Chapter 12 – IP Addressing and Subnetting

List of all possible valid network numbers….reference table for the number of network, size of the network part, size of the host part, for Class A,B and C ip networks.

	Class A	Class B	Class C
First Octect range	1 to 126	128 - 191	192 – 223
Valid Network Numbers	1.0.0.0 to 126.0.0.0	128.0.0.0 191.255.0.0	192.0.0.0 to 223.255.255.0
Number of networks in this Class	2 ^ 7 – 2 = 128	2 ^ 14 = 16,384	2 ^ 21= 2,097,152
Number of hosts per network	2 ^ 24 – 2 = 16,777,214	2 ^ 16 – 2 = 65,534	2 ^ 8 – 2 = 254
Size of network part of the address (bytes)	1	2	3
Size of hosts part of the address (bytes)	3	2	1

^ *raised to*

CLASS A (7 Network Bits)

0	N	N	N	N	N	N	N	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8

CLASS B (6 + 8 = 14 Network Bits)

1	0	N	N	N	N	N	N	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8

CLASS C (5 + 16 = 21 Network Bits)

1	1	0	N	N	N	N	N	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8

Class A , B and C network, network and host parts and default mask

Class of Address	Size of network part of address in bits	Size of host part of address in bits	Default mask for each class of network
A	8	24	255.0.0.0.
B	16	16	255.255.0.0
C	24	8	255.255.255.0

RFC 1918 Private IP Address Space

Private IP Networks	Class of Networks	Number of Networks
10.0.0.0 through 10.0.0.0	A	1
172.16.0.0 through 172.31.0.0	B	16
192.168.0.0 through 192.168.255.0	C	255

IPv6 – 128 bit IP address : can provide 10 ^ 38 IP Addresses.
Currently in the earth there are 10 ^ 10 people living.

IPv4 vs IPv6

Feature	IPv4	IPv6
Size of address	32 bits , 4 octects	128 bits , 16 octects
Example address	10.1.1.1	0000:0000:0000:0000:FFFF:FFFF:0A01:0101
Same address abrreviated	----	::FFFF:FFFF:0A01:0101
Number of possible addresses, ignoring reseved addresses	2 ^ 32 Approx 4 billion	2 ^ 128 , or roughly 3.4 x 10 ^ 38

Bitwise Boolean AND example

	Decimal	Binary
Address	150.150.2.1	10010110 10010110 00000010 00000001
Mask	255.255.255.0	11111111 11111111 11111111 00000000
Result of AND	150.150.2.0	10010110 10010110 00000010 00000000

255.255.255.0 – 11111111 11111111 11111111 00000000
Is written as a /24 subnet mask.

Binary process to convert between Dotted decimal and prefix notation

Step 1. Covert the dotted decimal mask to binary
Step 2. Count the number of binary 1s in the 32 bit binary mask, this is the value of the prefix notation mask

Eg. 255.255.240.0 converts to….
11111111 11111111 11110000 00000000
The mask has 20 binary 1s, so the prefix notation of the same mask is /20.

Convert prefix notation to a dotted decimal format…

Step 1. write down x binary 1s, where x is the value listed in the prefix notation of the mask

Step 2. Write down binary 0s after binary 1s until you have written down all the 32 bits

Step 3. Convert this binary number, 8 bit at a time to dotted decimal format.

Eg. /20 converts to
11111111 11111111 11110000 00000000
255.255.240.0

Nine possible Decimal Numbers in a subnet mask

Subnet mask's Decimal Octect	Binary Equivalent	Number of Binary 1s	Number of Binary 0s
0	00000000	0	8
128	10000000	1	7
192	11000000	2	6
224	11100000	3	5
240	11110000	4	4
248	11111000	5	3
252	11111100	6	2
254	11111110	7	1
255	11111111	8	0

Convert a dotted decimal subnet mask format to a prefix format….

Step 1. Start with a prefix value of 0
Step 2. For each dotted decimal octect, add the number of binary 1s, listed for that decimal value in the table above
Step 3. Prefix length is /x , where x is the sum calculated in Step 2.

Eg. 255.255.240.0

Start from 0
First octect 255 add 8
Second octect 255 add 8
Third octect 240 add 4
Fourth octect 0 add 0

Prefix is 20

Converting a /20 subnet into dotted decimal format….

Step 1. Divide x by 8 (x / 8) , noting the number of times 8 goes fully into x , the dividend represented as d, and the number left over, the reminder represented as r.

Step 2. write down d octets of 255,

Step 3. for the next octet, find the decimal number that begins with r, binary 1s, Followed by all binary 0s.

Step 4. for any remaining octets write down value 0

20 / 8 = 2 and a reminder of 4

2 octects with all binary 1s , third octed with 1 birary 1 and 4 binary 0 , and last one with all binary 0s.

255.255.240.0

Appendix D. Problem Set 1.

