كلية التقنية الالكترونية — قسم الاتصالات. أسئلة 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.

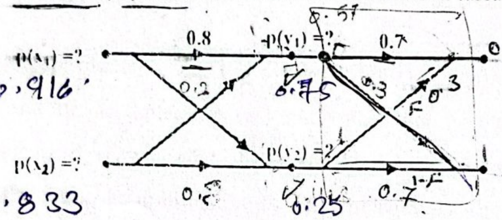
Q1. A discrete source transmits messages x_1, x_2, x_3 with probabilities $p(x_1) = 0.3$, $p(x_2) = 0.25$, $p(x_3) = 0.45$. The source is connected to the channel whose conditional probability matrix is

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

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

B. Obtain the probabilities p (y1), p (y2) and p (y3)? (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)

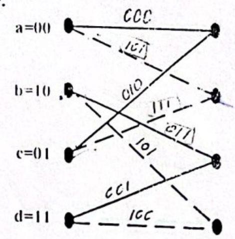
Q4. (14 Marks) Consider the **Systematic Linear Block Code** with the following parity check matrix.

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

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

تمنياتي للجميع بالتوفيق

استاذ المادة : أ. حسام الدين الهنشيري.

ترميز

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)**

dash
0.6

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)**

p(dot) = 2p(dash)

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)**

Good luck!

Information Theory and Coding (CM303)

Answer of Midterm Exam (40%)

07 June, 2015

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):

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

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

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

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

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

$\therefore$ 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 "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:

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

$\therefore$ $H(X) = (2/3) \log_2 [3/2] + (1/3) \log_2 [3] = 0.3899 + 0.5283 = 0.9182$ 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 × 2) + (0.25 × 2) + (0.125 × 3) + (0.125 × 3) + (0.125 × 3) + (0.0625 × 4) + (0.0625 × 4)
=2.6250 bits/message

Entropy of the source (H):

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

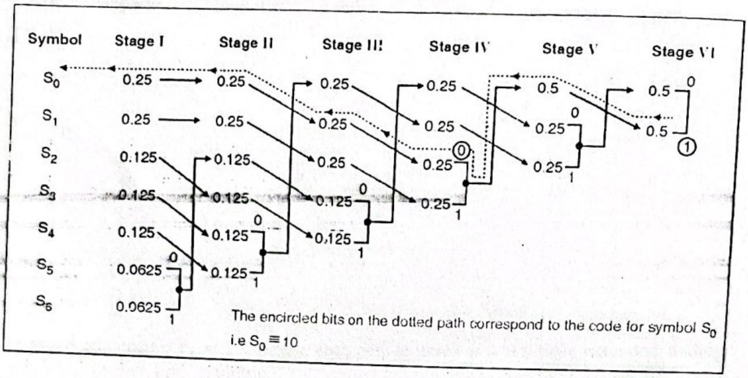
=0.25 $\log_2$ (1 / 0.25) + 0.25 $\log_2$ (1 / 0.25) + 0.125 $\log_2$ (1 / 0.125) + 0.125 $\log_2$ (1 / 0.125) + 0.125 $\log_2$ (1 / 0.125) + 0.0625 $\log_2$ (1 / 0.0625) + 0.0625 $\log_2$ (1 / 0.0625) = 2.6250 bits/symbols

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

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

Good luck!

2. Huffman Code:



Symbol	Probability	Codeword	Codeword length
S_0	0.25	10	2 bit
S_1	0.25	11	2 bit
S_2	0.125	001	3 bit
S_3	0.125	010	3 bit
S_4	0.125	011	3 bit
S_5	0.0625	0000	4 bit
S_6	0.0625	0001	4 bit

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

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

Note: As the average information per symbol (H) is equal to the average code length (L), the code efficiency is 100%.

Good luck!

Information Theory and Coding (CM303)
Midterm (40%)
26 Dec 2017

Instructor: Eng. Hosam Almqadim — **Time Allowed: 2 ho**

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

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

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 2^{nd} **order extension Z** of **A**? (2 Marks)

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:

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

H(S Rs bit/sec Rr log2(m) log2(m)

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.

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**? (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: 01010001101100100001101111100000001.... (2 Marks)

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

H(b/a1) =

H(b/a1) =

hmswhmsw

H(b/a) =

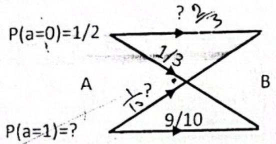
Good luck

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



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

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=s³)**.

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.

