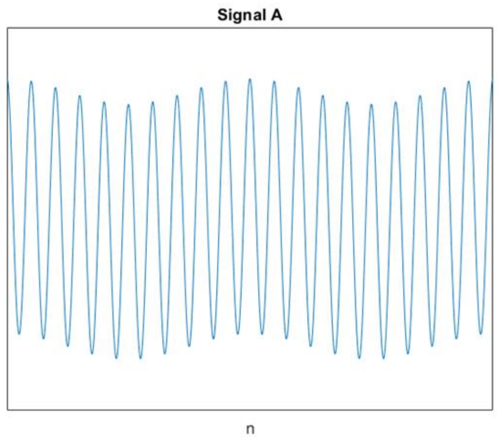
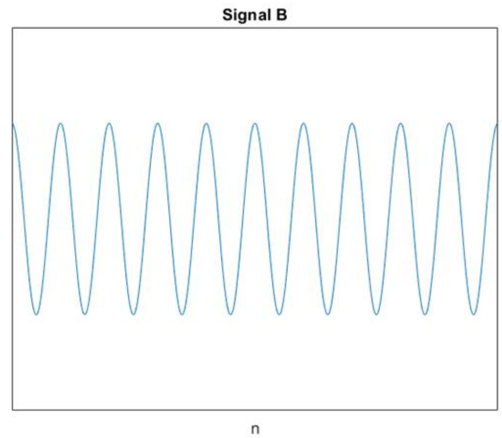
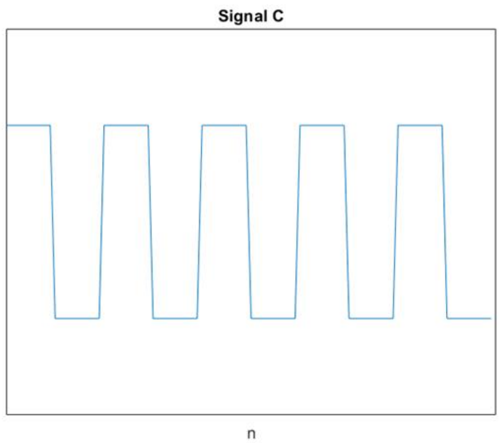
ELEC1200 Final Exam: 2:30 – 3:40 pm (70 minutes)

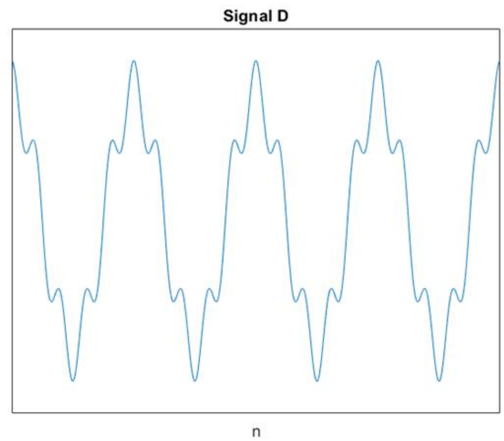
Part I: 10 Questions [4 marks each] – Mark ONLY ONE answer for multiple-choice questions

