The Bryant Advantage

WORLD-CLASS CISCO® TRAINING

Mastering Binary Math And Subnetting

An Exclusive Ebook From The Bryant Advantage®

www.thebryantadvantage.com

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Welcome To The Mastery Series!

Thanks for purchasing the first edition of ***The Bryant Advantage Mastery Series.*** This series will concentrate on one major Cisco topic per issue, and there's no better topic to start with than binary math.

In my ICND classes, binary math is my favorite topic to teach. Why? Because I love the look in students' eyes as they go from a bit of intimidation to absolutely mastering the topic. My method of teaching binary math has helped many students master this topic, and it's going to do the same for you.

The number one reason students fail their CCNA® exams is a not just a lack of understanding binary math, but a lack of experience in applying it to answer subnetting questions. **The only way to become a master of binary math is to practice using it.** You hold in your hand a book that will not only explain binary math to you, but show you how to apply it in different situations.

Mastering binary math is simply a matter of mastering the fundamentals. Therefore, even if you think you have a good grip on binary-decimal and decimal-binary conversions, do not skip those sections. Go through each section thoroughly, and make sure you understand the concept before moving on to the next section. Like most Cisco concepts, these binary math concepts build on each other.

With practice, you will get better and better at these questions, until you have mastered the techniques used to answer the different question types. On exam day, you will have no hesitancy when confronted with binary math questions.

Again, I appreciate you purchasing this book. Make sure to visit my website, www.thebryantadvantage.com, on a regular basis to be the first to know when new editions of The Bryant Advantage Mastery Series come out.

To your success,

Chris Bryant
Cisco Certified Internetwork Expert #12933

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Section One: Introduction To Binary Math

If there's one section that trips up otherwise prepared CCNA candidates, it's binary math. One reason for this is that Cisco has several different formats of subnetting and binary math questions that they'll hit you with on the CCNA exam. Another reason is that it's different than any other type of math you've ever done; not many of us are exposed to binary math in high school or college.

Some instructors and training schools go so far as to not really teach binary math and how it works; rather, they teach chart memorization. This is really, really a bad idea. Why? First, Cisco has adapted its CCNA exam questions to weed out candidates who don't understand binary math; these questions demand that you know how to perform binary math rather than memorize a chart of subnet masks.

Second, let's face it: Any chart you memorize for any exam, whether it's for your CCNA exam or a history exam in high school or college, is quickly forgotten. Facts that are memorized but not understood do not stay with you, but once you truly understand a subject, you'll carry that understanding with you for the rest of your life. I've seen more than one job candidate fold like a cheap table when they had to solve a simple subnetting question during an interview. Why? They had forgotten their chart!

There's good news, though! The simple fact is that if you know how to add, subtract, and double "1" seven times, you can perform any binary math question Cisco ever asks you.

The question I'm continually asked by my students is how to make subnetting easy. The answer is always the same: "Practice".

In this book, we'll look at the most common seven types of binary math and subnetting questions you'll be faced with during your Cisco certification pursuit and your job. Practice each section diligently, and you'll be ready for any question on subnetting you get from Cisco, your employer, or a potential employer!

Before we look at the different question types, let's review the basics of binary math.

Conquering Your Anxiety Of Binary Math

In teaching my CCNA and CCNP prep courses, I can see people actually get physically tense when we get to the binary math section. As I said, very few of us are exposed to binary math in high school or college, so part of the anxiety is learning something new.

The larger part of that anxiety, though, seems to come from the thinking that binary math is some kind of advanced calculus. Nothing could be further from the truth.

I often give these students what I call "The Bryant Advantage Binary Math Qualification Exam". I simply ask them these questions:

- Can you add?
- Can you subtract?
- If I gave you the number "1" to start with, could you double it seven times?

Here's the good news: If you can do these three things, you can solve binary math questions. All you need is practice.

That last sentence is key: All you need is practice. Why did I repeat that? Because not only do you have to be good with binary math to pass the CCNA exam, you have to be fairly quick. You don't have 20 minutes to solve each question. I've seen many candidates post notes on the Internet stating that they made mistakes because they understood binary math, but they had to hurry too much.

This happens because of a lack of practice. It's not enough to be right; you have to be right and quick. The only way to get that good is to practice constantly. This method has been used by thousands of CCNAs, and it will work for you, too. (It will also give you a big leg up on the CCNP exams.)

The IP Address Classes

You do have to know these classes by heart, as they will impact the answers you give on the exam and in real life. You should know these address classes cold, and their default subnet masks as well.

	Class A	Class B	Class C
1st Octet Range	1 - 126	128 - 191	192 – 223
Default Subnet Mask	255.0.0.0	255.255.0.0	255.255.255.0
Default # of Network Bits	8	16	24
Default # of Host Bits	24	16	8

Expressing Numbers In Binary And Decimal Format

Where does the term "binary" in "binary math" come from, anyway? Let's compare how numbers are expressed in binary and decimal format.

The number format we use every day is expressed in decimal format. If you express a number as "47", for instance, that is expressing a number in decimal format. When an IP address is written as 100.45.45.48, that's referred to as "dotted decimal".

Binary numbers are expressed in strings of ones and zeroes. Throughout your Cisco studies, you'll see such strings as "01001000". That's binary numbering.

What does that string of zeroes and ones mean? The more familiar decimal numbering is used to convert a number from binary to decimal, or decimal to binary. Remember when I said that if you can double the number "1" seven times, you can do any binary math problem? Here's the simple table you'll use to solve many binary math problems. Note the values in the table start with "1" in the rightmost column, and simply double from right to left until the boxes are filled:

128	64	32	16	8	4	2	1

You can also start with 128 in the leftmost box and keep dividing by 2 until all the boxes are filled, but it's my experience that most students are more comfortable starting with "1" and doubling from right to left.

You'll see in future sections how this chart is used in almost every subnetting question you'll ever see, and how that chart will help you truly understand binary math. For now, decide whether you want to start with "1' and double from right to left, or start with "128" and divide by 2 from left to right, and use that method for all your questions. Choose the one you're more comfortable with, but decide on your method now and stick with it.

Introduction To The "Boolean AND" Operation

You must be comfortable performing Boolean ANDs as well. I see anxiety in students' eyes when I bring this up as well, but this is even simpler than binary math.

A Boolean AND is simply a bit-by-bit comparison of the bits in an IP address and subnet mask. In future sections, you'll clearly see how the Boolean AND will help you solve many subnetting questions. For now, keep in mind that these bits being compared will either be set to "1" or "0". If both bits are "1", the result of the Boolean AND is "1". *Any other combination will result in "0".*

Here is a quick example using two pairs of six-digit binary numbers.

	1^{st}	2^{nd}	3^{rd}	4^{th}	5^{th}	6^{th}
1st Binary Number: 001100	0	0	1	1	0	0
2nd Binary Number: 111101	1	1	1	1	0	1
Boolean AND Result	0	0	1	1	0	0

Note that the 3^{rd} and 4^{th} numbers are both "1", so the AND result is "1". All other combinations, whether it's "1" and "0" or "0" and "0", result in "0".

With a basic understanding of the default masks of the different types of networks, as well as how binary and decimal numbers are expressed, you're ready to begin tackling binary and decimal conversions.

Section Two: Converting Binary To Dotted Decimal

An example of a binary-to-dotted decimal question:

"*What is the dotted decimal equivalent of the binary number 01100010 00111100 11111100 01010101?*"

To answer this type of question, use the chart we developed in Section One. The first set of eight numbers refers to the first octet of an IP address, and so on, so use the following variation of the chart:

	128	64	32	16	8	4	2	1
First Octet								
Second Octet								
Third Octet								
Fourth Octet								

For binary-to-decimal conversion, just plug the binary number strings into the table. After doing so, add up all the values that have a "1" in them from left to right, and that will give you the decimal value for each octet.

Let's take the first octet as an example. The binary string is 01100010. Filling in your chart from left to right, the first octet looks like this:

	128	64	32	16	8	4	2	1
First Octet	0	1	1	0	0	0	1	0

There are ones in the column for 64, 32, and 2. Just add them up, and that is the decimal value for the first octet – 98. Repeat the process for each octet, and you quickly have the dotted decimal equivalent of the binary string.

	128	64	32	16	8	4	2	1	Total
First Octet	0	1	1	0	0	0	1	0	98
Second Octet	0	0	1	1	1	1	0	0	60
Third Octet	1	1	1	1	1	1	0	0	252
Fourth Octet	0	1	0	1	0	1	0	1	85

The dotted decimal equivalent of the binary string we were given is 98.60.252.85.

Exam Tip

When you're taking a Cisco exam, the clock is ticking from the moment you see the first question. However, it's up to you when you press the button to see the first question. It's wise to draw a couple of these charts **before** you begin the exam, as well as any other diagrams or charts you want to use.

Many testing centers now give candidates laminated boards with markers to use during the exam. These markers tend not to be fine-point markers, which can make them difficult to use for solving binary math questions. I strongly recommend to you that you ask the test proctor for real paper and a pen.

Binary-to-decimal conversion is the simplest type of question you'll get, but don't underestimate them. Practice these using your chart, and it will give you the foundation you need to answer the more difficult subnetting questions.

Binary-To-Decimal Practice Questions

What is the dotted decimal equivalent of the binary string 11110000 00110101 00110011 11111110?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	1	1	0	0	0	0	240
Second Octet	0	0	1	1	0	1	0	1	53
Third Octet	0	0	1	1	0	0	1	1	51
Fourth Octet	1	1	1	1	1	1	1	0	254

Answer: 240.53.51.254.

What is the dotted decimal equivalent of the binary string 00001111 01101111 00011100 00110001?

	128	64	32	16	8	4	2	1	Total
First Octet	0	0	0	0	1	1	1	1	15
Second Octet	0	1	1	0	1	1	1	1	111
Third Octet	0	0	0	1	1	1	0	0	28
Fourth Octet	0	0	1	1	0	0	0	1	49

Answer: 15.111.28.49.

What is the dotted decimal equivalent of the binary string 11100010 00000001 11001010 01110110?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	1	0	0	0	1	0	226
Second Octet	0	0	0	0	0	0	0	1	1
Third Octet	1	1	0	0	1	0	1	0	202
Fourth Octet	0	1	1	1	0	1	1	0	118

Answer: 226.1.202.118.

What is the dotted decimal equivalent of the binary string 01010101 11111101 11110010 00010101?

	128	64	32	16	8	4	2	1	Total
First Octet	0	1	0	1	0	1	0	1	85
Second Octet	1	1	1	1	1	1	0	1	253
Third Octet	1	1	1	1	0	0	1	0	242
Fourth Octet	0	0	0	1	0	1	0	1	21

Answer: 85.253.242.21.

What is the dotted decimal equivalent of the binary string 00000010 11111001 00110111 00111111?

	128	64	32	16	8	4	2	1	Total
First Octet	0	0	0	0	0	0	1	0	2
Second Octet	1	1	1	1	1	0	0	1	249
Third Octet	0	0	1	1	0	1	1	1	55
Fourth Octet	0	0	1	1	1	1	1	1	63

Answer: 2.249.55.63.

What is the dotted decimal equivalent of the binary string 11001001 01011111 01111111 11111110?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	0	1	0	0	1	201
Second Octet	0	1	0	1	1	1	1	1	95
Third Octet	0	1	1	1	1	1	1	1	127
Fourth Octet	1	1	1	1	1	1	1	0	254

Answer: 201.95.127.254

What is the dotted decimal equivalent of the binary string 11111000 00000000 11111001 01100110?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	1	1	1	0	0	0	248
Second Octet	0	0	0	0	0	0	0	0	0
Third Octet	1	1	1	1	1	0	0	1	249
Fourth Octet	0	1	1	0	0	1	1	0	102

Answer: 248.0.249.102.

What is the dotted decimal equivalent of the binary string 00111110 11111111 01011010 01111110?

	128	64	32	16	8	4	2	1	Total
First Octet	0	0	1	1	1	1	1	0	62
Second Octet	1	1	1	1	1	1	1	1	255
Third Octet	0	1	0	1	1	0	1	0	90
Fourth Octet	0	1	1	1	1	1	1	0	126

Answer: 62.255.90.126.

Exam Tip

When solving binary-to-decimal questions, don't be concerned about octets that resolve to "0" or "255". As you'll read later, those addresses are considered unusable for host addresses. When performing an address conversion, don't worry about whether it's a valid host address. Just perform the conversion as the question asks.

What is the dotted decimal equivalent of the binary string 11001101 11110000 00001111 10111111?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	0	1	1	0	1	205
Second Octet	1	1	1	1	0	0	0	0	240
Third Octet	0	0	0	0	1	1	1	1	15
Fourth Octet	1	0	1	1	1	1	1	1	191

Answer: 205.240.15.191

What is the dotted decimal equivalent of the binary string 10011001 11110000 01111111 00100101?

