

IP Addressing and Subnetting

Workbook
Version 1.5

11111110

10010101

00011011

10000110

11010011

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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

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Workbooks included in the series:

IP Addressing and Subnetting Workbooks
ACLs - Access Lists Workbooks
VLSM Variable-Length Subnet Mask Workbooks

Instructors (and anyone else for that matter) please do not post the Instructors version on public websites. When you do this you are giving everyone else worldwide the answers. Yes, students look for answers this way. It also discourages others; myself included, from posting high quality materials.

Binary To Decimal Conversion

128	64	32	16	8	4	2	1	Answers	Scratch Area	
1	0	0	1	0	0	1	0	<u>146</u>	128	64
0	1	1	1	0	1	1	1	<u>119</u>	16	32
1	1	1	1	1	1	1	1	<u>255</u>	2	16
1	1	0	0	0	1	0	1	<u>197</u>	146	4
1	1	1	1	0	1	1	0	<u>246</u>		2
0	0	0	1	0	0	1	1	<u>19</u>		1
1	0	0	0	0	0	0	1	<u>129</u>		119
0	0	1	1	0	0	0	1	<u>49</u>		
0	1	1	1	1	0	0	0	<u>120</u>		
1	1	1	1	0	0	0	0	<u>240</u>		
0	0	1	1	1	0	1	1	<u>59</u>		
0	0	0	0	0	1	1	1	<u>7</u>		
							00011011	<u>27</u>		
							10101010	<u>170</u>		
							01101111	<u>111</u>		
							11111000	<u>248</u>		
							00100000	<u>32</u>		
							01010101	<u>85</u>		
							00111110	<u>62</u>		
							00000011	<u>3</u>		
							11101101	<u>237</u>		
							11000000	<u>192</u>		

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	238	34
0	0	1	0	0	0	1	0	34	-128	-32
0	1	1	1	1	0	1	1	123	110	2
0	0	1	1	0	0	1	0	50	-64	-2
1	1	1	1	1	1	1	1	255	46	0
1	1	0	0	1	0	0	0	200	-32	
0	0	0	0	1	0	1	0	10	14	
1	0	0	0	1	0	1	0	138	-8	
0	0	0	0	0	0	0	1	1	6	
0	0	0	0	1	1	0	1	13	-4	
1	1	1	1	1	0	1	0	250	2	
0	1	1	0	1	0	1	1	107	-2	
1	1	1	0	0	0	0	0	224	0	
0	1	1	1	0	0	1	0	114		
1	1	0	0	0	0	0	0	192		
1	0	1	0	1	1	0	0	172		
0	1	1	0	0	1	0	0	100		
0	1	1	1	0	1	1	1	119		
0	0	1	1	1	0	0	1	57		
0	1	1	0	0	0	1	0	98		
1	0	1	1	0	0	1	1	179		
0	0	0	0	0	0	1	0	2		

Address Class Identification

Address	Class
10.250.1.1	<u>A</u>
150.10.15.0	<u>B</u>
192.14.2.0	<u>C</u>
148.17.9.1	<u>B</u>
193.42.1.1	<u>C</u>
126.8.156.0	<u>A</u>
220.200.23.1	<u>C</u>
230.230.45.58	<u>D</u>
177.100.18.4	<u>B</u>
119.18.45.0	<u>A</u>
249.240.80.78	<u>E</u>
199.155.77.56	<u>C</u>
117.89.56.45	<u>A</u>
215.45.45.0	<u>C</u>
199.200.15.0	<u>C</u>
95.0.21.90	<u>A</u>
33.0.0.0	<u>A</u>
158.98.80.0	<u>B</u>
219.21.56.0	<u>C</u>