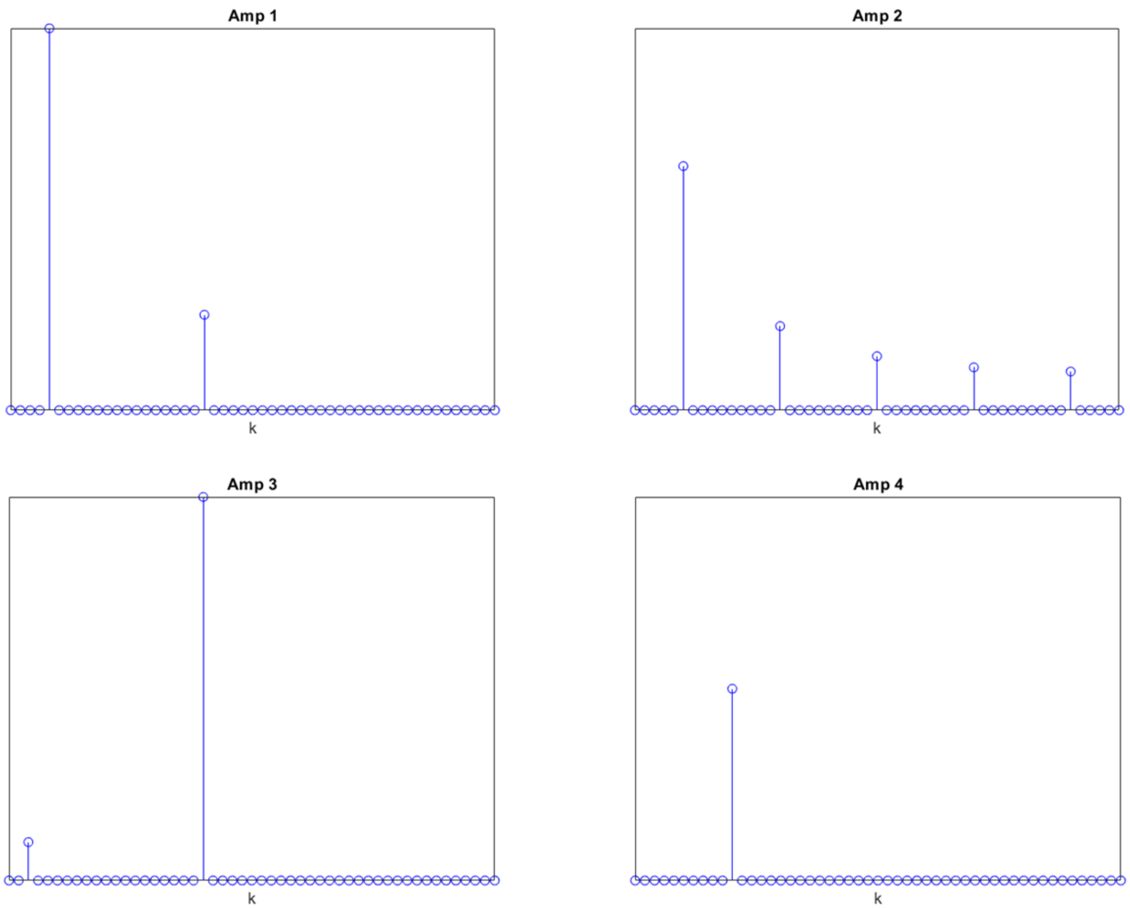
Q1: Each signal (labelled from A to D) shown below consists of 100 samples. For each signal, find the corresponding Amplitude Spectrum (numbered from 1 to 4).











Signal	Amplitude Spectrum
A	
B	
C	
D	

Q2: The transmit filter is used to restrict the spectral content of the transmitted signal so that it is contained within the frequency range allocated to the transmitter. How will the eye diagram of a BPSK signal at the receiver change if the bandwidth of the transmit filter at the transmitter is chosen so that the signal occupies less than its allocated spectrum?

A. The “eyes” will remain the same.
B. The “eyes” will become more open.
C. The “eyes” will become more closed.
D. Not enough information is given to determine that.

Q3: Which of the following statements are true about QPSK?

i. The I and Q channel carrier signals have the same phase.
ii. The bandwidth efficiency of QPSK is twice that of BPSK.
iii. Phase mismatch between the transmitter and the receiver does not cause any problems in the demodulation of a QPSK signal.
iv. BPSK and QPSK have the same constellation diagram, except for a rotation.
v. Each constellation point's position indicates the amplitude and the phase of the transmitted waveform.

A. i and iv
B. ii and iii
C. i and ii
D. ii and v
E. iv and v
F. iii and iv

Q4: Assume that the (9, 4, 4) parity bit block code studied in the course is used to encode bits $D_1D_2D_3D_4$ by adding parity bits $P_1P_2P_3P_4P_5$, which are computed so that each row and column containing data bits in the square below has even parity, and that the entire set of 9 data/parity bits has even parity.

