p(s_1)=0.36$, $p(s_2)=0.24$, $p(s_3)=0.15$, $p(s_4)=0.12$, $p(s_5)=0.08$, and $p(s_6)=0.05$. Construct a **Huffman code** for the source and find the **efficiency** of the constructed code? **(16 Marks)**

using

Q3: Consider a systematic block code whose parity check equations are:

$n \to$ code word
$k \to$ blocks message bits
$m=(n-k)$
$k=4$

$$b_0 = m_0 + m_1 + m_3$$
$$b_1 = m_0 + m_2 + m_3$$
$$b_2 = m_0 + m_1 + m_2$$
$$b_3 = m_1 + m_2 + m_3$$

Where m_i are the message bits, $i = 0, 1, 2, 3$, and b_i are the check bits, $i = 0, 1, 2, 3$.

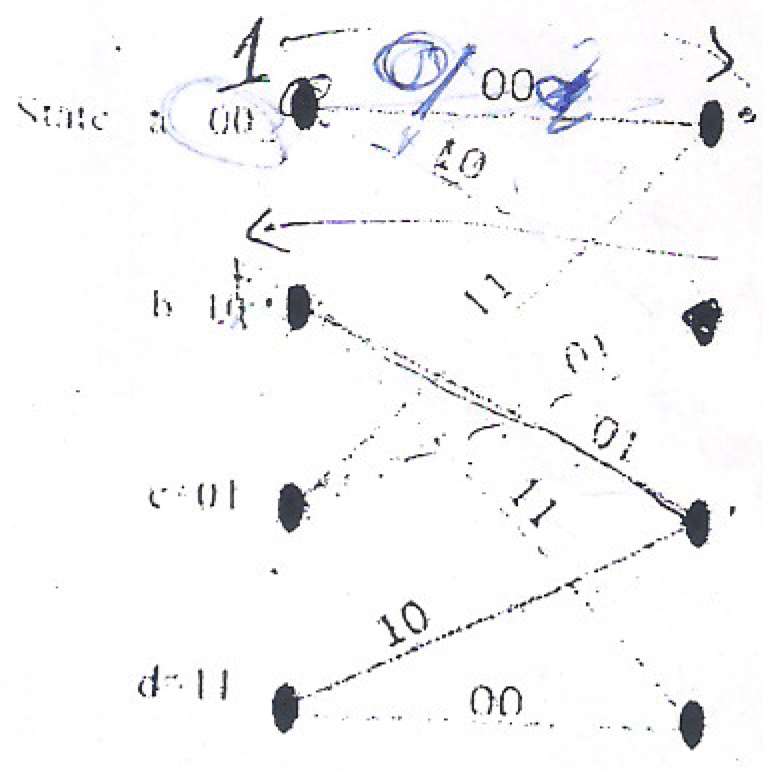
(a) What are the parameters n and k? Find the generator matrix for the code. **(2 Marks)**
(b) What is the **minimum Hamming distance**? How many errors can the code **correct**? **(2 Marks)**
(c) Is the vector [1 0 1 0 1 0 1 0] a valid codeword? $=0$ صح $\cdot H^T$ **(2 Marks)**
(d) Is the vector [0 1 0 1 1 1 0 0] a valid codeword? **(2 Marks)**

$t = \left\lfloor \frac{d_{min}-1}{2} \right\rfloor$

$e = d_{min} - 1$

Q4: For the given encoder trellis diagram:

a) Draw the encoder state diagram? (4 Marks)
b) Draw the encoder? (show your answer) (4 Marks)
c) Write the generator polynomial of the encoder? (2 Marks)
d) Encode the message sequence (01101) 00. (5 Marks)



نزيد أصفار حتى نرجع للبداية

عندما نقف نمشي للمقابل وين نبدأ لازم ننتهي

10110

$P_{k(n-k)} = kn - k^2$

Q5: Given that the mutual Information $I(X;Y) = \sum_{x\in X}\sum_{y\in Y} p(x,y)\log(p(y/x)/p(y))$, derive the follow $I(X,Y) = H(X) - H(X/Y)$? **(5 points)**