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

Network Addresses

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

188.10.18.2 255.255.0.0	<u>188 . 10 . 0 . 0</u>
10.10.48.80 255.255.255.0	<u>10 . 10 . 48 . 0</u>
192.149.24.191 255.255.255.0	<u>192 . 149 . 24 . 0</u>
150.203.23.19 255.255.0.0	<u>150 . 203 . 0 . 0</u>
10.10.10.10 255.0.0.0	<u>10 . 0 . 0 . 0</u>
186.13.23.110 255.255.255.0	<u>186 . 13 . 23 . 0</u>
223.69.230.250 255.255.0.0	<u>223 . 69 . 0 . 0</u>
200.120.135.15 255.255.255.0	<u>200 . 120 . 135 . 0</u>
27.125.200.151 255.0.0.0	<u>27 . 0 . 0 . 0</u>
199.20.150.35 255.255.255.0	<u>199 . 20 . 150 . 0</u>
191.55.165.135 255.255.255.0	<u>191 . 55 . 165 . 0</u>
28.212.250.254 255.255.0.0	<u>28 . 212 . 0 . 0</u>

Host Addresses

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

188.10.18.2 255.255.0.0	<i>0 . 0 . 18 . 2</i>
10.10.48.80 255.255.255.0	<i>0 . 0 . 0 . 80</i>
222.49.49.11 255.255.255.0	<i>0 . 0 . 0 . 11</i>
128.23.230.19 255.255.0.0	<i>0 . 0 . 230 . 19</i>
10.10.10.10 255.0.0.0	<i>0 . 10 . 10 . 10</i>
200.113.123.11 255.255.255.0	<i>0 . 0 . 0 . 11</i>
223.169.23.20 255.255.0.0	<i>0 . 0 . 23 . 20</i>
203.20.35.215 255.255.255.0	<i>0 . 0 . 0 . 215</i>
117.15.2.51 255.0.0.0	<i>0 . 15 . 2 . 51</i>
199.120.15.135 255.255.255.0	<i>0 . 0 . 0 . 135</i>
191.55.165.135 255.255.255.0	<i>0 . 0 . 0 . 135</i>
48.21.25.54 255.255.0.0	<i>0 . 0 . 25 . 54</i>

Default Subnet Masks

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

177.100.18.4	<u>255 . 255 . 0 . 0</u>
119.18.45.0	<u>255 . 0 . 0 . 0</u>
191.249.234.191	<u>255 . 255 . 0 . 0</u>
223.23.223.109	<u>255 . 255 . 255 . 0</u>
10.10.250.1	<u>255 . 0 . 0 . 0</u>
126.123.23.1	<u>255 . 0 . 0 . 0</u>
223.69.230.250	<u>255 . 255 . 255 . 0</u>
192.12.35.105	<u>255 . 255 . 255 . 0</u>
77.251.200.51	<u>255 . 0 . 0 . 0</u>
189.210.50.1	<u>255 . 255 . 0 . 0</u>
88.45.65.35	<u>255 . 0 . 0 . 0</u>
128.212.250.254	<u>255 . 255 . 0 . 0</u>
193.100.77.83	<u>255 . 255 . 255 . 0</u>
125.125.250.1	<u>255 . 0 . 0 . 0</u>
1.1.10.50	<u>255 . 0 . 0 . 0</u>
220.90.130.45	<u>255 . 255 . 255 . 0</u>
134.125.34.9	<u>255 . 255 . 0 . 0</u>
95.250.91.99	<u>255 . 0 . 0 . 0</u>

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:	<u>192 . 100 . 10</u> . 33
Host Portion:	192 . 100 . 10 . <u>33</u>

In order for your 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)

