101010
0
10001111100
1011100101011100
101100011101001
1011110100011010
0000101001011001 0
100101010101100111
1111010101000101
110100110101001 1
001010010101010
101010100011001 0
010101001011000
1010110011010
1010100001011
001010100110
100101001 0

Direccionamiento
y
Subneteo

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1111110

10010101

00011011

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Estudiante:

11010011

IP Address Classes

Class A	1 – 127	(Network 127 is reserved for loopback and internal testing)		
		Leading bit pattern	0	00000000.00000000.00000000.00000000 **Network . Host . Host . Host**
Class B	128 – 191	Leading bit pattern	10	10000000.00000000.00000000.00000000 **Network . Network . Host . Host**
Class C	192 – 223	Leading bit pattern	110	11000000.00000000.00000000.00000000 **Network . Network . Network . Host**
Class D	224 – 239	(Reserved for multicast)		
Class E	240 – 255	(Reserved for experimental, used for research)		

Private Address Space

Class A	10.0.0.0 to 10.255.255.255
Class B	172.16.0.0 to 172.31.255.255
Class C	192.168.0.0 to 192.168.255.255

Default Subnet Masks

Class A	255.0.0.0
Class B	255.255.0.0
Class C	255.255.255.0

> **Workbooks included in the series:**
>
> IP Addressing and Subnetting Workbooks
> ACLs - Access Lists Workbooks
> VLSM Variable-Length Subnet Mask Workbooks

Inside Cover

Binary To Decimal Conversion

128	64	32	16	8	4	2	1	Answers	Scratch Area
1	0	0	1	0	0	1	0	_146_	28 64
0	1	1	1	0	1	1	1	_119_	16 32
1	1	1	1	1	1	1	1	_____	2 16
1	1	0	0	0	1	0	1	_____	40 4
1	1	1	1	0	1	1	0	_____	2
0	0	0	1	0	0	1	1	_____	1
1	0	0	0	0	0	0	1	_____	119
0	0	1	1	0	0	0	1	_____	
0	1	1	1	1	0	0	0	_____	
1	1	1	1	0	0	0	0	_____	
0	0	1	1	1	0	1	1	_____	
0	0	0	0	0	1	1	1	_____	

	Answers
00011011	_____
10101010	_____
01101111	_____
11111000	_____
00100000	_____
01010101	_____
00111110	_____
00000011	_____
11101101	_____
11000000	_____

Decimal To Binary Conversion
Use all 8 bits for each problem

128	64	32	16	8	4	2	1	= 255	Scratch Area
1	1	1	0	1	1	1	0	238	
0	0	1	0	0	0	1	0	34	
								123	
								50	
								255	
								200	
								10	
								138	
								1	
								13	
								250	
								107	
								224	
								114	
								192	
								172	
								100	
								119	
								57	
								98	
								179	
								2	

Scratch Area:

```
238      34
-128    -32
 110      2
 -64     -2
  46      0
 -32
  14
  -8
   6
  -4
   2
  -2
   0
```

Address Class Identification

Address	Class
10.250.1.1	_A_
150.10.15.0	_B_
192.14.2.0	_____
148.17.9.1	_____
193.42.1.1	_____
126.8.156.0	_____
220.200.23.1	_____
230.230.45.58	_____
177.100.18.4	_____
119.18.45.0	_____
249.240.80.78	_____
199.155.77.56	_____
117.89.56.45	_____
215.45.45.0	_____
199.200.15.0	_____
95.0.21.90	_____
33.0.0.0	_____
158.98.80.0	_____
219.21.56.0	_____

Network & Host Identification

Circle the network portion of these addresses:

(177.100.)18.4

(119.)18.45.0

209.240.80.78

199.155.77.56

117.89.56.45

215.45.45.0

192.200.15.0

95.0.21.90

33.0.0.0

158.98.80.0

217.21.56.0

10.250.1.1

150.10.15.0

192.14.2.0

148.17.9.1

193.42.1.1

126.8.156.0

220.200.23.1

Circle the host portion of these addresses:

10.(15.123.50)

171.2.(199.31)

198.125.87.177

223.250.200.222

17.45.222.45

126.201.54.231

191.41.35.112

155.25.169.227

192.15.155.2

123.102.45.254

148.17.9.155

100.25.1.1

195.0.21.98

25.250.135.46

171.102.77.77

55.250.5.5

218.155.230.14

10.250.1.1

4

Network Addresses

Using the IP address and subnet mask shown write out the network address:

188.10.18.2
255.255.0.0   _____*188 . 10 . 0 . 0*_____

10.10.48.80
255.255.255.0   _____*10 . 10 . 48 . 0*_____

192.149.24.191
255.255.255.0   _____

150.203.23.19
255.255.0.0   _____

10.10.10.10
255.0.0.0   _____

186.13.23.110
255.255.255.0   _____

223.69.230.250
255.255.0.0   _____

200.120.135.15
255.255.255.0   _____

27.125.200.151
255.0.0.0   _____

199.20.150.35
255.255.255.0   _____

191.55.165.135
255.255.255.0   _____

28.212.250.254
255.255.0.0   _____

Host Addresses

Using the IP address and subnet mask shown write out the host address:

188.10.18.2
255.255.0.0
_____ *0 . 0 . 18 . 2* _____

10.10.48.80
255.255.255.0
_____ *0 . 0 . 0 . 80* _____

222.49.49.11
255.255.255.0
_____

128.23.230.19
255.255.0.0
_____

10.10.10.10
255.0.0.0
_____

200.113.123.11
255.255.255.0
_____

223.169.23.20
255.255.0.0
_____

203.20.35.215
255.255.255.0
_____

117.15.2.51
255.0.0.0
_____

199.120.15.135
255.255.255.0
_____

191.55.165.135
255.255.255.0
_____

48.21.25.54
255.255.0.0
_____

Default Subnet Masks

Write the correct default subnet mask for each of the following addresses:

177.100.18.4   _255 . 255 . 0 . 0_

119.18.45.0   _255 . 0 . 0 . 0_

191.249.234.191   _____

223.23.223.109   _____

10.10.250.1   _____

126.123.23.1   _____

223.69.230.250   _____

192.12.35.105   _____

77.251.200.51   _____

189.210.50.1   _____

88.45.65.35   _____

128.212.250.254   _____

193.100.77.83   _____

125.125.250.1   _____

1.1.10.50   _____

220.90.130.45   _____

134.125.34.9   _____

95.250.91.99   _____

ANDING With
Default subnet masks

Every IP address must be accompanied by a subnet mask. By now you should be able to look at an IP address and tell what class it is. Unfortunately your computer doesn't think that way. For your computer to determine the network and subnet portion of an IP address it must "AND" the IP address with the subnet mask.

Default Subnet Masks:

Class A	255.0.0.0
Class B	255.255.0.0
Class C	255.255.255.0

ANDING Equations:

1 AND 1 = 1
1 AND 0 = 0
0 AND 1 = 0
0 AND 0 = 0

Sample:

What you see...

IP Address: 192 . 100 . 10 . 33

What you can figure out in your head...

Address Class:	C
Network Portion:	**192 . 100 . 10** . 33
Host Portion:	192 . 100 . 10 . **33**

In order for you computer to get the same information it must AND the IP address with the subnet mask in binary.

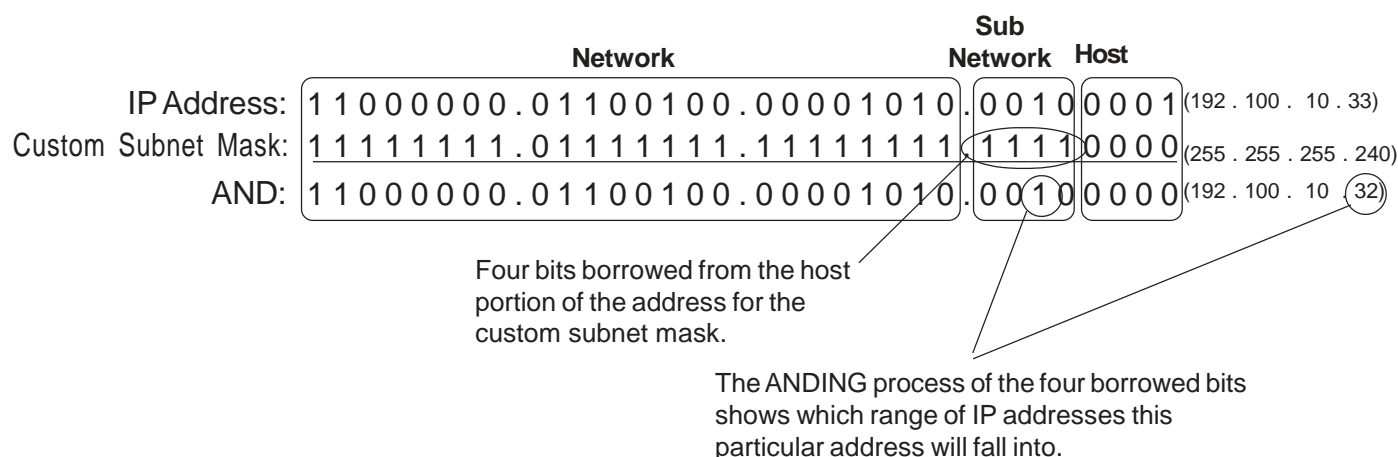|	**Network**			**Host**	
IP Address:	1 1 0 0 0 0 0 0 . 0 1 1 0 0 1 0 0 . 0 0 0 0 1 0 1 0 .	0 0 1 0 0 0 0 1	(192 . 100 . 10 . 33)
Default Subnet Mask:	1 1 1 1 1 1 1 1 . 0 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 .	0 0 0 0 0 0 0 0	(255 . 255 . 255 . 0)
AND:	1 1 0 0 0 0 0 0 . 0 1 1 0 0 1 0 0 . 0 0 0 0 1 0 1 0 .	0 0 0 0 0 0 0 0	(192 . 100 . 10 . 0)

ANDING with the default subnet mask allows your computer to figure out the network portion of the address.

ANDING With
Custom subnet masks

When you take a single network such as 192.100.10.0 and divide it into five smaller networks (192.100.10.16, 192.100.10.32, 192.100.10.48, 192.100.10.64, 192.100.10.80) the outside world still sees the network as 192.100.10.0, but the internal computers and routers see five smaller subnetworks. Each independent of the other. This can only be accomplished by using a custom subnet mask. A custom subnet mask borrows bits from the host portion of the address to create a subnetwork address between the network and host portions of an IP address. In this example each range has 14 usable addresses in it. The computer must still AND the IP address against the custom subnet mask to see what the network portion is and which subnetwork it belongs to.