	128	64	32	16	8	4	2	1	Total
First Octet	1	0	0	1	1	0	0	1	153
Second Octet	1	1	1	1	0	0	0	0	240
Third Octet	0	1	1	1	1	1	1	1	127
Fourth Octet	0	0	1	0	0	1	0	1	37

Answer: 153.240.127.37

What is the dotted decimal equivalent of the binary string 11011111 01110110 11000011 00111111?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	1	1	1	1	1	223
Second Octet	0	1	1	1	0	1	1	0	118
Third Octet	1	1	0	0	0	0	1	1	195
Fourth Octet	0	0	1	1	1	1	1	1	63

Answer: 223.118.195.63.

What is the dotted decimal equivalent of the binary string 00000100 00000111 00001111 00000001?

	128	64	32	16	8	4	2	1	Total
First Octet	0	0	0	0	0	1	0	0	4
Second Octet	0	0	0	0	0	1	1	1	7
Third Octet	0	0	0	0	1	1	1	1	15
Fourth Octet	0	0	0	0	0	0	0	1	1

Answer: 4.7.15.1.

Exam Tip

I occasionally hear from students that an answer to a binary math question "doesn't look right". Don't be concerned about how it looks; use your knowledge to determine the correct answer and go with it.

What is the dotted decimal equivalent of the binary string 11100000 00000111 10001111 00000100?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	1	0	0	0	0	0	224
Second Octet	0	0	0	0	0	1	1	1	7
Third Octet	1	0	0	0	1	1	1	1	143
Fourth Octet	0	0	0	0	0	1	0	0	4

Answer: 224.7.143.4.

What is the dotted decimal equivalent of the binary string 11000000 00000011 11011011 00100101?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	0	0	0	0	0	192
Second Octet	0	0	0	0	0	0	1	1	3
Third Octet	1	1	0	1	1	0	1	1	219
Fourth Octet	0	0	1	0	0	1	0	1	37

Answer: 192.3.219.37.

What is the dotted decimal equivalent of the binary string 10000000 01111111 00110011 10000011?

	128	64	32	16	8	4	2	1	Total
First Octet	1	0	0	0	0	0	0	0	128
Second Octet	0	1	1	1	1	1	1	1	127
Third Octet	0	0	1	1	0	0	1	1	51
Fourth Octet	1	0	0	0	0	0	1	1	131

Answer: 128.127.51.131

What is the dotted decimal equivalent of the binary string 11111011 11110111 11111100 11111000?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	1	1	1	0	1	1	251
Second Octet	1	1	1	1	0	1	1	1	247
Third Octet	1	1	1	1	1	1	0	0	252
Fourth Octet	1	1	1	1	1	0	0	0	248

Answer: 251.247.252.248.

Section Three: Converting Decimal To Binary

An example of a decimal-to-binary question:

"*What is the binary equivalent of the dotted decimal IP address 217.48.23.190?*"

Converting decimal to binary uses the same chart as binary to decimal, but the actions taken to achieve the answer are different. Instead of being given the 1s and 0s to be placed into a chart, you must determine which columns should have 1s and 0s.

As with the previous question type, solve the question one octet at a time. Let's walk through the first octet of this question. Keep in mind that this may be a little clumsy at first, but after getting in plenty of practice, this method will become second nature to you.

The decimal number of the first octet is 217. This number must now be converted to binary:

	128	64	32	16	8	4	2	1
1st Octet: 217								

You already know what the decimal value is. You must now determine whether each column should have a "1" or a "0" in it. Work from left to right, and ask this question: "Can I subtract this column's value from the current octet value with the result being a positive number or zero?" If so, perform the subtraction, put a "1" in the column, and go to the next column. If not, place a "0" in the column, and repeat the process for the next column.

That sounds like a longwinded operation, doesn't it? Believe me, it's much longer to explain than to actually do. Let's look at that chart again:

	128	64	32	16	8	4	2	1
1st Octet: 217								

Can 128 be subtracted from 217, and result in zero or a positive number? Sure, with the result being 89. Put a "1" in the 128 column and go to the next column, repeating the operation WITH THE NEW RESULT.

	128	64	32	16	8	4	2	1
1st Octet: 217	1							

Can 64 be subtracted from the new result, 89? Yes, with a remainder of 25. Put a "1" in the 64 column and repeat the operation in the next column, using the new result of 25.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1						

Can 32 be subtracted from 25, with the remainder being 0 or a positive number? No. Place a "0" in the 32 column, and repeat the operation in the next column with the value of 25.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0					

Can 16 be subtracted from 25? Yes, with a remainder of 9. Place a "1" in the 16 column, and go to the next column with the new value of 9.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1				

Can 8 be subtracted from 9? Yes, with a remainder of 1. Place a "1" in the 8 column, and repeat the operation in the next column with a remainder of 1.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1			

We can quickly see that neither of the next two columns, 4 or 2, can be subtracted from 1. Place a "0" in both of those columns.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	

Subtracting 1 from 1 brings us to zero, and also to the end of the columns. Place a "1" in the 1 column, and you have the binary equivalent of the decimal 217.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1

The binary equivalent of the decimal 217 is 11011001.

Once you can convert one octet, you can convert any number of octets. Using this method, let's go through the rest of the practice question.

The second octet's decimal value is 48. Using the same chart, you can see that you cannot subtract 128 or 64 from 48. Place a zero in both those columns, and move on to the next column, moving left to right.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0						

Can you subtract 32 from 48? Sure, with a remainder of 16. Place a 1 in the 16 column, and go to the next column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1					

Can you subtract 16 from 16? Obviously! Place a "1" in the 16 column. You're actually done with this octet, since the remainder is now zero. Once the remainder is zero, you can put a zero in all remaining columns for that octet.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0

Exam Tip

When converting decimal to binary, your remainder at the end of the octet's conversion MUST be zero. If you still have a remainder after the 1 column, you've made an error and you should go through that octet's conversion again from the beginning. Any octet with a value up to and including 255 can be converted from decimal to binary. If you have a decimal value of 256 or higher, it's not a legitimate IP dotted decimal address.

The third octet is 23. Working from left to right, you can see that you cannot subtract 128, 64, or 32 from this value. Place a zero in all three of these columns and move to the next column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0					

Can 16 be subtracted from 23? Yes, with a remainder of 7. Place a "1' in the 16 column and go to the next column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1				

Can 8 be subtracted from 7? No. Put a zero in that column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0			

Can 4 be subtracted from 7? Yes, with a remainder of three. Put a "1" in the 4 column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1		

Can 2 be subtracted from 3? Yes, with a remainder of 1. Put a "1" in the 2 column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1	1	

Finally, 1 is subtracted from the remainder of 1, giving you zero, which is what you want at the end of the conversion. Place a “1” in the 1 column, and this octet has been converted.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1	1	1

The last octet is 190. Working from left to right, can 128 be subtracted from 190? Yes, with a remainder of 62. Put a “1” in the 128 column and move to the next column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1	1	1
4th Octet: 190	1							

Can 64 be subtracted from 62? No. Put a zero in the 64 column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1	1	1
4th Octet: 190	1	0						

Can 32 be subtracted from 62? Yes, with a remainder of 30. Put a “1” in the 32 column, and go to the next column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1	1	1
4th Octet: 190	1	0	1					

Can 16 be subtracted from 30? Yes, with a remainder of 14. Put a “1” in the 16 column, and go to the next column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1	1	1
4th Octet: 190	1	0	1	1				

Can 8 be subtracted from 14? Yes, with a remainder of 6. Place a “1” in the 8 column, and go to the next column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1	1	1
4th Octet: 190	1	0	1	1	1			

Can 4 be subtracted from 6? Yes, with a remainder of 2. Place a “1” in the 4 column, and go to the next column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1	1	1
4th Octet: 190	1	0	1	1	1	1		

Can 2 be subtracted from 2? Yes, with a remainder of 0. Place a “1” in the 2 column, and since the remainder is 0, place a “0” in the remaining columns – in this case, the 1 column.

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 48	0	0	1	1	0	0	0	0
3rd Octet: 23	0	0	0	1	0	1	1	1
4th Octet: 190	1	0	1	1	1	1	1	0

Congratulations! You’ve determined that the binary equivalent of the dotted decimal number 217.48.23.190 is 11011001 00110000 00010111 10111110.

Exam Tip

If you're asked to perform binary-to-decimal conversion on your CCNA exam (and you probably will be), it will most likely be a multiple choice question. This can be a little tough on your eyes, since each choice is going to be a 32-number-long string of ones and zeroes. Put four to seven of those on top of each other, and they'll tend to look a lot alike.

Don't come up with the right answer on paper and then choose the wrong answer on the screen. One method that's worked well for me over the years is to take a piece of paper and hold it up to the screen while I view the answers one at a time.

On paper, that explanation is pretty long. Once you're doing it in practice and in the lab room, you'll see that it goes pretty quickly, and is a highly efficient method of converting decimal to binary. This method also has the extra benefit of continually reinforcing binary math. It all becomes second nature – ***with practice.***

Converting Decimal To Binary Questions

What is the binary equivalent of the dotted decimal IP address 100.10.1.200?

For decimal-to-binary conversions, always use this chart, and work from left to right as shown in this section.

	128	64	32	16	8	4	2	1
1st Octet: 100	0	1	1	0	0	1	0	0
2nd Octet: 10	0	0	0	0	1	0	1	0
3rd Octet: 1	0	0	0	0	0	0	0	1
4th Octet: 200	1	1	0	0	1	0	0	0

The binary equivalent is 01100100 00001010 00000001 11001000.

What is the binary equivalent of the dotted decimal IP address 190.4.89.23?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 190	1	0	1	1	1	1	1	0
2nd Octet: 4	0	0	0	0	0	1	0	0
3rd Octet: 89	0	1	0	1	1	0	0	1
4th Octet: 23	0	0	0	1	0	1	1	1

The binary equivalent is 10111110 00000100 01011001 00010111.

What is the binary equivalent of the dotted decimal IP address 10.255.18.244?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 10	0	0	0	0	1	0	1	0
2nd Octet: 255	1	1	1	1	1	1	1	1
3rd Octet: 18	0	0	0	1	0	0	1	0
4th Octet: 244	1	1	1	1	0	1	0	0

The binary equivalent is 00001010 11111111 00010010 11110100.

What is the binary equivalent of the dotted decimal IP address 240.17.23.239?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 240	1	1	1	1	0	0	0	0
2nd Octet: 17	0	0	0	1	0	0	0	1
3rd Octet: 23	0	0	0	1	0	1	1	1
4th Octet: 239	1	1	1	0	1	1	1	1

The binary equivalent is 11110000 00010001 00010111 11101111.

What is the binary equivalent of the dotted decimal IP address 217.34.0.214?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 217	1	1	0	1	1	0	0	1
2nd Octet: 34	0	0	1	0	0	0	1	0
3rd Octet: 0	0	0	0	0	0	0	0	0
4th Octet: 214	1	1	0	1	0	1	1	0

The binary equivalent is 11011001 00100010 00000000 11010110.

Exam Tip

As with Section Two, don't be thrown if you're asked to perform a decimal-binary conversion that results in an octet of 0 or 255. Just perform the conversion and give the answer you come up with. An octet of 0 or 255 does not mean your answer is wrong.

What is the binary equivalent of the dotted decimal IP address 20.244.182.69?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 20	0	0	0	1	0	1	0	0
2nd Octet: 244	1	1	1	1	0	1	0	0
3rd Octet: 182	1	0	1	1	0	1	1	0
4th Octet: 69	0	1	0	0	0	1	0	1

The binary equivalent is 00010100 11110100 10110110 01000101.

What is the binary equivalent of the dotted decimal IP address 145.17.206.89?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 145	1	0	0	1	0	0	0	1
2nd Octet: 17	0	0	0	1	0	0	0	1
3rd Octet: 206	1	1	0	0	1	1	1	0
4th Octet: 89	0	1	0	1	1	0	0	1

The binary equivalent is 10010001 00010001 11001110 01011001.

What is the binary equivalent of the dotted decimal IP address 198.3.148.245?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 198	1	1	0	0	0	1	1	0
2nd Octet: 3	0	0	0	0	0	0	1	1
3rd Octet: 148	1	0	0	1	0	1	0	0
4th Octet: 245	1	1	1	1	0	1	0	1

The binary equivalent is 11000110 0000001 10010100 11110101.

What is the binary equivalent of the dotted decimal IP address 14.204.71.250?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 14	0	0	0	0	1	1	1	0
2nd Octet: 204	1	1	0	0	1	1	0	0
3rd Octet: 71	0	1	0	0	0	1	1	1
4th Octet: 250	1	1	1	1	1	0	1	0

The binary equivalent is 00001110 11001100 01000111 11111010.

