1) For the address 24.46.8.95 identify the type of network and find the network address

→ 24 . 46 . 8 . 95

24 → Network id

46 . 8 . 95 → Host id

First byte = 24
i.e. between 0 to 127
So, it is a class A network
First byte defines net id.
We can find network address by replacing host id by 0s.

24 . 46 . 8 . 95
↓ ↓ replace host id by 0
24 . 0 . 0 . 0
↓
Network id

So, Network address is 24.0.0.0

2) For the address 132.7.21.84. Find the type of network & network address.

→ 132.7.21.84

First byte = network id

Host id

First byte = 132
ie between 128 to 192
so, it is class B network
* First 2 bytes define network id.
We can get network address by replacing host id by 0's

132.7.21.84

Network id

Host id → replace by 0's

132.7.0.0

So, network address is 132.7.0.0

3) Find class of network if address is 221.46.75.64

→ First byte = 221 ie bet^n 192 to 255

So, this is class C address.

221.46.75.64

Network id

Host id

$2^8\ 2^7\ 2^6\ 2^5\ 2^4\ 2^3\ 2^2\ 2^1\ 2^0$
256 128 64 32 16 8 4 2 1

4) The IP address of a host on Class C network is 198.123.46.237. 4 networks are allowed for this network. What is subnet mask?

→ Default mask for class C address network
255.255.255.0

To have 4 networks we must have 2 extra 1s (~~2 bits~~ → ~~00, 01, 10, 11~~)
255 . 255 . 255 . 0

default mask: 11111111 . 11111111 . 11111111 . 00000000

subnet mask: 11111111 . 11111111 . 11111111 . 11000000 (→ 2 extra 1's)
255 . 255 . 255 . 192

Thus required subnet mask is 255.255.255.192

AND Table			
	0	0	0
	0	1	0
	1	0	0
	1	1	1

5) A router inside an organization receive the same packet with a destination address 190.240.34.95 If the subnet mask is /19. Find the subnet address.

→ /19 → first 19 bits are 1's
Following bits are 0's

To find subnet address AND the destination address with subnet mask.

← 19 1's → ← 13 0's →

Subnet mask: 11111111.11111111.111 00000.00000000

Address: 190 . 240 . 34 . 95

11000010.11110000.001 00010.01011111

128
64
2
194

ANDing

Subnet address: 11000010.11110000.001 00000.00000000

190 . 240 . 32 . 0

Thus subnet mask is 190.240.32.0

6) What is the subnet address if the destination address is 200.45.34.56 & subnet mask is 255.255.240.0

→ To find subnet address AND the IP address and subnet mask

	200	45	34	56
Destn address.	11001000	00101101	00100010	00111000
Subnet mask	255	255	240	0
	11111111	11111111	11110000	00000000

ANDing

Subnet address	11001000	00101101	00100000	00000000
	200	45	32	0

→ A company granted a site address 201.70.64.0 The company needs six subnets. Design the subnets.

→ First byte = 201 i.e. this is Class C
Default mask - 255.255.255.0

We need 6 subnets → we need 3 extra 1's so

3 extra 1's

Subnet mask	11111111	11111111	11111111	111 00000
	255	255	255	224

To have 6 subnets - we can have 6 diffnt combinations of 3 extra 1's.

Combination	Subnet number
0 0 0	Subnet 1
0 0 1	subnet 2
0 1 0	subnet 3
0 1 1	subnet 4
1 0 0	subnet 5
1 0 1	subnet 6

Various addresses of 6 subnets are -

Subnet number	Addresses.
1	201.70.64.0 to 201.70.64.31
2	201.70.64.32 to 201.70.64.63
3	201.70.64.64 to 201.70.64.95
4	201.70.64.96 to 201.70.64.127
5	201.70.64.128 to 201.70.64.159
6	201.70.64.160 to 201.70.64.191

8) For IPv4 addresses given below, calculate subnet mask, broadcast address & number of hosts possible.

1. 10.0.199.237/22
2. 192.168.14.87/26

1. 10.0.199.237/22

First byte = 10 i.e. betⁿ 0 to 127
so, it is Class A network

Subnet mask

/22 → n = 22 i.e. prefix bits = 22
suffix bits = 32 - 22 = 10

To obtain subnet mask
set prefix bits to 1's & sufix to 0's

Given IP addr: 10 . 0 . 199 . 237
00001010 . 00000000 . 11000111 . 11101101

subnet mask: 11111111 . 11111111 . 11111100 . 00000000
255 . 255 . 252 . 0
← 22 bits → ← 10 bits →

So, subnet mask = 255.255.252.0.