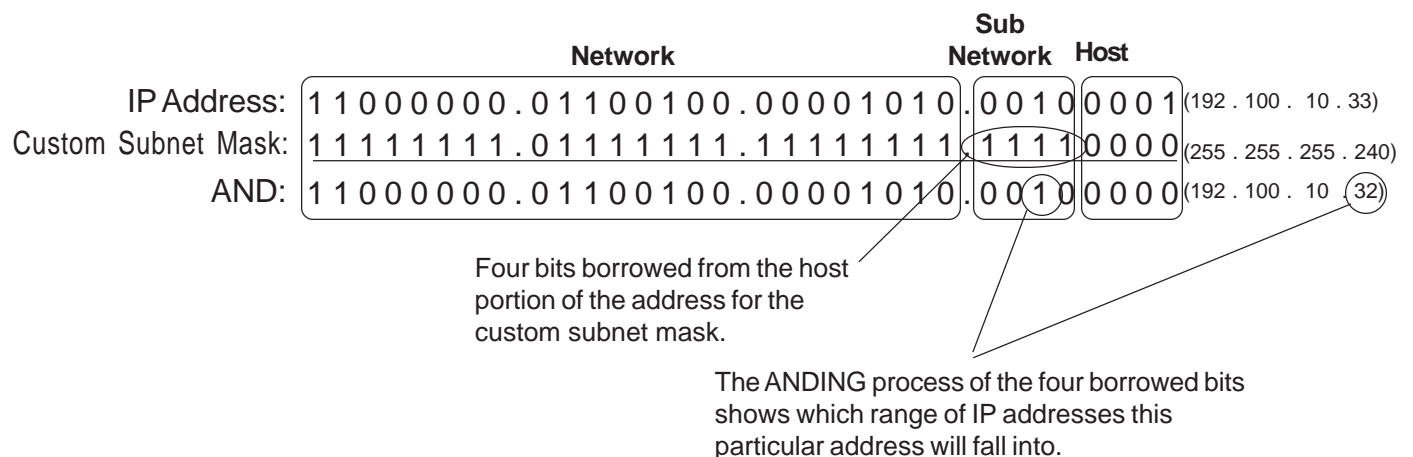
ANDING with the default subnet mask allows your computer to figure out the network portion of the address.

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



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 $2 \times 2 \times 2 = 8$ 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 $2 \times 2 \times 2 \times 2 \times 2 = 32$ 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 $2 \times 2 = 4$ subnets.

The number of hosts created by leaving 6 bits is $2^6 - 2$ or $2 \times 2 \times 2 \times 2 \times 2 \times 2 = 64 - 2 = 62$ 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 addresses.

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

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

Notice that the subnet and broadcast addresses match.

The primary reason the the zero and broadcast subnets were not used had to do primarily 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 whether 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 <u>don't use</u> the zero and broadcast ranges if...	Use the 2^S formula and <u>use</u> 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

Bottom line for the CCNA exams; if a question does not give you any clues as to whether or not to allow these two subnets, assume you can use them.

This workbook has you use the number of subnets = 2^S formula.

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.

	256	128	64	32	16	8	4	2	1	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 . 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
64
32
+16
<hr/> 240

16	Observe the total number of hosts.
-2	
<hr/> 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	4096	8192	16384	32768	65536
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

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
-2
62

Observe the total number of hosts.
Subtract 2 for the number of usable hosts.

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.

	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 Hosts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of Subnets	-	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768
Binary values	-	128	64	32	16	8	4	2	1	128	64	32	16	8	4	2
		148	75	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	
<u>255</u>	

64	Observe the total number of hosts.
-2	
<u>62</u>	Subtract 2 for the number of usable hosts.

1024	
-2	
<u>1,022</u>	Subtract 2 for the total number of subnets to get the usable number of 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 C

Default subnet mask 255 . 255 . 255 . 0

Custom subnet mask 255 . 255 . 255 . 224

Total number of subnets 8

Total number of host addresses 32

Number of usable addresses 30

Number of bits borrowed 3

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 .	0	0	0	0	0	0	0	0		

128	32	8
64	-2	-2
+32	30	6
224		

Custom Subnet Masks

Problem 5

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

Address class C

Default subnet mask 255 . 255 . 255 . 0

Custom subnet mask 255 . 255 . 255 . 224

Total number of subnets 8

Total number of host addresses 32

Number of usable addresses 30

Number of bits borrowed 3

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 .				0	0	0	0	0	0	0	0	0	
128													
64				8			32						
+32				-2			-2						
224				6			30						