255.240.0.0	- 8+4+0+0+ = /12
255.255.192.0	– 8+8+2+0 = /18
255.255.255.224	– 8+8+8+3 = /27
255.254.0.0	– 8+7+0+0 = /15
255.255.248.0	- 8+8+5+0 = /21

/30	- 255.255.255.252
/25	- 255.255.255.128
/11	- 255.224.0.0
/22	- 255.255.252.0
/24	- 255.255.255.0

255.240.0.0	- 11111111 11110000 00000000 00000000	-	/12
255.255.192.0	– 11111111 11111111 11000000 00000000		/18
255.255.255.224	– 11111111 11111111 11111111 11100000		/27
255.254.0.0	– 11111111 11111110 00000000 00000000		/15
255.255.248.0	- 11111111 11111111 11111000 00000000		/21

/30	- 11111111 11111111 11111111 11111100	255.255.255.252
/25	- 11111111 11111111 11111111 10000000	255.255.255.128
/11	- 11111111 11100000 00000000 00000000	255.224.0.0
/22	- 11111111 11111111 11111100 00000000	255.255.252.0
/24	- 11111111 11111111 11111111 00000000	255.255.255.0

ANALYSING AND CHOOSING SUBNET MASKS

SLSM – Static Length Subnet Mask
VLSM – Variable Length Subnet Mask

How to find the size of the Network , Subnet and Host part of an IP Address…

- The network part of the address is always defined by the class rule
- The host part of the address is defined by the subnet mask, the number of binary zeros in the subnet mask defines the number of host bits.
- Subnet part of the address is what is left over in the 32 bit address

IP Address : 8.1.4.5
Mask : 255.255.0.0
Class : A
Network Bits : 8
Host bits : 16
Subnet bits : 32 – 24 = 8

IP Address : 130.4.102.1
Mask : 255.255.255.0
Class : B
Network Bits : 16
Host bits : 8
Subnet bits : 32 – 24 = 8

IP Address : 199.1.1.100
Mask : 255.255.255.0
Class : C
Network Bits : 24
Host bits : 8
Subnet bits : 32 – 32 = 0

Facts about how the subnet mask identifies part of the structure of an IP address

- A subnet masks binary 1s define the combined network and subnet part of an IP address
- The masks binary 0s define the hosts part of the IP address
- Class rules define the size of the network part

Finding the Network, Subnet and Host part using binary…..

Step 1. Compare the first octet of the address to the table of Class A,B or C addresses, write down the number of network bits depending on the address class.

Step 2. Find the number of hosts bits by

a. Converting subnet masks to binary
b. Counting the number of binary 0s in the mask

Step 3. Calculate the number of subnet bits by subtracting the combined network and hosts bits from 32.

Decimal Process : Finding the Network, Subnet and Hosts bits in a subnet mask

Step 1. Compare the first octet of the address to the table of Class A,B or C addresses; write down the number of network bits based on the address class.

Step 2. If the mask is in dotted decimal format, convert the mask to prefix format

Step 3. To find the number of host bits, subtract the prefix length from 32

Step 4. Calculate the number of subnet bits by subtracting the combined network and hosts bits from 32

Given a class full network number and a single subnet mask is used throughout the classfull network.

Number of subnets :- 2 ^ s , where s is the number of subnet bits
Number of hosts :- 2 ^ h , where h is the number of host bits

When to use which formula for number of subnets

Use the 2 ^ s – 2 formula, and avoid using the zero subnet and broadcast subnet if…	Use the 2 ^ s formula, and use the zero and broadcast subnet if…
Classful routing protocol	Classless routing protocol
RIP version 1 or IGRP as the routing protocol	RIP Version 2, EIGRP or OSPF as the routing protocol
The **no ip subnet zero** command is configured	The **ip subnet zero** command is configured or ommited (default)
	VLSM is used
	No other clues provided

Analysing the subnet mask

8.1.4.5 /16

Hosts bits : 32 – 16 = 16
Class A network bits : 8
Subnet bits : 32 – 24 = 8
Number of subnets = 2 ^ 8 = 256
Number of host = 2 ^ 16 – 2 = 65,534

130.4.102.1/24

Hosts bits : 32 – 24 = 8
Class B network bits : 16
Subnet bits : 32 – 24 = 8
Number of subnets = 2 ^ 8 = 256
Number of host = 2 ^ 8 – 2 = 254

199.1.1.100/24

Hosts bits : 32 – 24 = 8
Class C network bits : 24
Subnet bits : 32 – 32 = 0
Number of subnets = 2 ^ 0 = 1
Number of host = 2 ^ 8 – 2 = 254

130.4.102.1/22

Hosts bits : 32 – 22 = 10
Class B network bits : 16
Subnet bits : 32 – 26 = 6
Number of subnets = 2 ^ 6 = 64
Number of host = 2 ^ 8 – 2 = 1022

199.1.1.100/27

Hosts bits : 32 – 27 = 5
Class C network bits : 24
Subnet bits : 32 – 29 = 3
Number of subnets = 2 ^ 3 = 8
Number of host = 2 ^ 5 – 2 = 30

Number of bits in the host or subnet field	Maximum number of hosts (2 ^ h – 2)	Maximum number of subnets (2 ^ s)
1	0	2
2	2	4
3	6	8
4	14	16
5	30	32
6	62	64
7	126	128
8	254	256
9	510	512
10	1022	1024
11	2046	2048
12	4094	4096
13	8190	8192
14	16,382	16,384

Finding the only possible MASK

With a Class B network 130.1.0.0 , what is the only subnet mask you can use to have upto 200 subnets and 200 hosts per subnets???

To have 200 subnets you need to have atleast 8 subnet bits
(2 ^ 8 = 256) , (2 ^ 7 is only 128)

Only possible subnet so is…(16 bits for network part as it is a Class B network).

NNNNNNNN NNNNNNNN SSSSSSSS HHHHHHHH

11111111 11111111 11111111 00000000

255.255.255.0 or a /24 mask.

Finding the multiple possible MASKs

With a Class B network, what are the subnet masks you can use to have upto 50 subnets and 200 hosts in the largest subnet???