D_1	D_2	P_1	S_1
D_3	D_4	P_2	S_2
P_3	P_4	P_5	
S_3	S_4		S_5

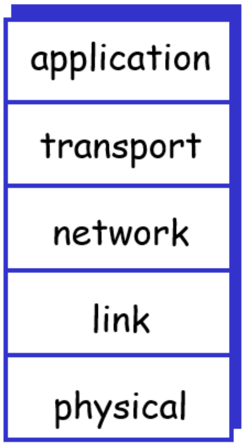
When a codeword is received, the decoder computes 5 syndrome bits $S_1S_2S_3S_4S_5$ checking for violations of each of the parity conditions.

Assume that the received codeword has at most two-bit errors.

What should be the original message if the received codeword is: 011011111

The original message is: ______________________________________

Q5: Match the following descriptions (numbered from 1 to 4) with the corresponding layer studied in the lecture as shown:



1. This layer is responsible for routing packets so that they can get to their correct destinations.

2. Architectures used in this layer include client-server and peer-to-peer.

3. This layer is often responsible for ensuring reliable and in-order packet delivery.

4. Protocols running on this layer control access to a shared communication medium.

Layer	Description
Application	
Transport	
Network	
Link	
Physical	

Q6: Pick the correct statements.

i. The Internet is a network of networks.
ii. A Tier 2 ISP connects exclusively to a single Tier 1 ISP above it and possibly to multiple Tier 3 ISPs below it, but it is not allowed to connect laterally to other Tier 2 ISPs.
iii. Typically, hosts forward data, while routers run applications.
iv. ISPs at lower levels of the hierarchy typically provide connectivity over smaller geographical regions.

A. i and iii
B. ii and iv
C. ii and iii
D. i and iv
E. iii and iv
F. i and ii

Q7: Indicate TRUE or FALSE for the following statements (numbered from 1 to 4).

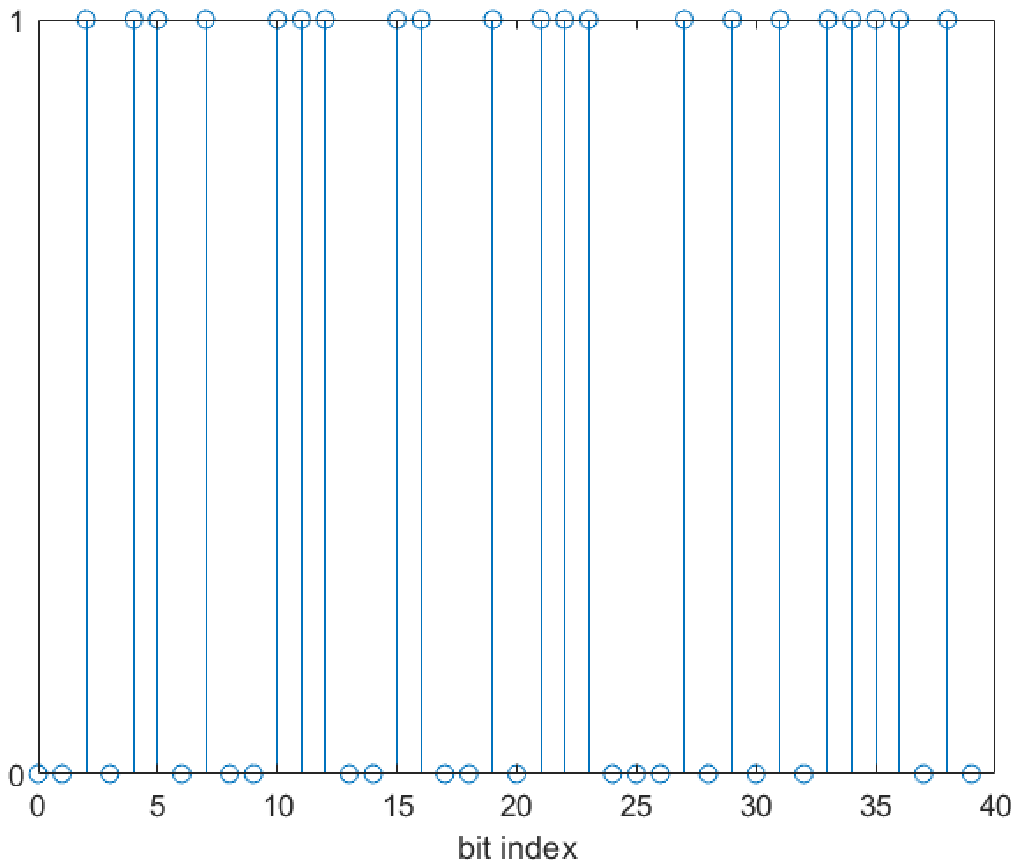
1. In circuit switching, links are shared using a technique called statistical multiplexing.