IP Address: 192 . 100 . 10 . 0
Custom Subnet Mask: 255.255.255.240

Address Ranges: 192.10.10.0 to 192.100.10.15
                   192.100.10.16 to 192.100.10.31
                   192.100.10.32 to 192.100.10.47   (Range in the sample below)
                   192.100.10.48 to 192.100.10.63
                   192.100.10.64 to 192.100.10.79
                   192.100.10.80 to 192.100.10.95
                   192.100.10.96 to 192.100.10.111
                   192.100.10.112 to 192.100.10.127
                   192.100.10.128 to 192.100.10.143
                   192.100.10.144 to 192.100.10.159
                   192.100.10.160 to 192.100.10.175
                   192.100.10.176 to 192.100.10.191
                   192.100.10.192 to 192.100.10.207
                   192.100.10.208 to 192.100.10.223
                   192.100.10.224 to 192.100.10.239
                   192.100.10.240 to 192.100.10.255

	Network	Sub Network	Host	
IP Address:	1 1 0 0 0 0 0 0 . 0 1 1 0 0 1 0 0 . 0 0 0 0 1 0 1 0 .	0 0 1 0	0 0 0 1	(192 . 100 . 10 . 33)
Custom Subnet Mask:	1 1 1 1 1 1 1 1 . 0 1 1 1 1 1 1 1 . 1 1 1 1 1 1 1 1 .	1 1 1 1	0 0 0 0	(255 . 255 . 255 . 240)
AND:	1 1 0 0 0 0 0 0 . 0 1 1 0 0 1 0 0 . 0 0 0 0 1 0 1 0 .	0 0 1 0	0 0 0 0	(192 . 100 . 10 . 32)

Four bits borrowed from the host portion of the address for the custom subnet mask.

The ANDING process of the four borrowed bits shows which range of IP addresses this particular address will fall into.

In the next set of problems you will determine the necessary information to determine the correct subnet mask for a variety of IP addresses.

How to determine the number of subnets and the number of hosts per subnet

Two formulas can provide this basic information:

Number of subnets = 2^S   (Second subnet formula: **Number of subnets = 2^S - 2**)
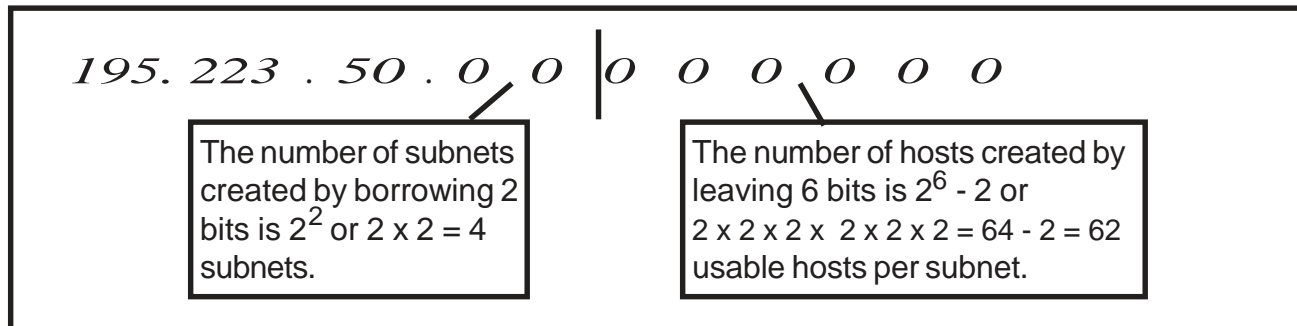
Number of hosts per subnet = 2^h - 2

Both formulas calculate the number of hosts or subnets based on the number of binary bits used. For example if you borrow three bits from the host portion of the address use the *number of subnets* formula to determine the total number of subnets gained by borrowing the three bits. This would be 2^3 or 2 x 2 x 2 = 8 subnets

To determine the number of hosts per subnet you would take the number of binary bits used in the host portion and apply this to the *number of hosts per subnet* formula If five bits are in the host portion of the address this would be 2^5 or 2 x 2 x 2 x 2 x 2 = 32 hosts.

When dealing with the *number of hosts per subnet* you have to subtract two addresses from the range. The first address in every range is the subnet number. The last address in every range is the broadcast address. These two addresses cannot be assigned to any device in the network which is why you have to subtract two addresses to find the number of usable addresses in each range.

For example if two bits are borrowed for the network portion of the address you can easily determine the number of subnets and hosts per subnets using the two formulas.

195. 223 . 50 . 0   0 | 0   0   0   0   0   0

> The number of subnets created by borrowing 2 bits is 2^2 or 2 x 2 = 4 subnets.

> The number of hosts created by leaving 6 bits is 2^6 - 2 or 2 x 2 x 2 x 2 x 2 x 2 = 64 - 2 = 62 usable hosts per subnet.

What about that second subnet formula:

Number of subnets = 2^S - 2

In some instances the first and last subnet range of addresses are reserved. This is similar to the first and last host addresses in each range of addreses.

The first range of addresses is the ***zero subnet***. The subnet number for the *zero subnet* is also the subnet number for the classful subnet address.

The last range of addresses is the ***broadcast subnet***. The broadcast address for the last subnet in *the broadcast subnet* is the same as the classful broadcast address.

Class C Address unsubnetted:

195. 223 . 50 . 0

195.223.50.0 to 195.223.50.255

Notice that the subnet and broadcast addresses match.

Class C Address subnetted (2 bits borrowed):

195. 223 . 50 . 0 0 | 0 0 0 0 0 0

(Invalid range) (0)	*195.223.50.0*	*to*	*195.223.50.63*
(1)	*195.223.50.64*	*to*	*195.223.50.127*
(2)	*195.223.50.128*	*to*	*195.223.50.191*
(Invalid range) (3)	*195.223.50.192*	*to*	*195.223.50.255*

The primary reason the the zero and broadcast subnets were not used had to do pirmarily with the broadcast addresses. If you send a broadcast to 195.223.255 are you sending it to all 255 addresses in the classful C address or just the 62 usable addresses in the broadcast range?

The **CCNA** and **CCENT** certification exams may have questions which will require you to determine which formula to use, and whehter or not you can use the first and last subnets. Use the chart below to help decide.