To have 50 subnets you need to have atleast 6 subnet bits
(2 ^ 6 = 64) , (2 ^ 5 is only 32)

To have 200 hosts you need to have atleast 8 host bits
(2 ^ 8 - 2 = 254) , (2 ^ 7 is only 128)

Possible subnet format is …(16 bits for network part as it is a Class B network).

NNNNNNNN NNNNNNNN SSSSSS**XX** HHHHHHHH

XX – can be either subnet or host bits

That mean you may get 2 ^ 2 = 4 possible combination of subnet masks, however

All masks must start with one unbroken consecutive string of binary 1s, followed by one unbroken consecutive string of binary 0s.

So the possible mask are listed below but only three are valid.

11111111 11111111 11111111 00000000 (8 subnets , 8 hosts)
11111111 11111111 11111110 00000000 (7 subnets, 9 hosts)
11111111 11111111 11111100 00000000 (6 subnets, 10 hosts)
11111111 11111111 11111101 00000000 (INVALID MASK)

255.255.255.0 prefix format /24
255.255.254.0 prefix format /23
255.255.252.0 prefix format /22

Choosing the subnet that maximizes the number of subnets or hosts

The mask with the most subnet bits : the mask with the wildcard bits set to binary 1s, there by increasing the subnet bits, maximizes the number of subnets and minimizes the number of hosts per subnet.

The mask with most host bits : the mask with the wildcard bits set to binrary 0s, thereby making the host part of the subnet address larger, maximizes the number of hosts per subnet and minimizes the number of subnets.

Choosing a subnet mask steps …..

Step 1. Find the number of network bits (N) based on the Class A,B or C rules
Step 2 : Find the number of subnet bits (S) based on the formula 2 ^ s , such that 2 ^ s > or = the number of required subnets.
Step 3. Find the number of host bits (H) based on the formula 2 ^ h – 2, such that 2 ^ h – 2 is >= the number of required hosts.
Step 4. Write down starting from the left N+S binary 1s
Step 5. Write down starting from right H binary 0s
Step 6. If the binary 1s and 0s together adds up to less than 32
a. fill in the remaining 'wildcard' bit positions with X between binary 1s and 0s.
b. find all combination of bits for the wildcard bit positions, meeting the requirement of having one unbroken consecutive string of binary 1s on left.
Step 7. convert the mask to decimal or prefix format
Step 8. To find the mask that maximizes the number of subnets pick the mask with most binary 1s init, and to find the mask that maximizes the number of hosts pick the mask with most binary 0s.

Problem set 2. Analysing unsubnetted IP addresses

10.55.44.3

Class of the address : A
Number of octets in the network part : 1
Number of octets in the host part : 3
Network number : 10.0.0.0
Network broadcast number : 10.255.255.255

128.77.6.7

Class of the address : B
Number of octets in the network part : 2
Number of octets in the host part : 2
Network number : 128.77.0.0
Network broadcast number : 128.77.255.255

192.168.76.54

Class of the address : C
Number of octets in the network part : 3
Number of octets in the host part : 1
Network number : 192.168.76.0
Network broadcast number : 192.168.76.255

190.190.190.190

Class of the address : B
Number of octets in the network part : 2
Number of octets in the host part : 2
Network number : 190.190.0.0
Network broadcast number : 190.190.255.255

9.1.1.1

Class of the address : A
Number of octets in the network part : 1
Number of octets in the host part : 3
Network number : 9.0.0.0
Network broadcast number : 9.255.255.255

200.1.1.1

Class of the address : C
Number of octets in the network part : 3
Number of octets in the host part : 1
Network number : 200.1.1.0
Network broadcast number : 200.1.1.255

Problem Set 3. Interpreting existing subnet masks

10.66.5.99 255.255.254.0

Steps
Mask in prefix format /23
Class : A

Results
Network bits 8
Subnet bits 32 – (8+9) = 15
Host bits 9
Number of subnets in the network 2 ^ 15 = 32,768
Number of hosts per subnet 2 ^ 9 – 2 = 510

172.16.203.42 255.255.252.0

Steps
Mask in prefix format /22
Class : B

Results
Network bits 16
Subnet bits 32 – (16+10) = 6
Host bits 10
Number of subnets in the network 2 ^ 6 = 64
Number of hosts per subnet 2 ^ 10 – 2 = 1022

192.168.55.55 255.255.255.224

Steps
Mask in prefix format /27
Class : C

Results
Network bits 24
Subnet bits 32 – (24+5) = 3
Host bits 5
Number of subnets in the network 2 ^ 3 = 8
Number of hosts per subnet 2 ^ 5 – 2 = 30

10.22.55.87 /30

Steps
Class : A

Results
Network bits 8
Subnet bits 32 – (8+2) = 22
Host bits 2
Number of subnets in the network 2 ^ 22 = 4,194,304
Number of hosts per subnet 2 ^ 2 – 2 = 2

172.30.40.166 /26

Steps
Class : B

Results
Network bits 16
Subnet bits 32 – (16+6) = 10
Host bits 6
Number of subnets in the network 2 ^ 10 = 1024
Number of hosts per subnet 2 ^ 6 – 2 = 62

192.168.203.18 /29

Steps
Class : C

Results
Network bits 24
Subnet bits 32 – (24+3) = 5
Host bits 3
Number of subnets in the network 2 ^ 5 = 32
Number of hosts per subnet 2 ^ 3 – 2 = 6

Problem set 4 : Choosing Subnet Masks

Network 10.0.0.0 needs 50 subnets and 200 hosts/subnets

Class : A
Network bits : 8
Min. Subnet bits 6
Min. Host bits 8

NNNNNNNN SSSSSSXX XXXXXXXX HHHHHHHH

10.0.0.0 /14 (Maximum number of hosts)
10.0.0.0 /15
10.0.0.0 /16
10.0.0.0 /17
10.0.0.0 /18

