IP Addressing and Subnetting

Workbook

Version 1.4

11111110

10010101

00011011

10000110

Student Name:

IP Address Classes

Class A	1 – 127	(Network 127 is reserved for loopback and internal testing)

Class A   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 Workbook Instructors Edition
IP Addressing and Subnetting IP Workbook
Access Lists Instructors Edition
Access Lists
VLSM Variable-Length Subnet Mask Instructors Edition
VLSM Variable-Length Subnet Mask

Binary To Decimal Conversion

128	64	32	16	8	4	2	1	Answers	Scratch Area
1	0	0	1	0	0	1	0	146	128 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		146 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	

1

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 work:

$$238$$
$$-128$$
$$\overline{110}$$
$$-64$$
$$\overline{46}$$
$$-32$$
$$\overline{14}$$
$$-8$$
$$\overline{6}$$
$$-4$$
$$\overline{2}$$
$$-2$$
$$\overline{0}$$

$$34$$
$$-32$$
$$\overline{2}$$
$$-2$$
$$\overline{0}$$

2

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:	Circle the host portion of these addresses:
(177.100.)18.4	10.(15.123.50)
(119.)18.45.0	171.2.(199.31)
209.240.80.78	198.125.87.177
199.155.77.56	223.250.200.222
117.89.56.45	17.45.222.45
215.45.45.0	126.201.54.231
192.200.15.0	191.41.35.112
95.0.21.90	155.25.169.227
33.0.0.0	192.15.155.2
158.98.80.0	123.102.45.254
217.21.56.0	148.17.9.155
10.250.1.1	100.25.1.1
150.10.15.0	195.0.21.98
192.14.2.0	25.250.135.46
148.17.9.1	171.102.77.77
193.42.1.1	55.250.5.5
126.8.156.0	218.155.230.14
220.200.23.1	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
_____ *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   (Invalid Range)
                       192.100.10.16 to 192.100.10.31   (1st Usable Range)
                       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 (Invalid Range)

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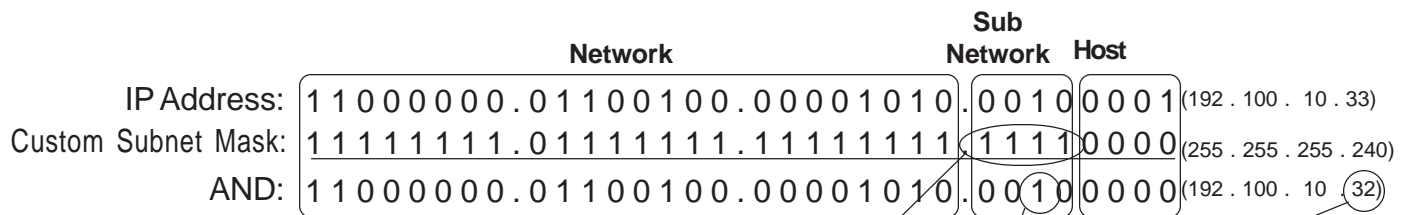
Four bits borrowed from the host portion of the address for the custom subnet mask.

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.

Custom Subnet Masks

Problem 1

Number of needed usable 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* _____

Number of usable subnets _____ *14* _____

Total number of host addresses _____ *16* _____

Number of usable addresses _____ *14* _____

Number of bits borrowed _____ *4* _____

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 . 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.

Subtract 2 for the total number of subnets to get the usable number of subnets.

16
−2
―――
14

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Custom Subnet Masks

Problem 2

Number of needed usable 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*_____

Number of usable subnets _____*1,022*_____

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

```
          128    128
           64   +64
           32   ----
           16    192
            8
            4
Add the binary value
numbers to the left of    2
the line to create the   +1
custom subnet mask.      ----
                         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
-----    subnets.
1,022
```

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Custom Subnet Masks

Problem 3

Network Address **148.75.0.0 /26**

Address class _____ *B* _____

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

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

Total number of subnets _____ *1,024* _____

Number of usable subnets _____ *1,022* _____

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     ────
  16      192
   8
   4
   2
  +1
 ────
 255
```

```
1024
 -2
────
1,022
```

Subtract 2 for the total number of subnets to get the usable number of subnets.