(2) N/w address.

performing AND opⁿ of IP address & subnet mask.

XOR table	0	0	0	1	0	1
	0	1	1	1	1	0

IP address	10	0	199	237
	00001010	00000000	11000111	11101101
Subnet mask	255	255	252	0
	11111111	11111111	11111100	00000000

AND ing

Network address	00001010	00000000	11000100	00000000
	10	0	196	0

So, network address = 10.0.196.0

③ Broad cast address

To find broadcast address
– take inverted subnet mask & perform XOR with network address.

N/w address	10	0	196	0
	00001010	00000000	11000100	00000000
Inverted subnet mask	00000000	00000000	00000011	11111111

XOR ing

Broad cast address	00001010	00000000	11000111	11111111
	10	0	199	255

So, Broadcast address = 10.0.199.255

④ No. of possible hosts $= 2^{32} - 2^{22} = 2^{10}$

$\therefore$ No. of possible hosts = 1024

2. 192.168.14.87/26

① subnet mask

First byte = 192 i.e. between 128-192
so, it is class B network.

/26 → n = 26 i.e number of prefix bits 26
So suffix bits = 32 - 26 = 6

to obtain subnet mask
set prefix bits to 1's
& suffix bits to 0's

Given IP addr: 192 . 168 . 14 . 87
11000000 . 10101000 . 00001110 . 01010111

subnet mask: 11111111 . 11111111 . 11111111 . 11000000
← 26 → ← 6 →

classB: 255 . 255 . 255 . 192

So, subnet mask = 255.255.255.192

② Network address

Performing AND operation of IP address & subnet mask to get network address.

Given IP addr.	192	168	14	87
	11000000	10101000	00001110	01010111
subnet mask	255	255	255	192
	11111111	11111111	11111111	11000000

ANDing

Network address	11000000	10101000	00001110	01000000
	192	168	14	64

So, Network address = 192.168.14.64

(3) Broad cast addrep:

Take inverted subnet mask & perform XOR with network address.

	192	168	14	64
N/w addr.	11000000	10101000	00001110	01000000
Inverted subnet mask	00000000	00000000	00000000	00111111
Broad Cast addr.	11000000	10101000	00001110	01111111
	192	168	14	127

So, Broadcast address = 192.168.14.127

No. of possible hosts $= 2^{32} - 2^{26} = 2^6$

So, No of hosts = 64

9) For IP addresses given below
1) 132.34.45.133
2) 191.0.200.45
3) 14.142.20.20
4) 129.16.123.85

A) Identify classes
B) Identify network address.
C) Identify host address.

	IP addr.	Class	N/w addr	Host addr
1	132.34.45.133	B	132.34	45.133
2	191.0.200.45	B	191.0	200.45
3	14.142.20.20	A	14	142.20.20
4	129.16.123.85	B	129.16	123.85

10) For the IP addresses given below
1. Identify classes to which they belong
2. Identify network address section.
3. Identify the host address section.
4. calculate no. of hosts that can be assigned with each network

i) 22.34.45.133
ii) 12.12.12.12
iii) 192.0.233.26
iv) 126.123.16.87

	IP addr	class	N/W section	Host section	No. of hosts
1	22.34.45.133	A	22	34.45.133	$2^{24}-2 = 16,777,214$
2	12.12.12.12	A	12	12.12.12	$2^{24}-2 = 16,777,214$
3	192.0.233.26	C	192.0.233	26	$2^{8}-2 = 254$
4	126.123.16.87	A	126	123.16.87	$2^{24}-2 = 16,777,214$

11) For the IP addresses given below find the range of addresses in following blocks.

a) 123.56.77.32/29

b) 200.17.21.128/27

c) 17.34.16.0/23

d) 180.34.64.64/30

a) Prefix bits = 29

Suffix bits = 32-29 = 3

Binary representation:

01111011.00111000.01001101.00100000

First address: Replace all last 3 bits with 0 to get 1st addr

01111011.00111000.01001101.00100[000]

123 . 56 . 77 . 32 → set to 0

So, First address = 123.56.77.32

Last address:

Replace last 3 bits with 1 to get last addr

01111011.00111000.01001101.00100[111]