When to use which formula to determine the number of subnets	
Use the $2^s - 2$ formula and **don't use** the zero and broadcast ranges if...	Use the 2^s formula and **use** the zero and broadcast ranges if...
Classful routing is used	Classless routing or VLSM is used
RIP version 1 is used	RIP version 2, EIGRP, or OSPF is used
The *no ip subnet zero* command is configured on your router	The *ip subnet zero* command is configured on your router (default setting)
	No other clues are given

Custom Subnet Masks

Problem 1

Number of needed subnets **14**
Number of needed usable hosts **14**
Network Address **192.10.10.0**

Address class _____*C*_____

Default subnet mask _____*255 . 255 . 255 . 0*_____

Custom subnet mask _____*255 . 255 . 255 . 240*_____

Total number of subnets _____*16*_____

Total number of host addresses _____*16*_____

Number of usable addresses _____*14*_____

Number of bits borrowed _____*4*_____

Show your work for Problem 1 in the space below.

										Number of
	256	*128*	*64*	*32*	*16*	*8*	*4*	*2*	*-*	*Hosts*
Number of Subnets	*-*	*2*	*4*	*8*	*16*	*32*	*64*	*128*	*256*	
	128	*64*	*32*	*16*	*8*	*4*	*2*	*1*	*-*	*Binary values*

192 . 10 . 10 . 0 0 0 0 | 0 0 0 0

Add the binary value numbers to the left of the line to create the custom subnet mask.

128
64
32
+16
240

Observe the total number of hosts.

16
−2
14

Subtract 2 for the number of usable hosts.

Custom Subnet Masks

Problem 2

Number of needed subnets **1000**
Number of needed usable hosts **60**
Network Address **165.100.0.0**

Address class ____*B*____

Default subnet mask ____*255 . 255 . 0 . 0*____

Custom subnet mask ____*255 . 255 . 255 . 192*____

Total number of subnets ____*1,024*____

Total number of host addresses ____*64*____

Number of usable addresses ____*62*____

Number of bits borrowed ____*10*____

Show your work for Problem 2 in the space below.

Number of Hosts –	65,536	32,768	16,384	8,192	4,096	2,048	1,024	512	. 256	128	64	32	16	8	4	2	
Number of Subnets –	2	4	8	16	32	64	128	256.	512	1024	2048	4,096	8,192	16,384	32,768	65,536	
Binary values –	128	64	32	16	8	4	2	1 .	128	64	32	16	8	4	2	1	
165 . 100 .	0	0	0	0	0	0	0	0 .	0	0	0	0	0	0	0	0	

128
64   *128*
32   *+64*
16   *192*
8
4
2
+1
255

Add the binary value numbers to the left of the line to create the custom subnet mask.

64   Observe the total number of hosts.
-2
62   Subtract 2 for the number of usable hosts.

14

Custom Subnet Masks

Problem 3

Network Address **148.75.0.0 /26**

> **/26** indicates the total number of bits used for the network and subnetwork portion of the address. All bits remaining belong to the host portion of the address.

Address class _____*B*_____

Default subnet mask _____*255 . 255 . 0 . 0*_____

Custom subnet mask _____*255 . 255 . 255 . 192*_____

Total number of subnets _____*1,024*_____

Total number of host addresses _____*64*_____

Number of usable addresses _____*62*_____

Number of bits borrowed _____*10*_____

Show your work for Problem 3 in the space below.

Number of Hosts –	65,536	32,768	16,384	8,192	4,096	2,048	1,024	512	. 256	128	64	32	16	8	4	2
Number of Subnets –	2	4	8	16	32	64	128	256 .	512	1024	2048	4,096	8,192	16,384	32,768	65,536
Binary values –	128	64	32	16	8	4	2	1 .	128	64	32	16	8	4	2	1
148 . 75 .	0	0	0	0	0	0	0	0 .	0	0	0	0	0	0	0	0

Add the binary value numbers to the left of the line to create the custom subnet mask.

```
 128      128
  64     +64
  32      192
  16
   8
   4
   2
  +1
 255
```

```
  64   Observe the total number of
  -2   hosts.
  62   Subtract 2 for the number of
       usable hosts.
```

```
 1024  Subtract 2 for the total number of
   -2  subnets to get the usable number of
 1,022 subnets.
```

Custom Subnet Masks

Problem 4

Number of needed subnets **6**
Number of needed usable hosts **30**
Network Address **195.85.8.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for Problem 5 in the space below.

	256	128	64	32	16	8	4	2	-	*Number of Hosts*
Number of Subnets	-	2	4	8	16	32	64	128	256	
	128	64	32	16	8	4	2	1	-	*Binary values*

195 . 85 . 8 . O O O | O O O O O

16

Custom Subnet Masks

Problem 5

Number of needed subnets **6**
Number of needed usable hosts **30**
Network Address **210.100.56.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for Problem 4 in the space below.

									Number of
	256	128	64	32	16	8	4	2	- Hosts
Number of Subnets	-	2	4	8	16	32	64	128	256
	128	64	32	16	8	4	2	1	- Binary values

210 . 100 . 56 . O O O | O O O O O

Custom Subnet Masks

Problem 6

Number of needed subnets **126**
Number of needed usable hosts **131,070**
Network Address **118.0.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for Problem 6 in the space below.