What is the binary equivalent of the dotted decimal IP address 7.209.18.47?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 7	0	0	0	0	0	1	1	1
2nd Octet: 209	1	1	0	1	0	0	0	1
3rd Octet: 18	0	0	0	1	0	0	1	0
4th Octet: 47	0	0	1	0	1	1	1	1

The binary equivalent is 00000111 11010001 00010010 00101111.

What is the binary equivalent of the dotted decimal IP address 184.61.80.9?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 184	1	0	1	1	1	0	0	0
2nd Octet: 61	0	0	1	1	1	1	0	1
3rd Octet: 80	0	1	0	1	0	0	0	0
4th Octet: 9	0	0	0	0	1	0	0	1

The binary equivalent is 10111000 00111101 01010000 00001001.

What is the binary equivalent of the dotted decimal IP address 249.74.65.43?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 249	1	1	1	1	1	0	0	1
2nd Octet: 74	0	1	0	0	1	0	1	0
3rd Octet: 65	0	1	0	0	0	0	0	1
4th Octet: 43	0	0	1	0	1	0	1	1

The binary equivalent is 11111001 01001010 01000001 00101011.

What is the binary equivalent of the dotted decimal IP address 150.50.5.55?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 150	1	0	0	1	0	1	1	0
2nd Octet: 50	0	0	1	1	0	0	1	0
3rd Octet: 5	0	0	0	0	0	1	0	1
4th Octet: 55	0	0	1	1	0	1	1	1

The binary equivalent is 10010110 00110010 00000101 00110111.

What is the binary equivalent of the dotted decimal IP address 19.201.45.194?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 19	0	0	0	1	0	0	1	1
2nd Octet: 201	1	1	0	0	1	0	0	1
3rd Octet: 45	0	0	1	0	1	1	0	1
4th Octet: 194	1	1	0	0	0	0	1	0

The binary equivalent is 00010011 11001001 00101101 11000010.

What is the binary equivalent of the dotted decimal IP address 43.251.199.207?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 43	0	0	1	0	1	0	1	1
2nd Octet: 251	1	1	1	1	1	0	1	1
3rd Octet: 199	1	1	0	0	0	1	1	1
4th Octet: 207	1	1	0	0	1	1	1	1

The binary equivalent is 00101011 11111011 11000111 11001111.

What is the binary equivalent of the dotted decimal IP address 42.108.93.224?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 42	0	0	1	0	1	0	1	0
2nd Octet: 108	0	1	1	0	1	1	0	0
3rd Octet: 93	0	1	0	1	1	1	0	1
4th Octet: 224	1	1	1	0	0	0	0	0

The binary equivalent is 00101010 01101100 01011101 11100000.

What is the binary equivalent of the dotted decimal IP address 180.9.34.238?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 180	1	0	1	1	0	1	0	0
2nd Octet: 9	0	0	0	0	1	0	0	1
3rd Octet: 34	0	0	1	0	0	0	1	0
4th Octet: 238	1	1	1	0	1	1	1	0

The binary equivalent is 10110100 00001001 00100010 11101110.

What is the binary equivalent of the dotted decimal IP address 21.249.250.5?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 21	0	0	0	1	0	1	0	1
2nd Octet: 249	1	1	1	1	1	0	0	1
3rd Octet: 250	1	1	1	1	1	0	1	0
4th Octet: 5	0	0	0	0	0	1	0	1

The binary equivalent is 00010101 11111001 11111010 00000101.

What is the binary equivalent of the dotted decimal IP address 243.79.68.30?

Answer:

	128	64	32	16	8	4	2	1
1st Octet: 243	1	1	1	1	0	0	1	1
2nd Octet: 79	0	1	0	0	1	1	1	1
3rd Octet: 68	0	1	0	0	0	1	0	0
4th Octet: 30	0	0	0	1	1	1	1	0

The binary equivalent is 11110011 01001111 01000100 00011110.

Section Four: Determining The Number Of Valid Subnets

Examples of a "number of valid subnets" question:

"*How many valid subnets exist on the 10.0.0.0 /12 network?"*
"How many valid subnets exist on the 10.0.0.0 255.240.0.0 network?"

These two examples are actually asking the same thing, just in different formats. You're familiar with the standard dotted decimal mask, but what about the number following the slash in the first version of the question? This is **prefix notation**, and it's the more common way of expressing a subnet mask.

The number behind the slash indicates how many consecutive ones there are at the beginning of this network's mask. The dotted decimal mask 255.240.0.0, converted to decimal, is 11111111 11110000 00000000 00000000. (If you're unsure how this value is derived, review Section Three.) Note that there are twelve ones at the beginning of the mask. That is what the /12 refers to.

Why use this method of expressing a mask? It's easier to write and to say. Try expressing a Class C default network mask as "two fifty five, two fifty five, two fifty five, zero" a couple of times, then try saying "slash twenty-four". See what I mean?

You're going to hear the prefix notation version of network masks mentioned more often than someone reading out the entire mask, so familiarize yourself with expressing masks in this fashion. You're also likely to see prefix notation on any Cisco exam you ever take.

Now that prefix notation has been addressed, let's look at how to answer this kind of question. Before you can determine the number of valid subnets with a given network number and subnet mask, you must know the network masks for Class A, B, and C networks. They are listed here for review:

	Class A	Class B	Class C
1st Octet Range	1 - 126	128 - 191	192 – 223
Network Mask	255.0.0.0	255.255.0.0	255.255.255.0
Default # of Network Bits	8	16	24
Default # of Host Bits	24	16	8

The first key to answering this type of question is to remember that the number of network bits **never changes.** Subnetting always borrows bits from the host bits – *always.*

To determine the number of valid subnets, you first have to know how many subnet bits there are. Let's look at the example question again:

How many valid subnets exist on the 10.0.0.0 /12 network?

How many subnet bits are there? By looking at the major network number, we see that this is a Class A network. By default, a Class A network has 8 network bits and 24 host bits. In this mask, though, 12 bits are set to 1. This indicates that four host bits have been borrowed by the subnet mask.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Class "A" Network Mask:	11111111	00000000	00000000	00000000
This Question's Subnet Mask	11111111	**1111**0000	00000000	00000000

The highlighted bits are the subnet bits. By comparing the default network mask to the subnet mask expressed in the question, it is clear how many subnet bits there are.

Now that you know how many subnet bits there are, place that number into this formula:

The number of valid subnets =
*(2 raised to the power of the number of **subnet** bits) – 2*

In the example question, determine the value of 2 to the 4th power, which is 16. Subtract two from that, and you have 14. That's how many valid subnets you have in this network.

What two subnets are being subtracted? The "all-zeroes" subnet and the "all-ones" subnet are considered unusable, and therefore are not considered valid.

Exam Tips
For this question type, it is VITAL to remember to subtract those two subnets at the end. Failure to do so will most likely lead to you missing the question.

Let's go through another example:
"*How many valid subnets exist on the 150.10.0.0 /21 network?"*

This is a Class B network; the default subnet mask is 255.255.0.0, or /16 in prefix notation. The /21 mask has 21 bits set to "1", so there are five subnet bits.

2 to the 5^{th} power equals 32. Subtract 2 from that for the invalid all-zeroes and all-ones subnets, and that leaves 30 subnets. It's just that simple!

"Number Of Valid Subnets" Questions

How many valid subnets exist on the 15.0.0.0 /13 network?

This is a Class A network, with a default mask of /8. The subnet mask is /13, meaning there are five subnet bits. 2 to the 5^{th} power (2 x 2 x 2 x 2 x 2) equals 32; subtract 2 from that and 30 valid subnets remain.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Default Network Mask 255.0.0.0	11111111	**00000**000	00000000	00000000
Subnet Mask 255.254.0.0 (/13)	11111111	**11111**000	00000000	00000000

How many valid subnets exist on the 222.10.1.0 /30 network?

This is a Class C network, with a default mask of /24. The subnet mask is /30, meaning there are six subnet bits. 2 to the 6th power is 64; subtract 2 from that, and 62 valid subnets remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	**000000**00
Subnet Mask 255.255.255.252	11111111	11111111	11111111	**111111**00

How many valid subnets exist on the 145.45.0.0 /25 network?

This is a Class B network, with a default mask of /16. The subnet mask is /25, meaning there are nine subnet bits. 2 to the 9th power is 512; subtract 2 from that, and 510 valid subnets remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	**00000000**	**0**0000000
Subnet Mask 255.255.255.128	11111111	11111111	**11111111**	**1**0000000

How many valid subnets exist on the 20.0.0.0 255.192.0.0 network?

This is a Class A network, with a default mask of 255.0.0.0. When comparing masks expressed in dotted decimal, it may be helpful to you to convert them to binary to determine the number of subnet bits.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**00**000000	00000000	00000000
Subnet Mask 255.192.0.0	11111111	**11**000000	00000000	00000000

The bits that are set to "0" in the default mask but are set to "1" in the subnet mask are the subnet bits. There are two subnet bits. 2 to the 2nd power is 4; subtract 2 from that and there are 2 valid subnets left.

How many valid subnets exist on the 130.30.0.0 255.255.224.0 network?

This is a Class B network, with a default mask of 255.255.0.0. When comparing masks expressed in dotted decimal, it may be helpful to convert them to binary to determine the number of subnet bits.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	**000**00000	00000000
Subnet Mask 255.255.224.0	11111111	11111111	**111**00000	00000000

The bits that are set to "0" in the default mask but are set to "1" in the subnet mask are the subnet bits; there are three of them. 2 to the 3rd power is 8; subtract 2 from that, and six valid subnets remain.

How many valid subnets exist on the 128.10.0.0 /19 network?

This is a Class B network with a default mask of /16. The subnet mask is /19, indicating there are three subnet bits. 2 to the 3rd power is 8; subtract 2 from that, and six valid subnets remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	**000**00000	00000000
Subnet Mask 255.255.224.0	11111111	11111111	**111**00000	00000000

How many valid subnets exist on the 25.0.0.0 /20 network?

This is a Class A network with a default mask of /8. The subnet mask is /20, indicating there are 12 subnet bits. 2 to the 12th power is 4096; subtract 2 from that, and 4094 valid subnets remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**00000000**	**0000**0000	00000000
Subnet Mask 255.255.240.0	11111111	**11111111**	**1111**0000	11111100

How many valid subnets exist on the 99.0.0.0 /17 network?

This is a Class A network with a default mask of /8. The subnet mask is /17, indicating there are 9 subnet bits. 2 to the 9th power is 512; subtract 2 from that, and 510 valid subnets remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**00000000**	**0**0000000	00000000
Subnet Mask 255.255.128.0	11111111	**11111111**	**1**0000000	00000000

How many valid subnets exist on the 222.10.8.0 /28 network?

This is a Class C network, with a default mask of /24. The subnet mask is /28, indicating 4 subnet bits. 2 to the 4th power is 16; subtract 2 from that, and 14 valid subnets remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	**0000**0000
Subnet Mask 255.255.255.240	11111111	11111111	11111111	**1111**0000

How many valid subnets exist on the 20.0.0.0 255.254.0.0 network?

This is a Class A network, with a default mask of 255.0.0.0. To compare the default and subnet masks, convert them to binary:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**0000000**0	00000000	00000000
Subnet Mask 255.254.0.0	11111111	**1111111**0	00000000	00000000

The bits where the default mask has a "0" and the subnet mask has a "1" are the subnet bits; there are 7 of them. 2 to the 7th power is 128; subtract 2 and 126 valid subnets remain.

How many valid subnets exist on the 210.17.90.0 /29 network?

This is a Class C network, with a default mask of /24. The subnet mask is /29, indicating there are 5 subnet bits. 2 to the 5th power is 32; subtract 2 from that and there are 30 valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	**00000**000
Subnet Mask 255.255.255.248	11111111	11111111	11111111	**11111**000

How many valid subnets exist on the 130.45.0.0 /26 network?

This is a Class B network, with a default mask of /16. The subnet mask is /26, indicating there are 10 subnet bits. 2 to the 10th power is 1024; subtract 2 from that and there are 1022 valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	**00000000**	**00**000000
Subnet Mask 255.255.255.192	11111111	11111111	**11111111**	**11**000000

How many valid subnets exist on the 200.1.1.0 /26 network?

This is a Class C network, with a default mask of /24. The subnet mask is /26, indicating there are 2 subnet bits. 2 to the 2nd power is 4; subtract 2 from that and there are 2 valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	**00**000000
Subnet Mask 255.255.255.192	11111111	11111111	11111111	**11**000000

How many valid subnets exist on the 45.0.0.0 255.240.0.0 network?

This is a Class A network, with a default mask of 255.0.0.0. To compare the default and subnet masks, convert them to binary.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**0000**0000	00000000	00000000
Subnet Mask 255.240.0.0	11111111	**1111**0000	00000000	00000000

The bits where the default mask has a "0" and the subnet mask has a "1" are the subnet bits. There are four subnet bits. 2 to the 4th power is 16; subtract 2 from that and there are 14 valid subnets.