10.0.0.0 /19
10.0.0.0 /20
10.0.0.0 /21
10.0.0.0 /22
10.0.0.0 /23
10.0.0.0 /24 (Maximum number of subnets)

Network 172.32.0.0 need 125 subnets and need 125 hosts/subnet

Class : B
Network bits : 16
Min. Subnet bits : 7
Min. Host bits : 7

NNNNNNNN NNNNNNNN SSSSSSSX XHHHHHHH
172.32.0.0 /23 255.255.254.0 (Maximum number of hosts)
172.32.0.0 /24 255.255.255.0
172.32.0.0 /25 255.255.255.128 (Maximum number of subnets)

Network 192.168.44.0 need 15 subnets and 6 host/subnet

Class : C
Network bits 24
Min. subnet bits : 4
Min. host bits : 3

NNNNNNNN NNNNNNNN NNNNNNNN SSSSXHHH

192.168.44.0 /28 255.255.255.240 (Maximum number of hosts/subnet)
192.168.44.0 /29 255.255.255.248 (Maximum number of subnets)

10.0.0.0 300 subnets and 500 hosts/subnet

Class : A
Network bits : 8
Min. subnet bits : 9
Min. host bits : 9

NNNNNNNN SSSSSSSS SXXXXXXH HHHHHHHH

10.0.0.0 /17 255.255.128.0 Maximum hosts/subnets

10.0.0.0 /18	255.255.192.0	
10.0.0.0 /19	255.255.224.0	
10.0.0.0 /20	255.255.240.0	
10.0.0.0 /21	255.255.248.0	
10.0.0.0 /22	255.255.252.0	
10.0.0.0 /23	255.255.254.0	Maximum subnets

172.32.0.0 500 subnets and 15 hosts/subnet

Class : B
Network bits : 16
Min. subnets bits : 9
Min. host bits : 5

NNNNNNNN NNNNNNNN SSSSSSSS SXXHHHHH

172.32.0.0 / 25	255.255.255.128	Maximum hosts/subnet
172.32.0.0 / 26	255.255.255.192	
172.32.0.0 / 27	255.255.255.224	Maximum subnets

Network 172.16.0.0 2000 subnets 2 hosts/subnet

Class : B
Network hosts : 16
Min. subnet bits : 11
Min. host bits : 2

NNNNNNNN NNNNNNNN SSSSSSSS SSSXXXHH

172.16.0.0 /27	255.255.255.224	Maximum number of hots/subnet
172.16.0.0 /28	255.255.255.240	
172.16.0.0 /29	255.255.255.248	
172.16.0.0 /30	255.255.255.252	Maximum number of subnets

ANALYSING EXISTING SUBNETS : BINARY

Learning resident subnet number using Boolean AND operation….

Step 1. Convert the IP address from decimal to binary
Step 2. Convert the subnet mask to binary and write it down under the binary ip address
Step 3. Perform a bit wise Boolean AND operation of the two numbers…
Step 4. Convert the resulting binary number back to decimal, to get the subnet number

Address	8.1.4.5	00001000 00000001 00000100 00000101
Mask	255.255.0.0	11111111 11111111 00000000 00000000
Subnet Number	8.1.0.0	00001000 00000001 00000000 00000000

Address	130.4.102.1	10000010 00000100 01100110 00000001
Mask	255.255.255.0	11111111 11111111 11111111 00000000
Subnet Number	130.4.102.0	10000010 00000100 01100110 00000000

Address	199.1.1.100	11000111 00000001 00000001 01100100
Mask	255.255.255.0	11111111 11111111 11111111 00000000
Sub. Number	199.1.1.0	11000111 00000001 00000001 00000000

Address	130.4.102.1	10000010 00000100 01100110 00000001
Mask	255.255.252.0	11111111 11111111 11111100 00000000
Subnet Number	130.4.100.0	10000010 00000100 01100100 00000000

Address	199.1.1.100	11000111 00000001 00000001 01100100
Mask	255.255.255.224	11111111 11111111 11111111 11100000
Subnet Number	199.1.1.96	11000111 00000001 00000001 01100000

Binary Short cut….

- Record decimal mask in the first row of the table, and decimal IP address below it
- For any mask octect of value 255, copy the IP address's octet value for the same octet of the decimal subnet number
- Similarly for any mask octet value of 0, write down decimal 0 for the same octet of the subnet number
- If the subnet number has still has one remaining octet to be filled in, then
    - Convert the remaining octet of the ip address to binary
    - Convert the remaining octet of the mask to binary
    - AND the two 8-bit numbers together
    - Covert the 8 bit number to decimal, and place the value in the remaining octet of the subnet number

Address	199.1.1.100	
Mask	255.255.255.0	
Sub. Number	199.1.1.0	

Address	130.4.**102**.1	01100110
Mask	255.255.**252**.0	11111100
Subnet Number	130.4.**100**.0	01100100

Calculating the Broadcast address – Binary

Address	8.1.4.5	
Mask	255.255.0.0	nnnnnnnn nnnnnnnn hhhhhhhhh hhhhhhh
Subnet Address	8.1.0.0	00001000 00000001 00000000 00000000
Broadcast Address	8.1.255.255	00001000 00000001 11111111 11111111

Address	130.4.102.1	
Mask	255.255.255.0	
Subnet Address	130.4.102.0	
Broadcast Address	130.4.102.255	
Address	199.1.1.100	
Mask	255.255.255.0	
Subnet Address	199.1.1.0	
Broadcast Address	199.1.1.255	

Address	130.4.102.1	01100110
Mask	255.255.252.0	11111100
Subnet Address	130.4.100.0	01100100
Broadcast Address	130.4.103.255	01100111

Address	199.1.1.100	0110 0100
Mask	255.255.255.224	1110 0000
Subnet Address	199.1.1.96	0110 0000
Broadcast Address	199.1.1.127	0111 1111

Steps to determine Subnet Broadcast Address…..