Number of Hosts		4,194,304—	2,097,152—	1,048,576—	524,288—	262,144—	131,072—	65,536—	32,768—	16,384—	8,192—	4,096—	2,048—	1,024—	512—	.	256	128	64	32	16	8	4	2	
		—	—	—	—	—	—	—	—	—	—	—	—	—	—				131,072	262,144	524,288	1,048,576	2,097,152	4,194,304	
Number of Subnets	-	2	4	8	16	32	64	128	256	.	512	1,024	2,048	4,096	8,192	16,384	32,768	65,536	.	131,072	262,144	524,288	1,048,576	2,097,152	4,194,304
Binary values	-128	64	32	16	8	4	2	1	.	128	64	32	16	8	4	2	1	.	128	64	32	16	8	4	2	1

118. 0 0 0 0 0 0 0 | 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

Custom Subnet Masks

Problem 7

Number of needed subnets **2000**
Number of needed usable hosts **15**
Network Address **178.100.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for <u>Problem 7</u> in the space below.

Number of Hosts	–	65,536	32,768	16,384	8,192	4,096	2,048	1,024	512	. 256	128	64	32	16	8	4	2
Number of Subnets	–	2	4	8	16	32	64	128	256 .	512	1024	2048	4,096	8,192	16,384	32,768	65,536
Binary values	–	128	64	32	16	8	4	2	1 .	128	64	32	16	8	4	2	1

178 . 100 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

Custom Subnet Masks

Problem 8

Number of needed subnets **3**
Number of needed usable hosts **45**
Network Address **200.175.14.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for <u>Problem 8</u> in the space below.

Custom Subnet Masks

Problem 9

Number of needed subnets **60**
Number of needed usable hosts **1,000**
Network Address **128.77.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for Problem 9 in the space below.

Custom Subnet Masks

<u>Problem 10</u>

Number of needed usable hosts **60**

Network Address **198.100.10.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for <u>Problem 10</u> in the space below.

Custom Subnet Masks

Problem 11

Number of needed subnets **250**
Network Address **101.0.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for Problem 11 in the space below.

Custom Subnet Masks

Problem 12

Number of needed subnets **5**

Network Address **218.35.50.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for Problem 12 in the space below.

Custom Subnet Masks

Problem 13

Number of needed usable hosts **25**

Network Address **218.35.50.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for Problem 13 in the space below.

Custom Subnet Masks

Problem 14

Number of needed subnets **10**
Network Address **172.59.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for <u>Problem 14</u> in the space below.

Custom Subnet Masks

Problem 15

Number of needed usable hosts **50**

Network Address **172.59.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for <u>Problem 15</u> in the space below.

Custom Subnet Masks

Problem 16

Number of needed usable hosts **29**

Network Address **23.0.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for <u>Problem 16</u> in the space below.

Subnetting

Problem 1

Number of needed subnets **14**
Number of needed usable hosts **14**
Network Address **192.10.10.0**

Address class _____*C*_____

Default subnet mask _____*255 . 255 . 255 . 0*_____

Custom subnet mask _____*255 . 255 . 255 . 240*_____

Total number of subnets _____*16*_____

Total number of host addresses _____*16*_____

Number of usable addresses _____*14*_____

Number of bits borrowed _____*4*_____

What is the 4th
subnet range? _*192.10.10.48 to 192.10.10.63*_

What is the subnet number
for the 8th subnet? _*192 . 10 . 10 . 112*_

What is the subnet
broadcast address for
the 13th subnet? _*192 . 10 . 10 . 207*_

What are the assignable
addresses for the 9th
subnet? _*192.10.10.129 to 192.10.10.142*_

Show your work for <u>Problem 1</u> in the space below.

	256	128	64	32	16	8	4	2	-	Number of Hosts
Number of Subnets	-	2	4	8	16	32	64	128	256	
	128	64	32	16	8	4	2	1	-	Binary values

192. 10 . 10 . *O O O O* | *O O O O*

(1)	O O O O	192.10.10.0	to	192.10.10.15
(2)	O O O 1	192.10.10.16	to	192.10.10.31
(3)	O O 1 O	192.10.10.32	to	192.10.10.47
(4)	O O 1 1	192.10.10.48	to	192.10.10.63
(5)	O 1 O O	192.10.10.64	to	192.10.10.79
(6)	O 1 O 1	192.10.10.80	to	192.10.10.95
(7)	O 1 1 O	192.10.10.96	to	192.10.10.111
(8)	O 1 1 1	192.10.10.112	to	192.10.10.127
(9)	1 O O O	192.10.10.128	to	192.10.10.143
(10)	1 O O 1	192.10.10.144	to	192.10.10.159
(11)	1 O 1 O	192.10.10.160	to	192.10.10.175
(12)	1 O 1 1	192.10.10.176	to	192.10.10.191
(13)	1 1 O O	192.10.10.192	to	192.10.10.207
(14)	1 1 O 1	192.10.10.208	to	192.10.10.223
(15)	1 1 1 O	192.10.10.224	to	192.10.10.239
(16)	1 1 1 1	192.10.10.240	to	192.10.10.255

Custom subnet mask
$$128$$
$$64$$
$$32$$
$$+16$$
$$240$$

Usable subnets
$$16$$
$$-2$$
$$14$$

Usable hosts
$$16$$
$$-2$$
$$14$$

The binary value of the last bit borrowed is the range. In this problem the range is 16.

The first address in each subnet range is the subnet number.

The last address in each subnet range is the subnet broadcast address.