How many valid subnets exist on the 222.33.44.0 255.255.255.248 network?

This is a Class C network, with a default mask of 255.255.255.0. To compare the network and subnet masks, convert them to binary.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	**00000**000
Subnet Mask 255.255.255.248	11111111	11111111	11111111	**11111**000

The bits where the default mask has a "0" and the subnet mask has a "1" are the subnet bits. There are 5 subnet bits. 2 to the 5th power is 32; subtract 2 and there are 30 valid subnets.

How many valid subnets exist on the 23.0.0.0 255.255.224.0 network?

This is a Class A network, with a default mask of 255.0.0.0. To compare the network and subnet masks, convert them to binary.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**00000000**	**000**00000	00000000
Subnet Mask 255.255.224.0	11111111	**11111111**	**111**00000	00000000

The bits where the default mask has a "0" and the subnet mask has a "1" are the subnet bits. There are 11 subnet bits. 2 to the 11th power is 2048; subtract 2 from that and there are 2046 valid subnets.

How many valid subnets exist on the 111.11.0.0 /15 network?

This is a Class A network, with a default mask of /8. The subnet mask is /15, indicating there are 7 subnet bits. 2 to the 7th power is 128; subtract 2 from that and there are 126 valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**0000000**0	00000000	00000000
Subnet Mask 255.254.0.0	11111111	**1111111**0	00000000	00000000

How many valid subnets exist on the 130.45.0.0 /19 network?

This is a Class B network, with a default mask of /16. The subnet mask is /19, indicating there are 3 subnet bits. 2 to the 3rd power is 8; subtract 2 from that and there are 6 valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	**000**00000	00000000
Subnet Mask 255.255.224.0	11111111	11111111	**111**00000	00000000

How many valid subnets exist on the 99.0.0.0 /16 network?

This is a Class A network, with a default mask of /8. The subnet mask is /16, indicating there are 8 subnet bits. 2 to the 8th power is 256; subtract 2 from that and there are 254 valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**00000000**	00000000	00000000
Subnet Mask 255.255.0.0	11111111	**11111111**	00000000	00000000

How many valid subnets exist on the 220.10.78.0 /24 network?

This is a Class C network, with a default mask of /24. The supplied mask is /24 as well; this network has not been subnetted.

How many valid subnets exist on the 34.0.0.0 /18 network?

This is a Class A network, with a default mask of /8. The subnet mask is /18, indicating there are 10 subnet bits. 2 to the 10th power is 1024; subtract 2 and there are 1022 valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**00000000**	**00**000000	00000000
Subnet Mask 255.255.192.0	11111111	**11111111**	**11**000000	00000000

How many valid subnets exist on the 200.10.56.0 /29 network?

This is a Class C network, with a default mask of /24. The subnet mask is /29, indicating there are 5 subnet bits. 2 to the 5th power is 32; subtract 2 from that and there are 30 valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	**00000**000
Subnet Mask 255.255.255.248	11111111	11111111	11111111	**11111**000

How many valid subnets exist on the 128.10.0.0 /18 network?

This is a Class B network, with a default mask of /16. The subnet mask is /18, indicating there are 2 subnet bits. 2 to the 2nd power is 4; subtract 2 from that and there are 2 valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	**00**000000	00000000
Subnet Mask 255.255.192.0	11111111	11111111	**11**000000	00000000

Section Five: Determining The Number Of Valid Hosts

An example of a "number of valid hosts" question:

"*How many valid hosts exist on the 150.10.0.0 /20 subnet?"*
"How many valid hosts exist on the 150.10.0.0 255.255.240.0 subnet ?"

As in Section Four, both of the above questions are asking the same thing. A /20 mask indicates that the first 20 bits are set to "1", which in expressed in dotted decimal as 255.255.240.0.

The process for determining the number of valid hosts is much like determining the number of valid subnets, in that you must first determine how many subnet bits are present. The difference is that when determining the number of valid hosts, it is the number of host bits you're concerned with, rather than the number of subnet bits.

Once the number of host bits is determined, use this formula to arrive at the number of valid hosts:

The number of valid hosts =
*(2 raised to the power of the number of **host** bits) – 2*

In the example question, there is a Class B network, with a default mask of /16. The subnet mask is /20, indicating there are four subnet bits.

Here's where the difference comes in. There are 16 network bits and 4 subnet bits. That's 20 out of 32 bits, meaning that there are 12 host bits. 2 to the 12^{th} power is 4096; subtract 2 from that, and there are 4094 valid host addresses.

Illustrating the masks in binary illustrates where the host bits lie:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	0000**0000**	**00000000**
Subnet Mask 255.255.240.0	11111111	11111111	1111**0000**	**00000000**

Remember from Section Four that the bits that are set to "0" in the default mask and "1" in the subnet mask are the subnet bits? The bits that are set to "0" in both masks are the host bits. That's the value you need to have for the formula to determine the number of valid hosts.

Note that in both the formula for determining the number of valid hosts and valid subnets, 2 is subtracted at the end. What two hosts are being subtracted? The "all-zeroes" and "all-ones" host addresses, which are considered unusable.

"Number Of Valid Hosts" Questions

How many valid host addresses exist in the 220.11.10.0 /26 subnet?

This is a Class C network, with a default mask of /24. The subnet mask is /26, indicating that there are 2 subnet bits. With 24 network bits and 2 subnet bits, that leaves 6 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	00**000000**
Subnet Mask 255.255.255.192 (/26)	11111111	11111111	11111111	11**000000**

2 to the 6^{th} power equals 64; subtract 2 from that, and 62 valid host addresses remain.

How many valid host addresses exist in the 129.15.0.0 /21 subnet?

This is a Class B network, with a default mask of /16. The subnet mask is /21, indicating there are 5 subnet bits. With 16 network bits and 5 subnet bits, that leaves 11 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	00000**000**	**00000000**
Subnet Mask 255.255.248.0 (/21)	11111111	11111111	11111**000**	**00000000**

2 to the 11th power equals 2048; subtract 2 from that and 2046 valid host addresses remain.

How many valid host addresses exist in the 50.0.0.0 /20 subnet?

This is a Class A network, with a default mask of /8. The subnet mask is /20, indicating there are 12 subnet bits. This leaves 12 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	11111111	0000**0000**	**00000000**
Subnet Mask 255.255.240.0 (/20)	11111111	11111111	1111**0000**	**00000000**

2 to the 12th power equals 4096; subtract 2 from that and 4094 valid host addresses remain.

How many valid host addresses exist in the 222.22.2.0 /30 subnet?

This is a Class C network, with a default mask of /24. The subnet mask is /30, indicating there are 6 subnet bits. This leaves 2 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	000000**00**
Subnet Mask 255.255.255.252	11111111	11111111	11111111	111111**00**

2 to the 2^{nd} power equals 4; subtract 2 from that and 2 valid host addresses remain. (This is a common subnet mask for point-to-point connections.)

How many valid host addresses exist in the 212.10.3.0 /28 subnet?

This is a Class C network, with a default mask of /24. The subnet mask is /28, indicating there are 4 subnet bits. This leaves 4 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	0000**0000**
Subnet Mask 255.255.255.240 (/28)	11111111	11111111	11111111	1111**0000**

2 to the 4^{th} power equals 16; subtract 2 from that and 14 valid host addresses remain.

How many valid addresses exist in the 14.0.0.0 /20 subnet?

This is a Class A network, with a default mask of /8. The subnet mask is /20, indicating there are 12 subnet bits. This leaves 12 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	00000000	0000**0000**	**00000000**
Subnet Mask 255.255.240.0 (/20)	11111111	11111111	1111**0000**	**00000000**

2 to the 12^{th} power is 4096; subtract 2 from that and 4094 valid host addresses remain.

How many valid host addresses exist in the 45.0.0.0 255.255.192.0 subnet?

This is a Class A network, with a default mask of /8, or 255.0.0.0. Comparing the subnet mask to the default mask in binary form reveals that there are 10 subnet bits and 14 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	00000000	00**000000**	**00000000**
Subnet Mask 255.255.192.0 (/18)	11111111	11111111	11**000000**	**00000000**

2 to the 14th power is 16384; subtract 2 from that, and 16382 valid host addresses remain.

How many valid host addresses exist on the 221.10.78.0 255.255.255.224 subnet?

This is a Class C network, with a default mask of /24, or 255.255.255.0. Comparing the subnet mask to the default mask in binary form reveals that there are 3 subnet bits and 5 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	000**00000**
Subnet Mask 255.255.255.224	11111111	11111111	11111111	111**00000**

2 to the 5th power is 32; subtract 2 from that, and 30 valid host addresses remain.

How many valid host addresses exist on the 143.34.0.0 255.255.255.192 subnet?

This is a Class B network, with a default mask of /16, or 255.255.0.0. Comparing the subnet mask to the default mask in binary form reveals that there are 10 subnet bits and 6 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	00000000	00**000000**
Subnet Mask 255.255.255.192	11111111	11111111	11111111	11**000000**

2 to the 6th power is 64; subtract 2 from that, and 62 valid host addresses remain.

How many valid host addresses exist on the 128.12.0.0 255.255.255.240 subnet?

This is a Class B network, with a default mask of /16, or 255.255.0.0. Comparing the subnet mask to the default mask in binary form reveals that there are 4 subnet bits and 4 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	00000000	00000000
Subnet Mask 255.255.255.240	11111111	11111111	11111111	1111**0000**

2 to the 4th power is 16; subtract 2 from that, and 14 valid host addresses remain.

How many valid host addresses exist on the 125.0.0.0 /24 subnet?

This is a Class A network, with a default mask of /8, or 255.0.0.0. Comparing the default and subnet masks in binary reveals that there are 16 subnet bits and 8 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	00000000	00000000	**00000000**
Subnet Mask 255.255.255.0	11111111	11111111	11111111	**00000000**

2 to the 8th power is 256; subtract 2 from that, and 254 valid host addresses remain.

How many valid addresses exist on the 221.10.89.0 255.255.255.248 subnet?

This is a Class C network, with a default mask of 255.255.255.0, or /24. Comparing the default and subnet masks in binary reveals that there are 5 subnet bits and 3 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	00000000
Subnet Mask 255.255.255.248	11111111	11111111	11111111	11111**000**

2 to the 3rd power is 8; subtract 2 from that, and 6 valid host addresses remain.

How many valid addresses exist on the 134.45.0.0 /22 subnet?

This is a Class B network, with a default mask of /16, or 255.255.0.0. The subnet mask is /22, indicating that 6 subnet bits have been set. With 16 network bits and 6 subnet bits set, that leaves 10 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	00000000	00000000
Subnet Mask 255.255.252.0 (/22)	11111111	11111111	111111**00**	**00000000**

2 to the 10th power is 1024; subtract 2 from that and 1022 valid host addresses remain.

As you've now seen, determining the number of valid subnets or valid hosts is a matter of breaking the masks down into binary and determining how many subnet bits and host bits there are.

As your skill increases, you'll be able to answer some of these questions without breaking the masks down into binary. I strongly recommend that you do break them down into binary whenever possible, though. As you progress through the Cisco certifications, you'll see subnet masks that are progressively more complex. Developing the habit of breaking masks down into binary will be key in your success not only on the CCNA exam, but CCNP and CCIE exams as well.

Section Six: Determining The Subnet Number Of A Given IP Address

An example of a "determine the subnet number" question:

"*What subnet is the address 200.17.49.200 /23 a member of?"*
"On what subnet can the address 200.17.49.200 /23 be found?"

In my experience, this is the type of question that most often trips up CCNA candidates. Why? Because they don't understand the Boolean AND operation, and that is the only way you can properly answer this question. This section will review the Boolean AND operation and show you how to use it in order to solve this question type. Once you get used to using the Boolean AND, this question type becomes simple. And as you'll soon see, this particular operation is very simple.

As mentioned in an earlier section, the Boolean AND is simply a bit-by-bit comparison of the IP address and a subnet mask. In this case, the Boolean AND will reveal the subnet upon which this IP address resides. Your knowledge of binary math will be key in you answering this question type as well, since the address and mask must be broken down into binary in order to perform the Boolean AND.

Let's walk through the above question. You will use the skills you learned in Section Three, "Converting Dotted Decimal To Binary", to convert the IP address to binary:

	128	64	32	16	8	4	2	1
1st Octet: 200	1	1	0	0	1	0	0	0
2nd Octet: 17	0	0	0	1	0	0	0	1
3rd Octet: 49	0	0	1	1	0	0	0	1
4th Octet: 200	1	1	0	0	1	0	0	0

The IP address, in binary, is 11001000 00010001 00110001 11001000.

Your knowledge of prefix notation tells you that a subnet mask of /23 is 11111111 11111111 11111110 00000000. (The first 23 bits are ones).