123 . 56 . 77 . 39 → set to 1

So, Last address = 123.56.77.39

Range ⇒ 123.56.77.32 to 123.56.77.39

b) 200.17.21.128/27
prefix bits = 27
suffix bits = 32-27 = 5

Binary representation:
11001000.00010001.00010101.10000000

First address:
Replace last 5 bits with 0's to get 1st addr.
11001000.00010001.00010101.100[00000]
200 . 17 . 27 . 128 ↳set to 0

So, First address = 200.17.27.128

Last address:
Replace last 5 bits with 1's to get last addr
11001000.00010001.00010101.100[11111]
200 . 17 . 27 . 159 ↳set to 1

So, Last address = 200.17.27.159

∴ Range = 200.17.27.128 to 200.17.27.159

c) 17.34.16.0/23
prefix bits = 23
suffix bits = 32-23 = 9
Binary representation
00010001.00100010.00010000.00000000

First address - replace last 9 bits by 0's.
00010001.00100010.0001000[0.00000000]
17 . 34 . 16 . 0 ↳set to 0

So first address = 17.34.16.0

Last address: replace last 9 bits by 1's

00010001 . 00100010 . 00010000 | 1 . 1111 1111 |

17 . 34 . 17 . 255 ← set to

∴ Last address = 17.34.17.255

So, Range = 17.34.16.0 to 17.34.17.255

d) suffix 2, range = 180.34.64.64
to 180.34.64.67

12) For the addresses given below:

i) 122.34.45.133

ii) 12.12.12.12

iii) 192.10.233.26

1) Identify classes
2) Identify host address section
3) Identify n/w addr. section
4) Calculate no. of hosts.

	IP addr	Class	N/w addr. section	Host section	No. of hosts/n/w
1	122.34.45.133	A	122	34.45.133	$2^{24}-2 = 16777214$
2	12.12.12.12	A	12	12.12.12	$2^{24}-2 = 16777214$
3	192.10.233.26	C	192.10.233	26	$2^8-2 = 254$

13) Find out error if any in following IPv4 addresses.

a) 111.56.054.78

There should be no leading zeros (054) in the dotted decimal notation.

b) 222.34.7.8.20

We cannot have more than 4 bytes in an IPv4 address.

c) 75.45.301.14

Each number in the dotted decimal notation should be less than or equal to 255 → 301 is outside this range

d) 11100101.23.14.67

A mixture of binary notation & dotted decimal is not allowed.

14) For the given IP addresses

1) 121.33.43.131
2) 15.15.15.15
3) 198.22.5.36
4) 126.120.10.80

1) identify class
2) identify host address
3) identify n/w address
4) calculate no. of hosts.

	IP addr	Class	N/w address	Host addr	No. of hosts / N
1	121.33.43.131	A	121.0.0.0	33.43.131	$2^{24}-2=16777$
2	15.15.15.15	A	15.0.0.0	15.15.15	$2^{24}-2=16777214$
3	198.22.5.36	C	198.22.5.0	.36	$2^{8}-2=254$
4	126.120.10.80	A	126.0.0.0	120.10.80	$2^{24}-2=16777211$

15) A block of address is granted to a small organization. From this block one address is 205.16.37.39/28 Find:
1) First address of the block
2) Last address of the block
3) Subnet mask
4) No. of hosts.

→ Given IP address → 205.16.37.39/28
prefix bits = 28
suffix bits = 32 - 28 = 4

Binary Representation:
11001101.00010000.00100101.00100111

1) First address: Replace last 4 bits by 0's
11001101.00010000.00100101.0010[0000]
205 . 16 . 37 . 32 ← set to 0
∴ First address ⇒ 205.16.37.32

2) Last address: Replace last 4 bits by 1's
11001101.00010000.00100101.0010[1111]
205 . 16 . 37 . 47 ← set to 1
∴ Last address ⇒ 205.16.37.47

3) Subnet mask.
First byte = 205 i.e. between 192 to 223
so it is class C address.

as per slash notation n = 28
so prefix bits = 28
suffix bits = 32 - 28 = 4

to obtain subnet mask
all prefix bits are set to 1's
& suffix bits are set to 0's

Given IP addr.	205	. 16	. 37	. 39
	11001101	. 00010000	. 00100101	. 00100111
Subnet mask	11111111	. 11111111	. 11111111	. 11110000
	255	. 255	. 255	. 240

So subnet mask = 255.255.255.240

4) No. of hosts = $2^4 - 2 = 14$

16) For following IP address
1) 208.34.54.12 2) 238.34.2.1
3) 114.34.2.8 4) 129.14.6.8
1) Identify class
2) Identify n/w address section
3) Identify host address section.
4) Calculate no. of hosts that can be assigned with each network