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**)

كلية التقنية الالكترونية
College of Electronic Technology - Tripoli

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

الفصل الدراسي : خريف 2016-2015   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)**

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

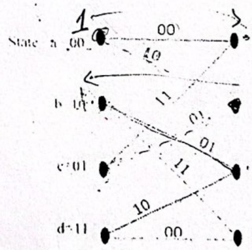
$$b_0 = m_0 + m_1 + m_3$$
$$b_1 = m_0 + m_2 + m_3$$
$$b_2 = m_0 + m_1 + m_2$$
$$b_3 = m_1 + m_2 + m_3$$

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? **(2 Marks)**
(d) Is the vector [0 1 0 1 1 1 0 0] a valid codeword? **(2 Marks)**

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). (5 Marks)



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

تمنياتي للجميع بالتوفيق
أستاذ المادة : م. حسام الدين الهنشيري

Information Theory and Coding (CM303)

Answer of Midterm Exam (40%)
07 June, 2015

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):

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

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

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

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

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

$\therefore$ 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!

سر مُعَر

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)

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)**

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

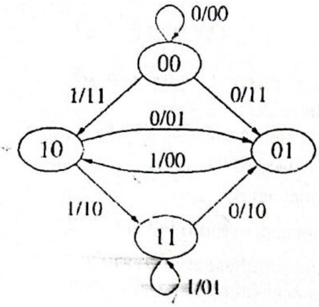
Symbol	S_0	S_1	S_2	S_3	S_4	S_5	S_6
Probability	0.25	0.25	0.125	0.125	0.125	0.0625	0.0625

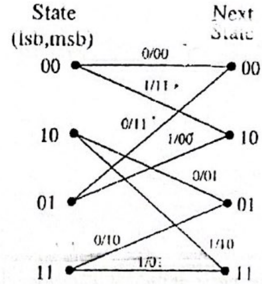
1. Construct a Shannon-Fano code for the source and calculate the efficiency of coding? **(10 points)**
2. Construct a Huffman code for the source and calculate the efficiency of coding? And compare the results? **(10 points)**

Good luck!

توضیح

Consider the encoder:





$\mathbf{m} = [1, 1, 0, 0, 1, 0, 1, 0, \ldots]$

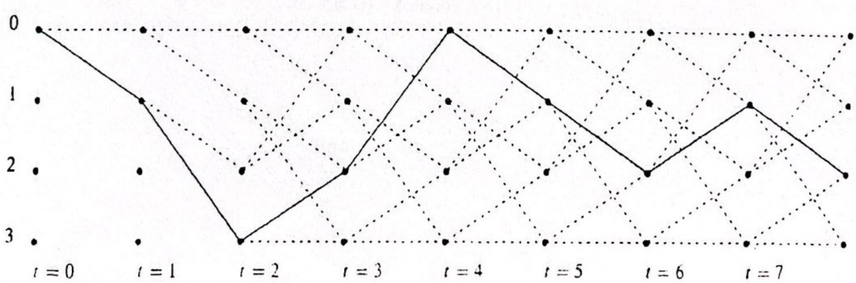
is applied to the encoder, the coded output bit sequence is

$$\mathbf{c} = [11, 10, 10, 11, 11, 01, 00, 01, \ldots]$$

The output sequence and corresponding states of the encoder are shown here,

t	Input m_k	Output $\mathbf{c}_t$
0	1	11
1	1	10
2	0	10
3	0	11
4	1	11
5	0	01
6	1	00
7	0	01

Path through trellis corresponding to true sequence



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 "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

$P + \frac{1}{3}P = 1$

$\frac{4}{3}P = 1$ $\Rightarrow \frac{3}{4}$ $\frac{1}{4}$

2. Average information H (X) per symbol:

$\therefore$ H (X) = P (dot) · $\log_2$ [1/P (dot)] + P (dash) · $\log_2$ [1/P (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:

I. 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 × 2) + (0.25 × 2) + (0.125 × 3) + (0.125 × 3) + (0.125 × 3) + (0.0625 × 4) + (0.0625 × 4)

=2.6250 bits/message

Entropy of the source (H):