تمنياتي للجميع بالتوفيق
أستاذ المادة : م. حسام الدين الهنشيري

0 0 0 0

G

1000 1100 100 1011

Information Theory and Coding (CM303)

Midterm Exam (40%)

07 June, 2015

Instructor: MEng. Hosam Almqadim

Time Allowed: 2 hours

Q1. What is the maximum entropy H(s) for Binary Discrete Memoryless Source (BDMS)? Prove your answer? **(10 points)**

$\frac{2}{3} \times 0.6 = 0.4s$

$T_d = 0.6 \, se$

$T = 0.5s$

Q2. A telegraph source having two symbols, dot and dash. The dash duration is 0.6 seconds; and the dot duration is two third of the dash duration. The probability of the dot occurring is twice that of the dash, and the time between symbols is 0.2 seconds. Calculate the information rate of the telegraph source? **(10 points)**

occurance

RB

SDM

Q3. A discrete memoryless source has an alphabet of seven symbols with probabilities for its output as described in following table:

Symbol	S_0	S_1	S_2	S_3	S_4	S_5	S_6
Probability	0.25	0.25	0.125	0.125	0.125	0.0625	0.0625

1. Construct a Shannon-Fano code for the source and calculate the efficiency of coding? **(10 points)**
2. Construct a Huffman code for the source and calculate the efficiency of coding? And compare the results? **(10 points)**

12

Good luck!

Information Theory and Coding (CM303)

Answer of Midterm Exam (40%)

07 June, 2015

2 of 7

Instructor: MEng. Hosam Almqadim — Time Allowed: 2 hours

Q1. Answer:

Since it BDMS, then the source has two symbols s1 and s2. Let the probability of s1 is p(s1)=a then the probability of s2 is p(s2)=1-a. The entropy H(s) of this source:

$H(s) = -a\ \log_2(a) - (1-a)\ \log_2(1-a)$

Note that when $a=0 \rightarrow H(s)=0$

$a=1 \rightarrow H(s)=0$

The maximum entropy can be found by the differentiation of H(s):

$$\frac{dH(s)}{da} = \frac{d(-\text{a}\ \log_2(\text{a}) - (1-\text{a})\ \log_2(1-\text{a}))}{da} = -[a\cdot\frac{1}{a} - \log_2(a)] - [1-a\cdot\frac{-1}{1-a} - \log_2(1-a)]$$

$$= -1\ \log_2(a) + 1 + \log_2(1-a) = \log_2\left(\frac{1-a}{a}\right)$$

$$\frac{dH(s)}{da} = -\log_2(\text{a}) + \log_2(1-\text{a})$$

$$\frac{dH(s)}{da} = \log_2\left(\frac{1-\text{a}}{a}\right)$$

The maximum is found when $\frac{dH(s)}{da} = 0$

$$\log_2\left(\frac{1-\text{a}}{a}\right) = 0 \text{ when } \frac{1-\text{a}}{a} = 1$$

$\therefore$ a=0.5

Which means when a=0.5 H(s) is maximum

$H(s) = -0.5\ \log_2(0.5) - (1-0.5)\ \log_2(1-0.5) = 1$ bit/symbol

Good luck!

Q2. Answer:

Given that:
1. Dash duration: 0.6 sec.
2. Dot duration: $2/3 \times 0.6 = 0.4$ sec.
3. P (dot) = 2 P (dash).
4. Space between symbols is 0.2 sec.

Information rate =?

1. Probabilities of dots and dashes:

Let the probability of a dash be $\boxed{\text{"P"}}$. Therefore the probability of a dot will be "2P". The total probability of transmitting dots and dashes is equal to 1.

