Address Class (Exercise)	
Address	**Class**
177.100.18.4	B
119.18.45.0	A
192.249.234.191	C
10.10.251.12	A
223.32.232.190	C
129.132.24.2	B
18.250.1.1	A
150.10.15.0	B
197.14.2.0	C
174.17.9.1	B
148.17.9.1	B
193.42.1.1	C
126.8.156.0	A
220.220.23.1	C
117.18.54.0	A
249.214.87.90	E
191.155.77.65	C
95.0.21.90	A
33.2.5.97	A

Network and Host Identification

Circle the **Network** portion of these addresses:	Circle the **Host** portion of these addresses:
177.100.18.4	10.51.132.51
119.18.45.0	171.2.191.13
193.249.234.191	198.125.78.145
10.10.251.12	223.252.211.241
223.32.232.190	17.54.22.54
129.132.24.2	126.102.231.45
9.250.1.1	191.41.35.112
150.10.15.0	155.25.168.227
192.14.2.0	194.15.155.2
174.17.9.1	123.102.45.254
148.17.9.1	148.17.9.155
194.42.1.1	100.25.1.1
126.8.156.0	195.0.21.98
220.220.23.1	25.250.135.46
119.18.54.0	171.102.77.55
249.214.87.90	55.250.5.6
199.155.77.65	218.155.234.18
95.0.21.90	12.25.5.6
33.2.5.97	148.18.91.5

Binary Place Value (Examples)								
Decimal	**128**	**64**	**32**	**16**	**8**	**4**	**2**	**1**
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	1	1
10	0	0	0	0	1	0	1	0
11	0	0	0	0	1	0	1	1
12	0	0	0	0	1	1	0	0
13	0	0	0	0	1	1	0	1
14	0	0	0	0	1	1	1	0
15	0	0	0	0	1	1	1	1
31	0	0	0	1	1	1	1	1
63	0	0	1	1	1	1	1	1
127	0	1	1	1	1	1	1	1
128	1	0	0	0	0	0	0	0
192	1	1	0	0	0	0	0	0
224	1	1	1	0	0	0	0	0
240	1	1	1	1	0	0	0	0
248	1	1	1	1	1	0	0	0
252	1	1	1	1	1	1	0	0
254	1	1	1	1	1	1	1	0
255	1	1	1	1	1	1	1	1
160	1	0	1	0	0	0	0	0
96	0	1	1	0	0	0	0	0
112	0	1	1	1	0	0	0	0
120	0	1	1	1	1	0	0	0
170	1	0	1	0	1	0	1	0

EXAMPLE: 170 = 128 + 32 + 8 + 2

	Binary to Decimal Conversion Exercise								
	Decimal	**128**	**64**	**32**	**16**	**8**	**4**	**2**	**1**
	198	1	1	0	0	0	1	1	0
	204	1	1	0	0	1	1	0	0
	85	0	1	0	1	0	1	0	1
	189	1	0	1	1	1	1	0	1
	60	0	0	1	1	1	1	0	0
	27	0	0	0	1	1	0	1	1
	192	1	1	0	0	0	0	0	0
	146	1	0	0	1	0	0	1	0
	254	1	1	1	1	1	1	1	0
	246	1	1	1	1	0	1	1	0
	7	0	0	0	0	0	1	1	1
	237	1	1	1	0	1	1	0	1
	111	0	1	1	0	1	1	1	1
	250	1	1	1	1	1	0	1	0
	150	1	0	0	1	0	1	1	0
	190	1	0	1	1	1	1	1	0
	119	0	1	1	1	0	1	1	1
	220	1	1	0	1	1	1	0	0
	177	1	0	1	1	0	0	0	1
	249	1	1	1	1	1	0	0	1
	199	1	1	0	0	0	1	1	1
	215	1	1	0	1	0	1	1	1
	219	1	1	0	1	1	0	1	1
	123	0	1	1	1	1	0	1	1
	217	1	1	0	1	1	0	0	1
	88	0	1	0	1	1	0	0	0
	59	0	0	1	1	1	0	1	1
	69	0	1	0	0	0	1	0	1
	135	1	0	0	0	0	1	1	1

