北京郵電大學

Queen Mary University of London

Joint Programme examinations 2010/11

For examiner's use only

1	
2	
3	
4	
5	
6	
Total	

EBU5302 Telecoms Systems

Paper A

Time allowed 2hours 30 minutes

Answer FOUR questions only.

Complete the information below about yourself very carefully.

QM student number	
BUPT student number	
Class number	

Make and type of any electronic calculator you are using	

INSTRUCTIONS TO CANDIDATES

1. **You must not take answer books, used or unused, from the examination room.**
2. Write only in black or blue pen **and in English.**
3. **Write your answers in the space provided**
4. Do all rough work in the "Rough Working Section" – do not tear out any pages.
5. Write clearly so that it can be easily read.

Examiners

Prof Laurie Cuthbert
Dr Michael Chai

Filename: 1011_EBU5302_A No answerbook required

Question 1

a) **[5 marks]** A communications link consists of three elements, each with a signal to noise ratio (SNR) as shown in Figure 1. Calculate the overall SNR for the link.

Figure 1

b) **[6 marks]** Show that the Entropy for a source emitting two symbols (A and B) is maximum when the probability of A being emitted ($p(A)$) is 0.5. Do this by *plotting a graph* of Entropy against $p(A)$.

c) **[9 marks]** A source emits 5 symbols (A, B, C, D, E) with probabilities as shown in Figure 2.

A	B	C	D	E
0.3	0.3	0.2	0.1	0.1

Figure 2

i) Code this data with a Huffman variable-length code representing each symbol and determine the average number of bits/symbol that could be used to transmit this source.

ii) Determine how many bits/symbol would be required if source coding was not used.

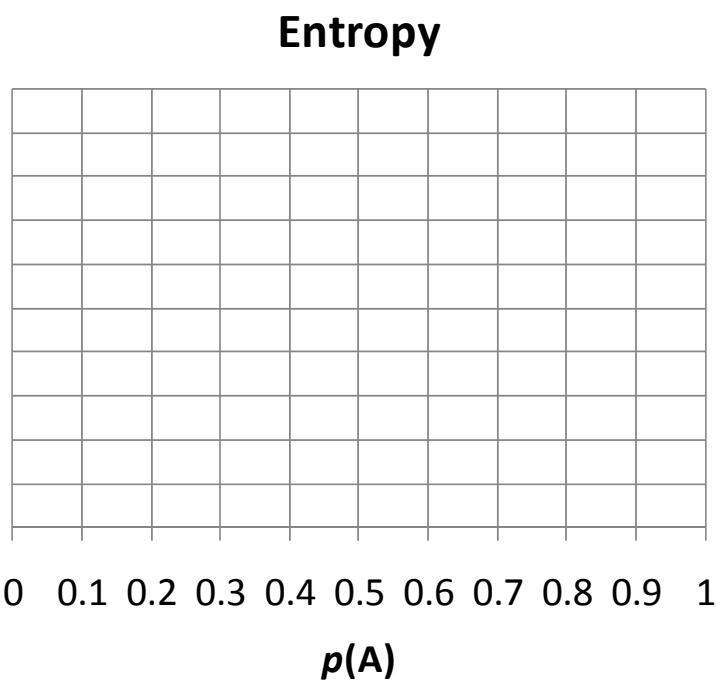
d) **[5 marks]** A fax machine has to transmit the following sequence of black (B) and white (W) pixels:

260W 9B 135W 5B 5W 7B

Use the extract from the T4 code shown on the answers section to determine the average number of bits / pixel transmitted:

Write your answer on the next 3 pages

Answers to Question 1

	Do not write in this column
a)	
	5 marks
b)	
	**6 marks**

	Do not write in this column
c)	
	9 marks

Do not write in this column

d)

Terminating White Codes		Makeup White Codes		Terminating Black Codes		Makeup Black Codes	
Code	Run	Code	Run	Code	Run	Code	Run
00110101	0	11011	64	0000110111	0	0000001111	64
000111	1	10010	128	010	1	000011001000	128
0111	2	010111	192	11	2	000011001001	192
1000	3	0110111	256	10	3	000001011011	256
1011	4	00110110	320	011	4	000000110011	320
1100	5	00110111	384	0011	5	000000110100	384
1110	6	01100100	448	0010	6	000000110101	448
1111	7	01100101	512	00011	7	0000001101100	512
10011	8	01101000	576	000101	8	0000001101101	576
10100	9	01100111	640	000100	9	0000001001010	640
00111	10	011001100	704	0000100	10	0000001001011	704

5 marks

Question 2

a) **[6 marks]** State the name and briefly explain the purpose of the following elements in a mobile network:

(i) BSC (ii) MSC (iii) SGSN

b) **[9 marks]** A 3-cell cluster and a 7-cluster are being considered for a GSM network. Each cluster would cover *the same area*. Determine the ratio of co-channel interference power that would be seen for the two clusters. Assume that the received signal power is proportion to $1/d^4$ where d is the distance between transmitter and receiver.

c) **[6 marks]** A source generates packets of 1024 bits at a rate of 1 Mbit/s. These are to be transmitted over a communications link using a sliding window ARQ error correction method. If (i) the windows size is W=80, (ii) the return packet length for acknowledgements is also 1024 bits, (iii) the delay can be neglected and (iv) the probability of a single-bit error is 10^{-4}, calculate the throughput (effective data rate).

d) **[4 marks]** Determine the window size that would achieve the optimum throughput and what that throughput would be.