$\therefore$ P (dot) + P (dash) = 1

$\therefore$ P + 2P = 1 $\therefore$ P = 1/3

$\therefore$ Probability of dash = 1/3

And Probability of dot = 2/3

2. Average information H (X) per symbol:

$\therefore$ $H(X) = P(\text{dot}) \cdot \log_2 [1/P(\text{dot})] + P(\text{dash}) \cdot \log_2 [1/P(\text{dash})]$

$\therefore$ $H(X) = (2/3) \log_2 [3/2] + (1/3) \log_2 [3] = 0.3899 + 0.5283 = 0.9182$ bits/symbol.

3. Symbol rate (Number of symbols/sec.):

The total average time per symbol can be calculated as follows:

Average symbol time $T_s = [T_{DOT} \times P(DOT)] + [T_{DASH} \times P(DASH)] + T_{space}$

$\therefore$ $T_s = [0.4 \times 2/3] + [0.6 \times 1/3] + 0.2 = 0.6667$ sec/symbol.

Hence the average rate of symbol transmission is given by:

$R_s = 1/T_s = 1.5000$ symbols/sec.

4. Information rate (R_I):

$R_I = R_s \times H(s) = 1.5000 \times 0.9182 = 1.~~72~~$ bits/sec.

1.3773

Good luck!

Q3. Answer:

1. Shannon-Fano code:

Symbols	Probability	Step 1	Step 2	Step 3	Step 4	Code word
S_0	0.25	0	0			00
S_1	0.25	0	1			01
S_2	0.125	1	0	0		100
S_3	0.125	1	0	1		101
S_4	0.125	1	1	0		110
S_5	0.0625	1	1	1	0	1110
S_6	0.0625	1	1	1	1	1111

Average code word length (L): $L = \sum_{k=0}^{6} pi \times ni$

$= (0.25 \times 2) + (0.25 \times 2) + (0.125 \times 3) + (0.125 \times 3) + (0.125 \times 3) + (0.0625 \times 4) + (0.0625 \times 4)$

$= 2.6250$ bits/message

Entropy of the source (H):

$H(s_i) = \sum_{k=0}^{6} p_i \times \log_2(1/p_i)$

$= 0.25 \log_2(1/0.25) + 0.25 \log_2(1/0.25) + 0.125 \log_2(1/0.125) + 0.125 \log_2(1/0.125) + 0.125 \log_2(1/0.125) + 0.0625 \log_2(1/0.0625) + 0.0625 \log_2(1/0.0625) = 2.6250$ bits/symbols

Code efficiency $\eta = \frac{H}{L} \times 100 = \frac{2.625}{2.625} \times 100$

$\therefore \quad \eta = 100\%$

Good luck!

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قســم الاتصالات. أسئلة الامتحان النهائي لمادة: نظرية المعلومات و الترميز

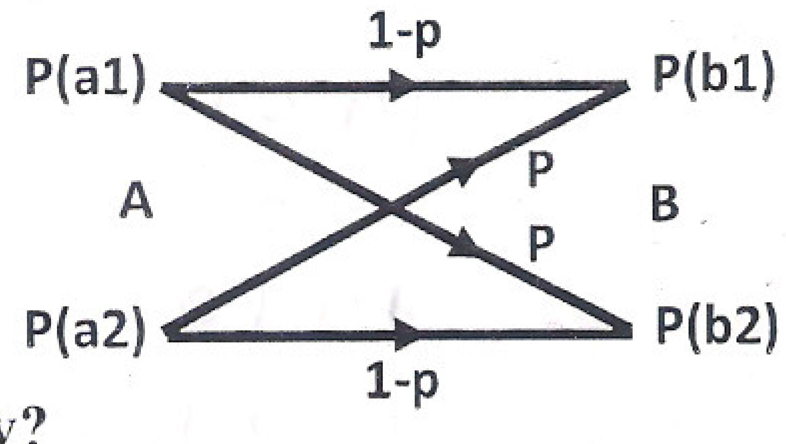
الفصل: السادس. رمز المادة: CM 303. التاريخ: 19- 07 - 2018م

الفصل الدراسي: ربيع 2018 اسم الأستاذ/المنسق: حسام الدين الهنشيري. الزمن: ساعتان.