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

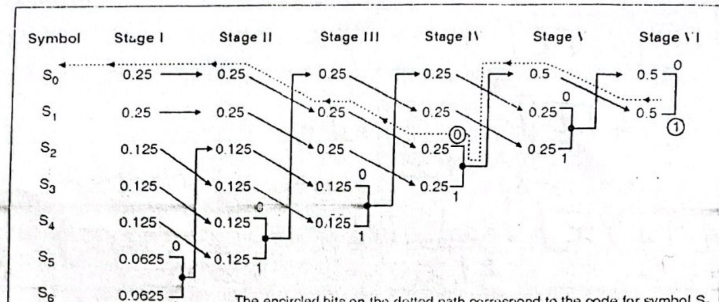
$= 0.25 \log_2 (1/0.25) + 0.25 \log_2 (1/0.25) + 0.125 \log_2 (1/0.125) + 0.125 \log_2 (1/0.125) + 0.125 \log_2 (1/0.125) + 0.0625 \log_2 (1/0.0625) + 0.0625 \log_2 (1/0.0625) = 2.6250$ bits/symbols

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

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

Good luck!

2. Huffman Code:



The encircled bits on the dotted path correspond to the code for symbol S_0 i.e $S_0 \equiv 10$

Symbol	Probability	Codeword	Codeword length
S_0	0.25	10	2 bit
S_1	0.25	11	2 bit
S_2	0.125	001	3 bit
S_3	0.125	010	3 bit
S_4	0.125	011	3 bit
S_5	0.0625	0000	4 bit
S_6	0.0625	0001	4 bit

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

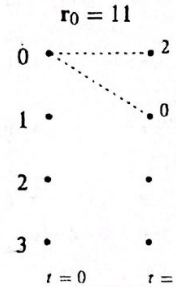
$\therefore \quad \eta = 100\%$

Note: As the average information per symbol (H) is equal to the average code length (L), the code efficiency is 100%.

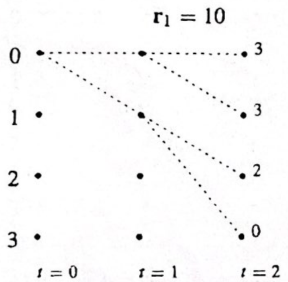
Good luck!

The algorithm proceeds as follows:

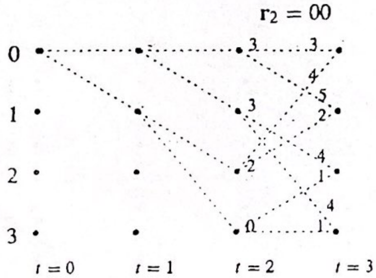
$t = 0$: The received sequence is $\mathbf{r}_0 = 11$. We compute the metric to each state at time $t = 1$ by finding the (Hamming) distance between $\mathbf{r}_0$ and the possible transmitted sequence $\mathbf{c}_0$ along the branches of the first stage of the trellis. Since state 0 was known to be the initial state, we end up with only two paths, with path metrics 2 and 0, as shown here:



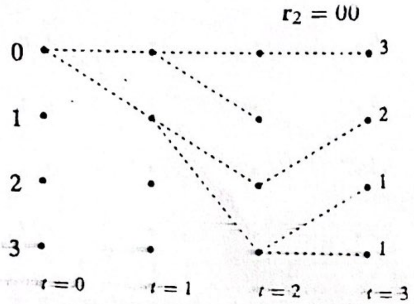
$t = 1$: The received sequence is $\mathbf{r}_1 = 10$. Again, each path at time $t = 1$ is simply extended, adding the path metric to each branch metric:



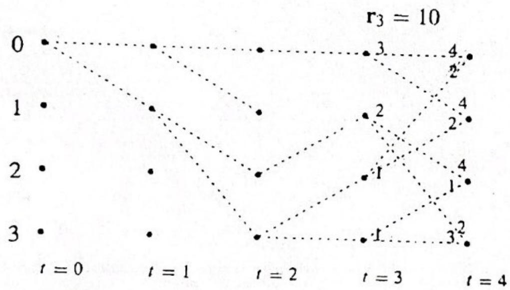
$t = 2$: The received sequence is $\mathbf{r}_2 = 00$. Each path at time $t = 2$ is extended, adding the path metric to each branch metric of each path.