CIDR - Classless Inter Domain Route

	IP address	Class	N/w addr.	Host addr.	No. of hosts / N/w
1	208.34.54.12	C	208.34.54	12	$2^8 - 2 = 254$
2	238.34.2.1	D	N/A	N/A	N/A
3	114.34.2.8	A	114.0.0.0	34.2.8	$2^{24} - 2 = 16777214$
4	129.14.6.8	B	129.14.0.0	6.8	$2^{16} - 2 = 65534$

17) Find out the values of prefix & suffix length in classless addressing if all available addresses in IPv4 is to be considered as one single block.

→ total no. of addresses in IPv4 is $2^{32} = 4,294,967,296$

all available addresses fall in 1 block
so $n = 0$.

So all hosts will have their individual addresses.
Means all 32 bits will be allotted to suffix length.

18) For the following addresses identify the no. of prefix & bits & write down n/w mask
1) 12.26.25.79/8 2) 130.12.230.156/16

1) Classless CIDR address: 12.26.25.79/8

→ as per slash notation $n = 8$
i.e. prefix bits = 8
∴ no. of suffix bits = 32 − 8 = 24

to obtain n/w mask - prefix bits are set to 1's & suffix bits are set to 0's

n=8

Given IP 12 . 26 . 25 . 79 /8

12 → prefix bits set to 1

26 . 25 . 79 → suffix bits set to 0's

N/w mask 255 . 0 . 0 . 0

so n/w mask = 255.0.0.0

2) As per slash notation n=16

prefix bits =16.

suffix bits =32-16=16

set all prefix bits to 1's & suffix to 0's

Given IP 130 . 12 . 230 . 156

← prefix → ← suffix →

N/w mask 255 . 255 . 0 . 0

so n/w mask = 255.255.0.0

* Extracting block information:

1) to obtain no. of addresses in a block

No. of addresses in a block $N = 2^{(32-n)}$

where n = number of prefix bits

First address = Network address

↳ obtained by ANDing address with n/w mask

First address = (Any addr) AND (Network mask)

OR keep n leftmost digits as it is & set remaining (32-n) bits to 0

2) To obtain last address
- add first address with number of addresses in the block directly.

Last address = first address + No. of addresses in the block.

↳ also possible to obtain last address by ORing addr. with complement of N/w mask

Last address = (any address) OR (NOT (n/w mask))

↳ other way - keep all n left bits as it is & suffix (32-n) to 1

18) If an address in a block is given in CIDR classless notation as 64.32.16.8/27 then find

1) No. of addresses in the block (N)
2) The first address
3) The last address

1) Find n

Given address = 64.32.16.8/27

Hence n = 27 → slash notation.

n = 27 bits.

prefix bits = 27

suffix bits = 32 − 27 = 5

No. of addresses in the block $N = 2^{(32-n)} = 2^{(32-27)}$

$= 2^5 = 32$

2) Find first addr.

ANDing given address with n/w addr

N/w mask = | 27 ones | 5 zeros | → | n | 32−n |

Given addr	64 . 01000000	32 . 00100000	16 . 00010000	8 . 00001000
N/w mask	255 . 11111111	255 . 11111111	255 . 11111111	224 . 11100000

← 27 bits → ← 5 bits →

First address	01000000 . 64	00100000 . 32	00010000 . 16	00000000 . 0

So 1st address = 64.32.16.0

3) Find the last address

Keep left 27 bits as it is
& set remaining 5 bits to 1's

	64	32	16	8
given addr.	01000000	00100000	00010000	00001000

27 bits → as it is

5 bits → set to 1

	64	32	16	31
Last addr.	01000000	00100000	00010000	00011111

So, last addr = 64.32.16.31

Block allocation

For Individual internet users addresses are not allotted by ICANA

ISP's or large organizations are assigned with blocks.

↳ They will allot blocks to individual users.

* Restrictions

1) address block should be continuous ie. serial manner.

2) Total no. of addresses in a block should be equal to power of 2
ie. $2^1, 2^2, 2^3$ ----

3) First address should be evenly divisible by no. of addresses.

* Relation to classful addressing

Class	Prefix length
A	/8
B	/16
C	/24
D	/4
E	/4

* Subnetting -
Used for creating 3-level hirearchy

Address are divided into subgroups of addresses — assigned to subnetworks or subnets.

* Designing Subnets.