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Subnetting

Problem 2

Number of needed subnets **1000**
Number of needed usable hosts **60**
Network Address **165.100.0.0**

Address class _____B_____

Default subnet mask ____255 . 255 . 0 . 0_____

Custom subnet mask ____255 . 255 . 255 . 192___

Total number of subnets _____1,024_____

Total number of host addresses _____64_____

Number of usable addresses _____62_____

Number of bits borrowed _____10_____

What is the 15th
subnet range? _165.100.3.128 to 165.100.3.191_

What is the subnet number
for the 6th subnet? __165 . 100 . 1 . 64___

What is the subnet
broadcast address for
the 6th subnet? __165 . 100 . 1 . 127__

What are the assignable
addresses for the 9th
subnet? _165.100.2.1 to 165.100.0.62_____

Number of Hosts	–	65,536	32,768	16,384	8,192	4,096	2,048	1,024	512	.	256	128	64	32	16	8	4	2	
Number of Subnets	–	2	4	8	16	32	64	128	256.		512	1024	2048	4,096	8,192	16,384	32,768	65,536	
Binary values	–	128	64	32	16	8	4	2	1	.	128	64	32	16	8	4	2	1	
165 . 100 .		0	0	0	0	0	0	0	0	.	0	0	0	0	0	0	0	0	

```
                                      (1)        .   0    165.100.0.0     to  165.100.0.63
                                      (2)            1    165.100.0.64    to  165.100.0.127
                          64   128    (3)        1   0    165.100.0.128   to  165.100.0.191
                Usable  -2    64     (4)        1   1    165.100.0.192   to  165.100.0.255
                hosts   62    32     (5)    1 . 0   0    165.100.1.0     to  165.100.1.63
                              16     (6)    1 . 0   1    165.100.1.64    to  165.100.1.127
                               8     (7)    1 . 1   0    165.100.1.128   to  165.100.1.191
                Custom 128     4     (8)    1 . 1   1    165.100.1.192   to  165.100.1.255
               subnet mask +64  2    (9)  1  0 . 0   0  165.100.2.0     to  165.100.2.63
                        192    +1    (10) 1  0 . 0   1  165.100.2.64    to  165.100.2.127
The binary value of the last bit borrowed is 255  (11) 1  0 . 1   0  165.100.2.128   to  165.100.2.191
the range. In this problem the range is 64.        (12) 1  0 . 1   1  165.100.2.192   to  165.100.2.255
The first address in each subnet range is the      (13) 1  1 . 0   0  165.100.3.0     to  165.100.3.63
The last address in each subnet range is the       (14) 1  1 . 0   1  165.100.3.64    to  165.100.3.127
subnet broadcast address.                          (15) 1  1 . 1   0  165.100.3.128   to  165.100.3.191
                                                   (16) 1  1 . 1   1  165.100.3.192   to  165.100.3.255

                                                        Down to

(1023) 1 1 1 1 1 1 1 1 . 1 0  165.100.255.128 to 165.100.255.191
(1024) 1 1 1 1 1 1 1 1 . 1 1  165.100.255.192 to 165.100.255.255
```

Subnetting

Problem 3

Number of needed subnets **2**

Network Address **195.223.50.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 2nd subnet range? _____

What is the subnet number for the 2nd subnet? _____

What is the subnet broadcast address for the 1st subnet? _____

What are the assignable addresses for the 1st subnet? _____

Show your work for <u>Problem 3</u> in the space below.

	256	128	64	32	16	8	4	2	-	Number of Hosts
Number of Subnets -	2	4	8	16	32	64	128	256		
	128	64	32	16	8	4	2	1	-	Binary values
195. 223 . 50 . 0		0	0	0	0	0	0	0		

Subnetting

Problem 4

Number of needed subnets **750**
Network Address **190.35.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 15th
subnet range? _____

What is the subnet number
for the 13th subnet? _____

What is the subnet
broadcast address for
the 10th subnet? _____

What are the assignable
addresses for the 6th
subnet?_____

Show your work for <u>Problem 4</u> in the space below.

Subnetting

Problem 5

Number of needed usable hosts **6**

Network Address **126.0.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 2nd subnet range? _____

What is the subnet number for the 5th subnet? _____

What is the subnet broadcast address for the 7th subnet? _____

What are the assignable addresses for the 10th subnet? _____

Show your work for <u>Problem 5</u> in the space below.

Subnetting

Problem 6

Number of needed subnets **10**

Network Address **192.70.10.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 9th
subnet range? _____

What is the subnet number
for the 4th subnet? _____

What is the subnet
broadcast address for
the 12th subnet? _____

What are the assignable
addresses for the 10th
subnet? _____

Show your work for <u>Problem 6</u> in the space below.

Subnetting

Problem 7

Network Address **10.0.0.0 /16**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 11th
subnet range? _____

What is the subnet number
for the 6th subnet? _____

What is the subnet
broadcast address for
the 2nd subnet? _____

What are the assignable
addresses for the 9th
subnet? _____

Show your work for <u>Problem 7</u> in the space below.

Subnetting

Problem 8

Number of needed subnets **5**

Network Address **172.50.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 4th
subnet range? _____

What is the subnet number
for the 5th subnet? _____

What is the subnet
broadcast address for
the 6th subnet? _____

What are the assignable
addresses for the 3rd
subnet? _____

Show your work for <u>Problem 8</u> in the space below.

Subnetting

Problem 9

Number of needed usable hosts **28**

Network Address **172.50.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 2nd
subnet range? _____

What is the subnet number
for the 10th subnet? _____

What is the subnet broadcast
address for
the 4th subnet? _____

What are the assignable
addresses for the 6th
subnet? _____

Show your work for <u>Problem 9</u> in the space below.

Subnetting

Problem 10

Number of needed subnets **45**

Network Address **220.100.100.0**

Address class __C__

Default subnet mask __255.255.255.0__

Custom subnet mask __255.255.255.252__

Total number of subnets __64__

Total number of host addresses __4__

Number of usable addresses __2__

Number of bits borrowed __6__

What is the 5th subnet range? __220.100.100.16 – 220.100.100.19__

What is the subnet number for the 4th subnet? __220.100.100.12__

What is the subnet broadcast address for the 13th subnet? __220.100.100.51__

What are the assignable addresses for the 12th subnet? __220.100.100.45 – 220.100.100.46__

Show your work for <u>Problem 10</u> in the space below.