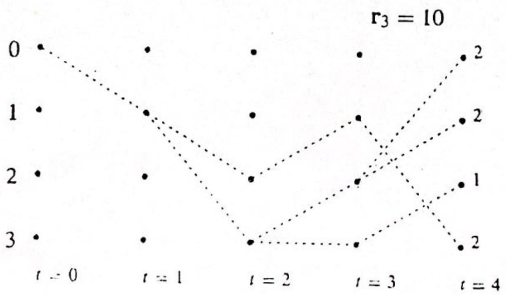
There are now multiple paths to each node at time $t = 3$. We select the path to each node with the best metric and eliminate the other paths. This gives the diagram as follows:



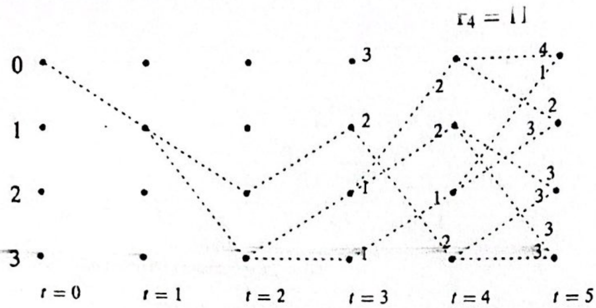
$t = 3$: The received sequence is $r_3 = 10$. Each path at time $t = 3$ is extended, adding the path metric to each branch metric of each path.



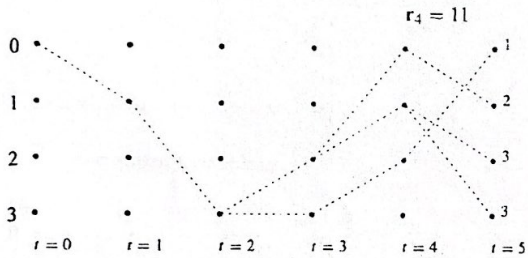
Again, the best path to each state is selected. We note that in selecting the best paths, some of the paths to some states at earlier times have no successors; these orphan paths are deleted now in our portrayal:



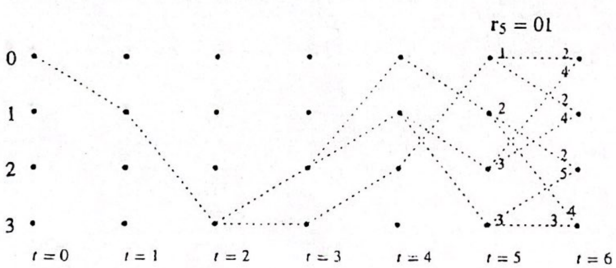
$t = 4$: The received sequence is $\mathbf{r}_4 = 11$. Each path at time $t = 4$ is extended, adding the path metric to each branch metric of each path.



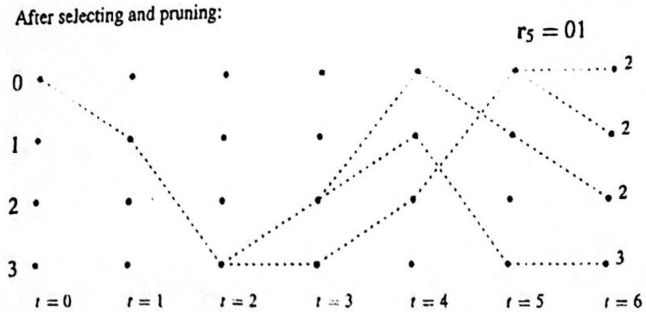
In this case, we note that there are multiple paths into state 3 which both have the same path metric; also there are multiple paths into state 2 with the same path metric. Since one of the paths must be selected, the choice can be made arbitrarily (e.g., at random). After selecting and pruning of orphan paths we obtain:



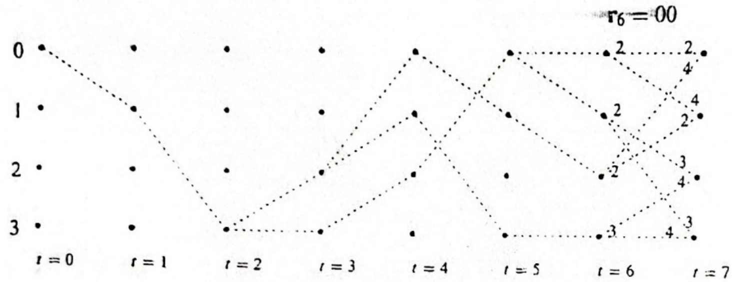
$t = 5$: The received sequence is $\mathbf{r}_5 = 01$.