N → Total no. of addresses granted to an organization.
n → Prefix length.
N_{sub} → Assigned no. of addresses to each subnetwork
n_{sub} → Prefix length for each subnetwork
S → Total no. of subnetworks.

To find prefix length of each subnetwork

$$n_{sub} = n + \log_2\left[\frac{N}{N_{sub}}\right]$$

19) A block of addresses granted to an ISP is given by 130.34.13.64/26. These addresses are to be divided into 4 subnetworks with equal no. of hosts. Design subnetworks & obtain all information about each subnet.

→ 1) Find total no. of addresses (N)

Given address: 130.34.13.64/26.
From slash notation: n = 26 - prefix length

No. of addresses in whole network

$$N = 2^{(32-n)} = 2^{(32-26)} = 2^6 = 64$$

↳ The first address → 130.34.13.64/26
↳ by AND's with n/w mask
Last address → 130.34.13.127/26
↳ by setting non mask bits to 1

2) Subnet Design.
~~Find the no of hosts per subnetwork~~

~~$n_1 = n_2 = n$~~

There are 4 subnetworks with equal no. of hosts.

No. of hosts per subnet work

$$N_1 = N_2 = N_3 = N_4 = \frac{N}{4} = \frac{64}{4} = 16$$

↳ First restriction satisfied as $\frac{64}{16}$ → equal to power of 2

- Find prefix length of subnets.

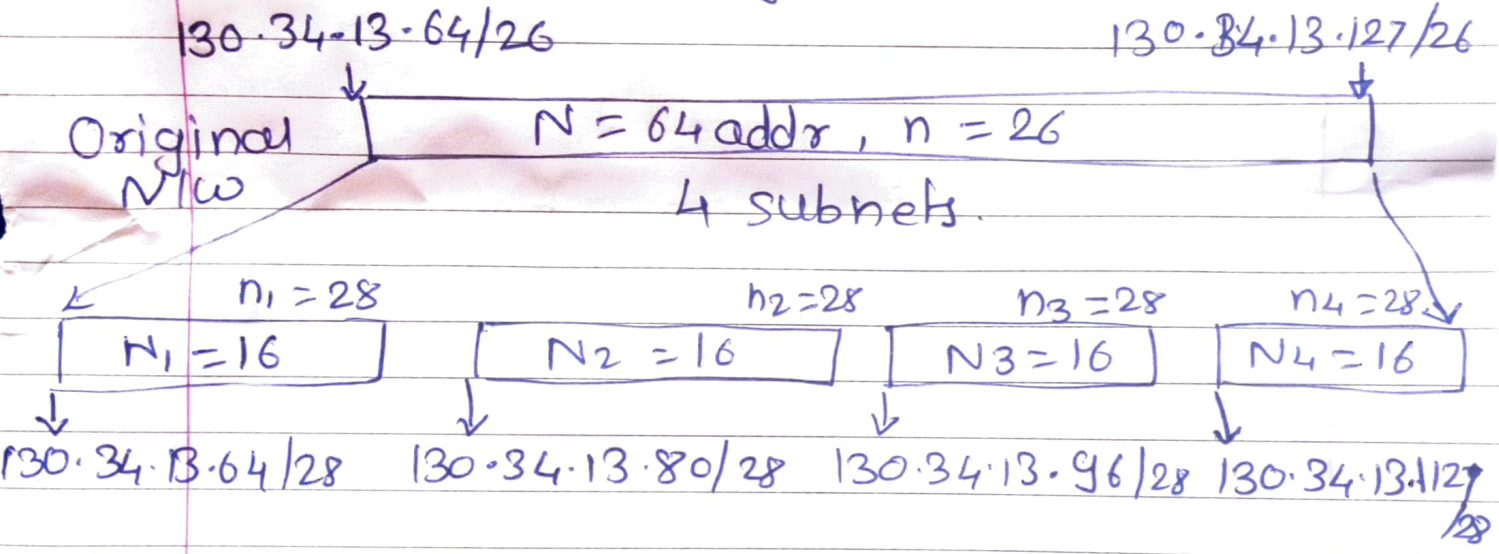
$$n_1 = n_2 = n_3 = n_4 = n + \log_2\left[\frac{N}{N_{sub}}\right]$$

$$= 26 + \log_2\left[\frac{64}{16}\right] = 26 + \log_2(4)$$

$$= 26 + 2 = 28$$

So, $n_1 = n_2 = n_2 = n_3 = 28$

- Starting & ending address of subnets.



All these starting addresses are divisible by 16