Custom Subnet Masks

Problem 7

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

Address class B

Default subnet mask 255 . 255 . 0 . 0

Custom subnet mask 255 . 255 . 255 . 224

Total number of subnets 2,048

Total number of host addresses 32

Number of usable addresses 30

Number of bits borrowed 11

Show your work for Problem 7 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	0

$$\begin{array}{r}
 128 \\
 64 \\
 32 \\
 16 \\
 8 \\
 4 \\
 2 \\
 +1 \\
 \hline
 255
 \end{array}
 \qquad
 \begin{array}{r}
 2,048 \\
 -2 \\
 \hline
 2,046
 \end{array}
 \qquad
 \begin{array}{r}
 32 \\
 -2 \\
 \hline
 30
 \end{array}$$

Custom Subnet Masks

Problem 8

Number of needed subnets **3**

Number of needed usable hosts **45**

Network Address **200.175.14.0**

Address class C

Default subnet mask 255 . 255 . 255 . 0

Custom subnet mask 255 . 255 . 255 . 192

Total number of subnets 4

Total number of host addresses 64

Number of usable addresses 62

Number of bits borrowed 2

Show your work for Problem 8 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
200 . 175 . 14 .	0	0	0	0	0	0	0	0		

128	4	64
+64	-2	-2
<hr/> 240	<hr/> 2	<hr/> 62

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 B

Default subnet mask 255 . 255 . 0 . 0

Custom subnet mask 255 . 255 . 252 . 0

Total number of subnets 64

Total number of host addresses 1,024

Number of usable addresses 1,022

Number of bits borrowed 6

Show your work for Problem 9 in the space below.

	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 Hosts	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Number of Subnets	-	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768
Binary values	-	128	64	32	16	8	4	2	1	128	64	32	16	8	4	2
		128	77	0	0	0	0	0	0	0	0	0	0	0	0	0

128		
64		
32		
16		
8	64	1,024
+4	-2	-2
<hr/> 252	<hr/> 62	<hr/> 1,022

Custom Subnet Masks

Problem 10

Number of needed usable hosts **60**

Network Address **198.100.10.0**

Address class C

Default subnet mask 255 . 255 . 255 . 0

Custom subnet mask 255 . 255 . 255 . 192

Total number of subnets 4

Total number of host addresses 64

Number of usable addresses 62

Number of bits borrowed 2

Show your work for Problem 10 in the space below.

	256	128	64	32	16	8	4	2	1	Number of Hosts
Number of Subnets	-	2	4	8	16	32	64	128	256	
	128	64	32	16	8	4	2	1	-	Binary values
198 . 100 . 10 .	0	0	0	0	0	0	0	0	0	

128	64	4
+64	-2	-2
192	62	2

Custom Subnet Masks

Problem 11

Number of needed subnets **250**

Network Address **101.0.0.0**

Address class A

Default subnet mask 255 . 0 . 0 . 0

Custom subnet mask 255 . 255 . 0 . 0

Total number of subnets 256

Total number of host addresses 65,536

Number of usable addresses 65,534

Number of bits borrowed 8

Show your work for **Problem 11** in the space below.