Now that the IP address and subnet mask have been converted to binary, the subnet on which the IP address resides can be found by performing a Boolean AND. Remember, a Boolean AND is simply a bit-by-bit comparison of the address and mask.

If both the address and mask have the same bit set to "1", the result is 1. Any other combination results in a "0". To further illustrate this concept, let's run a Boolean AND on only the first octet of the IP address and mask.

	Bit 1	Bit 2	Bit 3	Bit 4	Bit 5	Bit 6	Bit 7	Bit 8
IP Address Octet 1	1	1	0	0	1	0	0	0
Subnet Mask Octet 1	1	1	1	1	1	1	1	1
Boolean AND Result	1	1	0	0	1	0	0	0

Note that where a bit in the same position is "1" in both the IP address and subnet mask, the Boolean AND result is also "1". ***Any other combination results in the Boolean AND resulting in "0".***

Now that we've taken a look at the Boolean AND being run on a single octet, let's run it on the entire IP address and subnet mask. This is the chart you should use on exam day to answer this question type:

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 200.17.49.200	11001000	00010001	00110001	11001000
Subnet Mask 255.255.254.0 (/23)	11111111	11111111	11111110	00000000
Boolean AND Result	11001000	00010001	00110000	00000000

Once the Boolean AND result is achieved, it has to be converted into dotted decimal. Using your knowledge of converting binary to dotted decimal, you see that the IP address you were given is found on the 200.17.48.0 /23 subnet.

	128	64	32	16	8	4	2	1	
First Octet	1	1	0	0	1	0	0	0	200
Second Octet	0	0	0	1	0	0	0	1	17
Third Octet	0	0	1	1	0	0	0	0	48
Fourth Octet	0	0	0	0	0	0	0	0	0

There's more going on with this question type that in previous ones, so let's review the basic process:

1. Convert the IP address and subnet mask into binary.
2. Run the Boolean AND on the address and mask.
3. Convert the Boolean AND result back into dotted decimal. This is the subnet that contains the given IP address.

Exam Tip

Don't forget that the subnet mask is considered part of the answer. For example, in the example question, "200.17.48.0" by itself is not correct, but "200.17.48.0 255.255.254.0" and "200.17.48.0 /23" are.

Additionally, watch the choices you're given. You may be presented with a multiple choice question where some of the masks are given in prefix notation and some are given in dotted decimal.

You can now see where the skills you learned in earlier sections come into play in the more complex subnetting questions. When you master the fundamentals of binary math, as you have, you can answer any question Cisco gives you.

Let's walk through one more example.

"On what subnet can the address 10.17.2.14 255.255.192.0 be found?"

Step One: Convert the IP address and subnet mask into binary:

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 10.17.2.14	00001010	00010001	00000010	00001110
Subnet Mask 255.255.192.0 (/18)	11111111	11111111	11000000	00000000

If you're unsure as to how these conversions were performed, review Section Three, "Converting Decimal To Binary".

Step Two: Perform the Boolean AND operation.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 10.17.2.14	00001010	00010001	00000010	00001110
Subnet Mask 255.255.192.0 (/18)	11111111	11111111	11000000	00000000
Boolean AND Result	00001010	00010001	00000000	00000000

Step Three: Convert the Boolean AND result to dotted decimal. This is the subnet upon which this IP address can be found. This result converts to the dotted decimal subnet 10.17.0.0 /18, or 10.17.0.0 255.255.192.0.

Your skill in converting binary to dotted decimal and dotted decimal to binary now pays off not only in answering "basic" binary math questions, but now allows you to quickly and accurately answer more complex questions. As with all things Cisco, everything comes back to the fundamentals. Continue to practice binary math, and you can answer any question Cisco gives you on any exam.

The skills you learn in this section are vital in resolving another type of subnetting question you may see on Cisco exams. That question type is addressed in the next section, so make sure you totally understand how to determine the subnet address of a given IP address before moving to the next section.

“Determining The Subnet” Questions

On what subnet can the address 210.17.23.200 /27 be found?

Remember the steps: First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 210.17.23.200	11010010	00010001	00010111	11001000
Subnet Mask 255.255.255.224 (/27)	11111111	11111111	11111111	11100000
Boolean AND Result	11010010	00010001	00010111	11000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	1	0	0	1	0	210
Second Octet	0	0	0	1	0	0	0	1	17
Third Octet	0	0	0	1	0	1	1	1	23
Fourth Octet	1	1	0	0	0	0	0	0	192

The subnet on which this IP address is found is 210.17.23.192 /27.

On what subnet can the IP address 24.194.34.12 /10 be found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 24.194.34.12	00011000	11000010	00100010	00001100
Subnet Mask 255.192.0.0 (/10)	11111111	11000000	00000000	00000000
Boolean AND Result	00011000	11000000	00000000	00000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	0	0	0	1	1	0	0	0	24
Second Octet	1	1	0	0	0	0	0	0	192
Third Octet	0	0	0	0	0	0	0	0	0
Fourth Octet	0	0	0	0	0	0	0	0	0

The subnet is 24.192.0.0 /10.

On what subnet can the IP address 190.17.69.175 /22 be found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 190.17.69.175	10111110	00010001	01000101	10101111
Subnet Mask 255.255.252.0 (/22)	11111111	11111111	11111100	00000000
Boolean AND Result	10111110	00010001	01000100	00000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	0	1	1	1	1	1	0	190
Second Octet	0	0	0	1	0	0	0	1	17
Third Octet	0	1	0	0	0	1	0	0	68
Fourth Octet	0	0	0	0	0	0	0	0	0

The subnet is 190.17.68.0 /22.

On what subnet can the IP address 111.11.126.5 255.255.128.0 be found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 111.11.126.5	01101111	00001011	01111110	00000101
Subnet Mask 255.255.128.0 (/17)	11111111	11111111	10000000	00000000
Boolean AND Result	01101111	00001011	00000000	00000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	0	1	1	0	1	1	1	1	111
Second Octet	0	0	0	0	1	0	1	1	11
Third Octet	0	0	0	0	0	0	0	0	0
Fourth Octet	0	0	0	0	0	0	0	0	0

The subnet is 111.11.0.0 255.255.128.0, or 111.11.0.0 /17.

On what subnet can the IP address 210.12.23.45 255.255.255.248 be found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 210.12.23.45	11010010	00001100	00010111	00101101
Subnet Mask 255.255.255.248 (/29)	11111111	11111111	11111111	11111000
Boolean AND Result	11010010	00001100	00010111	00101000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	1	0	0	1	0	210
Second Octet	0	0	0	0	1	1	0	0	12
Third Octet	0	0	0	1	0	1	1	1	23
Fourth Octet	0	0	1	0	1	0	0	0	40

The subnet is 210.12.23.40 255.255.255.248.

On what subnet is the IP address 222.22.11.199 /28 found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 222.22.11.199	11011110	00010110	00001011	11000111
Subnet Mask 255.255.255.240 (/28)	11111111	11111111	11111111	11110000
Boolean AND Result	11011110	00010110	00001011	11000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	1	1	1	1	0	222
Second Octet	0	0	0	1	0	1	1	0	22
Third Octet	0	0	0	0	1	0	1	1	11
Fourth Octet	1	1	0	0	0	0	0	0	192

The subnet is 222.22.11.192 /28, or 222.22.11.192 255.255.255.240.

On what subnet is the IP address 111.9.100.7 /17 found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 111.9.100.7	01101111	00001001	01100100	00000111
Subnet Mask 255.255.128.0 (/17)	11111111	11111111	10000000	00000000
Boolean AND Result	01101111	00001001	00000000	00000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	0	1	1	0	1	1	1	1	111
Second Octet	0	0	0	0	1	0	0	1	9
Third Octet	0	0	0	0	0	0	0	0	0
Fourth Octet	0	0	0	0	0	0	0	0	0

The subnet is 111.9.0.0 /17, or 111.9.0.0 255.255.128.0.

On what subnet is the IP address 122.240.19.23 /10 found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 122.240.19.23	01111010	11110000	00010011	00010111
Subnet Mask 255.192.0.0 (/10)	11111111	11000000	00000000	00000000
Boolean AND Result	01111010	11000000	00000000	00000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	0	1	1	1	1	0	1	0	122
Second Octet	1	1	0	0	0	0	0	0	192
Third Octet	0	0	0	0	0	0	0	0	0
Fourth Octet	0	0	0	0	0	0	0	0	0

The subnet is 122.192.0.0 /10, or 122.192.0.0 255.192.0.0.

On what subnet is the IP address 184.25.245.89 /20 found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 184.25.245.89	10111000	00011001	11110101	01011001
Subnet Mask 255.255.240.0 (/20)	11111111	11111111	11110000	00000000
Boolean AND Result	10111000	00011001	11110000	00000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	0	1	1	1	0	0	0	184
Second Octet	0	0	0	1	1	0	0	1	25
Third Octet	1	1	1	1	0	0	0	0	240
Fourth Octet	0	0	0	0	0	0	0	0	0

The subnet is 184.25.240.0 /20, or 184.25.240.0 255.255.240.0.

On what subnet is the IP address 210.67.39.5 /30 found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 210.67.39.5	11010010	01000011	00100111	00000101
Subnet Mask 255.255.255.252 (/30)	11111111	11111111	11111111	11111100
Boolean AND Result	11010010	01000011	00100111	00000100

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	1	0	0	1	0	210
Second Octet	0	1	0	0	0	0	1	1	67
Third Octet	0	0	1	0	0	1	1	1	39
Fourth Octet	0	0	0	0	0	1	0	0	4

The subnet is 210.67.39.4 255.255.255.252, or 210.67.39.4 /30.

On what subnet is the IP address 99.140.23.143 /10 found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 99.140.23.143	01100011	10001100	00010111	10001111
Subnet Mask 255.192.0.0 (/10)	11111111	11000000	00000000	00000000
Boolean AND Result	01100011	10000000	00000000	00000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	0	1	1	0	0	0	1	1	99
Second Octet	1	0	0	0	0	0	0	0	128
Third Octet	0	0	0	0	0	0	0	0	0
Fourth Octet	0	0	0	0	0	0	0	0	0

The subnet is 99.128.0.0 /10, or 99.128.0.0 255.192.0.0.

On what subnet is the IP address 203.27.18.161 255.255.255.224 found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 203.27.18.161	11001011	00011011	00010010	10100001
Subnet Mask 255.255.255.224 (/27)	11111111	11111111	11111111	11100000
Boolean AND Result	11001011	00011011	00010010	10100000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	0	1	0	1	1	203
Second Octet	0	0	0	1	1	0	1	1	27
Third Octet	0	0	0	1	0	0	1	0	18
Fourth Octet	1	0	1	0	0	0	0	0	160

The subnet is 203.27.18.160 255.255.255.224, or 203.27.18.160 /27.

On what subnet is the IP address 10.191.1.1 /10 found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 10.191.1.1	00001010	10111111	00000001	00000001
Subnet Mask 255.192.0.0 (/10)	11111111	11000000	00000000	00000000
Boolean AND Result	00001010	10000000	00000000	00000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	0	0	0	0	1	0	1	0	10
Second Octet	1	0	0	0	0	0	0	0	128
Third Octet	0	0	0	0	0	0	0	0	0
Fourth Octet	0	0	0	0	0	0	0	0	0

The subnet is 10.128.0.0 /10, or 10.128.0.0 255.192.0.0.

On what subnet is the IP address 187.23.191.95 /27 be found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 187.23.191.95	10111011	00010111	10111111	01011111
Subnet Mask 255.255.255.224 (/27)	11111111	11111111	11111111	11100000
Boolean AND Result	10111011	00010111	10111111	01000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	0	1	1	1	0	1	1	187
Second Octet	0	0	0	1	0	1	1	1	23
Third Octet	1	0	1	1	1	1	1	1	191
Fourth Octet	0	1	0	0	0	0	0	0	64

The subnet is 187.23.191.64 /27, or 187.23.191.64 255.255.255.224.

On what subnet is the IP address 222.17.32.244 /28 found?

First, convert the IP address and mask to binary. Second, perform the Boolean AND. Third, convert the Boolean AND back to dotted decimal.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 222.17.32.244	11011110	00010001	00100000	11110100
Subnet Mask 255.255.255.240 (/28)	11111111	11111111	11111111	11110000
Boolean AND Result	11011110	00010001	00100000	11110000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	1	1	1	1	0	222
Second Octet	0	0	0	1	0	0	0	1	17
Third Octet	0	0	1	0	0	0	0	0	32
Fourth Octet	1	1	1	1	0	0	0	0	240

The subnet is 222.17.32.240 /28, or 222.17.32.240 255.255.255.240.