```
 64
 -2
────
 62
```

Observe the total number of hosts.

Subtract 2 for the number of usable hosts.

Custom Subnet Masks

Problem 4

Number of needed usable 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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for Problem 4 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

210 . 100 . 56 . 0 0 0 | 0 0 0 0 0

Custom Subnet Masks

Problem 5

Number of needed usable 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 _____

Number of usable 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 . 0 0 0 | 0 0 0 0 0

Custom Subnet Masks

Problem 6

Number of needed usable 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 _____

Number of usable 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	
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 usable 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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

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

Custom Subnet Masks

Problem 8

Number of needed usable subnets **1**

Number of needed usable hosts **45**

Network Address **200.175.14.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Number of usable 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 usable 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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

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

Custom Subnet Masks

Problem 10

Number of needed usable hosts **60**

Network Address **198.100.10.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Number of usable 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 usable subnets **250**

Network Address **101.0.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Number of usable 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 usable subnets **5**

Network Address **218.35.50.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Number of usable 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 _____

Number of usable 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 usable subnets **10**

Network Address **172.59.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Number of usable 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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

Show your work for Problem 15 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 _____

Number of usable 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 usable 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*_____

Number of usable subnets _____*14*_____

Total number of host addresses _____*16*_____

Number of usable addresses _____*14*_____

Number of bits borrowed _____*4*_____

What is the 3rd usable
subnet range? _____*192.10.10.48 to 192.10.10.63*_____

What is the subnet number
for the 7th usable subnet? _____*192 . 10 . 10 . 112*_____

What is the subnet
broadcast address for
the 12th usable subnet? _____*192 . 10 . 10 . 207*_____

What are the assignable
addresses for the 8th
usable subnet? _____*192.10.10.129 to 192.10.10.142*_____

	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

(Invalid range)	(0)	O O O O	192.10.10.0	to	192.10.10.15
	(1)	O O O 1	192.10.10.16	to	192.10.10.31
	(2)	O O 1 O	192.10.10.32	to	192.10.10.47
	(3)	O O 1 1	192.10.10.48	to	192.10.10.63
	(4)	O 1 O O	192.10.10.64	to	192.10.10.79
	(5)	O 1 O 1	192.10.10.80	to	192.10.10.95
	(6)	O 1 1 O	192.10.10.96	to	192.10.10.111
	(7)	O 1 1 1	192.10.10.112	to	192.10.10.127
	(8)	1 O O O	192.10.10.128	to	192.10.10.143
	(9)	1 O O 1	192.10.10.144	to	192.10.10.159
	(10)	1 O 1 O	192.10.10.160	to	192.10.10.175
	(11)	1 O 1 1	192.10.10.176	to	192.10.10.191
	(12)	1 1 O O	192.10.10.192	to	192.10.10.207
	(13)	1 1 O 1	192.10.10.208	to	192.10.10.223
	(14)	1 1 1 O	192.10.10.224	to	192.10.10.239
(Invalid range)	(15)	1 1 1 1	192.10.10.240	to	192.10.10.255

Custom subnet mask
$$\begin{array}{r} 128 \\ 64 \\ 32 \\ +16 \\ \hline 240 \end{array}$$

Usable subnets
$$\begin{array}{r} 16 \\ -2 \\ \hline 14 \end{array}$$

Usable hosts
$$\begin{array}{r} 16 \\ -2 \\ \hline 14 \end{array}$$

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

The first and last range of addresses are not usable.

The first usable range of addresses is: 192.10.10.16 to 192.10.10.31.

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 usable 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_____

Number of usable subnets _____1,022_____

Total number of host addresses _____64_____

Number of usable addresses _____62_____

Number of bits borrowed _____10_____

What is the 14th usable
subnet range? _____165.100.3.128 to 165.100.3.191_____

What is the subnet number
for the 5th usable subnet? _____165 . 100 . 1 . 64_____

What is the subnet
broadcast address for
the 5th usable subnet? _____165 . 100 . 1 . 127_____

What are the assignable
addresses for the 8th
usable subnet? _____165.100.2.1 to 165.100.0.62_____

Number of Hosts ~ 65,536 32,768 16,384 8,192 4,096 2048 1024 512 256 128

Number of Subnets ~ 2 4 8 16 32 64 128 256 512

