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# Simple Tricks To Ace the Subnetting Portion of Any Certification Exam

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## Introduction

Subnetting seems to be a battle of fighting bits, decimal numbers, and countless methods and processes to convert from one to the other. While the methods may be confusing, the mathematics behind them is the same for all. In this paper, you will learn some of the simpler ways to figure out many of the subnetting questions that you will find on the industry certification tests.

Unlike some of the more complex methods, these methods use subtraction, addition, multiplication, and division—no converting from binary or decimal. As a matter of fact, if you can do the four basic math functions, you can learn these failure-free methods quickly and easily.

**Warning:** The basic assumption is that you are already familiar with subnetting and have actually learned subnetting concepts elsewhere. This white paper does not teach subnetting, it teaches useful methods for passing certification test questions.

## Overview of Subnetting

The reason we subnet is to break larger IP networks into smaller ones. Often we have networks that are the same size. These use a fixed length subnet mask for all networks. Other network designs employ different subnet masks, depending on the number of addresses required for each subnet. This is called variable length subnet masking or VLSM.

As I learned subnetting, I began to realize that subnetting is much like my grandmothers kitchen. When my grandmother made pies, she cut the pies in various configurations depending on the needs of the pie eaters. Often, the pie was cut with all pieces the same size. Other times she cut the slices in various sizes, depending on who was eating. My grandfather always got the biggest piece . . . go figure.

In the end analysis, subnetting is taking a pie, your assigned address space, and cutting the address space into variously sized pieces depending on need. My grandmother cut her pies with a knife. We cut our address space by using subnet masks. By visually inspecting the pie my grandmother cut, you could determine how big each piece was. By looking at the address and subnet mask, you can see how many addresses are found in each subnet and what those addresses are.

Let's review some of the more important concepts related to subnetting.

## Address Class Identification

You will often need to identify the class of an IP address in order to complete test questions successfully. Below is an address class table to assist you.

Address Class	First Octet Value Range	First Octet Binary Value
A	0-127	0nnnnnnn
B	128-191	10nnnnnn
C	192-223	110nnnnn
D	224-239	1111nnnn

**Address Class Table**

## The Octet and the Binary Progression

An octet is an eight bit data element. When IP was being developed, the term byte had two possible meanings, a seven bit byte or an eight bit byte. The IP developers started using the term "octet" to reflect the eight bit byte format. An eight bit data element has the ability to store the binary equivalent of decimal numbers from 0 to 255.

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

**Binary Table**

The subnet mask and IP addressing revolve around the table shown above. This is the binary to decimal equivalent table. One of the first things you might consider doing in a certification test environment is to copy this table from memory on to your scratch paper or erasable worksheet provided at the testing center.

Another table to record is below:

Binary	Mask	Addresses
00000000	0	256
10000000	128	128
11000000	192	64
11100000	224	32
11110000	240	16
11111000	248	8
11111100	252	4
11111110	254	2
11111111	255	1

**Mask Table**

This table contains the eight possible octet values for any mask along with the decimal equivalent. It will be used to determine the mask when the number of subnets required is given.

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## Mask-to-Prefix or Prefix-to-Mask Conversion

255.255.255.0 is equivalent to a prefix of /24.

If you see masks or prefixes on your exam, don't panic. The prefix is simply another way to state the mask. The prefix contains a count of the total number of 1 bits in the subnet mask. The conversion is quite simple. You can use the mask table above to help determine the number of bits in each octet of the mask.

**To convert from mask to prefix:** simply add together the number of bits found in the mask. For example, the mask 255.255.248.0 is equivalent to a /21 bit prefix. Here's how the conversion is done.

255 = 8 bits  
255 = 8 bits  
248 = 5 bits  
0 = 0 bits

The sum of  $8 + 8 + 5 + 0$  is 21.

Here's another example:

What is the prefix when the mask is 255.255.255.192?

255 = 8 bits  
255 = 8 bits  
255 = 8 bits  
192 = 2 bits

The sum of  $8 + 8 + 8 + 2$  is 26. The correct answer would be /26.

**To convert from prefix to mask:** rather than add, you will subtract.

In this example, you are asked to convert the mask prefix /23 to a mask. Here's how it is done.

Begin by subtracting 8 from the prefix number.	$23 - 8 = 15$	255.
Then subtract another 8 from the remainder	$15 - 8 = 7$	255.255.
Find the seven bit entry in the mask table and add it to the mask		255.255.254.
Since there are no bits left, add 0 to the mask		255.255.254.0

The answer is 255.255.254.0

Another way to arrive at the same solution is to take the prefix and divide it by 8.

$23 / 8 = 2$  with a remainder of 7.

There are two 255s in the front of the mask with seven additional bits in the third octet and no bits in the fourth. 255.255.254.0

I prefer the remainder method. Here's another example.