Section Seven: Determining Broadcast Addresses And Valid IP Address Ranges For A Given Subnet

The next two sections involve determinations that will force you to perform more than one operation in order to get the answer. These are the most complex type of binary math questions. The good news is that with the fundamentals you have mastered in the first six sections, you can solve any complex binary math question simply by knowing the correct approach.

This type of question can be obvious, such as the following:

"What is the range of valid IP addresses for the subnet 210.210.210.0 /25?"

"What is the broadcast address for the subnet 210.210.210.0 /25?"

Or it could be a little less obvious:

"Which of the following IP addresses are found on the same subnet as the IP address 210.210.210.1 /25?"

"Which of the following IP addresses are not found on the same subnet as the IP address 210.210.210.1 /25?"

Exam Tip

Cisco exams are infamous for the small details in a question, but most of the details people miss are generally right in front of them. Note that the third and fourth examples above are referring to the same IP address, but are asking for addresses either found or NOT found on that subnet.

It's always a good idea to give a Cisco exam question a quick second read before beginning to answer it.

No matter the format, you can use your knowledge of binary math to solve this question. You will convert the subnet address into binary, and determine the range of valid addresses as well as the broadcast address at the same time.

Let's examine how to best answer the "range of valid IP address" question first, and then you'll see how to quickly determine the broadcast address as well.
The question: *"What is the range of valid IP addresses for the subnet 210.210.210.0 /25?"*

As with previous sections, you will use your binary math skills to convert the subnet address and subnet mask into binary. This will allow you to quickly spot the host bits, which are key to answering this question and the broadcast address question. The host bits are those bits set to "0" in the subnet mask.

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 210.210.210.0	11010010	11010010	11010010	0**0000000**
Subnet Mask 255.255.255.128 (/25)	11111111	11111111	11111111	1**0000000**

There are three basic rules to remember when determining the subnet address, broadcast address, and range of valid addresses once you've identified the host bits as shown above:

1. The address with all 0s for host bits is the subnet address, also referred to as the "all-zeroes" address. This is not a valid host address.
2. The address with all 1s for host bits is the broadcast address, also referred to as the "all-ones" address. This is not a valid host address.
3. All addresses between the all-zeroes and all-ones addresses are valid host addresses, unless the question specifically states otherwise.

You can quickly see that the "all-zeroes" address is 210.210.210.0. What will the value be if those host bits are set to all 1s? Use your knowledge of binary math to determine this before looking at the next page!

The “all-ones” address is 210.210.210.127. If you had trouble making that conversion, review Section Two, “Converting Binary To Decimal”.

This conversion actually answers *two* different questions. This quick conversion shows you what the range of valid IP addresses is, and also gives you the broadcast, or “all-ones”, address. The second example question, *“What is the broadcast address for the subnet 210.210.210.0 /25?”,* is answered by using the same method.

Let’s look at another set of examples:

“*What is the range of valid IP addresses in the subnet 150.10.64.0 /18?”*

“What is the broadcast address of the subnet 150.10.64.0 /18?”

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 150.10.64.0	11010010	00001010	01**000000**	**00000000**
Subnet Mask 255.255.192.0 (/18)	11111111	11111111	11**000000**	**00000000**

If all the host bits are “zeroes”, the address is 150.10.64.0, the subnet address itself. This is not a valid host address.

If all the host bits are “ones”, the address is 150.10.127.255. That is the broadcast address for this subnet.

All bits between the subnet address and broadcast address are considered valid addresses. This gives you the range 150.10.64.1 – 150.10.127.254.

Again, the method used to arrive at the range of valid IP addresses is the same as that used to discover the broadcast address of a given subnet.

Let's take a look at the other question type from the first part of this section.

"Which of the following IP addresses are found on the same subnet as the IP address 210.210.210.130 /25?"

"Which of the following IP addresses are not found on the same subnet as the IP address 210.210.210.130 /25?"

For some subnetting questions, you're going to have to determine more than one factor before you can give the correct answer. This question looks simple enough on the surface, but to answer this question type correctly, you must determine two things:

1. On what subnet can this address be found?
2. What is the range of valid IP addresses for this subnet?

Exam Tip

Do not just come up with the subnet address. If you're presented with such a question, determine the subnet address AND the range of valid IP addresses for the subnet before answering the question.

In the example, you must first determine the subnet address of the IP address in question, which you learned how to do in Section Six:

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 210.210.210.130	11010010	11010010	11010010	10000010
Subnet Mask 255.255.255.128 (/25)	11111111	11111111	11111111	10000000
Boolean AND Result	11010010	11010010	11010010	10000000

Converting The Boolean AND Into Dotted Decimal:

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	1	0	0	1	0	210
Second Octet	1	1	0	1	0	0	1	0	210
Third Octet	1	1	0	1	0	0	1	0	210
Fourth Octet	1	0	0	0	0	0	0	0	128

The subnet is 210.210.210.128 /25, or 210.210.210.128 255.255.255.128.

You know the subnet number; you must now determine the valid range of IP addresses, which you learned earlier in this section.

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 210.210.210.128	11010010	11010010	11010010	1**0000000**
Subnet Mask 255.255.255.128 (/25)	11111111	11111111	11111111	1**0000000**
Identify The Host Bits				0000000

If all the host bits are 0, the all-zeroes address is 210.210.210.128. If all the host bits are 1, the all-ones address is 210.210.210.255. All addresses between these two are valid. You would now look at the different IP addresses presented by the question and then determine which ones fall in the range 210.210.210.129 – 210.210.210.254 (or which ones don't, if that's what the question asks for.)

At first, it seems like a lot of work, but as with all other binary math operations, once you practice it, it will become second nature. This question seems longer to solve because it is, since two operations are needed to solve it. Since you're well-versed in the fundamentals of binary math, this question will present no problems for you.

"Determining Broadcast Addresses" and "Determining Valid IP Address Ranges" Questions

What is the valid IP address range for the subnet 222.23.48.64 /26?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 222.23.48.64	11011110	00010111	00110000	01**000000**
Subnet Mask 255.255.255.192	11111111	11111111	11111111	11**000000**
Identify The Host Bits				**000000**

All-Zeroes (Subnet) Address: 222.23.48.64 /26
All-Ones (Broadcast) Address: 222.23.48.127 /26
Valid IP address range: 222.23.48.65 – 222.23.48.126

What is the valid IP address range for the subnet 140.10.10.0 /23?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 140.10.10.0	10001100	00001010	0000101**0**	**00000000**
Subnet Mask 255.255.254.0	11111111	11111111	1111111**0**	**00000000**

All-Zeroes (Subnet) Address: 140.10.10.0 /23
All-Ones (Broadcast) Address: 140.10.11.255 /23
Valid IP address range: 140.10.10.1 – 140.10.11.254

What is the valid IP address range for the subnet 10.200.0.0 /17?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 10.200.0.0	00001010	11001000	0**0000000**	**00000000**
Subnet Mask 255.255.128.0 (/17)	11111111	11111111	1**0000000**	**00000000**

All-Zeroes (Subnet) Address: 10.200.0.0 /17
All-Ones (Broadcast) Address: 10.200.127.255 /17
Valid IP address range: 10.200.0.1 – 10.200.127.254

What is the valid IP address range for the subnet 198.27.35.128 /27?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 198.27.35.128	11000110	00011011	00100011	100**00000**
Subnet Mask 255.255.255.224 (/27)	11111111	11111111	11111111	111**00000**

All-Zeroes (Subnet) Address: 198.27.35.128 /27
All-Ones (Broadcast) Address: 198.27.35.159 /27

Valid IP address range: 198.27.35.129 – 198.27.35.158

What is the broadcast address for the subnet 132.12.224.0 /27?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 132.12.224.0	10000100	00001100	11100000	000**00000**
Subnet Mask 255.255.255.224	11111111	11111111	11111111	111**00000**

All-Zeroes (Subnet) Address: 132.12.224.0 /27
All-Ones (Broadcast) Address: 132.12.224.31 /27
Valid IP address range: 132.12.224.1 – 132.12.224.30

What is the broadcast address for the subnet 211.18.39.16 /28?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 211.18.39.16	11010011	00010010	00100111	0001**0000**
Subnet Mask 255.255.255.240 (/28)	11111111	11111111	11111111	1111**0000**

All-Zeroes (Subnet) Address: 211.18.39.16 /28
All-Ones (Broadcast) Address: 211.18.39.31 /28
Valid IP address range: 211.18.39.17 – 211.18.39.30

What is the broadcast address for the subnet 10.1.2.20 /30?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 10.1.2.20	00001010	00000001	00000010	000101**00**
Subnet Mask 255.255.255.252 (/30)	11111111	11111111	11111111	111111**00**

All-Zeroes (Subnet) Address: 10.1.2.20 /30
All-Ones (Broadcast) Address: 10.1.2.23 /30
Valid IP address range: 10.1.2.21 – 10.1.2.22

Exam Tip

The previous exercise used a subnet mask of /30, which in dotted decimal is 255.255.255.252. This is a common mask to use on point-to-point links, whether they be Serial or ISDN links. It's also the most restrictive subnet mask that's legal to use.

You cannot use a subnet mask of /31 or /32 on a point-to-point link. A subnet mask of /31 would have only one host bit; a subnet mask of /32 mask would have no host bits. You will see /32 masks later in your Cisco studies, but don't attempt to use them for point-to-point links. A subnet mask of /30 is your best bet for point-to-point links.

What is the valid IP address range for the subnet 144.45.24.0 /21?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 144.45.24.0	10010000	00101101	00011**000**	**00000000**
Subnet Mask 255.255.248.0 (/21)	11111111	11111111	11111**000**	**00000000**

All-Zeroes (Subnet) Address: 144.45.24.0 /21
All-Ones (Broadcast) Address: 144.45.31.255 /21
Valid IP address range: 144.45.24.1 – 144.45.31.254

What is the valid IP address range for the subnet 10.10.128.0 255.255.192.0 ?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 10.10.128.0	00001010	00001010	10**000000**	**00000000**
Subnet Mask 255.255.192.0 (/15)	11111111	11111111	10**000000**	**00000000**

All-Zeroes (Subnet) Address: 10.10.128.0 255.255.192.0
All-Ones (Broadcast) Address: 10.10.191.255 255.255.192.0
Valid IP address range: 10.10.128.1 – 10.10.191.254

What is the broadcast address for the subnet 221.18.248.224 /28?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 221.18.248.224	11011101	00010010	11111000	1110**0000**
Subnet Mask 255.255.255.240	11111111	11111111	11111111	1111**0000**

All-Zeroes (Subnet) Address: 221.18.248.224 /28
All-Ones (Broadcast) Address: 221.18.248.239 /28
Valid IP address range: 221.18.248.225 – 238

What is the broadcast address for the subnet 123.1.0.0 /17?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 123.1.0.0	01111011	00000001	0**0000000**	**00000000**
Subnet Mask 255.255.128.0 (/17)	11111111	11111111	1**0000000**	**00000000**

All-Zeroes (Subnet) Address: 123.1.0.0 /17
All-Ones (Broadcast) Address: 123.1.127.255 /17
Valid IP address range: 123.1.0.1 – 123.1.127.254

What is the broadcast address for the subnet 203.12.17.32 /27?

Determining The All-Zeroes and All-Ones Subnet Addresses

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 203.12.17.32	11001011	00001100	00010001	001**00000**
Subnet Mask 255.255.255.224 (/27)	11111111	11111111	11111111	111**00000**

All-Zeroes (Subnet) Address: 203.12.17.32 /27
All-Ones (Broadcast) Address: 203.12.17.63 /27
Valid IP address range: 203.12.17.33 – 203.12.17.62

Which of the following IP addresses can be found on the same subnet as the IP address 221.23.32.17 /28?

A. 221.23.32.15 /28
B. 221.23.32.19 /28
C. 221.23.32.26 /28
D. 221.23.32.33 /28
E. 221.23.32.17 255.255.255.240
F. 221.23.32.25 255.255.255.224
G. 221.23.32.21 255.255.255.192

Your mastery of the foundations of binary math will allow you to resolve any such question! First, you must determine the subnet upon which this IP address can be found. Second, you must determine the range of valid IP addresses on that subnet. Doing so will allow you to determine which of the listed addresses are (or are not) on the same subnet.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 221.23.32.17	11011101	00010111	00100000	00010001
Subnet Mask 255.255.255.240 (/28)	11111111	11111111	11111111	11110000
Boolean AND Result	11011101	00010111	00100000	00010000

Converting the Boolean AND result reveals that the subnet is 221.23.32.16 /28, or 221.23.32.16 255.255.255.240. Now you must determine the valid range of host addresses for this subnet, which you learned how to do earlier in this section:

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 221.23.32.16	11011101	00010111	00100000	0001**0000**
Subnet Mask 255.255.255.240	11111111	11111111	11111111	1111**0000**

All-Zeroes (Subnet) Address: 221.23.32.16 /28
All-Ones (Broadcast) Address: 221.23.32.31 /28
Valid IP address range: 221.23.32.17 – 221.23.32.30

Check the valid IP address range against any IP addresses you're presented with in the question. ***Watch the subnet masks.***

The correct answers: B, C, E.

