Name:

Student ID:

E-mail:

- Duration: 120 minutes.
- Closed book, closed notes.
- 13 multi-item questions.
- Total of points.
- Read all questions carefully before you start.
- Explain all your answers.
- Budget your time.

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**Question 1: 10 points** Match the following functions to one or more layers of the TCP/IP protocol stack:

(a) End-to-end error detection and correction Layer(s):

(b) Flow control Layer(s):

(c) Transmission of signals Layer(s):

(d) Process-to-process message delivery Layer(s):

(e) Framing Layer(s):

(f) Routing Layer(s):

(g) Forwarding Layer(s):
(h) Congestion control Layer(s):

(i) Hop-by-hop error detection and correction Layer(s):

(j) Name to IP address resolution Layer(s):

**Question 2: 10 points** Datagram- versus virtual circuit (VC) networks:

(a) In a VC network, a user in host A wants to send data to a user in host B, both attached to the network. What needs to happen before the first user data transmission can take place? Explain. (2 points)

(b) How long does it take before the first user data can be sent? Explain. (2 points)
(c) Use the same scenario and compare to what happens in a datagram network. Explain. (2 points)

(d) Based on this example, can you draw a parallel between the network layer services provided by datagram- and VC networks and the transport-layer services provided by TCP and UDP? Explain. (4 points)

**Question 3: 6 points**  Your friend is hired by a company to interconnect the company’s several branches together. He comes to you for advice and tells you that the company has been using IPv6.

(a) You tell him: “Just use tunneling!” But you need to tell him why. So, how do you justify tunneling in this case? (2 points)
(b) Show how the tunnel would work. Use a diagram to illustrate what happens at the tunnel end points when IPv6 packets need to be transmitted. (4 points)

Question 4: 8 points  Addressing:
(a) Are IP addresses flat or hierarchical? Explain.

(b) How about MAC addresses? Explain.

(c) IP addresses are said to be non-portable. Do you agree? Explain.

(d) Are MAC addresses non-portable? Explain.
Question 5: 8 points  In the TCP/IP network architecture, there is a certain degree of redundancy in functionality, i.e., the same function may be performed by more than one layer.

(a) Error control is an example function that is performed in multiple layers. Which layers perform error control in the TCP/IP stack? (3 points)

(b) Why do you think it is a good idea to have some degree of duplication? Use error control and a concrete scenario to illustrate your argument. (5 points)

Question 6: 12 points  The Aloha protocol was the precursor of random-access MAC protocols. Later MAC protocols tried to improve on Aloha’s performance.

(a) Describe the operation of Aloha.
(b) What feature was introduced by CSMA? How does it improve on Aloha’s efficiency? Does it guarantee 100% collision-freedom?

(c) What about CSMA-CD, i.e., how does it improve over CSMA’s efficiency?

(d) What is CSMA-CA? How does it work?
Question 7: 8 points  A NAT device typically sits at the “entrance/exit” of an organization’s network. Describe what the NAT device does, including information it needs to maintain, when:

(a) A host within the organization’s network sends traffic to another host within the network.

(b) A host within the organization’s network sends traffic to a host on the Internet.

(c) How do you think this addresses the problem of IP address depletion?

(d) Explain how NAT handles incoming traffic in response to traffic originating within the organization’s network.
Question 8: 10 points  Consider the network topology below.

(a) How many subnets are shown?

(b) Based on the IP addresses shown, what is the subnet mask?

(c) Based on your answer for item (b), how many subnets can be connected to the network?

(d) How many hosts can each subnet have?

(e) If a new host wants to connect to the network as shown in the figure, what IP address can it get from the DHCP server?
Question 9: 9 points  Consider the topology for Question 8. Suppose that the new host wants to send data to host E for the first time.

(a) How does the new host find E’s MAC address? Assume it knows E’s IP address.

(b) Shortly afterwards, the new host needs to send data to E again. How does it find E’s MAC address?

(c) Now, it takes a while for the new host to send traffic to E. How does it find E’s MAC address?
Question 10: 12 points  Suppose the following topology:

B ──────── C ──────── D
   |        |        |
   |        |        |
   A ──────── F ──────── E

where link costs are: AB = 1, AF = 6, BC = 1, CD = 1, CF = 5, FE = 1, and DE = 1.

(a) Show how the Dijkstra algorithm running at router A would compute the shortest paths to the rest of the nodes in the network. Show each step of the algorithm. (6 points)
(b) Show the shortest-path tree rooted at A. (3 points)

(c) Show the forwarding table at node A. (3 points)
**Question 11: 12 points**  In an IPv4 network, one of the routers have 4 links numbered 0 through 3. The router’s forwarding table is as follows:

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<th>Destination address range</th>
<th>Outgoing interface</th>
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<tr>
<td>11100000 00000000 00000000 00000000 through 11100000 00111111 11111111 11111111</td>
<td>0</td>
</tr>
<tr>
<td>11100000 01000000 00000000 00000000 through 11100000 01000000 11111111 11111111</td>
<td>1</td>
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<tr>
<td>11100000 01000001 00000000 00000000 through 11100001 01111111 11111111 11111111</td>
<td>2</td>
</tr>
<tr>
<td>default</td>
<td>3</td>
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How does the router forward datagrams that arrive with the following destination IP addresses? Show your work.

(a) 192.145.81.85

(b) 225.64.195.60

(c) 193.128.17.119
**Question 12: 5 points**  In TCP, the sequence number space is a function of the window size. In the case of a window size of 8 segments, what is the sequence number range and how many bits do we need to represent the sequence numbers?

**Question 13: 10 points**  Suppose a Web client at UCLA is requesting a page from www.bbc.co.uk. Show the steps required to resolve www.bbc.co.uk using a recursive DNS look-up. Assume that the requested information is not cached anywhere. You may draw a diagram to illustrate the steps.