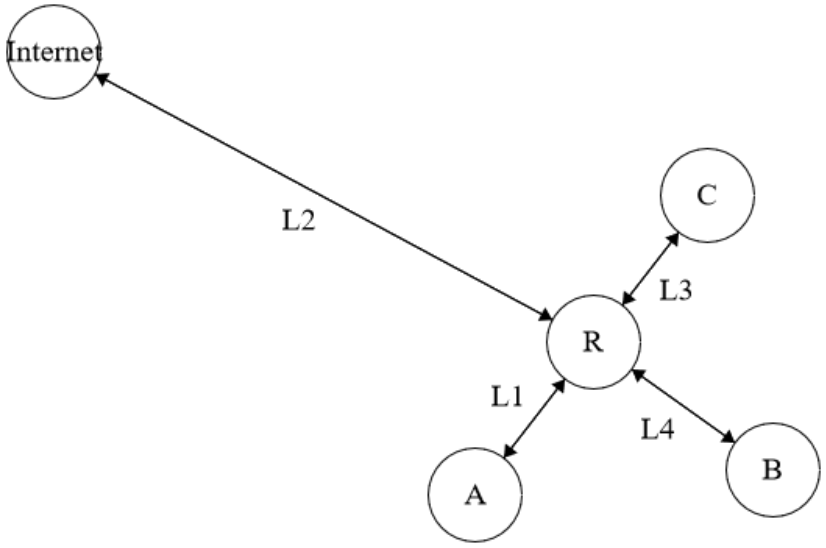
TCP (8 pts):

1. For question 1, assume the flow control window is very large. Starting with a congestion control window of 1 and a slow start phase, how many RTTs does it take to send 40 packets? (Unlike the problem we did in class, we are asking how long it takes to send the packets, not trying to reach a certain size congestion window; this means that each RTT allows exactly one congestion window's worth of packets.)
2. If the slow start threshold is 8 packets, how many congestion windows does it take to send 40 packets?
3. Assume that when 9 or more packets are sent at once, the last packet in that window drops and times out (ex. If the window is of size 20, 19 packets will be sent successfully and the 20th will time out). How many RTTs does it take to successfully send 40 packets with the details from question 1?
4. With the same packet dropping scheme as question 3, how many RTTs does it take to successfully send 50 packets with the details from question 2? (For simplicity, assume the slow start threshold stays the same after packet drop.)

HTTP Multiplexing (9 pts)

1. Assume we have 3 files - file A, file B, and file C - of lengths 1.5 MB, 0.1 MB, and 2 MB respectively. Assume a link with speed 1 Mbps (Megabits per second). Assume negligible propagation delay. How long does it take to receive all the files with a multiplexed HTTP 2.0 connection?
2. There is a client on the other end that spends 1 second reading each file, no matter the size. The client starts reading each file as soon as it is received, and it can read files while receiving other files. Assume the client requests the files in order of A, B, C and this particular client must get the files in the order they are requested. How long does it take for the client to finish reading each of the three files (what is the finish time for each file)?
3. Now consider true mutliplexing where the client can receive the files in whatever order is most efficient. (Hint: It will therefore request the files in order A, B, C, but receive them in order B, A, C.) How long does it take to finish reading each of the three files now (what is the finish time for each file)?

IP Layer (13 pts)



1. An ISP has the above network structure. The internet node represents the rest of the internet. A, B, and C represent 3 subnets. The ISP has a 128.6.7.0/24 block of IP addresses. A needs 128 IP addresses, B needs 64 IP addresses and C needs 32 IP addresses. How many IP addresses will the ISP have left over if they give each customer the IP addresses they need (2 pts)?
2. Divide up the IP addresses between the customers. Use CIDR notation to fill in the following routing table at R (5 pts) (Route unused IP addresses back to the rest of the internet.)