- Step 1. Write down the subnet number (IP address), and subnet mask in binary form,
- Step 2. Separate the network/subnet and host bits by a vertical line
- Step 3. To find the subnet broadcast address in binary

- Copy the bits of the subnet number (IP address) that are to the left of the vertical line
- Write down binary 1s for the (HOST) bits to the right of the vertical line

- Step 4. Convert the 32 bit binary subnet broadcast address to decimal, 8 bits at a time, ignoring the vertical line

Steps to find the first and last IP address in a subnet

Step 1. To find the first IP address, Copy the subnet number but add 1 to the fourth octet
Step 2. To find the last IP address, Copy the subnet broadcast address but substract1 from the fourth octet

Address	8.1.4.5	
Mask	255.255.0.0	nnnnnnnn nnnnnnnn hhhhhhhhh hhhhhhh
Subnet Address	8.1.0.0	00001000 00000001 00000000 00000000
Broadcast Address	8.1.255.255	00001000 00000001 11111111 11111111
First Address	8.1.0.1	
Last Address	8.1.255.254	

Address	130.4.102.1
Mask	255.255.255.0
Subnet Address	130.4.102.0
Broadcast Address	130.4.102.255
First Address	130.4.102.1
Last Address	130.4.102.254

Address	199.1.1.100
Mask	255.255.255.0
Subnet Address	199.1.1.0
Broadcast	

Address	199.1.1.255	
First Address	199.1.1.1	
Last Address	199.1.1.254	

Address	130.4.102.1	01100110
Mask	255.255.252.0	11111100
Subnet Address	130.4.100.0	01100100
Broadcast Address	130.4.103.255	01100111
First Address	130.4.100.1	
Last Address	130.4.103.254	

Address	199.1.1.100	0110 0100
Mask	255.255.255.224	1110 0000
Subnet Address	199.1.1.96	0110 0000
Broadcast Address	199.1.1.127	0111 1111
First Address	199.1.1.97	
Last Address	199.1.1.126	

Finding subnet address, broadcast address and range of address using Decimal – Difficult Mask

Subnet Chart 130.4.102.1 / 255.255.252.0

Octet	**1**	**2**	**3**	**4**	**Comments**
Mask	255	255	252	0	
Address	130.	4	102	1	
Subnet Address	130	4	100	0	Magic number = 256 – 252 = 4 **100** is the multiple of 4 closes to but not higher than **102**
First Address	130	4	100	1	Add 1 to the subnets last octet
Last Address	130	4	103	254	Subtract 1 from broadcast address's fourth octet
Broadcast Address	130	4	103	255	Subnet's interesting octet + magic number – 1 (100+4 – 1)

Summary of decimal process to find the subnet, broadcast and range

Step 1. Write down the subnet mask in the first empty row of the subnet chart, and the IP address in the second empty row.

Step 2. Find the octet for which subnet mask's value is not 255 or 0. This octet is called the interesting octet. Draw a dark rectangle around the interesting octet's column of the table, top to bottom.

Step 3. Record the subnet numbers value for the uninteresting octets as follows

a. for each octet to the left of the rectangle, drawn in step 2, copy the IP address value in the same octet.

b. for each octet to the right of the rectangle: write down decimal 0

Step 4. To find the subnet numbers value for this interesting octet

a. calculate the magic number by subtracting the subnet mask's interesting octet value from 256

b. calculate the multiple of magic number starting from 0 through to 256

c. write down the interesting octet value, calculated as follows, Find the multiple of magic number that is closest to, but not higher than the **IP Address's interesting octet value.**

Step 5 : Find the subnet broadcast address as follows

a. for each subnet mask octet to the left of the rectangle, copy the IP address octet value

b. for each subnet mask octet to the right of the rectangle, write down 255

c. find the value for the interesting octet by adding the subnet number's value in the interesting octet to the magic number and subtract 1.

Step 6. To find the first IP address, copy the decimal subnet number, but add 1 to the fourth octet.

Step 7. To find the last IP address, copy the decimal subnet broadcast address, but subtract 1 from the fourth octet.

Problem 1
10.180.10.18 255.192.0.0

Size of Network Part	8
Size of Subnet Part	2
Size of Host part	22
Number of hosts per subnet	2 ^ 22 – 2 = 4,194,302
Number of subnets	2 ^ 2 = 4
	255.192.0.0
	10.180.10.18
	(256 – 192) = 64
	64 x 3 = 192
	64 x 2 = 128
Subnet Number	10.128.0.0
Broadcast Address	10.191.255.255
Range of valid IP addresses	
First Address	10.128.0.1
Last Address	10.191.255.254

Problem 2
10.200.10.18 255.224.0.0

Size of Network Part	8
Size of Subnet Part	3
Size of Host part	21
Number of hosts per subnet	2 ^ 21 – 2 = 2,097,150
Number of subnets	2 ^ 3 = 8
	255.224.0.0
	10.200.10.18
	(256 – 224) = 32
	32 x 6 = 192
Subnet Number	10.192.0.0
Broadcast Address	10.223.255.255
Range of valid IP addresses	
First Address	10.192.0.1
Last Address	10.223.255.254

