Check to be sure that there are 5 problems on 5 pages. You are encouraged to answer all 5 problems. Your grade will be based on the four best answers. You have 2 hours. Note that some problems are more time-consuming than others. Use your time wisely. This is an open book and open note examine.

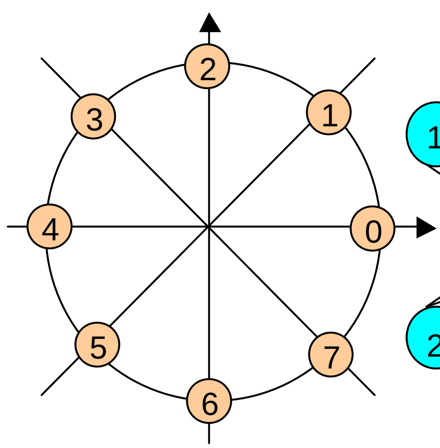
Show all your work. If a problem statement is unclear to you, state your assumptions. If you use additional sheets of paper, identify them and arrange them in sequence.

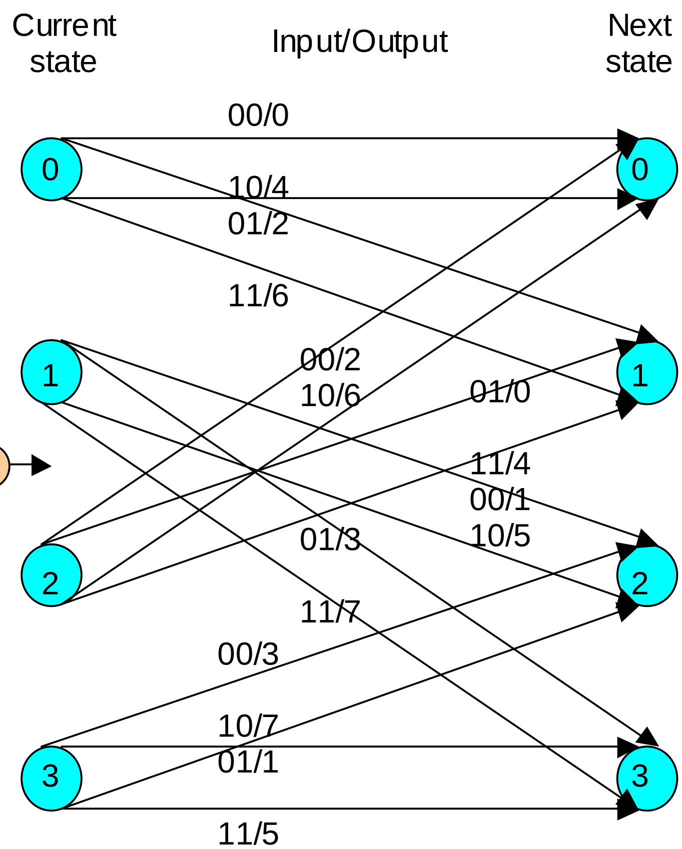
Write down your name here

work phone or
home phone
(optional)

**Problem 1. Trellis Modulation**

Assume that the following 8 signal set constellation diagram and state transition diagram are used for trellis modulation, and within 22.5 degrees deviated from the legal signal is consider to be good signal. Bad signal is an indicatioin of out of sync situation between the sender and the receiver. For example, the receiver at state 0 receives a signal with phase angle of 130 degree will be considered as bad signal. The receiver, at state 0, considers signals with the phase angle between 0 and 22.5 degrees, and between 337.5 and 360 degrees as signal 0; signals with the phase angle between 67.5 and 112.5 degrees are considered as signal 2; signals with the phase angle between 157.5 and 202.5 degrees are considered as signal 4; signals with the phase angle between 247.5 and 292.5degrees are considered as signal 6.




a) What signal sequence will be sent out when sender gets 00011011 at state 0?

b) What bit patterns should be delivered to the receiver's computer if at state 0, signals with the phase angles, 250, 300, 130, and 80 degrees are received? If out of sync happens, when the receiver detects it.

c) What bit patterns should be delivered to the receiver's computer if at state 0, signals with the phase angles, 80, 225, 140, and 170 degrees are received? If out of sync happens, when the receiver detect it.

**Problem 2. CRC**

Assume Generator Polynomial G(x)=x4+x+1 is used to compute the check sum of the frame. Show your work.

a) Given the data 10000000, what is the check sum? What is the codeword to be sent?

Ans: The checksum is 1 1 1 0.

The codeword to be sent is 1 0 0 0 0 0 0 0 1 1 1 0.

b) The receiver receives 111111000100. Is this a good frame?

Ans:

Note that in the final you will not have access to laptop or Internet.

blanca.uccs.edu> crcdecode.pl 111111000100 10011

```
c(x)=111111000100  g(x)=10011
length(c(x))=12  length(g(x))=5
degree(c(x))=11 degree(g(x))=4

c(x)=x^11+x^10+x^9+x^8+x^7+x^6+x^2
g(x)=x^4+x^1+1
d(x)=1 1 1 1 1 1 0 0 0 1 0 0
dx=111111000100
1 1 1 1 1 1 0 0 0 1 0 0
1 0 0 1 1

1 1 1 1 1
1 0 0 1 1
--------
  1 1 0 0 1
  1 0 0 1 1
  --------
    1 0 1 0 0
    1 0 0 1 1
    --------
      0 1 1 1 0
      0 0 0 0 0
      --------
        1 1 1 0 0
        1 0 0 1 1
        --------
          1 1 1 1 1
          1 0 0 1 1
          --------
            1 1 0 0 0
            1 0 0 1 1
```

```
        --------
          1 0 1 1 0
          1 0 0 1 1
          --------
            0 1 0 1
```

r(x)= 0 1 0 1
q(x)=1 1 1 0 1 1 1 1
crc check detects error!

