课程名称　数字通信　考试学期　09-10-2　得分

适用专业　信息科学与工程学院　考试形式　闭卷　考试时间长度　120 分钟

Section A : True or False （10%，1% for each question）

1. When the period is exactly 2^{m-1}, the PN sequence is called a maximal-length-sequence or simply m-sequence.
2. Frequency diversity can be accomplished by choosing a frequency spacing equal to or greater than the coherence time of the channel.
3. All error patterns that differ by a code word have the same syndrome.
4. For fast-frequency hopping, hop rate R_h of MFSK signal is an integer multiple of the symbol rate R_s. That is, the carrier frequency will change or hop several times during the transmission of one symbol.
5. A preferred pair of primitive polynomials of degree m whose corresponding shift registers generate m-sequences of period 2^m-1
6. Any source code that satisfies the Kraft-McMillan inequality can be a prefix code.
7. The mutual information of a channel depends not only on the channel but also on the way in which the channel used.
8. The minimum distance of a linear block code is the smallest Hamming weight of the nonzero code vectors in the code.
9. Unlike the entropy of a discrete random variable, the differential entropy of a continuous random variable can be negative.
10. A feedback shift register is said to be linear when the feedback logic consists entirely of modulo-2 adders.

Section A : True or False （每题 1 分，共 10 分）

1. False	2. False	3. True	4. True	5. True
6. False	7. True	8. True	9. True	10. True

Section B: Fill in the blanks (30%, 1% for each blank)

1. For Linear block codes , detect all error patterns of Hamming weight $w(e) \le t_1$, *if and only if* $d_{min} \ge$ ________________.
2. The satellite communication channel is closely modeled as an ________________ channel.
3. Three major sources of degradation in wireless communications are ______________, _______, and __________; the latter two are byproducts of multipath, and large ___________is responsible for the intersymbol interference.
4. The two commonly used types of spread-spectrum modulation are: _____________ and _______________.
5. There are the following diversity techniques in our discussion , ___________ diversity, _____ diversity, ______diversity.
6. The information capacity of a continuous channel of bandwidth B hertz with averaged transmitted power P, perturbed by additive white Gaussian noise of power spectral density $N_0/2$ and limited in bandwidth to B, is given by

__________________________.

7. In a DS/BPSK system, the feedback shift register used to generate

__________________________.

7. In a DS/BPSK system, the feedback shift register used to generate the PN sequence has length m=15, than the processing gain is _______ .
8. A cyclic code is uniquely determined by the generator polynomial g(X), g(X) is a polynomial of degree ________, g(X) is a factor of ______________.
9. For a m-sequence generated by a linear feedback shift register of length 7, the period of the m-sequence is ____________, the total number of runs is _____, number of length-four runs is _____, the autocorrelation R(j)=______(j≠0).
10. The *error-syndrome vector* (or *syndrome)* is defined as: ________.
11. Let a discrete memoryless source with an alphabet φ have entropy $H(\varphi)$ and produce symbols once every T_s seconds. Let a discrete memoryless channel have capacity C and be used once every T_c seconds . Then , if _____________ , there exists a coding scheme for which the source output can be transmitted over the channel and be reconstructed with an arbitrarily small probability of error.
12. A voice-grade channel of the telephone network has a bandwidth of

3.4kHz, the information capacity of the telephone channel for a signal-to-noise ratio of 30dB is ________________,the minimum signal-to-noise ratio required to support information transmission through the telephone channel at the rate of 4,800b/s is _____.

13. The distortion of D will ______________ as the rate distortion function R(D) is decreased.

14. A source emits one of six symbols $s_0 \sim s_5$ with probabilities 1/2, 1/8, 1/8, 1/8, 1/16, 1/16 respectively. The successive symbols emitted by the source are statistically independent. The entropy of the source is ______________. The average code-word length for any distortionless source encoding scheme for this source is bounded as___________.

15. For a constrained peak magnitude M, the __________distributed random variable X has the largest differential entropy attainable by any random variable, and the differential entropy is __________________.