Problem 3
10.100.18.18 255.240.0.0

Size of Network Part	8
Size of Subnet Part	4
Size of Host part	20
Number of hosts per subnet	2 ^ 20 – 2 = 1,048,574
Number of subnets	2 ^ 4 = 16
	255.240.0.0
	10.100.18.18
	(256 – 240) = 16
	16 x 6 = 96
Subnet Number	10.96.0.0
Broadcast Address	10.111.255.255
Range of valid IP addresses	
First Address	10.96.0.1
Last Address	10.111.255.254

Problem 4
10.100.18.18 255.248.0.0

Size of Network Part	8
Size of Subnet Part	5
Size of Host part	19
Number of hosts per subnet	2 ^ 19 – 2 = 524,286
Number of subnets	2 ^ 5 = 32
	255.248.0.0
	10.100.18.18
	(256 – 248) = 8
	8 * 12 = 96
Subnet Number	10.96.0.0
Broadcast Address	10.103.255.255
Range of valid IP addresses	
First Address	10.96.0.1
Last Address	10.103.255.254

Problem 5
10.150.200.200 255.252.0.0

Size of Network Part	8
Size of Subnet Part	6
Size of Host part	18
Number of hosts per subnet	2 ^ 18 – 2 = 262,142
Number of subnets	2 ^ 6 = 64

255.252.0.0
10.150.200.200
(256 – 252) = 4
37 * 4 = 148

Subnet Number	10.148.0.0
Broadcast Address	10.251.255.255

Range of valid IP addresses

First Address	10.148.0.1
Last Address	10.251.255.254

Problem 6
10.150.200.200 255.254.0.0

Size of Network Part	8
Size of Subnet Part	7
Size of Host part	17
Number of hosts per subnet	2 ^ 17 – 2 = 131,070
Number of subnets	2 ^ 5 = 32

255.254.0.0
10.150.200.200
(256 – 254) = 2
75 * 2 = 150

Subnet Number	10.150.0.0
Broadcast Address	10.151.255.255

Range of valid IP addresses

First Address	10.150.0.1
Last Address	10.151.255.254

Problem 7
10.220.100.18 255.255.0.0

Size of Network Part	8
Size of Subnet Part	8
Size of Host part	16
Number of hosts per subnet	2 ^ 16 – 2 = 65,534
Number of subnets	2 ^ 8 = 256
	255.255.0.0
	10.220.100.18
	(256 – 255) = 1
	220 * 1 = 220
Subnet Number	10.220.0.0
Broadcast Address	10.220.255.255

Range of valid IP addresses

First Address	10.220.0.1
Last Address	10.220.255.254

Problem 8
10.220.100.18 255.255.128.0

Size of Network Part	8
Size of Subnet Part	9
Size of Host part	15
Number of hosts per subnet	2 ^ 15 – 2 = 32,766
Number of subnets	2 ^ 9 = 512
	255.255.128.0
	10.220.100.18
	(256 – 128) = 128
	0 * 128 = 0
Subnet Number	10.220.0.0
Broadcast Address	10.220.127.255

Range of valid IP addresses

First Address	10.220.0.1
Last Address	10.220.127.254

Problem 9

172.31.100.100	255.255.192.0
Size of Network Part	16
Size of Subnet Part	2
Size of Host part	14
Number of hosts per subnet	2 ^ 14 – 2 = 16,382
Number of subnets	2 ^ 2 = 4
	255.255.192.0
	172.31.100.100
	(256 – 192) = 64
	1 * 64 = 64
Subnet Number	172.31.64.0
Broadcast Address	172.31.127.255
Range of valid IP addresses	
First Address	172.31.64.1
Last Address	172.31.127.254

Problem 10

172.31.100.100	255.255.224.0
Size of Network Part	16
Size of Subnet Part	3
Size of Host part	13
Number of hosts per subnet	2 ^ 13 – 2 = 8,190
Number of subnets	2 ^ 3 = 8
	255.255.224.0
	172.31.100.100
	(256 – 224) = 32
	3 * 32 = 96
Subnet Number	172.31.96.0
Broadcast Address	172.31.127.255
Range of valid IP addresses	
First Address	172.31.96.1
Last Address	172.31.127.254

Problem 11

172.31.200.10	255.255.240.0
Size of Network Part	16
Size of Subnet Part	4
Size of Host part	12
Number of hosts per subnet	2 ^ 12 – 2 = 4,094
Number of subnets	2 ^ 4 = 16
	255.255.240.0
	172.31.200.10
	(256 – 240) = 16
	12 * 16 = 192
Subnet Number	172.31.192.0
Broadcast Address	172.31.207.255
Range of valid IP addresses	
First Address	172.31.192.1
Last Address	172.31.207.254

Problem 12

172.31.200.10	255.255.248.0
Size of Network Part	16
Size of Subnet Part	5
Size of Host part	11
Number of hosts per subnet	2 ^ 11 – 2 = 2,046
Number of subnets	2 ^ 5 = 32
	255.255.248.0
	172.31.200.10
	(256 – 248) = 8
	25 * 8 = 200
Subnet Number	172.31.200.0
Broadcast Address	172.31.207.255
Range of valid IP addresses	
First Address	172.31.200.1
Last Address	172.31.207.254

