- Before you begin, **write your USC ID**.
- **READ THESE INSTRUCTIONS CAREFULLY.**
- The exam is closed book and closed notes.
- No Calculators or any electronics
- Answer the questions *only* in the spaces provided on the question sheets. If you run out of room for an answer, your answer is probably incorrect.
- Your answers do not need to be complete, grammatically correct sentences.

USC ID: _____

Question:	1	2	3	4	5	6	Total
Points:	31	10	25	12	14	8	100
Score:							

1. Please answer the following questions in two-three sentences.
   (a) (2 points) The number of addresses represented by the IP Prefix 10.3.4.0/27 is: ?

   .....

   Solution: 32 -27 = 5 bits ... 2^5 = 32 addresses

   (b) (2 points) A typical Class **A** network has:

   .....

   Solution: 2^7 networks and 2^{24} hosts in each network

   (c) (4 points) A broadcast address is used to reach all the hosts on the network. What is the IP address for the broadcasting on the local network? Give with an example how it can be used in a protocol.

   .....

   .....

   Solution: 255.255.255.255
   It is used in ARP to find the MAC address of the specified IP address. or It is used in DHCP to request an IP address

   (d) (2 points) The narrow waist in the Internet protocol stack occurs at which layer? Explain why it is called the narrow waist.

   .....

   Solution: The network layer as it supports many transport protocols above and link types below.

   (e) (2 points) What does the ARP protocol enables resolving?

   .....

   Solution: IP addresses to MAC addresses

   (f) (3 points) Expand the acronym DHCP. Does a network always need a DHCP server and/or a DHCP relay.

   .....

   .....

   Solution: Dynamic host configuration protocol. (1 pt)
   No, because it may assign static IP addresses to all the hosts in the network (2 pts)

(g) (2 points) You are connected to a channel with a transmission rate of 1Gbps. The packet size is 1000 bytes and includes the headers. How much time required to transfer a packet?

. . . . . .

. . . . . .

Solution: $8000bits/10^9$ = 8 microsecs

(h) (2 points) What is the binary equivalent of IP address 123.1.67.2?

. . . . . .

(i) (2 points) What is the size of and IPv4 address in bits? What is the size of an IPv6 address in bits?

. . . . . .

Solution: 32 bits and 128 bits

(j) (2 points) Internet routing works at inter- and intra-levels. Explain what this means.

. . . . . .

. . . . . .

Solution: inter- between networks/ ASes intra - within networks or ASes

(k) (2 points) Name two types of network links that can be used when a mobile device connects to http://www.cnn.com

. . . . . .

Solution: wireless /wifi/ cellular
wired,/optical/copper

(l) (2 points) A constant bit rate applications (for example, uncompressed voice and video) alway send data at a fixed rate. Explain why a virtual circuit-based network is more suitable for such applications.

. . . . . .

Solution: the bandwidth and data rate does not fluctuate and hence can be efficiently multiplexed

(m) (2 points) How can a sender check if the destination host is on the same network?

. . . . . .

Solution: by comparing the sender address and the destination address using the network mask

(n) (2 points) What does the acronym AS stand for and explain what it means.

. . . . . .

. . . . . .

Solution: Autonomous systems. it is a region of the network under a single administrative entity

2. The IP Header

(a) (3 points) The IP header has a 4 bit IHL field. Expand the acronym and explain why it is needed? What is the minimum size of this field?

. . . . . .

. . . . . .

Solution: It is the Internet Header Length (IHL),
Since an IPv4 header may contain a variable number of options, this field specifies the size of the header.
Minimum size of IP header is 20 bytes

(b) (3 points) The IP header has a ToS field. Expand the acronym and explain how it is used?

. . . . . .

. . . . . .

Solution:
Type of service (ToS) field. It is used to provide special/additional service, minimize delay, maximize throughput reduce drops..

(c) (4 points) What is the purpose of the Identification field? Explain how it is used?

. . . . . .

. . . . . .

Solution:
Used to identify fragments of the same packet. (2 pts)
A packet is fragmented when the size of the packet is larger than the MTU of the underlying network. (2 pts)

3. Routing

(a) In Link State routing, each node floods the information about its link state on the network. This information is received by all the nodes and then used to compute the shortest path.

i. (2 points) Name two mechanisms that are used to ensure that it scales reasonably in medium scale networks.

. . . . . .

. . . . . .

Solution: suppress duplicates sequence numbers, acknowledgments, retransmissions of lost updates

ii. (2 points) Explain two scenarios that will trigger link state flooding by a node.

. . . . . .

. . . . . .

Solution: topology change, link cost change,

(b) Distance vector routing uses the Bellman-Ford Algorithm to compute routes.

i. (2 points) Explain in words what is the initialization at each node?

. . . . . .

. . . . . .

Solution: (2pts) Link costs to each neighbor, infinity if node is not a neighbor (Not full topology)

ii. (2 points) Explain in words what is the output of the algorithm at each node?

. . . . . .

. . . . . .

Solution: (2pts) Next hop to each destination and the corresponding cost (Not the complete path to the destination)

(c) Routing relies on weights assigned to edges to compute the shortest path.

i. (2 points) List two metrics that can be used to assign weights.

. . . . . .

. . . . . .

Solution: (any two for 2pts) * Number of router hops Propagation delay Congestion, Load balance metrics Bandwidth (available, capacity, maximal, bbw) Price, Reliability Loss rate

ii. (2 points) What does the term *non-additive* metric mean? List one non-additive metric.

. . . . . .

. . . . . .

Solution: a metric that cannot be computed by adding up the weight on each link Example of non-additive metric: maximum capacity minimum loss

(d) In class we discussed Distance vector routing is a decent starting point for BGP

i. (1 point) Expand the acronym BGP.