Convert /29 to a subnet mask.

$$29 / 8 = 3 \text{ with a remainder of } 5$$

There are three 255s in the mask with a five bit fourth octet. 255.255.255.248

## What Mask To Use, Part 1

One of the problem classes used in certification tests is the "what mask" class. You are given a description of a networking situation and are asked to select the correct mask to use in subnetting the network.

Here is a typical question:

XYZ Corporation is using the 192.168.100.0 private address to implement a workgroups in their network. Each workgroup will consist of 17 devices requiring IP addresses. One additional address is required for the router interface in each subnet. What subnet mask should XYZ use?

First, determine the number of addresses in each subnet; in this case, 18. Next, round up to the next power of 2. The next larger power of 2 beyond 18 is 32. Subtract 32 from 256. The result is 224. This is the fourth octet of the mask to complete this subnetting problem: 255.255.255.224

This method works with Class C addresses where the number of required addresses is known. It can also be extended to any addressing situation where the number of addresses in each subnet is known.

Another example:

XYZ Corporation is using 172.16.0.0 for their networking needs. Each subnet requires 280 IP addresses including the router interface. What subnet mask should be used?

For IP addressing requirement where the number of addresses is greater than 256, divide the number of addresses by 256. 280 divided by 256 is 1 with a remainder of 26. If there is a remainder, add 1 to the quotient. Our operational number is now 2. As we did before, subtract 2 from 256. The result is 254 which is the third octet of the subnet mask for this problem; 255.255.254.0.

## What Mask To Use, Part 2

In the two previous examples, we were given the number of addresses required in each subnet. What if the question provides the number of subnets required? Here's a method to solve those problems.

XYZ Corporation is using the 192.168.100.0 private address to implement a workgroups in their network. There will be 5 subnets implemented. What subnet mask should XYZ use?

The 192.168.100.0 network is a Class C network. The default mask is 255.255.255.0. We will need to determine the value of the mask in the fourth octet only.

The process in this example requires that we determine the number of bits in the mask required to hold the five subnet numbers. Using the binary table above, find the next decimal number greater than five. The number is 8. Now, look above the 8 to find the exponent of 2 that is equivalent to 8. That exponent is 3,  $2^3 = 8$ . Locate the mask in the Mask Table with three binary ones. You have found the last octet of the mask; 255.255.255.224. This solution is fairly simple.

Here is an example for a Class A network with a large number of subnets.

XYZ Corporation will be subnetting the 10.0.0.0 network into 18,000 subnets. Each subnet will contain the same number of addresses. What subnet mask should they use?

We know that with a Class A address, our default mask will be 255.0.0.0. Next we need to determine what the remainder of the mask will be.

The simple math example is to determine the number of bits required to hold the number 18,000. With a calculator, that would be simple. Without, we need to practice a bit of twos multiplication. Start with the number 1, multiply by 2 and then continue as illustrated below:

1,2,4,8,16,32,64,128,256,512,1024,2048,4096,8192,16384 . . . **stop right there.**

What we have done is prepare a simple, power of two table by multiplying our preceding values by two each time. Now, count the number of numbers you have recorded. There are 15 numbers in the list indicating that 15 bits are required to hold the number 18,000. Why did we stop at 16384 and not continue? If we add all of the numbers together, we would have 32,767. This is greater than the 18,000 we needed. That would have allocated too many bits.

Now, what is the mask? We need 15 subnetting bits plus the 8 bits for the Class A mask. That's a prefix of 23 bits; or a /23. Converting /23 to a mask results in 255.255.254.0.

## The Subnet Range of Addresses Problem

One of the more popular questions found on certification tests is the "range of addresses" problem. In this type of problem you are given an IP address and a subnet mask and are asked to identify addresses that are in the same subnet as the given address. For example:

You are trying to determine why a user cannot connect to a server from their workstation. The workstation IP address and subnet mask are given below.

IP address = 193.168.22.104

Subnet Mask = 255.255.255.224

Select the addresses that are in the same subnet as the IP address given.

a. 193.168.22.114

b. 193.168.22.69

c. 193.168.22.127

d. 193.168.22.85

Depending on how you learned subnetting, you might try to approach this using a technique using binary numbers. There is a much easier way.

For a situation such as this, a class C address, the first step is to subtract the last octet of the subnet mask from 256. That will give you the number of addresses in each subnet.

$$256 - 224 = 32$$

Now, divide the last octet of the address by 32, the number of addresses in each subnet.

$$104 / 32 = 3 \text{ (Forget about the fraction or remainder part - you don't need it.)}$$

Next, multiply the number of addresses in each subnet by the result of division above.

$$32 * 3 = 96$$

The beginning address of the subnet is 193.168.22.96! Since there are 32 addresses in the subnet, the ending address is 193.168.22.127. 193.168.22.96 through 193.168.22.127 there are 32 addresses when counting inclusively.