Problem 13

172.31.50.50	255.255.252.0
Size of Network Part	16
Size of Subnet Part	6
Size of Host part	10
Number of hosts per subnet	2 ^ 10 – 2 = 1022
Number of subnets	2 ^ 6 = 64
	255.255.252.0
	172.31.50.50
	(256 – 252) = 4
	12 * 4 = 48
Subnet Number	172.31.48.0
Broadcast Address	172.31.51.255
Range of valid IP addresses	
First Address	172.31.48.1
Last Address	172.31.51.254

Problem 14

172.31.50.50	255.255.254.0
Size of Network Part	16
Size of Subnet Part	7
Size of Host part	9
Number of hosts per subnet	2 ^ 9 – 2 = 510
Number of subnets	2 ^ 7 = 128
	255.255.254.0
	172.31.50.50
	(256 – 254) = 2
	25 * 2 = 50
Subnet Number	172.31.50.0
Broadcast Address	172.31.51.255
Range of valid IP addresses	
First Address	172.31.50.1
Last Address	172.31.51.254

Problem 15

172.31.140.14	255.255.255.0
Size of Network Part	16
Size of Subnet Part	8
Size of Host part	8
Number of hosts per subnet	2 ^ 8 – 2 = 254
Number of subnets	2 ^ 8 = 256
	255.255.255.0
	172.31.140.14
Subnet Number	172.31.140.0
Broadcast Address	172.31.140.255
Range of valid IP addresses	
First Address	172.31.140.1
Last Address	172.31.140.254

Problem 16

172.31.140.14	255.255.255.128
Size of Network Part	16
Size of Subnet Part	9
Size of Host part	7
Number of hosts per subnet	2 ^ 7 – 2 = 126
Number of subnets	2 ^ 9 = 512
	255.255.255.128
	172.31.140.14
	256 – 128 = 128
	0 * 128 = 0
Subnet Number	172.31.140.0
Broadcast Address	172.31.140.127
Range of valid IP addresses	
First Address	172.31.140.1
Last Address	172.31.140.126

Problem 17

192.168.15.150 255.255.255.192

Size of Network Part	24
Size of Subnet Part	2
Size of Host part	6
Number of hosts per subnet	2 ^ 6 – 2 = 62
Number of subnets	2 ^ 2 = 4
	255.255.255.192
	192.168.15.150
	256 – 192 = 64
	2 * 64 = 128
Subnet Number	192.168.15.128
Broadcast Address	192.168.15.191
Range of valid IP addresses	
First Address	192.168.15.129
Last Address	192.168.15.190

Problem 18

192.168.15.150 255.255.255.224

Size of Network Part	24
Size of Subnet Part	3
Size of Host part	5
Number of hosts per subnet	2 ^ 5 – 2 = 30
Number of subnets	2 ^ 3 = 8
	255.255.255.224
	192.168.15.150
	256 – 224 = 32
	4 * 32 = 128
Subnet Number	192.168.15.128
Broadcast Address	192.168.15.159
Range of valid IP addresses	
First Address	192.168.15.129
Last Address	192.168.15.158

Problem 19

192.168.100.100 255.255.255.240

Size of Network Part	24
Size of Subnet Part	4
Size of Host part	4
Number of hosts per subnet	2 ^ 4 – 2 = 14
Number of subnets	2 ^ 4 = 16
	255.255.255.240
	192.168.100.100
	256 – 240 = 16
	6 * 16 = 96
Subnet Number	192.168.100.96
Broadcast Address	192.168.100.111

Range of valid IP addresses

First Address	192.168.100.97
Last Address	192.168.100.110

Problem 20

192.168.100.100 255.255.255.248

Size of Network Part	24
Size of Subnet Part	5
Size of Host part	3
Number of hosts per subnet	2 ^ 3 – 2 = 6
Number of subnets	2 ^ 5 = 32
	255.255.255.248
	192.168.100.100
	256 – 248 = 8
	12 * 8 = 96
Subnet Number	192.168.100.96
Broadcast Address	192.168.100.103

Range of valid IP addresses

First Address	192.168.100.97
Last Address	192.168.100.102

A NOTE : In the above examples, Number of subnets means, maximum number of subnets possible for the subnets mask (eg. 255.255.255.248),

Subnet address and Broadcast address are the subnet and broadcast address for the subnet the given IP addresss 192.168.100.100 belongs to. (see the binary version in appendix d for more details)

Problem 21

192.168.15.230	255.255.255.252
Size of Network Part	24
Size of Subnet Part	5
Size of Host part	3
Number of hosts per subnet	2 ^ 3 – 2 = 6
Number of subnets	2 ^ 5 = 32
	255.255.255.248
	192.168.100.100
	256 – 248 = 8
	12 * 8 = 96
Subnet Number	192.168.100.96
Broadcast Address	192.168.100.103
Range of valid IP addresses	
First Address	192.168.100.97
Last Address	192.168.100.102

Problem 22

10.1.1.1	255.248.0.0
Size of Network Part	8
Size of Subnet Part	5
Size of Host part	19
Number of hosts per subnet	2 ^ 19 – 2 = 524,286
Number of subnets	2 ^ 5 = 32
	255.248.0.0
	10.1.1.1
	256 – 248 = 8
	0 * 8 = 0
Subnet Number	10.0.0.0
Broadcast Address	10.7.255.255
Range of valid IP addresses	
First Address	10.0.0.1
Last Address	10.7.255.254

Problem 23

172.16.1.200	255.255.240.0
Size of Network Part	16
Size of Subnet Part	4
Size of Host part	12
Number of hosts per subnet	2 ^ 12 – 2 = 4094
Number of subnets	2 ^ 4 = 16
	255.255.240.0
	172.16.1.200
	256 – 240 = 16
	0 * 16 = 0
Subnet Number	172.16.0.0
Broadcast Address	172.16.15.255
Range of valid IP addresses	
First Address	172.16.0.1
Last Address	172.16.15.254

