

Example 1.18: Convert 98 to binary

```

98 → 0×128
98 → 1×64 → remainder 34
34 → 1×32 → remainder 2
2 → 0×16
2 → 0×8
2 → 0×4
2 → 1×2 → remainder 0
0×1

```

The binary number for 98 is 01100010. Since the left most bit is 0, you might see this number written as 1100010 also. Remember we really count from RIGHT to LEFT.

At the end of this chapter are exercises to convert binary numbers to decimal and decimal to binary.

1.2 IP Address Classes and Subnet Masks

The Internet Authorities originally organized the IP address space into 5 classes. The classes are defined by how many 1's in the left most bits.

```

Class A    00000000.00000000.00000000.00000000 to 01111111.11111111.11111111.11111111
Class B    10000000.00000000.00000000.00000000 to 10111111.11111111.11111111.11111111
Class C    11000000.00000000.00000000.00000000 to 11011111.11111111.11111111.11111111
Class D    11100000.00000000.00000000.00000000 to 11101111.11111111.11111111.11111111
Class E    11110000.00000000.00000000.00000000 to 11111111.11111111.11111111.11111111

```

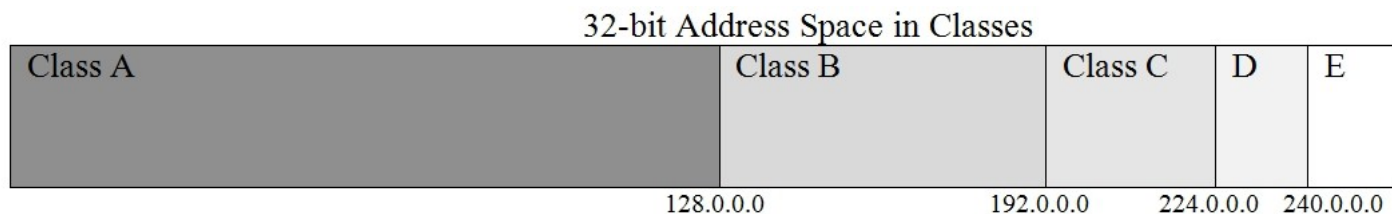
In decimal form...

```

Class A    0.0.0.0 to 127.255.255.255
Class B    128.0.0.0 to 191.255.255.255
Class C    192.0.0.0 to 223.255.255.255
Class D    224.0.0.0 to 239.255.255.255
Class E    240.0.0.0 to 255.255.255.255

```

If we were to visualize the allocation of the addresses into the classes, it would look like this:



The Internet Authorities originally thought that most of the addresses would be used in a few very large subnets. Classes are not used today on the real internet. Classless Inter-domain Routing, or CIDR, will be discussed in Chapter 3. But an understanding of IP address classes is still very useful when learning about subnetting.

We'll take the 192.168.2.192/28 for our subnet to hold 10 hosts. On the exam, the other 2 subnets could be listed as possible answers also. The answers we choose are:

192.168.2.0/25
192.168.2.128/26
192.168.2.192/28

This doesn't mean these answers will be listed on the exam. They might list 192.168.2.128/25 as the right answer, which means they wanted you to subnet the 192.168.2.0 subnet (the reverse of what we did here). In other words, VLSM questions usually have more than one way to solve. That's what we mean when we said that VLSM questions tend to be "open ended". There are always more than one right answer, and more than one way to arrive at the right answers. **On the exams, you have to look carefully at all the multiple choice answers!** You need to know all the possible answers, and see all the wrong answers. Also, all the answers you choose have got to make sense. Here are examples of some wrong answers, and combination of answers that don't make sense.

192.168.2.0/29
 192.168.2.225/25
 192.168.2.140/24
 192.168.2.128/25
 192.168.2.192/27

For example, why would you choose 192.168.2.128/25 **and** 192.168.2.192/27 together? The first subnet has 128 hosts, and the second subnet is only 64 hosts away ($128 + 64 = 192$)! You can't subnet like that. That combination of answers won't make sense.

Example 2.31:

We have a Class network of 200.113.14.0/25, and we want a subnet to hold **50 hosts**, another to **30 hosts**, and another to hold **2 hosts**.

We can see that 200.113.14.0/25 already has 2 subnets:

200.113.14.0/25
 200.113.14.128/25

Let's work with 200.113.14.0/25, and save 200.113.14.128/25 for future use. With 200.113.14.0/25, we can subnet to /26. This makes the $m = 1$ and $n = 6$, so we get 2 subnets, each with 64 hosts.

200.113.14.0/26
 200.113.14.64/26

We choose 200.113.14.0/26 for our 50 host subnet. For the 30 host subnet, we subnet to /27, so $m = 1$ and $n = 5$, so we get 2 subnets with 32 hosts each (actually 30 hosts).

200.113.14.0/26 (used on 50 host subnet)
 200.113.14.64/27
 200.113.14.96/27

We choose 200.113.14.64/27 for the 30 host subnet. For the 2 host subnet, we subnet to /30, so $m = 3$ and $n = 2$, so we get 8 subnets with 4 hosts each (actually 2 hosts).

200.113.14.0/26 (used on 50 host subnet)

Answer: 143.217.181.88/29

Example 4.2: 73.0.0.0/30 What is the network address for Subnet 4194299?

This is a Class A network, so the default subnet mask is /8. With a subnet mask /30, there are $2^{22} = 4194304$ subnets created. $N = 4194299$.

01001001.xxxxxxxxx.xxxxxxxxx.xxxxxxxxx ← all possible IP addresses in 73.0.0.0/8

11111111.11111111.11111111.11111100 ← new subnet mask /30

01001001.xxxxxxxxx.xxxxxxxxx00 ← all possible network addresses

The network addresses are derived from doing a Logical AND operation between every possible IP address in the original 143.217.0.0/8 block and the new subnet mask. The value of Subnet N is related directly to the value of N.

All subnet network addresses:

00000000.00000000.00000000	N = 0 0.0.0
00000000.00000000.00000100	N = 1 0.0.4
00000000.00000000.00001000	N = 2 0.0.8
00000000.00000000.00001100	N = 3 0.0.12

.
.

11111111.11111111.11110000	N = 4194300 255.255.240
11111111.11111111.11110100	N = 4194301 255.255.244
11111111.11111111.11111000	N = 4194302 255.255.248
11111111.11111111.11111100	N = 4194303 255.255.252

Convert $N = 4194299$ to binary = 111111111111111111011

Add 2 zeroes on the right: 11111111111111111101100

Add the dots and octets from RIGHT to LEFT: .11111111.11111111.11101100

Convert octets to decimal: .255.255.236

So the network address for Subnet 4194299 is 73.255.255.236

Answer: 73.255.255.236/30

This procedure of converting the N value to binary, then forming octets, and converting the octets to decimal numbers also works for Class C networks. But for Class C networks, it is faster to use the **Last octet = $N \times$ (increment)** formula.

4.2 Advance VLSM Problems

In Chapters 1 and 2, we studied VLSM questions which asked for a subnet network address for each group of hosts. More advance VLSM questions deal with finding multiple subnets for each requirement. This is basically a task of organizing and planning subnet address ranges. Use the network increment to get the address ranges.