2. In packet switching, when a host wants to send a large amount of data to another host, it breaks the data into smaller chunks.

3. In circuit switching, link resources must be reserved in advance before two hosts can communicate.

4. In packet switching, since user activity is assumed to be random, there is always a non-zero probability that the link will be overloaded, no matter what the number of users.

Q8: Assume that we encode an 8-bit message using a (5,1,5) repetition encoder. Suppose that we receive the following bit sequence with occasional bit errors. The first bit starts at index 0. If at most two-bit errors occur within each codeword, what was the original 8-bit message?

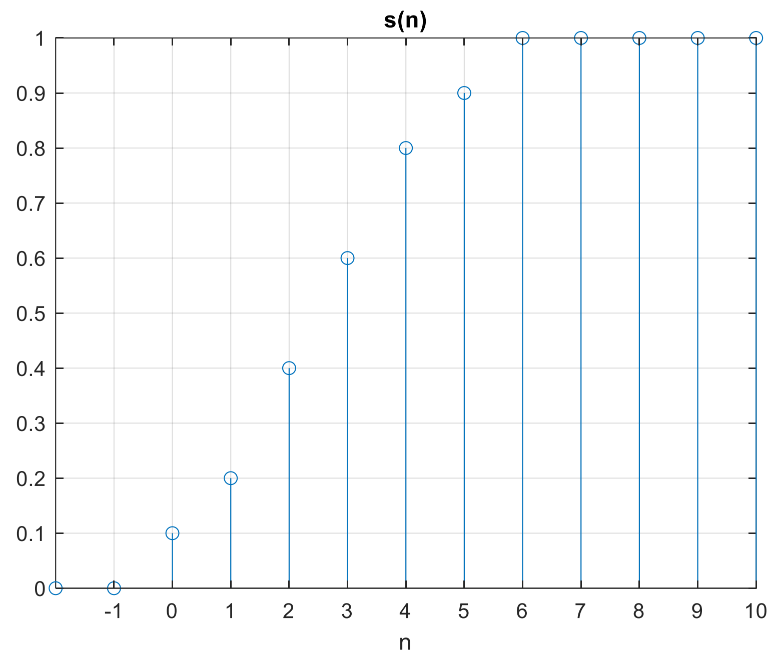


The original 8-bit message: ____

Q9: Suppose that you are transmitting information over a channel and you increase the transmitted power so that the difference between **r_max** and **r_min** increases from 1.2 volt to 2.1 volt. Assume that the noise power remains the same. How much does the signal to noise ratio increase in dB?

Please give the exact numerical value with two decimal places (e.g., x.xx)

Q10: Consider an LTI channel with step response $s(n)$, as $s(n) = 0$ for $n < 0$ and $s(n) = 1$ for $n > 10$, as shown below.



Assume that the input is $x(n)$ with $x(0{:}19) = [00011100110011000000]$. What is the numerical value of the channel output $y(n)$ for n = 15?