Write your answer below and on the following 2 pages

Answers to Question 2

	Do not write in this column
a)	
BSC	
MSC	
SGSN	
	6 marks
b)	

	Do not write in this column
	9 marks
c)	
	6 marks

	Do not write in this column
d)	
	4 marks

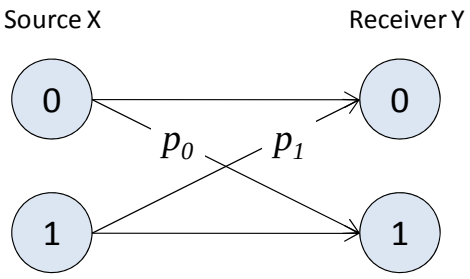
Question 3

a) **[9 marks]** A channel with AWGN (Additive White Gaussian Noise) has a ratio of E_b/N_0 of 20dB. By plotting E_b/N_0 against spectral efficiency, show that the value of spectral efficiency is approximately 10 bits/s/Hz at this level of E_b/N_0.

b) **[11 marks]** A binary *asymmetric* channel is shown in Figure 3.

i) Calculate the probabilities for each symbol being obtained at the receiver, i.e. P(Y=0) and P(Y=1)

ii) Calculate the reverse probabilities P(X=0|Y=0), P(X=0|Y=1), P(X=1|Y=0), P(X=1|Y=1) and show that ∑P(X=x|Y=y) = 1 for any particular value of y.



P(X=0) = 0.5

P(X=1) = 0.5

p_0 = P(Y=1|X=0) = 0.1

p_1 = P(Y=0|X=1) = 0.2

Figure 3

c) **[5 marks]** The *Equivocation* is given by:

$$E = \sum_j P(Y=j) \sum_i P(X=i \mid Y=j) \log_2 \frac{1}{P(X=i \mid Y=j)}$$

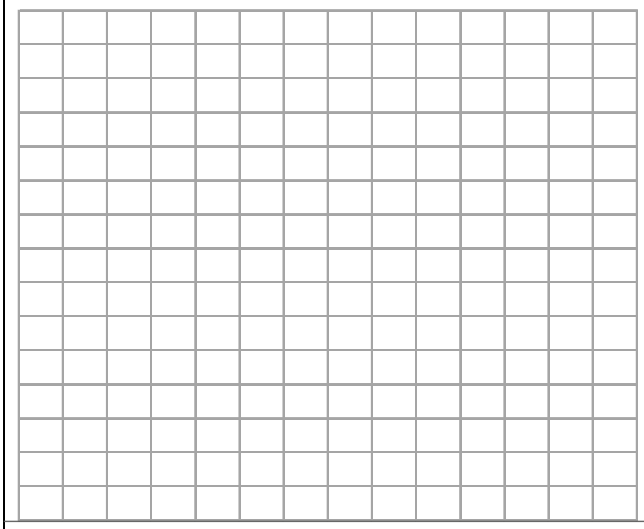
Calculate the Equivocation for this channel.

Write your answer below and on the following 2 pages

Answers to Question 3

	Do not write in this column
a)	

Do not write in this column



9 marks

b) P(X=0) = 0.5 P(X=1) = 0.5 p_0 = P(Y=1|X=0) = 0.1 p_1 = P(Y=0|X=1) = 0.2

	Do not write in this column
	11 marks
c) $E = \sum_j P(Y = j) \sum_i P(X = i \mid Y = j) \log_2 \frac{1}{P(X = i \mid Y = j)}$	
	5 marks

Question 4

a) **[10 marks]** With the aid of a 4-stage block diagram, explain how analogue signals can be converted to digital form for processing and then converted back to analogue form. For each block in the diagram, briefly describe its function and indicate how its specification is affected by the bandwidths of the analogue input and output signals.

b) **[7 marks]** Given a signal $x(t)=15\cos(70t+\pi/3)+10\cos(750t+\pi/5)$ to be uniformly sampled for digital transmission.

i) What is the minimum sampling rate for this signal to have perfect reproduction?

ii) Explain what will happen if the applied sampling rate is lower than the minimum sampling rate.

c) **[8 marks]** Given an analogue signal x(t) in a range of -5V to +5V and the quantisation distortion must not exceed 1% of the peak to peak analogue signal.

i) Calculate the minimum number of bits per PCM word.

ii) Determine the minimum step size between quantisation.

iii) Explain why the minimum number of bits per PCM word could increase the quantisation errors.