Subnetting

Problem 11

Number of needed usable hosts **8,000**

Network Address **135.70.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 6th
subnet range? _____

What is the subnet number
for the 7th subnet? _____

What is the subnet
broadcast address for
the 3rd subnet? _____

What are the assignable
addresses for the 5th
subnet? _____

Show your work for <u>Problem 11</u> in the space below.

Subnetting

Problem 12

Number of needed usable hosts **45**

Network Address **198.125.50.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 2nd
subnet range? _____

What is the subnet number
for the 2nd subnet? _____

What is the subnet
broadcast address for
the 4th subnet? _____

What are the assignable
addresses for the 3rd
subnet? _____

Show your work for <u>Problem 12</u> in the space below.

Subnetting

Problem 13

Network Address **165.200.0.0 /26**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 10th
subnet range? _____

What is the subnet number
for the 11th subnet? _____

What is the subnet
broadcast address for
the 1023rd subnet? _____

What are the assignable
addresses for the 1022nd
subnet? _____

Show your work for <u>Problem 13</u> in the space below.

Subnetting

Problem 14

Number of needed usable hosts **16**

Network Address **200.10.10.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 7th
subnet range? _____

What is the subnet number
for the 5th subnet? _____

What is the subnet
broadcast address for
the 4th subnet? _____

What are the assignable
addresses for the 6th
subnet? _____

Show your work for <u>Problem 14</u> in the space below.

Subnetting

Problem 15

Network Address **93.0.0.0 \19**

Address class _____ Class A

Default subnet mask _____ 255.0.0.0

Custom subnet mask _____ 255.255.224.0

Total number of subnets _____ 2048 (2^{11})

Total number of host addresses _____ 8192 (2^{13})

Number of usable addresses _____ 8190

Number of bits borrowed _____ 11

What is the 15th
subnet range? _____ 93.1.192.0 – 93.1.223.255

What is the subnet number
for the 9th subnet? _____ 93.1.0.0

What is the subnet
broadcast address for
the 7th subnet? _____ 93.0.223.255

What are the assignable
addresses for the 12th
subnet? _____ 93.1.96.1 – 93.1.127.254

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**Show your work for <u>Problem 15</u> in the space below.**

IP Address Breakdown

/24 8+8+8 255.255.255.0 256 Hosts	/25 8+8+8+1 255.255.255.128 128 Hosts	/26 8+8+8+2 255.255.255.192 64 Hosts	/27 8+8+8+3 255.255.255.224 32 Hosts	/28 8+8+8+4 255.255.255.240 16 Hosts	/29 8+8+8+5 255.255.255.248 8 Hosts	/30 8+8+8+6 255.255.255.252 4 Hosts
0-255	0-127	0-63		0-15	0-7	0-3
						4-7
					8-15	8-11
						12-15
				16-31	16-23	16-19
						20-23
					24-31	24-27
						28-31
				32-47	32-39	32-35
						36-39
					40-47	40-43
						44-47
				48-63	48-55	48-51
						52-55
					56-63	56-59
						60-63
		64-127		64-79	64-71	64-67
						68-71
					72-79	72-75
						76-79
				80-95	80-87	80-83
						84-87
					88-95	88-91
						92-95
				96-111	96-103	96-99
						100-103
					104-111	104-107
						108-111
				112-127	112-119	112-115
						116-119
					120-127	120-123
						124-127
	128-255	128-191		128-143	128-135	128-131
						132-135
					136-143	136-139
						140-143
				144-159	144-151	144-147
						148-151
					152-159	152-155
						156-159
				160-175	16-167	160-163
						164-167
					168-175	168-171
						172-175
				176-191	176-183	176-179
						180-183
					184-191	184-187
						188-191
		192-255		192-207	192-199	192-195
						196-199
					200-207	200-203
						204-207
				208-223	208-215	208-211
						212-215
					216-223	216-219
						220-223
				224-239	224-231	224-227
						228-231
					232-239	232-235
						236-239
				240-255	240-247	240-243
						244-247
					248-255	248-251
						252-255

Visualizing Subnets Using
The Box Method

The box method is the simplest way to visualize the breakdown of subnets and addresses into smaller sizes.

Start with a square. The whole square is a single subnet comprised of 256 addresses.

```
0



                        255
```

/24
255.255.255.0
256 Hosts
1 Subnet
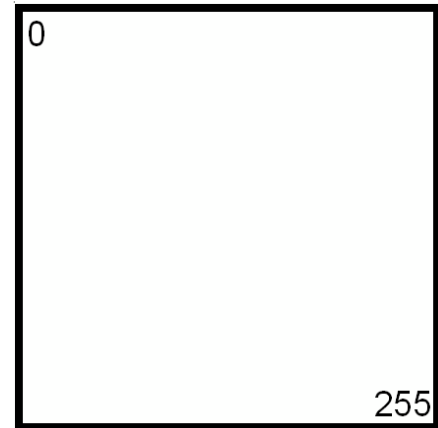
Split the box in half and you get two subnets with 128 addresses,

```
0          128



   127        255
```

/25
255.255.255.128
128 Hosts
2 Subnets
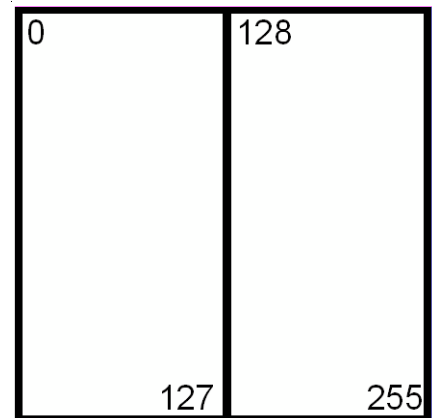
Divide the box into quarters and you get four subnets with 64 addresses,

```
0          128

        63        191
64         192

   127        255
```