Network Address Exercise		
Using the IP address shown and default subnet mask, write out the network address:		
1	188.10.18.2	188.10.0.0
2	10.10.48.80	10.0.0.0
3	192.149.24.191	192.149.24.0
4	150.203.23.19	150.203.0.0
5	12.10.10.1	12.0.0.0
6	186.13.23.110	186.13.0.0
7	223.69.230.250	223.69.230.0
8	200.120.135.15	200.120.135.0
9	27.125.200.151	27.0.0.0
10	199.20.150.35	199.20.150.0
11	191.55.165.135	191.55.0.0
12	28.212.250.254	28.0.0.0
13	177.100.18.4	177.100.0.0
14	119.18.45.5	119.0.0.0
15	191.249.234.191	191.249.0.0
16	223.220.215.109	223.220.215.0
17	126.123.23.1	126.0.0.0

CIDR and Subnet masks	
/31	255.255.255.254
/30	255.255.255.252
/29	255.255.255.248
/28	255.255.255.240
/27	255.255.255.224
/26	255.255.255.192
/25	255.255.255.128
/24	255.255.255.0
/23	255.255.254.0
/22	255.255.252.0
/21	255.255.248.0
/20	255.255.240.0
/19	255.255.224.0
/18	255.255.192.0
/17	255.255.128.0
/16	255.255.0.0
/15	255.254.0.0
/14	255.252.0.0
/13	255.248.0.0
/12	255.240.0.0
/11	255.224.0.0
/10	255.192.0.0
/9	255.128.0.0
/8	255.0.0.0
/7	254.0.0.0

Powers of 2	
2^{24}	16,777,216
2^{23}	8,388,608
2^{22}	4,194,304
2^{21}	2,097,152
2^{20}	1,048,576
2^{19}	524,288
2^{18}	262,144
2^{17}	131,072
2^{16}	65,536
2^{15}	32,768
2^{14}	16,384
2^{13}	8,192
2^{12}	4,096
2^{11}	2,048
2^{10}	1,024
2^{9}	512
2^{8}	256
2^{7}	128
2^{6}	64
2^{5}	32
2^{4}	16
2^{3}	8
2^{2}	4
2^{1}	2
2^{0}	1

Custom Subnet Masks

Problem 1

Number of needed subnets: **14**

Number of needed usable IPs: **14**

Network address: **192.10.10.0**

Address Class	*C*
Default Subnet mask	*255.255.255.0*
Number of bits converted	*4*
Custom Subnet mask	*255.255.255.240*
Total number of subnets	*16*
Total number of IP addresses	*16*
Number of usable addresses	*14*

Show your work for this problem below.

	128	192	224	240	248	252	254	255
	128	64	32	16	8	4	2	1
	/25	/26	/27	/28	/29	/30	/31	/32
240	*1*	*1*	*1*	*1*	*0*	*0*	*0*	*0*

$2^4 = 16$

Formula: Networks = 2^S (where S is equal to number of bits subnetted.)

Nodes = 2^H -2 (where H is equal to number of bits needed for hosts. The -2 is because of the Network ID and Broadcast address.

Custom Subnet Masks

Problem 2

Number of needed subnets: **1000**

Number of needed usable IPs: **60**

Network address: **165.100.10.0**

Address Class	B
Default Subnet mask	255.255.0.0
Number of bits converted	10
Custom Subnet mask	255.255.255.192
Total number of subnets	1,024
Total number of IP addresses	64
Number of usable addresses	62

Show your work for this problem below.

128	192	224	240	248	252	254	255
128	64	32	16	8	4	2	1
/17	/18	/19	/20	/21	/22	/23	/24
/25	/26	/27	/28	/29	/30	/31	/32

	1	1	1	1	1	1	1	1
192	1	1	0	0	0	0	0	0

$2^{10} = 1{,}024$

Custom Subnet Masks

Problem 3

/25 indicates the total number of bits used for the network and subnetwork portion of the address. All bits remaining belong to the node portion of the address.