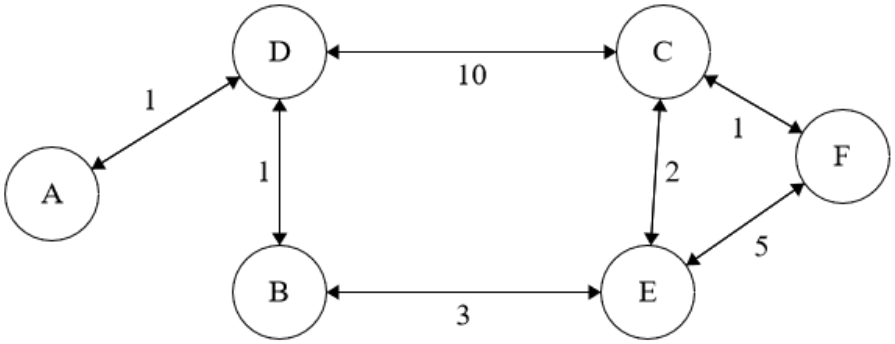
CIDR mask	**Link**
	L1
	L2
	L3
	L4

3. Add a column for subnet mask into the table (3 pts).

Subnet Mask	**Link**
	L1
	L2
	L3
	L4

4. Use the table to route the following 2 IP addresses 128.6.7.1, 128.6.8.2 (3 pts.)

Routing (10 pts)



1. Look at the above network. Use Dijkstra's algorithm to find the shortest paths to all nodes from A and copy the steps into the table below. (You will need to copy and paste the table into your answer) (I have filled in the first row for you, there may be extra rows) (5 pts)

Used Nodes	A	B	C	D	E	F
{A}	**A,0**	-,inf	-,inf	D,1	-,inf	-,inf

2. Show the distance vector at A after 2 rounds of the distance vector algorithm (round 1 everyone only has the distance to immediate neighbors, round 2 they get their neighbors distance vectors(information from round 1)) (3 pts)

Node	Link	Cost
A	-	0
B		
C		
D		
E		
F		

3. How many rounds will it take for A to be able to reach F (2 pts)?

Link Layer (15 pts):

1. Consider 4 receivers near each other using CDMA (code division multiple access) to communicate. They have the following codes:

Reciever	**Code**
R1	`-1,-1, 1, 1`
R2	`-1,-1,-1,-1`
R3	`-1, 1, 1,-1`
R4	`-1, 1,-1, 1`

They each want to send the following signals:

Reciever	**Signal**
R1	`10`
R2	`11`
R3	`10`
R4	`01`

1. What is the signal that is sent over the airwaves (6 pts)?
2. Show how R3 can recover its message from the signal (3 pts).
3. Instead of CDMA, assume that the receivers use TDMA, where R1 gets slot 1, R2 gets slot 2, and so on. Assume each node only gets to transfer one bit per slot. Now what is the signal? (4 pts)
4. How can R3 read its signal with TDMA? (2 pts)

Security (16 pts)

1. Bob wants to talk to Alice about a surprise birthday party they are throwing for their friend Carol. Carol is a pretty good hacker and is curious what her friends want to talk about behind her back. Bob has a public private key pair (22, 78) and Alice has a public private key pair (18, 58) Carol has a public private key pair (25, 37). The protocol goes as follows:
    a. Bob sends a message “Hello I’m Bob, my public key is 22 what is yours?”
    b. He gets a response, encrypted with his public key, that says “Hello I am Alice my public key is __”
    c. He then takes that public key from the response and uses it to encrypt a symmetric key (e.g. 100)
    d. He gets an encrypted response which says “OK, that works my symmetric key is __” which he can decrypt using his private key.

    e. He uses a combination of the two symmetric keys to encrypt the rest of the conversation.
    Unfortunately, Carol is able to pretend to be Alice and find out about the birthday party. How does she do it? (Please show what she sends at each step of the protocol.)
2. The next year they use a new protocol to prevent that exact attack. What is the new protocol?
3. In the second year, after the birthday party, Bob accidentally lets his guard down and Carol sees his private key. Unfortunately she had recorded all the previous data and can use this mistake to find out that they were also planning a surprise trip later in the year. How does she do this?
4. What new protocol would prevent Carol from decoding previous conversations?

Multimedia (9 pts)

1. You have a multimedia stream with video and audio offerings. The video is 720 × 576 with 3 bytes per pixel and 24 frames per second. You have a bandwidth of 50 Megabytes per second. How long does it take to fill a 1 Gigabyte buffer?
2. Assume that after the buffer is 30% full you start the stream. Now how long does it take to fill the buffer (including the time it takes to become 30% full)?
3. Some time after the buffer is full, you lose internet connection. Now how long can you continue streaming before running out of data to show the user?