/26
255.255.255.192
64 Hosts
4 Subnets

Split each individual square and you get eight subnets with 32 addresses,

0	32	128	160
31	63	159	191
64	96	192	224
95	127	223	255

/27
255.255.255.224
32 Hosts
8 Subnets

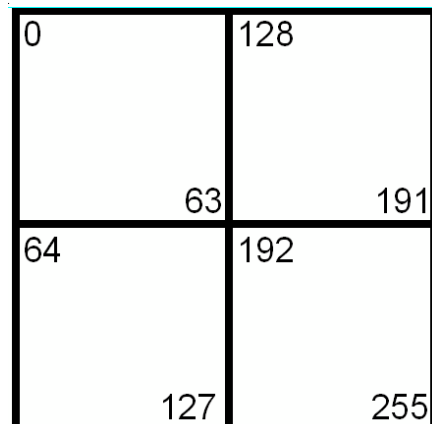Split the boxes in half again and you get sixteen subnets with sixteen addresses,

0	32	128	160
15	47	143	175
16	48	144	176
31	63	159	191
64	96	192	224
79	111	207	239
80	112	208	240
95	127	223	255

/28
255.255.255.240
16 Hosts
16 Subnets

The next split gives you thirty two subnets with eight addresses,

0	8	32	40	128	136	160	168
7	15	39	47	135	143	167	175
16	24	48	56	144	152	176	184
23	31	55	63	151	159	183	191
64	72	96	104	192	200	224	232
71	79	103	111	199	207	321	239
80	88	112	120	208	216	240	248
87	95	119	127	215	223	247	255

/29
255.255.255.248
8 Hosts
32 Subnets

The last split gives sixty four subnets with four addresses each,

0	8	32	40	128	136	160	168
3	11	35	43	131	139	163	171
4	12	36	44	132	140	164	172
7	15	39	47	135	143	167	175
16	24	48	56	144	152	176	184
19	27	51	59	147	155	179	187
20	28	52	60	148	156	180	188
23	31	55	63	151	159	183	191
64	72	96	104	192	200	224	232
67	75	99	107	195	203	227	235
68	76	100	108	196	204	228	236
71	79	103	111	199	207	321	239
80	88	112	120	208	216	240	248
83	91	115	123	211	219	243	251
84	92	116	124	212	220	244	252
87	95	119	127	215	223	247	255

/30
255.255.255.252
4 Hosts
64 Subnets

Class A Addressing Guide

CIDR	# of Bits Borrowed	Subnet Mask	Total # of Subnets	Total # of Hosts	Usable # of Hosts
/8	0	255.0.0.0	1	16,777,216	16,777,214
/9	1	255.128.0.0	2	8,388,608	8,388,606
/10	2	255.192.0.0	4	4,194,304	4,194,302
/11	3	255.224.0.0	8	2,097,152	2,097,150
/12	4	255.240.0.0	16	1,048,576	1,048,574
/13	5	255.248.0.0	32	524,288	524,286
/14	6	255.252.0.0	64	262,144	262,142
/15	7	255.254.0.0	128	131,072	131,070
/16	8	255.255.0.0	256	65,536	65,534
/17	9	255.255.128.0	512	32,768	32,766
/18	10	255.255.192.0	1,024	16,384	16,382
/19	11	255.255.224.0	2,048	8,192	8,190
/20	12	255.255.240.0	4,096	4,096	4,094
/21	13	255.255.248.0	8,192	2,048	2,046
/22	14	255.255.252.0	16,384	1,024	1,022
/23	15	255.255.254.0	32,768	512	510
/24	16	255.255.255.0	65,536	256	254
/25	17	255.255.255.128	131,072	128	126
/26	18	255.255.255.192	262,144	64	62
/27	19	255.255.255.224	524,288	32	30
/28	20	255.255.255.240	1,048,576	16	14
/29	21	255.255.255.248	2,097,152	8	6
/30	22	255.255.255.252	4,194,304	4	2

Class B Addressing Guide

CIDR	# of Bits Borrowed	Subnet Mask	Total # of Subnets	Total # of Hosts	Usable # of Hosts
/16	0	255.255.0.0	1	65,536	65,534
/17	1	255.255.128.0	2	32,768	32,766
/18	2	255.255.192.0	4	16,384	16,382
/19	3	255.255.224.0	8	8,192	8,190
/20	4	255.255.240.0	16	4,096	4,094
/21	5	255.255.248.0	32	2,048	2,046
/22	6	255.255.252.0	64	1,024	1,022
/23	7	255.255.254.0	128	512	510
/24	8	255.255.255.0	256	256	254
/25	9	255.255.255.128	512	128	126
/26	10	255.255.255.192	1,024	64	62
/27	11	255.255.255.224	2,048	32	30
/28	12	255.255.255.240	4,096	16	14
/29	13	255.255.255.248	8,192	8	6
/30	14	255.255.255.252	16,384	4	2

Class C Addressing Guide

CIDR	# of Bits Borrowed	Subnet Mask	Total # of Subnets	Total # of Hosts	Usable # of Hosts
/24	0	255.255.255.0	1	256	254
/25	1	255.255.255.128	2	128	126
/26	2	255.255.255.192	4	64	62
/27	3	255.255.255.224	8	32	30
/28	4	255.255.255.240	16	16	14
/29	5	255.255.255.248	32	8	6
/30	6	255.255.255.252	64	4	2