The correct answer to the question above is a and c.

This method does not require any sophisticated mathematics, just simple subtraction, division and multiplication.

Here's another problem.

## Class B – Same Thing, Only Different

This time a class B address is used.

$$\begin{array}{l} 172.90.12.22 \\ 255.255.248.0 \end{array}$$

Now we have a slightly different issue, but you arrive at the solution the very same way. This time we could not care less about the fourth octet of the address or mask. The fourth octet of the mask is all zeros and does not indicate any subnetting structure. The fourth octet is part of the host field of the address. The subnetting structure is found in the third octet of the mask, the 248. Let's see how this works out.

As we did before, subtract the third octet of the subnet mask from 256.

$$256 - 248 = 8$$

In this case, the number 8 tells us how many groups of 256 addresses will be in each subnet. Now, divide the third octet of the address by 8, the number of groups in each subnet.

$$12 / 8 = 1 \text{ (Forget about the fraction or remainder part . . . you don't need it.)}$$

Multiply the number of groups by the result of division above.

$$1 * 8 = 8$$

The beginning address of the subnet is 172.90.8.0! Since there are 8 groups of 256 addresses in the subnet, the ending address is 172.90.15.255. 172.90.8.0 through 172.90.15.255 are 8 groups of 256 addresses when counting inclusively.

## Other Problem Types

Most problems you will find on the certification exams can be solved using the procedures above. Some of the questions will ask about the network address, first usable address, last usable address or the broadcast address for a network or subnet.

Remember, in this paper we are steering clear of binary so I won't go into that part of the discussion.

A couple of gentle reminders. Network addresses are always even and broadcast addresses are always odd. First usable addresses are always odd, last usable addresses are always even. This should help in some of the process of elimination steps you might use in test-taking.

Finding the network address is simple, finding the others is just as easy.

The IP address of a device is 201.234.1.99 and the subnet mask is 255.255.255.224. What is the last usable address in this subnet?

Remember how we figured out the subnet address? Subtract 224 from 256 to determine the number of addresses in the subnet. That result is 32 addresses in each subnet. Now divide 99 by 32 and forget the remainder.

$$99 / 32 = 2 \text{ (subnets before this one)}$$

Multiply 2 times 32 to get the subnet address.

<b>Subnet Address</b>	<b>First Usable Address</b>	<b>Last Usable Address</b>	<b>Broadcast Address</b>
201.234.1.64	201.234.1.65	201.234.1.126	201.234.1.127
	One more than subnet address	One less than broadcast	(Subnet address) + (Addresses in subnet) - 1 Add .255 in fourth octet

Here's a class B example:

The IP address is 165.33.9.211, and the subnet mask is 255.255.254.0

No subnet bits are found in the fourth octet so let's move to the third octet.

Subtract 254 from 256. There are two groups of 256 addresses in each subnet.

Divide 9 by 2 and discard the remainder.

$$9 / 2 = 4$$

Multiply 4 times 2 to determine subnet address. Place the calculated subnet address in the third octet of the address and zero in the fourth octet. The subnet address is 165.33.8.0. If we were to examine that address in binary, we would note that the host address is all zeros, the identifier set aside for network and subnet addresses.

Here's a class A example:

<b>Subnet Address</b>	<b>First Usable Address</b>	<b>Last Usable Address</b>	<b>Broadcast Address</b>
10.55.192.0	10.55.192.1	10.55.255.254	10.55.255.255
	One more than subnet address	One less than broadcast	Subnet address + number of groups minus 1 Add .255 in fourth octet

The IP address is 10.55.229.44, and the subnet mask is 255.255.192.0

No subnet bits are found in the fourth octet so let's move to the third octet.

Subtract 192 from 256. There are 64 groups of 256 addresses in each subnet.

Divide 229 by 64 and discard the remainder.

$$229 / 64 = 3$$

Multiply 64 times 3 to determine subnet address. Place the calculated subnet address in the third octet of the address and zero in the fourth octet. The subnet address is 10.55.192.0. If we were to examine that address in binary, we would note that the host address is all zeros, the identifier set aside for network and subnet addresses.

## Summary

Subnetting continues to be key element in many certification examinations. Learning how to quickly and correctly solve the subnetting questions will give you more time to spend on the other questions in your exam. The extra time can be the difference between failing and passing the test.

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## About the Author

Ted Rohling has been a contract instructor with Global Knowledge since 1995. With over 40 years of experience in information technology, telecommunications and security, Ted teaches in the Networking and Security product lines and focuses on TCP/IP, Networking Fundamentals, Network Management, Storage Networking, and CISSP Preparation. He currently holds the CISSP certification and has previously held various certifications from Nortel, Cisco and Microsoft. His educational background includes a BBA in Management Science, and MA in Information and Computer Management, and an MS in Educational Human Resource Development.