Number of Hosts	1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768	65536	131072	262144	524288	1048576	2097152	4194304	8388608	16777216	33554432	67108864	134217728	268435456	536870912	1073741824	2147483648	4294967296	8589934592	17179869184	34359738368	68719476736	137438953472	274877906944	549755813888	1099511627776	2199023255552	4398046511104	8796093022208	17592186044416	35184372088832	70368744177664	140737488355328	281474976710656	562949953421312	1125899906842624	2251799813685248	4503599627370496	9007199254740992	18014398509481984	36028797018963968	72057594037927936	144115188075855872	288230376151711744	576460752303423488	1152921504606846976	2305843009213693952	4611686018427387904	9223372036854775808	18446744073709551616	36893488147419103232	73786976294838206464	147573952589676412928	295147905179352825856	590295810358705651712	1180591620717411303424	2361183241434822606848	4722366482869645213696	9444732965739290427392	18889465931478580854784	37778931862957161709568	75557863725914323419136	151115727451828646838272	302231454903657293676544	604462909807314587353088	1208925819614629174706176	2417851639229258349412352	4835703278458516698824704	9671406556917033397649408	19342813113834066795298816	38685626227668133590597632	77371252455336267181195264	154742504910672534362390528	309485009821345068724781056	618970019642690137449562112	1237940039285380274899124224	2475880078570760549798248448	4951760157141521099596496896	9903520314283042199192993792	19807040628566084398385987584	39614081257132168796771975168	79228162514264337593543950336	158456325028528675187087900672	316912650057057350374175801344	633825300114114700748351602688	1267650600228229401496703205376	2535301200456458802993406410752	5070602400912917605986812821504	10141204801825835211973625643008	20282409603651670423947251286016	40564819207303340847894502572032	81129638414606681695789005144064	162259276829213363391578010288128	324518553658426726783156020576256	649037107316853453566312041152512	1298074214633706907132624082305024	2596148429267413814265248164610048	5192296858534827628530496329220096	10384593717069655257060992658440192	20769187434139310514121985316880384	41538374868278621028243970633760768	83076749736557242056487941267521536	166153499473114484112975882535043072	332306998946228968225951765070086144	664613997892457936451903530140172288	1329227995784915872903807060280344576	2658455991569831745807614120560689152	5316911983139663491615228241121378304	10633823966279326983230456482242756608	21267647932558653966460912964485513216	42535295865117307932921825928971026432	85070591730234615865843651857942052864	170141183460469231731687303715884105216	340282366920938463463374607431768210432	680564733841876926926749214863536420864	1361129467683753853853498429727072841728	2722258935367507707706996859454145683456	5444517870735015415413993718908291366912	10889035741470030830827987437816582733824	21778071482940061661655974875633165467648	43556142965880123323311949751266330935296	87112285931760246646623899502532661870592	17422457186352049329324779900506532354112	34844914372704098658649559801013064708224	69689828745408197317299119602026129416448	139379657490816394634598239204052258832896	278759314981632789269196478408104517665792	557518629963265578538392956816209035331584	1115037259926531157076785913632418070663168	2230074519853062314153571827264836141326336
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Custom Subnet Masks

Problem 12

Number of needed subnets **5**

Network Address **218.35.50.0**

Address class C

Default subnet mask 255 . 255 . 255 . 0

Custom subnet mask 255 . 255 . 255 . 224

Total number of subnets 8

Total number of host addresses 32

Number of usable addresses 30

Number of bits borrowed 3

Show your work for Problem 12 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
218 . 35 . 50 .	0	0	0	0	0	0	0	0		

128		
64	64	4
+32	-2	-2
224	62	2

Custom Subnet Masks

Problem 13

Number of needed usable hosts **25**

Network Address **218.35.50.0**

Address class C

Default subnet mask 255 . 255 . 255 . 0

Custom subnet mask 255 . 255 . 255 . 224

Total number of subnets 8

Total number of host addresses 32

Number of usable addresses 30

Number of bits borrowed 3

Show your work for Problem 13 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
218 . 35 . 50 .	0	0	0	0	0	0	0	0	0	

128		
64	8	32
+32	-2	-2
224	6	30

Custom Subnet Masks

Problem 14

Number of needed subnets **10**

Network Address **172.59.0.0**

Address class **B**

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

Custom subnet mask **255 . 255 . 240 . 0**

Total number of subnets **16**

Total number of host addresses **4,096**

Number of usable addresses **4,094**

Number of bits borrowed **4**

Show your work for Problem 14 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	4096	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
	172	59	0	0	0	0	0	0	0	0	0	0	0	0	0	0

$$\begin{array}{r}
 128 \\
 64 \\
 32 \\
 +16 \\
 \hline
 240
 \end{array}
 \qquad
 \begin{array}{r}
 16 \\
 -2 \\
 \hline
 14
 \end{array}
 \qquad
 \begin{array}{r}
 4,096 \\
 -2 \\
 \hline
 4,094
 \end{array}$$