16. If the message bandwidth is smaller compared to the coherent bandwidth of the channel, the fading is said to be ________________. If the coherence time of the channel is longer compared to the duration of the signal duration, the fading is

Section B: Fill in the blanks （每空 1 分，共 30 分）

1. $d_{min} \geq t_1 + 1$
2. AWGN
3. co-channel interference, fading, delay spread, delay spread
4. direct sequence(DS), frequency hopping(FH)
5. frequency, time, space
6. $C = B\log_2(1+\frac{P}{N_0B})$ bits per second
7. 2^{15}-1 = 32767 (45dB)
8. (n-k) , $(X^n + 1)$

2. AWGN 分)

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7. $2^{15}-1 = 32767$ (45dB)

8. (n-k) , $(X^n + 1)$

9. 127, 64, 4 , -1/127

10. $s = rH^T$

11. $\frac{H(\varphi)}{T_s} \le \frac{C}{T_c}$

12. 33.9 kbits/second , 2.2dB

13. increase

14. 17/8=2.125bits/symbol, $\bar{L} \ge H(\varphi)$

15. uniformly, $\log_2(2M)$

16. frequency nonselective (or flat) , time nonselective (or flat)

16. If the message bandwidth is smaller compared to the coherent bandwidth of the channel, the fading is said to be ________________. If the coherence time of the channel is larger compared to the duration of the signal duration, the fading is said to be ________________.

Section C: Problems （60%, 15% for each question）

1. A radio link uses a pair of 2m dish antennas with an efficiency of 75 percent each, as transmitting and receiving antennas. Other specifications of the link are:

Transmitted power = 4 dBW （not include the power gain of antenna）

Carrier frequency = 12 GHz

Distance of the receiver from the transmitter = 30000km

Calculate (a)the free-space loss,

(b) the power gain of each antenna,

(c)the received power in dBW.

Section C: Problems （每题 15 分，共 60 分）

1. (a) Free-space loss $L_{freespace} = 10\log_{10}\left(\frac{\lambda}{4\pi d}\right)^2 = 20\log_{10}\left(\frac{3\times10^8/12/10^9}{4\times\pi\times30000\times10^3}\right)$

$=-203.57\text{dB}$ （5 分）

(b) The power gain of each antenna is

$$10\log_{10}G_t = 10\log_{10}G_r = 10\log_{10}\left(\frac{4\times\pi\times A}{\lambda^2}\right) = 10\log_{10}\left(\frac{4\times\pi\times0.75\times\pi}{(3\times10^8/12/10^9)^2}\right)$$

$=46.75\text{dB}$ （5 分）

(c) The received power = transmitted power + G_t + G_r + free-space loss

= 4 + 46.75 + 46.75 + (-203.57)

= -106.07dBW （5 分）

2. A computer executes eight instructions that are used independently with probabilities (1/32, 1/32, 1/16, 1/8, 1/8, 1/8, 1/4, 1/4). Construct two different Huffman codes for the instructions.

(a) In one case, move a combined symbol in the coding procedure as high as possible;

(b) In the second case, move a combined symbol in the coding procedure as low as possible.

(c) For each of the two codes, find the average code-word length and the variance of the average code-word length over the ensemble of the instructions.

…6.75 + 46.75 + (-203.57)

= -106.07dBW （5 分）

2.

(a) As high as possible

Stage I	Stage II	Stage III	Stage IV	Stage V	Stage VI	Stage VII	Code word
1/4	1/4	1/4	1/4	1/4	1/2	1/2	10
1/4	1/4	1/4	1/4	1/4	1/4	1/2	11
1/8	1/8	1/8	1/4	1/4	1/4		001
1/8	1/8	1/8	1/8	1/4			010
1/8	1/8	1/8	1/8				011
1/16	1/16	1/8					0001
1/32	1/16						00000
1/32							00001

（5 分）

(b) As low as possible （5 分）

Stage I	Stage II	Stage III	Stage IV	Stage V	Stage VI	Stage VII	Code word
1/4	1/4	1/4	1/4	1/4	1/2	1/2	10
1/4	1/4	1/4	1/4	1/4	1/4	1/2	11
1/8	1/8	1/8	1/4	1/4	1/4		010
1/8	1/8	1/8	1/8	1/4			011
1/8	1/8	1/8	1/8				000
1/16	1/16	1/8					0010
1/32	1/16						00110
1/32							00111

（5 分）

(c)

Average code-word length = $2\frac{11}{16}$ （1 分）

As high as possible:

Variance of the average code-word length = $\frac{183}{256}$ （2 分）

As low as possible:

Variance of the average code-word length = $\frac{183}{256}$ （2 分）

3. Consider the (15,7) cyclic code defined by the generator polynomial

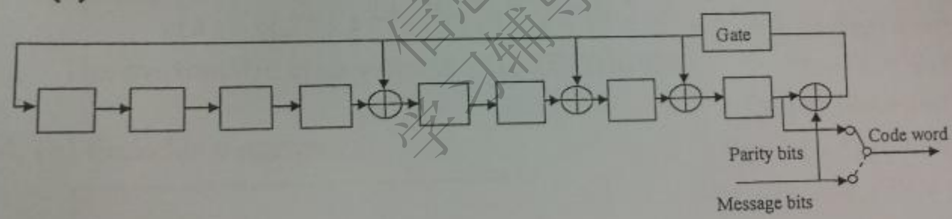
$$g(X) = 1 + X^4 + X^6 + X^7 + X^8$$

(a) Develop the encoder for this code.