. . . . . .

Solution: BGP : border gateway protocol

ii. (4 points) What is the difference between eBGP and iBGP and IGP.

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Solution: eBGP: BGP sessions between border routers in different ASes Learn routes to external destinations
iBGP: BGP sessions between border routers and other routers within the same AS distribute externally learned routes internally
IGP: Interior Gateway Protocol = Intradomain routing protocol provide internal reachability

iii. (4 points) List the four key differences between BGP and DV

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Solution: 1) BGP uses path vector routing 2) BGP does not use shortest path, uses policy to define path 3) selective route advertisement 4) BGP can aggregate routes

iv. (4 points) What are the three basic types of relationships between ASes.

. . . . . .

. . . . . .

. . . . . .

Solution: AS A can be AS Bs customer
AS A can be AS Bs provider
AS A can be AS Bs peer

4. Sliding Window Protocol

   You are tasked with designing the sliding window protocol over a link between a base station on earth and a geo-stationary satellite. The bandwidth of this link is 160kbps in both directions, the one-way latency is 125ms, and the packet size is 1000B.

   A few additional assumptions:

   - No re-ordering and processing delays
   - Sender application always has data to send
   - Receiver application always picks up data right away
   - Receiver application buffers out-of-order packets (that result from packet drops)

   (a) (6 points) What is the minimum sender window size (in packets) that will allow you to take full advantage of the bandwidth? Assume no packet loss, and negligible ACK size. Justify your answer.

   Solution: Solution 1 We want the window size to be equal to the bandwidth-delay product of the link to fill it up completely. This gives
   B * RTT = 160kbps * (2 * 125ms) = 40kb
   Express this in terms of packets by dividing by the packet size: 40kb / 1kB = 40kb / 8kb = 5 packets
   Solution 2: At time t = 0ms, the sender begins transmitting the first packet, which finishes at t = 50ms. Then, the ACK for this packet arrives after 1 RTT at t = 300ms. Within these 300ms, the number of packets that can be sent is: 300ms / (transmission delay of one packet) = 300ms / 50ms = 6 packets

   (b) (6 points) After deciding the sender window size WS above, you and your colleagues are debating how large to set the receiver window size WR. There are three options:

   Option 1 WR = 1

   Option 2 WR = WS

   Option 3 WR $>>$ WS

Which option is optimal? Explain why by comparing with the other two options?

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Solution:

Option 2 is the optimal or most favorable. (2 pts)

option 1 is not good because even in the absence of re-ordering, setting WR to less than WS means that if a packet is lost, anything beyond the first packet is dropped by the receiver, and must be retransmitted by the sender. This is even worse than stop-and-wait in terms of bandwidth usage by placing more stress on the network, contributing to congestion. (2 pts)

Option 3 is incorrect in the assertion that the larger WR, the higher the throughput. The throughput is the amount of data transmitted within a period of time. Simply making WR larger does not mean that the sender can send at a faster rate.

(2pts)

option 2 is correct in that setting WR ¿ WS offers no advantages over WR = WS, simply because the receiver cannot receive more quickly than the sender sends.

5. Wireless Networking

(a) (4 points) Transmission over a wireless links is different from transmission over wired networks such as ethernet. Give three challenges of communicating over a wireless network

.....

.....

.....

.....

.....

Solution: 1) Broadcast and multi-access medium and hence Anybody in proximity can hear and interfere 2) Cannot receive while transmitting since Own transmission (or nearby xmission) is deafening the receiver 3) Signals sent by sender dont always end up at receiver intact, BER is high due .

(b) (2 points) A sensor network field is represented by a 10 x 10 grid. There are three sensors present in the grid located at the (x,y) positions specified below. A is at location (2,5), B is at location (5,5) and C is at location (7,5) Each sensor has a circular wireless radio range of 5

Represent the sensors in the grid with their transmission ranges

Solution: a b and c in a row with a circle of 5 with the node in the center.

(c) In the sensor field above, at time t=0, sensor A starts to transmit data to sensor B.

At time t=5, sensor C starts to transmit data to sensor B.

At time t=8, sensor A stops transmitting data to sensor B.

At time t=10, sensor C stops transmitting data to sensor B.

Assume Sensor B passively receives the data without generating any response.

Explain what will happen to the data between the various periods below.

i. (2 points) Time period between t=0 and time t=5

.....

Solution: A sends data successful to B

ii. (2 points) Time period between t=5 and time t=8

.....

Solution: A and C collide, data is corrupted

iii. (2 points) Time period between time t=8 and time=10

.....

Solution: C sends data successful to B

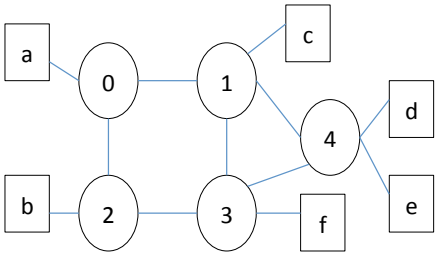
iv. (2 points) Explain why you observe the above behavior.

.....

.....

Solution: A and C can both send to B but cant hear each other A is a hidden terminal for C and vice versa Carrier Sense will be ineffective

6. Consider the following topology of switched ethernet switches. 0-4 are switches and a-f are end hosts.



(a) (4 points) List the root and edges of the spanning tree obtained by running the Spanning Tree protocol.

.....

.....

Solution: 0-1, 0-2, 1-3, 1-4

(b) (4 points) Suppose Switch 0 fails. What is the new spanning tree?

. . . . . .

. . . . . .

Solution: 1-3, 3-2, 1-4