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

165 . 100 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0 . 0 0 0 0 0 0 0 0

Number of Hosts:
512 ~ 2
1,024 ~ 4
2,048 ~ 8
4,096 ~ 16
8,192 ~ 32
16,384 ~ 64
32,768 ~ 128
65,536 ~ 256

64
Usable ~2
hosts 62

1024
Usable ~2
subnets 1,022

Custom   128
         +64
subnet mask 192
             +1
             255

128
64
32
16
8
4
2
+1

The binary value of the last bit borrowed is the range. In this problem the range is 64.

The first and last range of addresses are not usable.

The first usable range of addresses is: 165.100.0.64 to 165.100.0.127

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

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

(Invalid range) (0) 165.100.0.0 to 165.100.0.63
              (1) 165.100.0.64 to 165.100.0.127
              (2) 165.100.0.128 to 165.100.0.191
              (3) 165.100.0.192 to 165.100.0.255
              (4) 165.100.1.0 to 165.100.1.63
              (5) 165.100.1.64 to 165.100.1.127
              (6) 165.100.1.128 to 165.100.1.191
              (7) 165.100.1.192 to 165.100.1.255
              (8) 165.100.2.0 to 165.100.2.63
              (9) 165.100.2.64 to 165.100.2.127
             (10) 165.100.2.128 to 165.100.2.191
             (11) 165.100.2.192 to 165.100.2.255
             (12) 165.100.3.0 to 165.100.3.63
             (13) 165.100.3.64 to 165.100.3.127
             (14) 165.100.3.128 to 165.100.3.191
             (15) 165.100.3.192 to 165.100.3.255

Down to

          (1022) 165.100.255.128 to 165.100.255.191
(Invalid range) (1023) 165.100.255.192 to 165.100.255.255

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Subnetting

Problem 3

Number of needed usable subnets **1**

Network Address **195.223.50.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 2nd usable
subnet range? _____

What is the subnet number
for the 1st usable subnet? _____

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

What are the assignable
addresses for the 2nd
usable 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 usable subnets **750**

Network Address **190.35.0.0**

Address class _____ Class B

Default subnet mask _____ 255.255.0.0

Custom subnet mask _____ 255.255.255.192

Total number of subnets _____ 1024

Number of usable subnets _____ 1022

Total number of host addresses _____ 64

Number of usable addresses _____ 62

Number of bits borrowed _____ 10

What is the 14th usable subnet range? _____ 190.35.3.128 – 190.35.3.191

What is the subnet number for the 12th usable subnet? _____ 190.35.3.0

What is the subnet broadcast address for the 9th usable subnet? _____ 190.35.2.127

What are the assignable addresses for the 5th usable subnet? _____ 190.35.1.65 – 190.35.1.126

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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 1st usable
subnet range? _____

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

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

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

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

Subnetting

Problem 6

Number of needed usable subnets **10**

Network Address **192.70.10.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 8th usable
subnet range? _____

What is the subnet number
for the 3rd usable subnet? _____

What is the subnet
broadcast address for
the 11th usable subnet? _____

What are the assignable
addresses for the 9th
usable 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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 10th usable
subnet range? _____

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

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

What are the assignable
addresses for the 8th
usable subnet? _____

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

Subnetting

Problem 8

Number of needed usable subnets **4**

Network Address **172.50.0.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 3rd usable
subnet range? _____

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

What is the subnet
broadcast address for
the 5th usable subnet? _____

What are the assignable
addresses for the 2nd
usable 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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 1st usable
subnet range? _____

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

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

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

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

Subnetting

Problem 10

Number of needed usable subnets **45**

Network Address **220.100.100.0**

Address class _____

Default subnet mask _____

Custom subnet mask _____

Total number of subnets _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 4th usable
subnet range? _____

What is the subnet number
for the 3rd usable subnet? _____

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

What are the assignable
addresses for the 11th