Please give the exact numerical value with two decimal places (e.g., x.xx).

--- End of Part I ---

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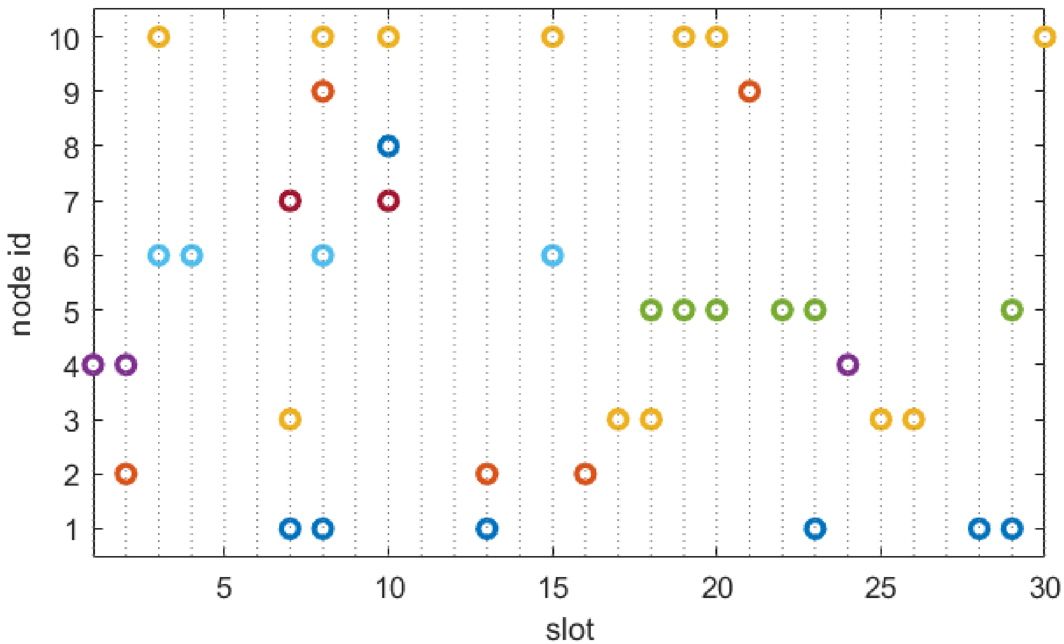
Part II: 3 Short questions [20 marks each]

<u>Question 1</u> **[20 points]**

Part I: Consider a system using the slotted Aloha random multiple access protocol. There are 10 nodes which send packets through a shared channel as shown in the following diagram, where a circle indicates that a node has transmitted a packet in the indicated time slot. Each time slot is 2.8 ms long. [6]



a) What is the efficiency?

b) What is the throughput?

c) What is the probability of a node sending a packet in each time slot?

Part II: Consider a slotted Aloha system where there are N backlogged nodes and the probability that a particular node transmits a frame (packet) in a slot is p. [10]

a) Write down an expression of the probability that no node transmits in a timeslot in terms of N and p.

b) Write down an expression of the probability that a particular node transmits a frame (packet) successfully in terms of N and p.

c) Write down an expression of the probability that collision occurs in a timeslot.

d) If $N = 2$, node 1 is 1.2 times as likely to send a packet as node 2.

   i. What is the probability of transmission of each node if the maximum efficiency is achieved?
   ii. What is the maximum efficiency?