**Problem 3. Hamming’s SECC.**

a) What is the code word for ‘d’=1100100 using Richard Hamming’s Single Error Correcting Code (SECC)?
Ans: Codeword bit pattern = 11111001100

b) When the receiver receives the Hamming's SECC code 10110001001, what are the 7 data bits it should deliver to the upper layer?
Ans: Single-bit error detected at position 5

Old data bit pattern = 1000001

New data bit pattern = 1100001

The 7 data bits to be deliered to the upper layer are 1100001

**Problem 4. EDC vs. ECC.**

Assume a channel with the error rate of 10^-4, with one million bits of data to send.

a) If we use EDC with block size of 1000 data bits and one parity bit,

1) How many blocks is needed to be sent by the sender, including the retransmission blocks, for correctly delivered all one million bits of data?

Ans: Here we assume error pattern are evenly distributed and an error occurs every 10000 bit. When we count how many blocks are garbled, we need to include all blocks, including those previous transmitted blocks, in the calculation.

1 million bits requires 1000 blocks. 1001000 bits will be sent.
With 10^-4, there will be 101 bit errors and hence 101 blocks needs to be retransmitted.
There will be 101*1001=101101 bits sent for these 101 retransmitted blocks.
Include the retransmission blocks, there will be a total of 1102101 bit sent
With 10^-4, there will be ceil(110.2)=111 bit errors and hence 111-101=10 blocks among those 101 blocks are garbled.
There will be 10*1001=1010 bits sent for 10 retransmitted blocks.
Altogether, there are 1001*(1000+101+10)=1112111 bits sent.
With 10^-4, there will be ceil(111.2)=112 bit errors and hence 112-111=1 blocks need to be resent.
There will be 1*1001=1001 bit sent.
Altogther, there are 1001*(1000+101+10+1)=1113112 bits sent.
With 10^-4, there will ceil(111.3)=112 bit errors and hence 112-112=0 blocks need to be resent. The last block is not garbled.

Therefore we need to send 1000+1001+10+1=1112 blocks.

2) Do we need an acknowledge channel for using ARQ?

Ans: Yes.

3) What is the overhead in this case?

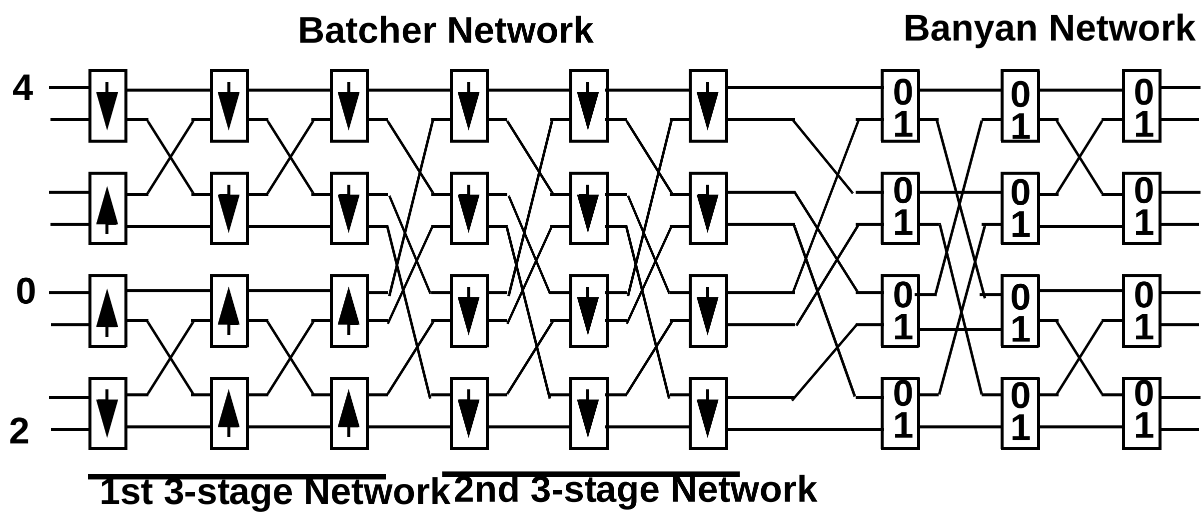
Ans: Overhead is defined to be (the # of control bits)/(the total # of bits sent).
The number of control bits include 1000 parity bits in the first 1000 blocks, plus the 112*1001=112112 bits in the retransmission blocks. Therefore it is 113112 bits.
The total number of bits sent is 1113112 bits.
Therefore the overhead is 113112/1113112=10.16%

b) If we use Hamming's SECC, what will be the block size you would like to choose for optimal performance?

Ans: 10000.
Since the SECC can only handle one bit error. With 10^-4 error rate, the maximum codeword with single bit error is 10000 bits length. For 10000 bit length codeword, m+r=10000. By examining m+r+1<2^r, 10001<2^r. r must be 14. 10001<2^14=16384. Therefore m=10000-16=9984. The block size of 9984 data bits and 14 check bits.

**Problem 5. Switching.**

a) 12 pts. Given the following 8x8 batcher banyan network and the 3 cell with routing tag. Mark




the 2x2 switch configurations (cross-over, or straight through) along their routes to destination ports.