Network address: **148.75.0.0/25**

Address Class: *B*

Default Subnet mask: *255.255.0.0*

Number of bits converted: *9*

Custom Subnet mask: *255.255.255.128*

Total number of subnets: *512*

Total number of IP addresses: *128*

Number of usable addresses: *126*

Show your work for this problem below.

128	192	224	240	248	252	254	255
128	64	32	16	8	4	2	1
/17	/18	/19	/20	/21	/22	/23	/24
/25	/26	/27	/28	/29	/30	/31	/32

1 1 1 1 1 1 1 1

128 *1 0 0 0 0 0 0 0*

$2^9 = 512$

Custom Subnet Masks

Problem 4

Number of needed subnets: **6**

Number of needed usable IPs: **30**

Network address: **195.85.8.0**

Address Class	C
Default Subnet mask	255.255.255.0
Number of bits converted	3
Custom Subnet mask	255.255.255.224
Total number of subnets	8
Total number of IP addresses	32
Number of usable addresses	30

Show your work for this problem below.

128	192	224	240	248	252	254	255
128	64	32	16	8	4	2	1
/25	/26	/27	/28	/29	/30	/31	/32

Custom Subnet Masks

Problem 5

Number of needed subnets: **4**

Number of needed usable IPs: **32**

Network address: **210.100.56.0**

Address Class	C
Default Subnet mask	255.255.255.0
Number of bits converted	2
Custom Subnet mask	255.255.255.192
Total number of subnets	4
Total number of IP addresses	64
Number of usable addresses	62

Show your work for this problem below.

128	192	224	240	248	252	254	255
128	64	32	16	8	4	2	1
/25	/26	/27	/28	/29	/30	/31	/32

Problem 6

Number of needed subnets: **126**

Number of needed usable IPs: **88,500**

Network address: **118.0.0.0**

Address Class	A
Default Subnet mask	255.0.0.0
Number of bits converted	7
Custom Subnet mask	255.254.0.0
Total number of subnets	128
Total number of IP addresses	131,072
Number of usable addresses	131,070

Show your work for this problem below.

128	192	224	240	248	252	254	255
128	64	32	16	8	4	2	1

Problem 7

Number of needed subnets: **2000**

Number of needed usable IPs: **15**

Network address: **178.100.0.0**

Address Class	B
Default Subnet mask	255.255.0.0
Number of bits converted	11
Custom Subnet mask	255.255.255.224
Total number of subnets	2048
Total number of IP addresses	32
Number of usable addresses	30

Show your work for this problem below.

128	192	224	240	248	252	254	255
128	64	32	16	8	4	2	1
/17	/18	/19	/20	/21	/22	/23	/24
/25	/26	/27	/28	/29	/30	/31	/32

Problem 8

Network address: **93.75.0.0/19**

Address Class	A
Default Subnet mask	255.0.0.0
Number of bits converted	11
Custom Subnet mask	255.255.224.0
Total number of subnets	2048
Total number of IP addresses	8,192
Number of usable addresses	8190

Show your work for this problem below.

128	192	224	240	248	252	254	255
128	64	32	16	8	4	2	1

Problem 9

Network address: **9.0.0.0/16**

Address Class	A
Default Subnet mask	255.0.0.0
Number of bits converted	8
Custom Subnet mask	255.255.0.0
Total number of subnets	256
Total number of IP addresses	65,536
Number of usable addresses	65,534

Show your work for this problem below.

128	192	224	240	248	252	254	255
128	64	32	16	8	4	2	1

Problem 10

Network address: **164.199.0.0/26**

Address Class	B
Default Subnet mask	255.255.0.0
Number of bits converted	10
Custom Subnet mask	255.255.255.192
Total number of subnets	1,024
Total number of IP addresses	64
Number of usable addresses	62

Show your work for this problem below.

128	192	224	240	248	252	254	255
128	64	32	16	8	4	2	1

Valid and Non-Valid IP Addresses

Identify which of the addresses below are correct and usable. If they are not usable, explain why.