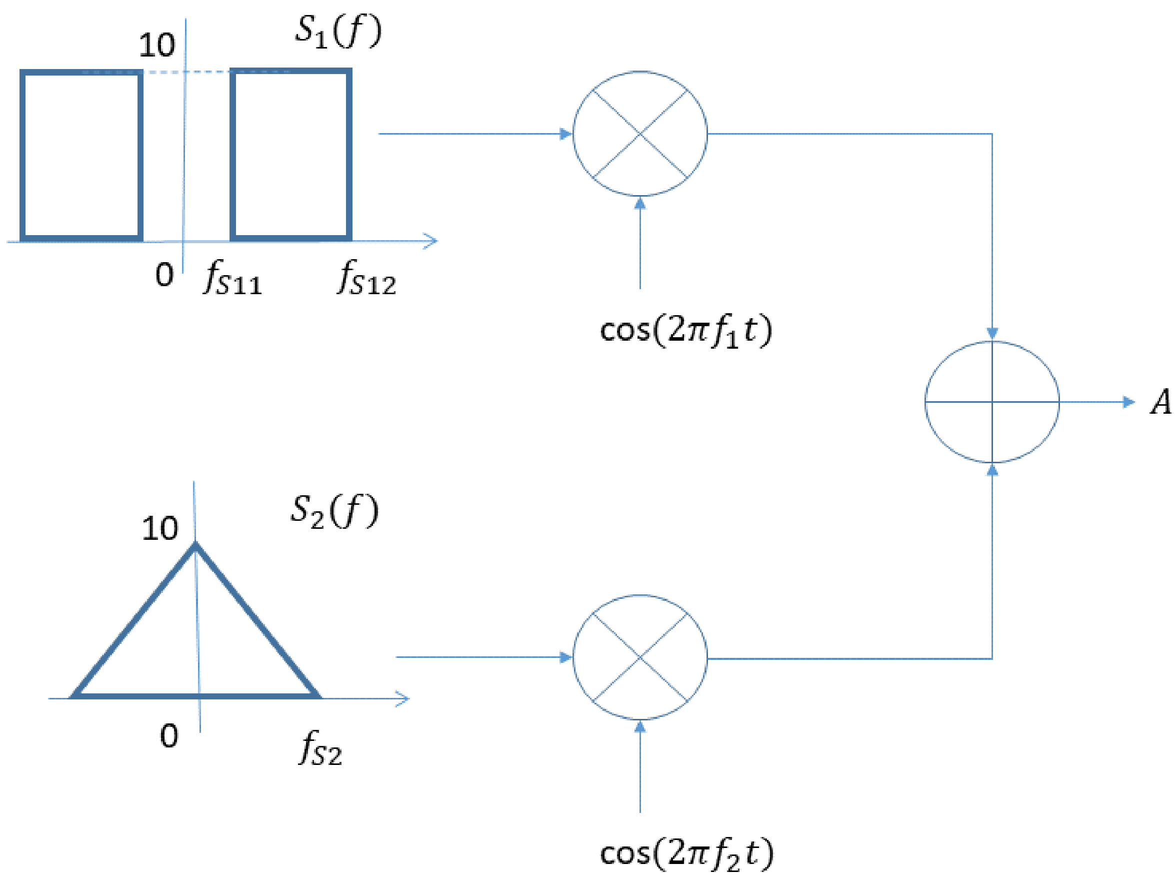
Part III: Consider a connection using the *Stop-and-Wait* protocol. Assume that the round trip time (RTT) is 1.5 seconds long (i.e., a constant) and the retransmission time out (RTO) is set to 2 seconds. [4]

a) Suppose that the packet loss probability for the connection is $p_L = 0.2$. What is the throughput for this connection?

b) What is the best case throughput if RTO can be optimized?

Question 2 **[20]**

Consider the frequency division multiplexing system shown below.



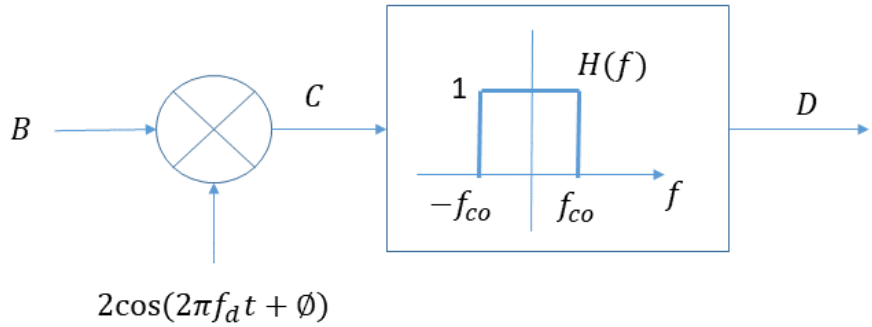
Assume that the two input signals S_1 and S_2, with $f_{S11} = 5\ kHz, f_{S12} = 10\ kHz$ and $f_{S2} = 5\ kHz$, respectively.