Write your answer below and on the following 2 pages

Answers to Question 4

a)	Do not write in this column

	10 marks
b)	
	7 marks

c)	Do not write in this column
	8 marks

Question 5

a) **[11 marks]** Figure 4 shows an eye diagram of a transmission signal.

i) Explain what is meant by Inter-symbol interference (ISI) in digital transmission systems, how ISI affects the signals in digital transmission and what causes ISI.

ii) With reference to Figure 4, explain how the signal quality can be identified from the eye diagram.

iii) Calculate the peak signal to ISI ratio of this signal (in dB).

iv) Suggest, with justifications, an initial sampling time, T_0 for this signal.

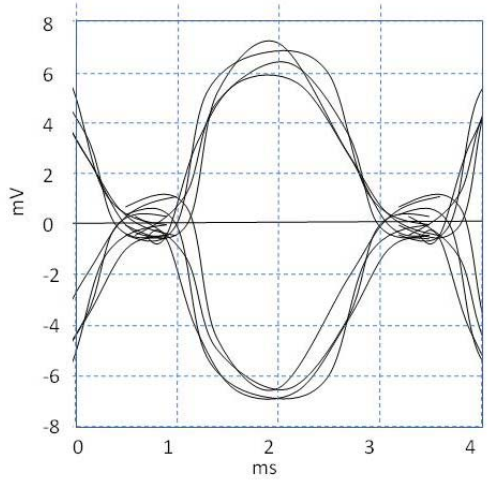


Figure 4

b) **[7 marks]** Explain why equalisation is needed in a transmission system. State where in a transmission the equalisation takes place.

c) **[7 marks]** The following data is to be transmitted using a suitable line code:

1010 0001 0000 0111

Sketch the resultant waveforms that would result from the following line codes:

i) HDB3

ii) 4B3T using the code table of Figure 5 (with running sum initially equal to 0 and start with A1 column).

iii) What are the benefits and drawbacks of HDB3 as compared with 4B3T?

4B3T code		
Binary	A1	A2
0000	0-+	0-+
0001	-+0	-+0
0010	-0+	-0+
0011	+-+	-+-
0100	0++	0--
0101	0+0	0-0
0110	00+	00-
0111	-++	+--
1000	0+-	0+-
1001	+-0	+-0
1010	+0-	+0-
1011	+00	-00
1100	+0+	-0-
1101	++0	--0
1110	++-	--+
1111	+++	---

Figure 5 4B3T code table

Write your answer below and on the following 2 pages

Answers to Question 5

a i)	Do not write in this column

a ii)

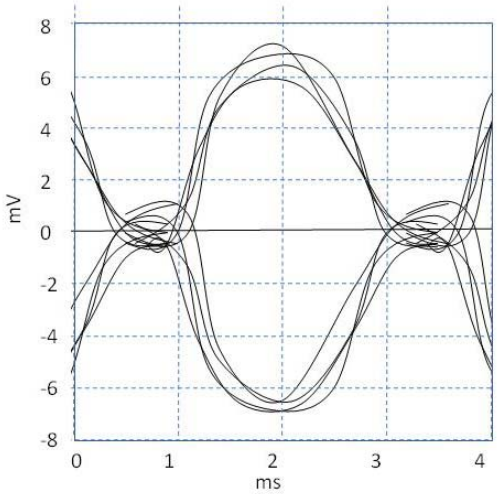


Figure 4

a iii)

a iv)

11 marks

b)

Do not write in this column

7 marks

c i)	Do not write in this column
c ii)	
c iii)	
	7 marks

Question 6

An organisation uses a single link operating at 10Mbps to connect to the Internet at present. The overall network traffic behaviour can be approximated using an M/M/1 queue. On average, the outgoing link deals with 1800 packets per second, with an average packet size of 500 bytes.

a) **[8 marks]** Explain the concept of a queueing model by using appropriate block diagrams. Your explanation should include the arrival time (λ); waiting time (t_w), service time (t_s) and queue time (t_q).

b) **[3 marks]** What are the mean arrival rate (in bit/s) and the utilisation of the system?

c) **[14 marks]** There are two possible solutions to improve the overall system speed of the connection:

Solution 1: Replace the 10Mbit/s link with a single 20Mbit/s link

Solution 2: Replace the 10Mbit/s link with two 10Mbit/s links

i) Calculate the mean queueing time for these two proposals.

ii) Bearing in mind that the traffic demand will continue to rise, evaluate which proposal you would recommend for the company as a better long term investment.

Hint: A general formula for the average number of items in a M/M/2 queue is $q = \frac{2\rho}{(1-\rho^2)}$

Write your answer below and on the following 3 pages

Answers to Question 6

a)	Do not write in this column

	8 marks

b)	Do not write in this column

	3 marks

c	Do not write in this column

14 marks

Rough Working Only

Rough Working Only

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