1	0.230.190.192 255.0.0.0	Invalid. You can not have 0 as the Network address.
2	192.10.10.1 255.255.255.0	OK
3	245.150.190.111 255.255.255.0	Invalid - this is a Class E address
4	135.70.254.255 255.255.254.0	OK
5	127.100.100.10 255.0.0.0	Invalid - this is the loop-back address
6	93.0.128.1 255.255.224.0	OK
7	200.10.10.128 255.255.255.224	Invalid - this is the network address
8	165.10.255.189 /26	OK
9	190.35.0.10 /26	Ok
10	218.350.50.195 /16	Invalid – The second Octet is larger than 255
11	200.10.10.175 /22	OK
12	135.70.254.255 /19	OK
13	144.80.191.255 255.255.254.0	Invalid - this is the broadcast address

To determine if an address is local or remote, you have to first identify the Network Address. If you are using the default class-based subnet mask, you should be able to get to the point where you can simply look at the addresses and make the determination. Take a look at this example:

- 119.254.192.1 119.1.2.3

This is a Class A example. In Class A, only the first octet represents the network. In this case, the Network address is 119.0.0.0 for both addresses, therefore these nodes are local to each other. Let's look at another example:

- 187.116.254.23 187.115.254.23

This is a Class B example. In Class B, the first 2 octets represent the network. Let me highlight the network portion for you….

- 187.116.254.23 187.115.254.23

Are the highlighted portions identical? No, therefore these nodes are remote to each other. Now it is your turn.

Local vs. Remote Network Determination

Determine if the pairs of IP addresses are local to each other or if they are on remote networks. The following items use the default class-based subnet masks:

1.	172.16.45.60	172.16.255.254	Local
2.	192.168.7.34	192.168.7.219	Local
3.	10.35.12.23	10.255.212.198	Local
4.	212.214.56.100	212.113.40.227	Remote
5.	5.9.3.5	5.211.3.2	Local
6.	209.245.211.240	214.245.211.241	Remote
7.	45.187.12.45	45.187.222.197	Local
8.	192.249.234.191	192.249.232.190	Remote
9.	129.132.24.2	129.132.255.1	Local
10.	223.32.232.190	223.31.232.54	Remote
11.	150.10.15.0	150.10.16.1	Local
12.	193.14.2.0	193.14.2.54	Local
13.	174.17.9.1	173.17.9.2	Remote
14.	148.17.8.2	148.17.99.124	Local
15.	95.0.21.90	95.21.0.10	Local

When using custom subnet masks, we have to do a little decimal to binary conversion before we can determine Local or Remote. First we look at the IP address and Subnet Mask and we focus on the first octet that is not 255, I call this the interesting octet. Next, we convert that octet to binary and mark the mask. For example:

Source IP:	177.100.181.201	Here we would focus on the third octet.
Destination IP:	177.100.126.160	
Subnet Mask:	255.255.192.0	

Source (3rd)	181	10110101 The highlighted portion represent the network bits.
Dest. (3rd)	126	01111110
SM (3rd)	192	11000000

Notice that the network portions of these addresses do not match. Therefore they are remote to each other.

Local vs. Remote with Custom Subnet Masks

Determine if the pairs of IP addresses are local to each other or if they are on remote networks. The subnet mask is also supplied:

1. 192.168.5.71 192.168.5.76 Local
   - **255.255.255.224**
2. 212.42.78.14 212.42.78.35 Remote
   - **255.255.255.252**
3. 199.45.76.20 199.45.76.34 Remote
   - **255.255.255.240**
4. 201.154.79.197 201.154.79.204 Remote
   - **255.255.255.248**
5. 215.16.190.45 215.16.190.52 Remote
   - **255.255.255.252**
6. 215.16.190.45 215.16.190.52 Local
   - **255.255.255.224**
7. 130.204.170.5 130.204.191.89 Local
   - **255.255.224.0**
8. 223.99.169.5 223.99.192.98 Remote
   - **255.255.224.0**
9. 126.42.78.98 126.42.78.132 Remote
   - **255.255.255.192**
10. 152.255.171.76 152.255.168.2 Local
    - **255.255.252.0**

Valid IP address range

First example: **63.128.152.141 /22**

Following the steps on the previous page we need to find the interesting octet. In this case it is the third octet but don't take my word for it. Let's convert the CIDR into dotted decimal. /22 means that the first 22 bits represent the network. It looks like this in binary:

11111111.11111111.11111100.00000000 which is 255.255.252.0 in dotted decimal.