If they are modulated using two different carrier frequencies (f_1 = 300 kHz and f_2 = 200 kHz) answer the following questions.

a) Sketch the spectrum at point A. Clearly label all the frequencies and amplitudes. [4]

b) What is the bandwidth (in kHz) of each modulated signal before adding them together? [2]

c) The block diagram shown below is a demodulator. [4]



The signal at Point A is transmitted and received at Point B. Assuming that the angle ϕ is zero, specify the values of f_d *and* f_{co} for each of the following cases.

i. if the shape of the spectrum observed at Point D is the same as $S_1(f)$.

ii. if the shape of the spectrum observed at Point D is the same as $S_2(f)$.

d) Sketch the spectrum at Point C for each of the cases specified in part c) i and ii. Clearly label all the frequencies and amplitudes. [4]

e) What will be observed at Point D if the angle ϕ is 90 degrees? [2]

Now assume that only the frequency band from 400 kHz to 420 kHz is available for transmission.

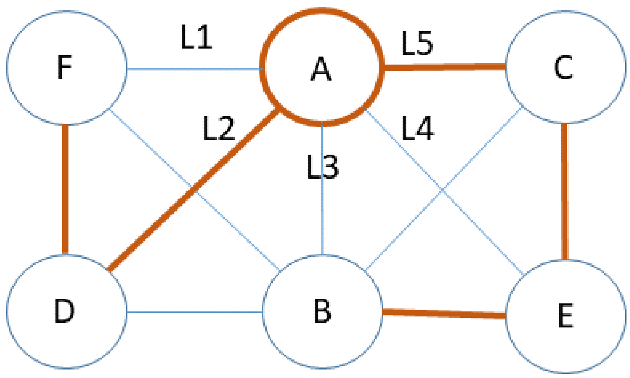
f) Redesign the modulator and redraw the block diagram so that S_1 and S_2 can be transmitted simultaneously with optimal bandwidth. Show all important values. [2]

g) What is the bandwidth efficiency for the modulator in Part a)? [1]

h) What is the bandwidth efficiency for the new design given in Part f)? [1]

Question 3 **[20 points]**

Part I: Consider the following network, where the bold orange lines indicate the least cost path from node A to every other node in the network.



What is the forwarding table in node A in the form of pairs (destination node, link), where "link" is the link leaving node A that should be taken to reach the "destination node" with least cost. [5]

Node A: (A, -) ____

Part II: Assume we have another network and that the source node **S** collects the following router traffic information from node A to node E.

From A		From B		From C		From D		From E	
Node	Cost	Node	Cost	Node	Cost	Node	Cost	Node	Cost
B	3	A	3	A	∞	A	∞	A	∞
C	∞	C	3	B	3	B	2	B	5
D	∞	D	2	D	∞	C	∞	C	7
E	∞	E	5	E	7	E	2	D	2
S	2	S	∞	S	1	S	3	S	∞

a) Use Dijkstra's shortest path algorithm:

Construct the set of the least cost paths (indicating the associated path costs) from **S** to all other nodes. Show all the steps in the following table. Let D(x) be the current path cost estimate from node S to node x and p(x) is the predecessor node to node x on the path from S. [5]

Step	N'	D(A), P(A)	D(B), P(B)	D(C), P(C)	D(D), P(D)	D(E), P(E)
0	**S**					

b) Draw the least-cost path tree from **S** to all other nodes. [5]

c) Find the resulting forwarding Table for **S.** [5]

--- End of Exam ---