Which of the following IP addresses cannot be found on the same subnet as the IP address 10.39.48.17 /11?

A. 10.32.7.7 /11
B. 10.64.7.7 /11
C. 10.128.7.7 /11
D. 10.48.7.7 /11
E. 10.22.22.22 /11
F. 10.100.7.7 /11
G. 10.63.254.254 /11

The process for approaching this question format:

1. Determine the subnet on which the address can be found.
2. Determine the range of valid addresses for that subnet.
3. Reread the question; verify whether the question is asking whether these addresses CAN or CANNOT be found on this subnet.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 10.39.48.17	00001010	00100111	00110000	00010001
Subnet Mask 255.224.0.0 (/11)	11111111	11100000	00000000	00000000
Boolean AND Result	00001010	00100000	00000000	00000000

The Boolean AND shows us that the subnet is 10.32.0.0 /11. Now what is the valid IP address range for this subnet?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 10.32.0.0	00001010	001**00000**	**00000000**	**00000000**
Subnet Mask 255.224.0.0	11111111	111**00000**	**00000000**	**00000000**

All-zeroes subnet address: 10.32.0.0 /11
All-ones subnet address: 10.63.255.255 /11
Valid IP address range: 10.32.0.1 – 10.63.255.254

Answer: B, C, E, F.

Which of the following IP addresses can be found on the same subnet as the IP address 150.119.201.26 /26?

A. 150.119.201.60 / 26
B. 150.119.201.129 /26
C. 150.119.201.200 /26
D. 150.119.201.220 /26
E. 150.119.201.240 /26
F. 150.119.201.20 /26
G. 150.119.201.32 /26

The process for approaching this question format:

1. Determine the subnet on which the address is found.
2. Determine the valid range of IP addresses for this subnet.
3. Reread the question; verify whether the question asks whether the question asks whether the IP addresses listed ARE or ARE NOT on this subnet.

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 150.119.201.26	10010110	01110111	11001001	00011010
Subnet Mask 255.255.255.192 (/26)	11111111	11111111	11111111	11000000
Boolean AND Result	10010110	01110111	11001001	00000000

The Boolean AND reveals that the subnet is 150.119.201.0. What is the range of valid IP addresses?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 150.119.201.0	10010110	01110111	11001001	00**000000**
Subnet Mask 255.255.255.192	11111111	11111111	11111111	11**000000**

All-zeroes subnet address: 150.119.201.0 /26.
All-ones subnet address: 150.119.201.63 /26.
Valid IP address range: 150.119.201.1 – 150.119.201.62.

Answer: A, F, G.

Which of the following IP addresses cannot be found on the same subnet as the IP address 217.39.48.209 /28?

A. 217.39.48.224 /28
B. 217.39.48.222 /28
C. 217.39.48.226 /28
D. 217.39.48.206 /28
E. 217.39.48.237 /28
F. 217.39.48.192 /28
G. 217.39.48.216 /28

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 217.39.48.209	11011001	00100111	00110000	11010001
Subnet Mask 255.255.255.240 (/28)	11111111	11111111	11111111	11110000
Boolean AND Result	11011001	00100111	00110000	11010000

The Boolean AND reveals the subnet is 217.39.48.208 /28. What is the valid range of IP addresses for this subnet?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 217.39.48.208	11011001	00100111	00110100	11010000
Subnet Mask 255.255.255.240	11111111	11111111	11111111	1111**0000**

All-zeroes subnet address: 217.39.48.208 /28.
All-ones subnet address: 217.39.48.223 /28.
Valid range of IP addresses: 217.39.48.209 – 217.39.48.222.

Answer: A, C, D, E, F.

Note that this question asked which IP addresses are **not** found on the given subnet. Always double-check what the question asks for.

Section Eight: Meeting The Stated Design Requirements

Example of a "meeting the stated design requirements" question:

"Using Class B network 150.50.0.0, you must design a subnetting scheme that allows for at least 200 subnets, but no more than 150 hosts. Which of the following subnet masks is best suited for this task?"

A. 255.255.0.0
B. 255.255.255.0
C. 255.255.255.128
D. 255.255.255.192
E. 255.255.255.224
F. 255.255.255.64

Welcome to the world of Cisco's "best answer" questions. The good news is that when you're dealing with design requirement questions, the answer is concrete.

What you must watch out for with design requirement questions is that many times, there will be more that one answer that works for one requirement but doesn't work for the other.   **There will be one answer that fits both requirements.**

This question seems demanding, but it actually plays to strengths that you've already developed in earlier sections. This question format demands that you know what the default masks for the different class addresses, and that you know how to determine how many subnet or host bits are needed for a given number of subnets or hosts.

To answer this type of question, the first thing you must do is determine where the network bits are. From your earlier studies, you know that Class A networks have 8 network bits and 24 host bits, Class B networks have 16 network bits and 16 host bits, and Class C networks have 24 network bits and 8 host bits.

You also know that when determining a subnet mask, the subnet bits are borrowed from the host bits. (If you need to review these concepts, review Section Four and Section Five.)

To develop a strategy for this question type, let's examine the sample question.

"Using Class B network 150.50.0.0, you must design a subnetting scheme that allows for at least 200 subnets, but no more than 150 hosts. Which of the following subnet masks is best suited for this task?"

The question was kind enough to tell us that we're dealing with a Class B network, but you already knew that. This means we have 16 network bits and 16 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Host Bits				

Remember the formulas for determining the number of bits needed for a given number of subnets or hosts? To review:

The number of valid subnets =
(2 raised to the power of the number of ***subnet*** *bits) – 2*

The number of valid hosts =
(2 raised to the power of the number of ***host*** *bits) – 2*

The key to this question type is to come up with the minimum number of bits you'll need for the required number of subnets, and make sure the remaining host bits give you ***enough*** hosts, but not ***too many.***

We need eight subnet bits to give us at least 200 subnets:

2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 = 256 – 2 = 254 subnets.

Note that this mask leaves eight host bits, which would result in 254 hosts. This violates the stated requirements.

Network Bits	11111111	11111111		
Subnet Bits			11111111	
Host Bits				00000000

This mask, 255.255.255.0, meets one requirement but does not meet the other.

You've met one requirement, but not the other. What happens if you borrow one more host bit for subnetting, giving you 9 subnet bits and 7 host bits?

9 Subnet Bits: 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 = 512 – 2 = 510

7 Host Bits: 2 x 2 x 2 x 2 x 2 x 2 x 2 = 128 – 2 = 126

This gives you 510 subnets and 126 hosts, meeting both requirements.

As I mentioned, the great thing about this question type is that it plays to your strengths; you already know how to work with subnet bits and host bits. What you must watch out for are answers that meet one requirement but do not meet the other.

Let's walk through another example:

"Using network 220.10.10.0, you must develop a subnetting scheme that allows for a minimum of six hosts and a minimum of 25 subnets. Which of the following is the best subnet mask to use?"

A. *255.255.255.0*
B. *255.255.255.128*
C. *255.255.255.192*
D. *255.255.255.224*
E. *255.255.255.240*
F. *255.255.255.248*
G. *255.255.255.252*

This is a Class C network, so 24 of the bits are already used with the network mask. You have only eight bits to split between the subnet and the host bits.

For at least 25 subnets, 5 subnet bits are needed:

2 x 2 x 2 x 2 x 2 = 32 – 2 = 30 subnets.

This would leave three host bits. Does this meet the other requirement?

2 x 2 x 2 = 8 – 2 = 6 hosts. That meets the second requirement, so a mask of 5 subnet bits and 3 host bits will get the job done.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111	11111111	
Subnet Bits				11111
Host Bits				000

Using your skills to convert this mask to dotted decimal, the resulting mask is 255.255.255.248.

As you've seen, this question type brings into play skills you've already developed. Just be careful when analyzing the question's requirements, and you'll get the correct answer every time.

There may be more than one mask that meets one requirement, but there will be only one that meets both.

“Meeting Design Requirements” Questions:

You’re working with Class A network 15.0.0.0. You must develop a subnetting plan that allows for at least 2000 subnets. To prevent LAN congestion, no subnet should contain more than 260 hosts but no fewer than 200. Which of the following subnet masks will allow this?

A. 255.255.0.0
B. 255.255.128.0
C. 255.255.192.0
D. 255.255.224.0
E. 255.255.255.0
F. 255.255.255.128
G. 255.255.255.192

Class A networks have 8 network bits, leaving 24 bits to be split between the subnet and host bits in this question.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111			
Subnet Bits				
Host Bits				

When presented with a question that has a minimum value and a maximum value, the best approach is to determine how many bits are needed to resolve the *minimum* value, and then determine if the remaining bits will meet the *maximum* requirement.

For the minimum requirement, the only number of host bits we can use is eight, which yields 254 valid host addresses. This also results in more than 2000 subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111			
Subnet Bits		11111111	11111111	
Host Bits				00000000

The resulting mask is 255.255.255.0. All of the other masks would result in too many host bits, except 255.255.255.128 and 255.255.255.192, which would result in too few host bits.

Your network has been assigned the address 140.10.0.0. Your network manager requires that you have at least 250 subnets, and that any of these subnets will support at least 250 hosts. Which of the following subnet masks will allow this?

A. 255.255.252.0
B. 255.255.255.0
C. 255.255.255.128
D. 255.255.255.192
E. 255.255.255.224
F. 255.255.255.240

This Class B network has 16 network bits and 16 bits remaining to be split between the subnet and host bits.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Subnet Bits				
Host Bits				

You must have at least 250 subnets. Eight subnet bits would be required for this:

2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 = 256 – 2 = 254

If you use eight subnet bits, that would leave eight host bits, which obviously results in 254 hosts. This mask meets both requirements. None of the other masks do.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Subnet Bits			11111111	
Host Bits				00000000

The resulting mask is 255.255.255.0.

Your network has been assigned the network number 200.10.10.0. Your network manager has asked you to come up with a subnet mask that will allow for at least 14 subnets. No subnet should ever contain more than 12 hosts, but should contain at least five. Which of the following subnet masks should you use?

A. /25
B. /26
C. /27
D. /28
E. /29
F. /30

This Class C network's mask has 24 network bits. There are only eight bits to be split between the subnet and host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111	11111111	
Subnet Bits				
Host Bits				

Looking at the requirements, you can quickly see that 4 subnet bits would give you 14 subnets (16 – 2). The problem is that this would leave 4 host bits, resulting in 14 hosts, which violates the second requirement.

The maximum number of host bits you can have in this answer is three, which would result in 6 hosts. You can't have less, because that would allow only two hosts.

That would leave five subnet bits, which meets the first requirement. The only mask that meets both requirements is /29.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111	11111111	
Subnet Bits				11111
Host Bits				000

Your network has been assigned the network number 134.100.0.0. Your network manager requests that you come up with a subnet mask that allows for at least 500 subnets, but no subnet must be able to hold more than 120 hosts. What is the best subnet mask to use?

A. 255.255.255.248
B. 255.255.255.240
C. 255.255.255.224
D. 255.255.255.192
E. 255.255.255.128

Network 134.100.0.0 is a Class B network, resulting in a network mask of 255.255.0.0. Sixteen bits remain to be split between the subnet bits and host bits.

For 500 subnets, a minimum of nine subnet bits will be needed (2 to the 9^{th} power is 512; subtract 2 and 510 remain.)

That would leave 7 host bits. Does this meet the second requirement? No. 2 to the 7^{th} power is 128; subtract 2 and 126 remain, violating the second requirement.

A mix of 10 subnet bits and 6 host bits will work, though. 10 subnet bits result in 1022 valid subnets, meeting the first requirement. That would leave 6 host bits, which yields 62 valid hosts. That meets the requirement.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Network Bits	11111111	11111111		
Subnet Bits			11111111	11
Host Bits				000000

The mask is 255.255.255.192.

This is the type of question you really have to watch. It would be easy to say "okay, 9 subnet bits gives me 510 subnets, that's the right answer", choose that answer, and move on. **You must ensure that your answer meets both requirements!**

Your network has been assigned the network number 202.10.40.0. Your network manager requests that you come up with a subnet mask that allows at least 10 subnets, but no subnet should allow more than 10 hosts. What is the best subnet mask to use?

A. 255.255.255.192
B. 255.255.255.128
C. 255.255.255.224
D. 255.255.255.248
E. 255.255.255.240

Network 202.10.40.0 is a Class C network, resulting in a network mask of 255.255.255.0. Only eight bits remain to be split between the subnet bits and host bits.

For a minimum of 10 subnets, at least four subnet bits would be needed (2 to the 4^{th} power = 16 – 2 = 14). This would leave four host bits. Does this meet the second requirement? No. There would be 14 hosts.