Problem 24

172.16.0.200	255.255.255.192
Size of Network Part	16
Size of Subnet Part	10
Size of Host part	6
Number of hosts per subnet	2 ^ 6 – 2 = 62
Number of subnets	2 ^ 10 = 1024
	255.255.255.192
	172.16.0.200
	256 – 192 = 64
	3 * 64 = 192
Subnet Number	172.16.0.192
Broadcast Address	172.16.0.255
Range of valid IP addresses	
First Address	172.16.0.193
Last Address	172.16.0.254

Problem 25

10.1.1.1	255.0.0.0
Size of Network Part	8
Size of Subnet Part	0
Size of Host part	24
Number of hosts per subnet	2 ^ 24 – 2 = 16,777,214
Number of subnets	2 ^ 0 = 1
Subnet Number	10.0.0.0
Broadcast Address	10.255.255.255
Range of valid IP addresses	
First Address	10.0.0.1
Last Address	10.255.255.254

Finding all subnets with fewer than 8 subnet bits

Generic list All Subnet Chart

Octect	1	2	3	4
Mask	255	255	252	0
Magic Number			4	
Network number/Zero subnet	130	4	0	0
Next subnet	130	4	4	0
Next subnet	130	4	8	0
Last subnet	130	4	248	0
Broadcast subnet	130	4	252	0
Out of range (used by process)	130	4	256	0

Step 1. Write down the subnet mask in decimal, in the first empty row of the table
Step 2. Identify the interesting octet, which is the octet with value other than 255 or 0, and draw a rectangle around the column of the interesting octet.
Step 3. Calculate the magic number by subtracting the mask's interesting octet from 256
Step 4. Write down the classful network number (zero subnet number)
Step 5. To find each successive subnet number
    a. for the three un-interesting octets copy the previous subnet numbers value
    b. for the interesting octet add the magic number to the previous subnet numbers interesting octet value.
Step 6. Once the sum calculated in stp 5.b becomes 256, stop the process, the number with 256 in it is out of range, and previous subnet number is the broadcast subnet number.

Finding all subnets with exact 8 subnet bits

The subnet octet is the interesting octet, to find all the subnets add 1 to the interesting octet till it reaches 256.

Finding all subnets with more than 8 subnet bits

The process follows the same five steps as with fewer than 8 subnet bits.

Step 6. When any steps addition results is in sum of 256
a. for the octet whose sum would have been 256 write down 0
b. for the octet to the left add 1 to the previous subnet's value in that octet
c. for any other octet copy the value of the same octet in the previous subnet number
d. start again with step 5

Step 7. each time the process results in a sum of 256, repeat step 6 of this process

Step 8. Repeat the steps until the addition in step 6b, would actually change the value of the network portion of the subnet number

Octect	1	2	3	4
Mask	255	255	255	192
Magic Number				64
Network number/Zero subnet	130	4	0	0
First non-zero subnet number	130	4	0	64
Next subnet	130	4	0	128
Next subnet	130	4	0	192
Next subnet (add 1 to the third octet, and write 0 in the fourth octet)	130	4	1	0
Next subnet	130	4	1	64
Next subnet	130	4	1	128
Next subnet	130	4	1	192
Broadcast subnet	130	4	255	192

Definitions….

Bitwise Boolean AND : A Boolean AND between two numbers of the same length where the first bit in each number is ANDed and the second bit and so on

Boolean AND : A math operation performed on a pair of one digit binary numbers, the result is another one digit binary number, binary 1 and 1 yields a result of binary 1, all other combinations yielding binary 0.

Broadcast subnet : When subnetting a Class A, B or C network, the one network in each classful network, for which all subnet bits have a value of binary 1s. The subnet broadcast address in this subnet has the same numeric value as the classful network's network wide broadcast address.

Classful network : An IPv4 Class A,B or C network, called classful network, because these networks are defined by the class rules for IPv4 addressing.

Default Mask : The mask used in Class A,B or C network, that does not create any subnets, specifically mask 255.0.0.0 for Class A, 255.255.0.0 for Class B, and 255.255.255.0 for a Class C network.

Prefix notation , CIDR notation : A shorter way to write subnet mask, in which number of binary 1s in the mask is simply written in decimal. For instance /24 denotes the subnet mask with 24 binary 1 bits in the subnet mask.

Private IP address : IP addresses within Class A,B and C, networks that are set aside for use within a private organization. These addresses are defined by RFC 1918, and are not routable through internet.

Public IP Address : An IP address that is part of a registered network number, as assigned by an Internet Assigned Numbers Authority (IANA) member agency. Routers in the internet forward (route) publicly assigned network numbers.

Subnet : Sub division of Class A, B or C network as configured by the network administrator. Subnets allow single Class A,B or C network to be used, instead of multiple networks but still allow multiple groups of ip addresses.

Subnet Mask : A 32 bit number that numerically represents the format of an IP address, by representing the network and subnet part with a mask bit value of 1, and host part with a mask bit value of binary 0s.

Subnet number/ Subnet address : In IPv4 a dotted decimal number that represents all addresses in a single subnet. Numerically smallest value in the range of numbers in a subnet, reserved so that it cannot be used as a uni cast IP address by a host.

Zero Subnet : For every class ful IPv4 network that is subnetted, the one subnet whose subnet number has all binary 0s in the subnet part. In decimal zero subnet can be easily identified, because it is the same number as the classful network number.