الاسم: .... رقم القيد: ....

Q1. (**10 Marks**) In a TV transmission, picture consists of **2×10^6 elements**, **32 different brightness levels** and pictures are repeated at a rate of **32 pictures per second**. I the brightness levels have **equal likelihood of occurrence** and picture elements are **independent**, find **average information rate** of this TV source?

Q2. (**12 Marks, 3 each**) For the **Binary Symmetrical Channels** shown below:



a) Find the **Channel capacity** when **p = 1**, **p = 0**, **p = 0.5**, and **p = 0.3**?
b) Find the **Maximum Capacity** of the Channel?
c) Find the **Input, output, channels forward probabilities, H(A), ... H(B),** and **H(B/A)** when the channel works at **Maximum Capacity**?
d) How can you make the channel works at **half** of its **Maximum Capacity?**

Q3. (**8 Marks, 2 each**) Consider a **DMS** Source with symbols **Si, i=1,2,3,4**. Table below lists 6 possible binary codes

a) Find which of them **distinct** codes are?
b) Find which of them **prefix-free** codes are?
c) Find weather **instantaneous** codes are existence for these codes?
d) Can you decide which code is **the best code** for this source, and **why**?

Table of Codes of the source S

Si	C 1	C 2	C 3	C 4	C 5	C 6
S1	00	11	01	111	10	0
S2	01	00	1	10	100	1110
S3	01	10	00	110	1000	110
S4	00	01	11	0	1	10

Q4. (**15 Marks, 3 each**) Consider a **Systematic Linear Block Code** whose **parity check equations** are:
$P_0 = m_0 + m_1 + m_3$, $P_1 = m_0 + m_2 + m_3$, $P_2 = m_0 + m_1 + m_2$, and $P_3 = m_1 + m_2 + m_3$,
Where m_i are the **message bits**, i = 0, 1, 2, 3, and P_i are the **check bits**, i = 0, 1, 2, 3. $K = 2^{-2} \times 4 = 1$

1

(a) Find the **generator matrix** of the code and **draw the Encoder?**
(b) Find **code bits, message bits, parity bits, code rate, Hamming weight**?
(c) Find **Hamming distance,** the **error-detection** and **error-correction capabilities** of the code?
(d) Find the **syndrome look-up table?**
(e) Are the vectors [1 0 1 0 1 0 1 0] and [0 1 0 1 1 1 0 0] **valid codewords**? (**show the answer steps**)

10
×2
×10
×8

Q5. (**4 Marks**) Given a **Binary Convolutional Encoder** with **K=3**, **rate 1/3**, and **Impulse Response 101011010.** **Encode** the input sequence bits **m = 10101**? And **write down** the **polynomial equations** of the encoder?

S = e H 9 0.5=1 0.9 = 0.152 ≈ 0.13
0.3 = 1.7

Q6. (**3 Marks**) Consider a **(4,1,4) convolutional encoder** with the following **generator polynomials**: **g1 = [1010], g2 = [0101], g3 = [1110], g4 = [1001]**. **Draw** the encoder and how many **states** does this encoder have?

8 4

v_1 v_2 v_3 3.4
m 101
011
011 0.2 = 2.32
0.4

Q7. (**8 Marks, 2 each**) **Briefly** answer the following:
[1] How do we **measure** information content in a message?
[2] What **reduces** mutual information between input and output of a channel?
[3] What is the **purpose** of source coding and channel coding?
[4] What is the **advantages** of convolutional codes over block codes?

20 40

1000 1101
0100 1011
0010 0100
0001 0111

100010
010011
00 0 0
000 6