Now that we have found the interesting octet, let's convert it to binary and mark the mask.

Source IP: 63.128.152.141 Here we would focus on the third octet.
Subnet Mask: 255.255.252.0

IP (3rd) 152 10011000 The portion highlighted in yellow represent the network bits.
SM (3rd) 252 11111100 The portion highlighted in green represent the node bits.

We now covert all node bits to 0. This will give us the Network Address.

63 . 128 . 152 . 141 63 . 128 . 152 . 0

IP 00111111.10000000.10011000.10001101 into 00111111.10000000.10011000.00000000

We now covert all node bits to 1. This will give us the Broadcast Address

63 . 128 . 152 . 141 63 . 128 . 155 . 255

IP 00111111.10000000.10011000.10001101 into 00111111.10000000.10011011.11111111

To find the 1st host IP, add 1 to the Network address. To find the Last Host IP, subtract 1 from the Broadcast address. This give us the following range of valid IP addresses.

63.128.152.141 /22	
Network Address	63.128.152.0
First Host IP Address	63.128.152.1
Last Host IP Address	63.128.155.254
Broadcast Address	63.128.155.255

Now it is your turn…

Problem 1

141.106.236.47 /20	
Network Address	141.106.224.0
First Host IP Address	141.106.224.1
Last Host IP Address	141.106.239.254
Broadcast Address	141.106.239.255

Problem 2

172.5.48.143 /21	
Network Address	172.5.48.0
First Host IP Address	172.5.48.1
Last Host IP Address	172.5.51.254
Broadcast Address	172.5.51.255

Problem 3

216.148.147.152 /28	
Network Address	216.148.147.144
First Host IP Address	216.148.147.145
Last Host IP Address	216.148.147.158
Broadcast Address	216.148.147.159

Final Exam – Given the following information, determine subnet IDs and Range of Host IDs:

Number of physical segments (subnets) needed: 5

Minimum number of IPs per segment needed: 5000

Network Address: **154.77.0.0**

1. Proposed Custom Subnet Mask: 255.255.224.0
2. Total number of subnets supported: 8
3. Total number of IPs per subnet: 8190

(Bonus) List the Subnet ID's:

154.77.0.0	154.77.00000000.0
154.77.32.0	154.77.00100000.0
154.77.64.0	154.77.01000000.0
154.77.96.0	154.77.01100000.0
154.77.128.0	154.77.10000000.0
154.77.160.0	154.77.10100000.0
154.77.192.0	154.77.11000000.0
154.77.224.0	154.77.11100000.0

(Bonus) List the Host ID ranges per subnet:

154.77.0.0	154.77.0.1	154.77.00000000.00000001
	154.77.31.254	154.77.00011111.11111110
	154.77.31.255	154.77.00011111.11111111
154.77.32.0	154.77.32.1	154.77.00100000.00000001
	154.77.63.254	154.77.00111111.11111110
	154.77.63.255	154.77.00111111.11111111
154.77.64.0	154.77.64.1	154.77.01000000.00000001
	154.77.95.254	154.77.01011111.11111110
	154.77.95.255	154.77.01011111.11111111
154.77.96.0	154.77.96.1	154.77.01100000.00000001
	154.77.127.254	154.77.01111111.11111110
	154.77.127.255	154.77.01111111.11111111
154.77.128.0	154.77.128.1	154.77.10000000.00000001
	154.77.159.254	154.77.10011111.11111110
	154.77.159.255	154.77.10011111.11111111
154.77.160.0	154.77.160.1	154.77.10100000.00000001
	154.77.191.254	154.77.10111111.11111110
	154.77.191.255	154.77.10111111.11111111
154.77.192.0	154.77.192.1	154.77.11000000.00000001
	154.77.223.254	154.77.11011111.11111110
	154.77.223.255	154.77.11011111.11111111
154.77.224.0	154.77.224.1	154.77.11100000.00000001
	154.77.255.254	154.77.11111111.11111110
	154.77.255.255	154.77.11111111.11111111