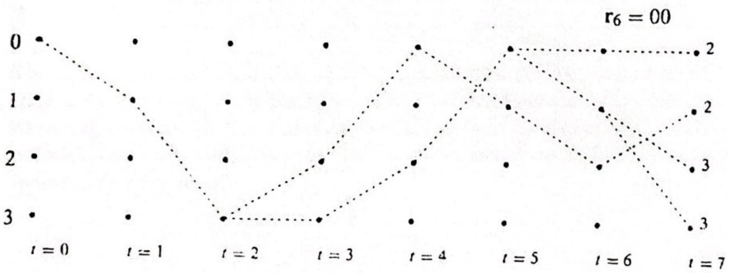
After selecting and pruning:



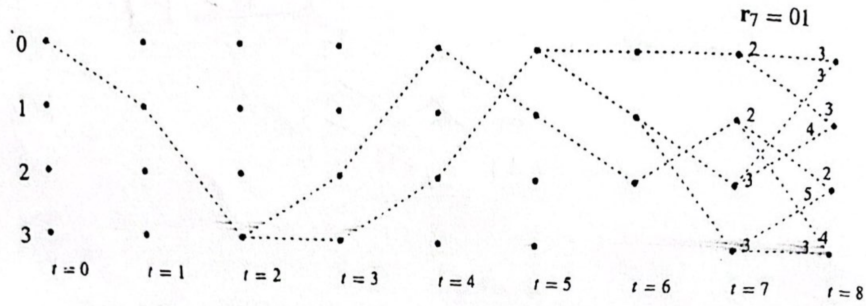
$t = 6$: The received sequence is $\mathbf{r}_6 = 00$.



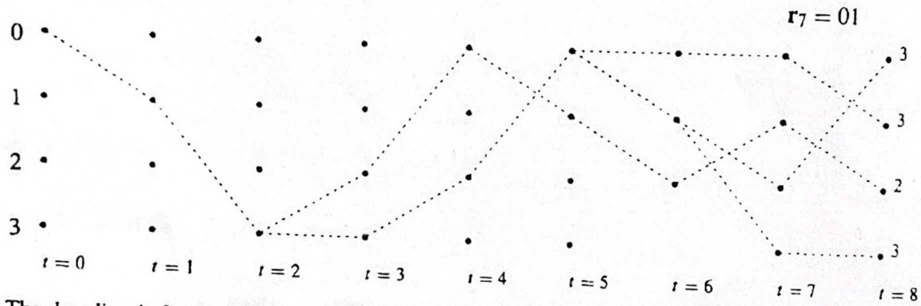
After selecting and pruning:



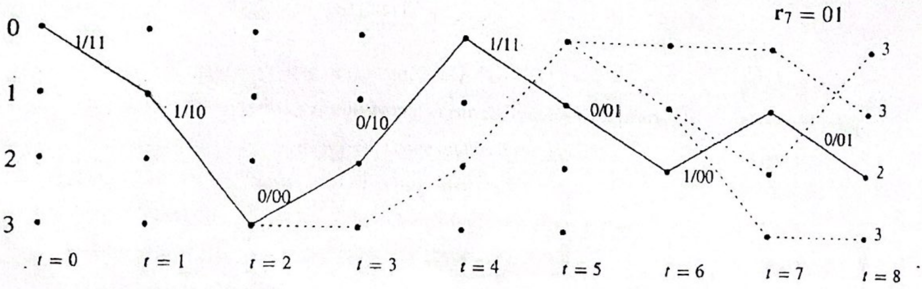
$t = 7$: The received sequence is $\mathbf{r}_7 = 01$.



After selecting and pruning:



The decoding is finalized at the end of the transmission (the 16 received data bits) by selecting the state at the last stage having the lowest cost, traversing backward along the path so indicated to the beginning of the trellis, then traversing forward again along the best path, reading the input bits and decoded output bits along the path. This is shown with the solid line below; input/output pairs are indicated on each branch.



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

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

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. **(4 Marks)**

B. Compute the **average code length** of the code. **(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

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) Are the generator vectors **linearly independent**? **(Justify your answer)** **(2 Marks)**

f) **Encode** the following bit stream 10110010000110111100....... **(2 Marks)**

g) **Draw** an encoder of the code? **(2 Marks)**

Good luck

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 $I(A;B)=I(B;A)$?

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?

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?

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?

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

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

Good luck

كلية التقنية الالكترونية
College of Electronic Technology - Tripoli

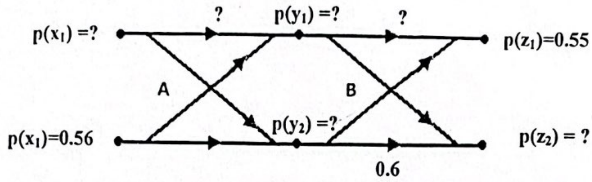
قســـم الاتصالات.   أسئلة الامتحان النهائي لمادة: نظرية المعلومات و الترميز

