1. (40 points) Suppose a router has the following routing table:

Destination	Next-Hop Router
205.36.0.0/16	205.36.0.1
205.36.128.0/19	205.36.128.1
205.36.136.0/21	205.36.136.1
0.0.0.0/0	205.36.1.1

Describe how the router looks up this routing table and makes the routing decision on where to forward a packet with the following **destination IP address**:

a. 205.36.140.1
   11001101 00100100 10001100 00000001
   Answer:
   205.36.140.1 & '/16' = 205.36.0.0   Match
   205.36.140.1 & '/19' = 205.36.128.0   Match
   205.36.140.1 & '/21' = 205.36.136.0   Match
   205.36.140.1 & '/0' = 0.0.0.0   Match
   Matches all four entries; by applying the "Longest Prefix Match" rule, the packet is forwarded according to the third entry to 205.36.136.1

b. 205.36.150.2
   11001101 01001101 10010110 00000010
   Answer:
   205.36.150.2 & '/16' = 205.36.0.0   Match
   205.36.150.2 & '/19' = 205.36.128.0   Match
   205.36.150.2 & '/21' = 205.36.144.0   No Match
   205.36.150.2 & '/0' = 0.0.0.0   Match
   Matches three entries; by applying the "Longest Prefix Match" rule, the packet is forwarded according to the second entry to 205.36.128.1

c. 205.77.160.3
   11001101 00100100 10100000 00000011
   Answer:
   205.77.160.3 & '/16' = 205.77.0.0   No Match
   205.77.160.3 & '/19' = 205.77.160.0   No Match
   205.77.160.3 & '/21' = 205.77.160.0   No Match
   205.77.160.3 & '/0' = 0.0.0.0   Match
   Matches the default entry only; so, the packet is forwarded to 205.36.1.1

d. 205.36.170.4
   11001101 00100100 10101010 00000100
   Answer:
   205.36.170.4 & '/16' = 205.36.0.0   Match
   205.36.170.4 & '/19' = 205.36.160.0   No Match
   205.36.170.4 & '/21' = 205.36.168.0   No Match
   205.36.170.4 & '/0' = 0.0.0.0   Match
   Matches two entries; by applying the "Longest Prefix Match" rule, the packet is forwarded according to the first entry to 205.36.0.1

2. (30 points) IP Addresses

   a. A host in an organization has an IP address of 150.160.170.180 with a network mask of "/19. What is the **network address of the subnet** that this IP address belongs to? (5 points) What is the **directed broadcast address of the subnet**? (5 points) What is the **range** of the IP addresses that an **individual** host can have on this subnet? (10 points) Justify your answers.

      Answer:
      The network address of the subnet that this IP address belongs to is:
      150.160.170.180 & '/19' = 150.160.160.0 (i.e., **10010110 10100000 101**00000 00000000)
      The directed broadcast address of the subnet is:
      150.160.191.255 (i.e., **10010110 10100000 101**11111 11111111)
      Hence, the range of the IP addresses that an individual host can have on this subnet is:
      from 150.160.160.1 to 150.160.191.254

   b. A host in another organization has an IP address of 200.150.100.50 with a network mask of "/19". What is the **network address of the supernet** that this IP address belongs to? (5 points) **How many Class-C address blocks** does this supernet include? (5 points) Justify your answers.

      Answer:
      Therefore, the network address of this supernet is:
      200.150.100.50 & '/19' = 200.150.96.0 (**11001000 10010110 011**00000 00000000)
      There is a total of 2^{24-19} = 32 Class-C address blocks in this supernet.

3. (30 points) An organization is assigned a Class-C network 200.137.66.0 and wants to form subnets for its three departments: D1 (90 hosts), D2 (75 hosts), and D3 (75 hosts). Describe a **possible arrangement of subnets** (i.e., describe the network address and the subnet mask of each subnet) to make this possible. Justify your answer. Note that a department may be assigned multiple subnets; subnets may have different sizes and they shall not overlap.

   Answer: One possible arrangement of the subnets is

Department	# Hosts	Network	Subnet Mask	# IP addresses available to individual hosts on this subnet
D1	90	200.137.66.0/26	255.255.255.192	62
		200.137.66.64/27	255.255.255.224	30
D2	75	200.137.66.128/26	255.255.255.192	62
		200.137.66.96/28	255.255.255.240	14
D3	75	200.137.66.192/26	255.255.255.192	62
		200.137.66.112/28	255.255.255.240	14