(b) Get the generator matrix and the parity-check matrix.

(c) Construct a systematic code word for the message sequence 1101010.

3. (a)



（3 分）

Message bits

(b) generator matrix

$g(X)=1+X^4+X^6+X^7+X^8$

$Xg(X)=X+X^5+X^7+X^8+X^9$

$X^2g(X)=X^2+X^6+X^8+X^9+X^{10}$

$X^3g(X)=X^3+X^7+X^9+X^{10}+X^{11}$

$X^4g(X)=X^4+X^8+X^{10}+X^{11}+X^{12}$

$X^5g(X)=X^5+X^9+X^{11}+X^{12}+X^{13}$

$X^6g(X)=X^6+X^{10}+X^{12}+X^{13}+X^{14}$

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

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

（4 分）

Parity-check matrix

$h(X)=1+X^4+X^6+X^7$

$X^7h(X^{-1})=1+X+X^3+X^7$

$X^8h(X^{-1})=X+X^2+X^4+X^8$

$X^9h(X^{-1})=X^2+X^3+X^5+X^9$

$X^{10}h(X^{-1})=X^3+X^4+X^6+X^{10}$

$X^{11}h(X^{-1})=X^4+X^5+X^7+X^{11}$

$X^{12}h(X^{-1})=X^5+X^6+X^8+X^{12}$

$X^{13}h(X^{-1})=X^6+X^7+X^9+X^{13}$

$X^{14}h(X^{-1})=X^7+X^8+X^{10}+X^{14}$

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

$\cdots + X^{12}$

$\cdots(X^{-1}) = X^6 + X^7 + X^9 + X^{13}$

$X^{14}h(X^{-1}) = X^7 + X^8 + X^{10} + X^{14}$

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

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

（4 分）

(c) For the message sequence 1101010, the corresponding message polynomial is

$$m(X) = 1 + X + X^3 + X^5$$

Firstly, $X^{n-k}m(X) = X^8 + X^9 + X^{11} + X^{13}$

Secondly, divide $X^{n-k}m(X)$ by $g(X)$,

$$\frac{X^8 + X^9 + X^{11} + X^{13}}{1 + X^4 + X^6 + X^7 + X^8} = X^5 + X^4 + X^3 + X + 1 + \frac{1 + X + X^3 + X^6 + X^7}{1 + X^4 + X^6 + X^7 + X^8}$$

The remainder is $b(X) = 1 + X + X^3 + X^6 + X^7$

Hence, the desired code polynomial is

$$c(X) = b(X) + X^{n-k}m(X) = 1 + X + X^3 + X^6 + X^7 + X^8 + X^9 + X^{11} + X^{13}$$

The systematic code word is 110100111101010 （4 分）

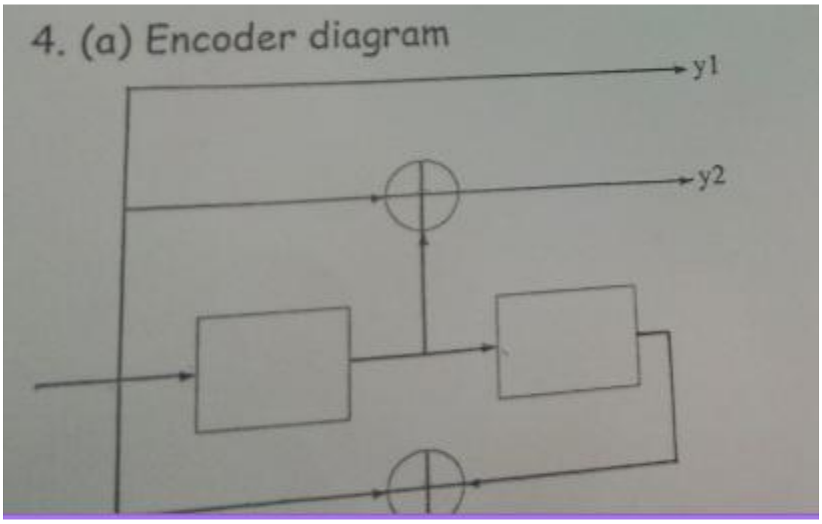
4. Consider the rate $r = 1/3$, constraint length $K = 3$ convolutional encoder. The generator sequences the encoder are as follows:

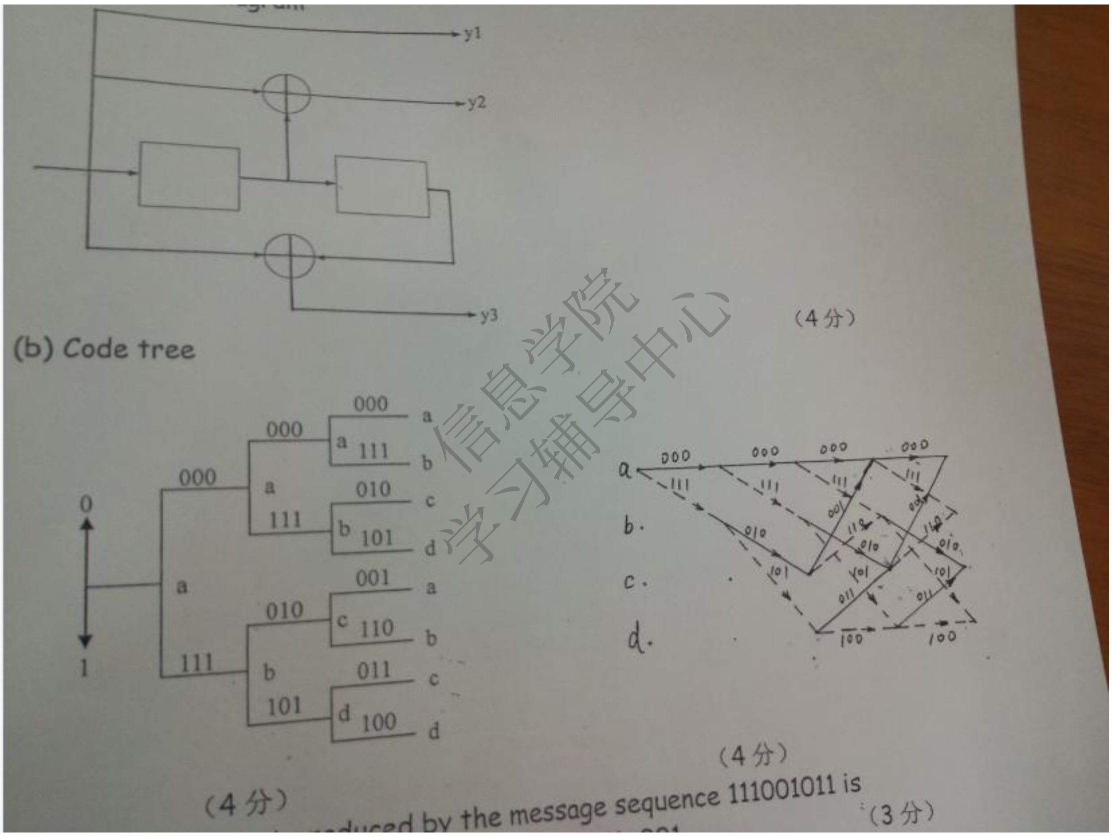
$g^{(1)} = (1,0,0)$, $g^{(2)} = (1,1,0)$, $g^{(3)} = (1,0,1)$

(a) Draw the block diagram of the encoder.

(b) Construct the code tree and trellis.

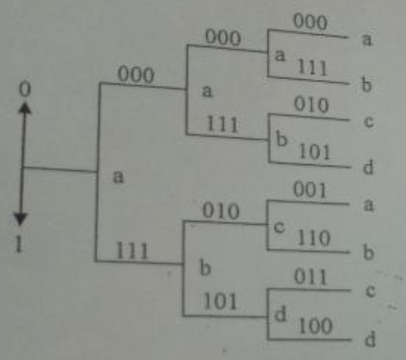
(c) Determine the encoder output produced by the message sequence 111001011....


4. (a) Encoder diagram
y1
y2

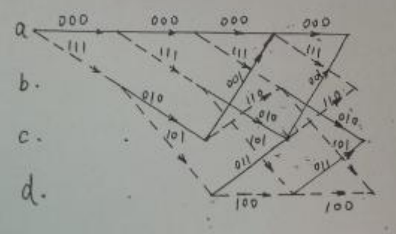

y1
y2
y3
(4分)
(b) Code tree
000
000
000
a
111
b
a
111
010
c
b
101
d
0
1
a
001
a
010
c
110
b
111
b
011
c
101
d
100
d
a
b.
c.
d.
000
000
000
000
111
111
111
111
010
101
001
110
010
101
011
010
101
011
100
100
信息学院
学习辅导中心
(4分)
(4分)
the message sequence 111001011 is
(3分)

(b) Code tree

（4 分）



（4 分）



（4 分）

(c) Encoder output produced by the message sequence 111001011 is

111, 101, 100, 011, 001, 111, 010, 110, 101, 011, 001, ... （3 分）