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

a) Find which of them **distinct** codes are? (2 Marks)

b) Find which of them **prefix-free** codes are? (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=110111100001001...?**

h) If r_1 = **1101011** and r_2= **0101101** were received, what are the **transmitted code-words** and **original messages?** (*clearly show the recovery steps*)

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

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

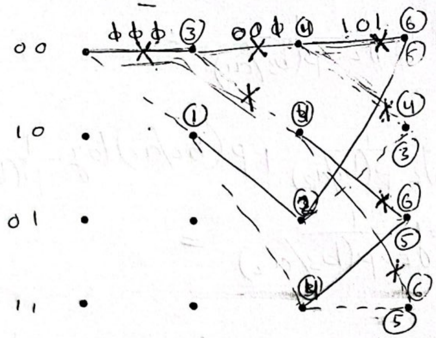
b) **Draw** the encoder? (**show your answer**) (6 Marks)

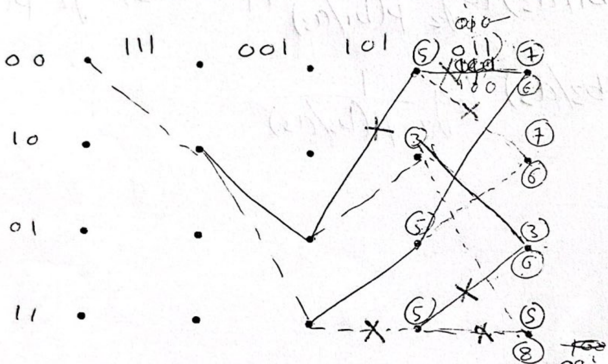
c) **Draw** the **Trills diagram** of the encoder? (5 Marks)

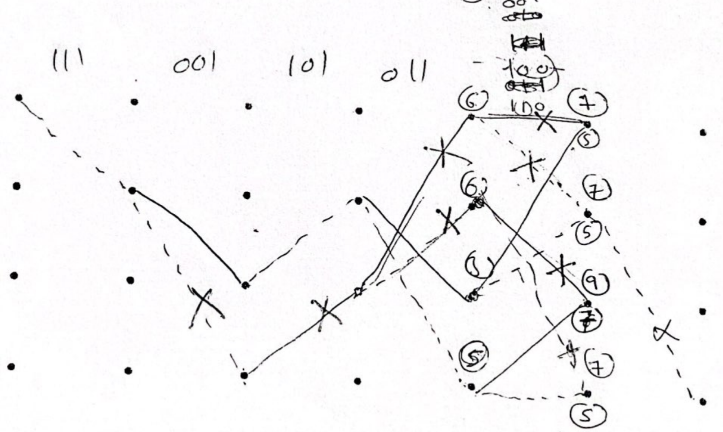
تمنياتي للجميع بالتوفيق

أ. حسام الدين الهنشيري

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







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

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

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

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:

(12 Marks)

A. The **information rate** of this telegraph.

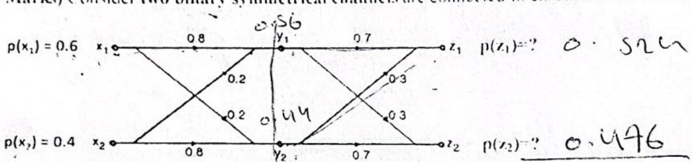
B. The **maximum possible information rate** with the same average symbol duration. (4 Marks)

~~**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)

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)

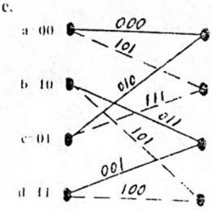
Q4. (10 Marks) Consider the **Systematic Linear Block Code** with the following parity check matrix.

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

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

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**

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

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

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

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

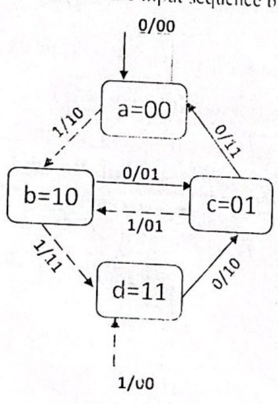
D. Compute the **syndrome** for the received vector **1101101**. Is this a valid code vector?

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?

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



Good luck

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

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

كلية التقنية الالكترونية

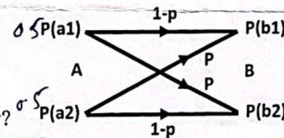
College of Electronic Technology - Tripoli

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.

(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)**

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?

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?

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?

تمنياتي للجميع بالتوفيق،،،، أ. حسام الدين الهنشيري