usable subnet? _____

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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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 5th usable
subnet range? _____

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

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

What are the assignable
addresses for the 4th
usable 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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 1st usable
subnet range? _____

What is the subnet number
for the 1st usable subnet? _____

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

What are the assignable
addresses for the 2nd
usable 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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 9th usable subnet range? _____

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

What is the subnet broadcast address for the 1022nd usable subnet? _____

What are the assignable addresses for the 1021st usable 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 _____

Number of usable subnets _____

Total number of host addresses _____

Number of usable addresses _____

Number of bits borrowed _____

What is the 6th usable
subnet range? _____

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

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

What are the assignable
addresses for the 5th
usable 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__

Number of usable subnets __2046__

Total number of host addresses __8192__

Number of usable addresses __8190__

Number of bits borrowed __11__

What is the 14th usable subnet range? __93.1.192.0 – 93.1.223.255__

What is the subnet number for the 8th usable subnet? __93.1.0.0__

What is the subnet broadcast address for the 6th usable subnet? __93.0.223.255__

What are the assignable addresses for the 11th usable subnet? __93.1.96.1 – 93.1.127.254__

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

Valid and Non-Valid IP Addresses

Using the material in this workbook identify which of the addresses below are correct and usable. If they are not usable addresses explain why.

IP Address: 0.230.190.192
Subnet Mask: 255.0.0.0
Reference Page Inside Front Cover

The network ID cannot be 0.
_____

IP Address: 192.10.10.1
Subnet Mask: 255.255.255.0
Reference Pages 26-27

_OK_ _____
_____

IP Address: 245.150.190.10
Subnet Mask: 255.255.255.0
Reference Page Inside Front Cover

_____
_____

IP Address: 135.70.191.255
Subnet Mask: 255.255.254.0
Reference Pages 46-47

_____
_____

IP Address: 127.100.100.10
Subnet Mask: 255.0.0.0
Reference Pages Inside Front Cover

_____
_____

IP Address: 93.0.128.1
Subnet Mask: 255.255.224.0
Reference Pages 54-55

_____
_____

IP Address: 200.10.10.128
Subnet Mask: 255.255.255.224
Reference Pages 52-53

_____
_____

IP Address: 165.100.255.189
Subnet Mask: 255.255.255.192
Reference Pages 28-29

_____
_____

IP Address: 190.35.0.10
Subnet Mask: 255.255.255.192
Reference Pages 32-33

_____
_____

IP Address: 218.35.50.195
Subnet Mask: 255.255.0.0
Reference Page Inside Front Cover

_____
_____

IP Address: 200.10.10.175 /22
Reference Pages 52-53 and/or Inside Front Cover

_____
_____

IP Address: 135.70.255.255
Subnet Mask: 255.255.224.0
Reference Pages 46-47

_____
_____

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IP Address Breakdown

/24 255.255.255.0 256 Hosts	/25 255.255.255.128 128 Hosts	/26 255.255.255.192 64 Hosts	/27 255.255.255.224 32 Hosts	/28 255.255.255.240 16 Hosts	/29 255.255.255.248 8 Hosts	/30 255.255.255.252 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.
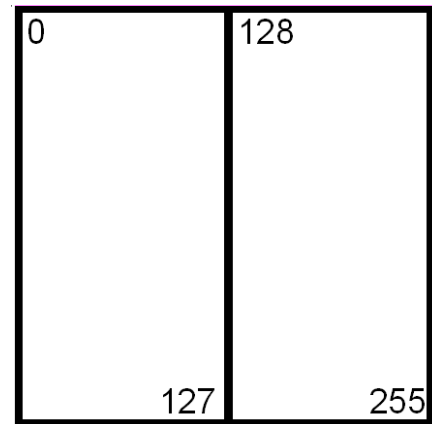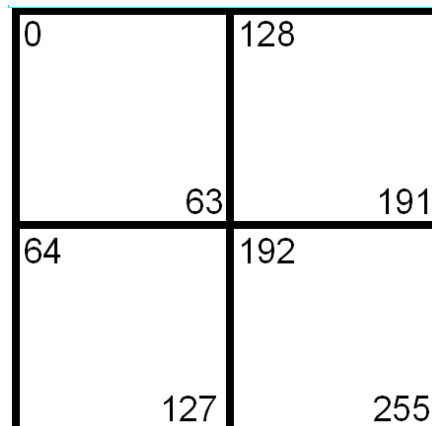
/24
255.255.255.0
256 Hosts
1 Subnet
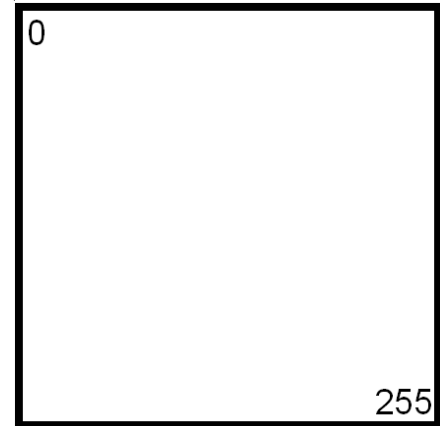
Split the box in half and you get two subnets with 128 addresses,

/25
255.255.255.128
128 Hosts
2 Subnets

Divide the box into quarters and you get four subnets with 64 addresses,

/26
255.255.255.192
64 Hosts
4 Subnets

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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

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

Class B Addressing Guide

# of Bits Borrowed	Subnet Mask	Total # of Subnets	Usable # of Subnets	Total # of Hosts	Usable # of Hosts
2	255.255.192.0	4	2	16,384	16,382
3	255.255.224.0	8	6	8,192	8,190
4	255.255.240.0	16	14	4,096	4,094
5	255.255.248.0	32	30	2,048	2,046
6	255.255.252.0	64	62	1,024	1,022
7	255.255.254.0	128	126	512	510
8	255.255.255.0	256	254	256	254
9	255.255.255.128	512	510	128	126
10	255.255.255.192	1,024	1,022	64	62
11	255.255.255.224	2,048	2,046	32	30
12	255.255.255.240	4,096	4,094	16	14
13	255.255.255.248	8,192	8,190	8	6
14	255.255.255.252	16,384	16,382	4	2

Class C Addressing Guide

# of Bits Borrowed	Subnet Mask	Total # of Subnets	Usable # of Subnets	Total # of Hosts	Usable # of Hosts
2	255.255.255.192	4	2	64	62
3	255.255.255.224	8	6	32	30
4	255.255.255.240	16	14	16	14
5	255.255.255.248	32	30	8	6
6	255.255.255.252	64	62	4	2