Five subnet bits and three host bits will meet the requirements. This would yield 30 subnets and 6 hosts.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Network Bits	11111111	11111111	11111111	
Subnet Bits				11111
Host Bits				000

The resulting mask is 255.255.255.248.

Your network manager has come to you for a subnetting scheme. You're working with network number 37.0.0.0. Your manager requests that you allow for at least 500 hosts per subnet; however, he wants as many subnets as possible without exceeding 1000 subnets. What is the best subnet mask to use?

A. 255.255.255.0
B. 255.255.128.0
C. 255.255.0.0
D. 255.248.0.0
E. 255.240.0.0
F. 255.128.0.0
G. 255.0.0.0

Network 37.0.0.0 is a Class A network, so we have 24 host bits to work with. The requirement for 500 hosts is no problem; we only need nine host bits to have 510 valid host addresses (2 to the 9th power – 2).

The problem comes in with the requirement of not having more than 1000 subnets. If we only used nine host bits, that would leave 15 subnet bits, which would result in over 32,000 subnets!

How many subnet bits can we borrow from the host bits without going over 1000 subnets? Nine subnet bits would give us 510 valid subnets; that's as close as we can come without going over. Doing so would leave us with 15 host bits, which would certainly meet the "minimum number of hosts" requirement.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111			
Subnet Bits		11111111	1	
Host Bits			0000000	00000000

The best mask to use is 255.255.128.0.

Do not let the "minimum" part of the requirement throw you off. If you're asked for a minimum of 500 hosts or 500 subnets, as long as you've got more than that, it doesn't matter how *many* more you have. The requirement is met. The key is to meet *both* requirements.

You are working with network number 157.200.0.0. You must develop a subnetting scheme where each subnet will support at least 200 hosts. To support the company's future growth, you need to allow for at least 100 valid subnets; however, at no time will the company ever need more than 150 valid subnets. What is the appropriate subnet mask to use?

A. 255.255.255.240
B. 255.255.255.128
C. 255.255.255.64
D. 255.255.255.0
E. 255.255.254.0
F. 255.255.252.0
G. 255.255.248.0
H. 255.255.240.0

This network number is a Class B, so we have 16 host bits to work with. Eight host bits would result in 256 hosts, enough for the first requirement. However, this would also result in 254 valid subnets, violating the second requirement. (2 to the 8^{th} power – 2 = 254).

The only number of subnet bits that results in between 100 and 150 valid subnets is 7; this yields 126 valid subnets. (Six subnet bits would yield 62 valid subnets.) This means we would have nine host bits left, more than meeting the "at least 200 hosts" requirement.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Network Bits	11111111	11111111		
Subnet Bits			1111111	
Host Bits			0	00000000

The proper mask is 255.255.254.0.

Note that there is no problem with having a "254" as the decimal value for the first, second, or third octet of a subnet mask. It's only when you see it in the fourth octet that there's a problem. The subnet mask 255.255.255.254 is invalid, as it leaves only one host bit.

You are working with network number 221.17.39.0. Your network manager has assigned you to develop a subnetting scheme where each subnet supports at least 30 valid host addresses. Disregarding the prospect for network growth, he requests that you do not allow more than 10 valid subnets to exist. What is the appropriate mask for you to use?

A. 255.255.255.128
B. 255.255.255.192
C. 255.255.255.224
D. 255.255.255.240
E. 255.255.255.248
F. 255.255.255.252
G. 255.255.255.0
H. 255.255.254.0

We've got a Class C network to work with, which leaves us eight host bits. Four host bits would result in exactly 30 valid host addresses (2 to the 4^{th} power – 2 = 30). However, this would also result in 30 valid subnets, violating the second requirement.

Will five host bits and three subnet bits work? Three subnet bits result in 6 valid subnets; the remaining five host bits result in 62 valid host addresses. Both requirements are met.

The appropriate subnet mask is 255.255.255.224.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Network Bits	11111111	11111111	11111111	
Subnet Bits				111
Host Bits				00000

Given network number 47.0.0.0, what subnet mask will result in at least 4000 subnets, but will allow between 400 – 500 valid hosts on each subnet?

A. 255.255.0.0
B. 255.255.128.0
C. 255.255.192.0
D. 255.255.224.0
E. 255.255.240.0
F. 255.255.252.0
G. 255.255.254.0
H. 255.255.255.128
I. 255.255.255.192

With a Class A network, there are 24 host bits. Borrowing subnet bits from these host bits, and using our formula for determining the number of bits needed for a certain number of valid subnets, we see that borrowing 12 bits for subnetting will result in 4094 valid subnets. This meets the first requirement, but does it meet the second?

No. That would leave 12 host bits, resulting in 4094 valid host addresses. We need to keep borrowing host bits until less than 1000 valid host addresses are available.

Eleven host bits would yield 2046 valid hosts; too many. Ten would result in 1022; still too many. Nine host bits yield 510 valid host addresses, and still leave more than enough valid subnets.

The proper mask is 255.255.254.0. The masks 255.255.255.128 and 255.255.255.192 would result in enough valid subnets, but not enough valid hosts per subnet.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111			
Subnet Bits		11111111	1111111	
Host Bits			0	00000000

Given network number 130.245.0.0, what subnet mask will result in at least 250 valid hosts per subnet, but between 50 and 60 valid subnets?

A. 255.255.255.0
B. 255.255.252.0
C. 255.255.254.0
D. 255.255.248.0
E. 255.255.240.0
F. 255.255.224.0
G. 255.255.0.0

With this Class B network, there are 16 host bits. How many subnet bits need to be borrowed to yield between 50 and 60 subnets?

The only number of subnet bits that yield this particular number is six, which gives us 62 valid subnets. Five subnet bits yield too few valid subnets (30), while seven subnet bits yield too many (126).

If you borrow six subnet bits, how many hosts will be available per subnet? The remaining ten host bits will give you 1022 valid host addresses, more than enough for the first requirement. Therefore, the appropriate mask is 255.255.252.0.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Subnet Bits			111111	
Host Bits			00	00000000

Section Nine: Your Final Exam

Now that you've reviewed the approach to take for the various types of binary math and subnetting questions you might see on the CCNA exams, it's time to get even more practice in. Remember, you pass the exam **before** you ever enter the exam room – and you pass it by the amount of practice and study you put in.

The following questions are presented to you in the order in which the question type was discussed in this book. When you're solid with the fundamentals, you're halfway home. If you have **any** hesitancy with any of the question types, go back to that section and practice them until you can answer the question flawlessly and without hesitation.

For the first few sections, you are not presented with choices. Your skill level will be more than enough to answer the questions without multiple choice.

Let's go!

Converting Binary To Dotted Decimal

What is the dotted decimal equivalent of the binary number 01010101 11100010 01101010 01001010?

	128	64	32	16	8	4	2	1	Total
First Octet	0	1	0	1	0	1	0	1	85
Second Octet	1	1	1	0	0	0	1	0	226
Third Octet	0	1	1	0	1	0	1	0	106
Fourth Octet	0	1	0	0	1	0	1	0	74

Answer: 85.226.106.74

What is the dotted decimal equivalent of the binary number 11110000 00001111 01111111 10000000?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	1	1	0	0	0	0	240
Second Octet	0	0	0	0	1	1	1	1	15
Third Octet	0	1	1	1	1	1	1	1	127
Fourth Octet	1	0	0	0	0	0	0	0	128

Answer: 240.15.127.128.

Exam Tip

As you can see in the previous question, the more you practice binary math, the more of it you'll be able to do in your head. You may have solved the last question without even writing it down. That's great, but be careful with it in the exam room. It only takes about thirty seconds to write it out, and since you'll be a binary math master before you walk into the testing room, time will not be a factor for you.

What is the dotted decimal equivalent of the binary number 11001101 00000011 11110010 00100101?

	128	64	32	16	8	4	2	1	Total
First Octet	1	1	0	0	1	1	0	1	205
Second Octet	0	0	0	0	0	0	1	1	3
Third Octet	1	1	1	1	0	0	1	0	242
Fourth Octet	0	0	1	0	0	1	0	1	37

Answer: 205.3.242.37.

What is the dotted decimal equivalent of the binary string 00110010 00100011 11110011 00100111?

	128	64	32	16	8	4	2	1	Total
First Octet	0	0	1	1	0	0	1	0	50
Second Octet	0	0	1	0	0	0	1	1	35
Third Octet	1	1	1	1	0	0	1	1	243
Fourth Octet	0	0	1	0	0	1	1	1	39

Answer: 50.35.243.39.

What is the dotted decimal equivalent of the binary string 10000111 00111111 01011111 00110010?

	128	64	32	16	8	4	2	1	Total
First Octet	1	0	0	0	0	1	1	1	135
Second Octet	0	0	1	1	1	1	1	1	63
Third Octet	0	1	0	1	1	1	1	1	95
Fourth Octet	0	0	1	1	0	0	1	0	50

Answer: 135.63.95.50

At this point in your studies, you should have had no trouble answering the previous five questions. If you did, or were unsure of the approach, review Section Two.

If not, let's proceed to the next section.

Converting Decimal To Binary

What is the binary equivalent of the dotted decimal IP address 195.29.37.126?

	128	64	32	16	8	4	2	1
1st Octet: 195	1	1	0	0	0	0	1	1
2nd Octet: 29	0	0	0	1	1	1	0	1
3rd Octet: 37	0	0	1	0	0	1	0	1
4th Octet: 126	0	1	1	1	1	1	1	0

Answer: 11000011 00011101 00100101 01111110.

What is the binary equivalent of the dotted decimal IP address 207.93.49.189?

	128	64	32	16	8	4	2	1
1st Octet: 207	1	1	0	0	1	1	1	1
2nd Octet: 93	0	1	0	1	1	1	0	1
3rd Octet: 49	0	0	1	1	0	0	0	1
4th Octet: 189	1	0	1	1	1	1	0	1

Answer: 11001111 01011101 00110001 10111101.

What is the binary equivalent of the dotted decimal IP address 21.200.80.245?

	128	64	32	16	8	4	2	1
1st Octet: 21	0	0	0	1	0	1	0	1
2nd Octet: 200	1	1	0	0	1	0	0	0
3rd Octet: 80	0	1	0	1	0	0	0	0
4th Octet: 245	1	1	1	1	0	1	0	1

Answer: 00010101 11001000 01010000 11110101.

What is the binary equivalent of the dotted decimal IP address 105.83.219.91?

	128	64	32	16	8	4	2	1
1st Octet: 105	0	1	1	0	1	0	0	1
2nd Octet: 83	0	1	0	1	0	0	1	1
3rd Octet: 219	1	1	0	1	1	0	1	1
4th Octet: 91	0	1	0	1	1	0	1	1

Answer: 01101001 01010011 11011011 01011011.

What is the binary equivalent of the dotted decimal IP address 123.54.217.4?

	128	64	32	16	8	4	2	1
1st Octet: 123	0	1	1	1	1	0	1	1
2nd Octet: 54	0	0	1	1	0	1	1	0
3rd Octet: 217	1	1	0	1	1	0	0	1
4th Octet: 4	0	0	0	0	0	1	0	0

Answer: 01111011 00110110 11011001 00000100.

At this point in your studies, you should have had no trouble answering the previous five questions. If you did, or were unsure of the approach, review Section Three. If not, let's proceed to the next section.

Determining The Number Of Valid Subnets

How many valid subnets exist on the 222.12.240.0 /27 network?

This is a Class C network, with a network mask of 255.255.255.0, or /24. The subnet mask is /27, indicating that there are three subnet bits. 2 to the 3rd power is 8; subtract two, and six valid subnets remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	**000**00000
Subnet Mask 255.255.255.224	11111111	11111111	11111111	**111**00000

How many valid subnets exist on the 10.1.0.0 /17 network?

This is a Class A network, with a network mask of 255.0.0.0, or /8. The subnet mask is /17, indicating that there are nine subnet bits. 2 to the 9th power is 512; subtract two, and 510 valid subnets remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	**00000000**	**0**0000000	00000000
Subnet Mask 255.255.128.0	11111111	**11111111**	**1**0000000	00000000

How many valid subnets exist on the 111.0.0.0 /14 network?

This is a Class A network, with a network mask of 255.0.0.0, or /8. The subnet mask is /14, indicating that there are six subnet bits. 2 to the 6^{th} power is 64; subtract two, and 62 valid subnets remain.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Default Network Mask 255.0.0.0	11111111	**000000**00	00000000	00000000
Subnet Mask 255.252.0.0	11111111	**111111**00	00000000	00000000

How many valid subnets exist on the 172.12.0.0 /19 network?

This is a Class B network, with a network mask of 255.255.0.0, or /16. The subnet mask is /19, indicating there are three subnet bits. 2 to the 3^{rd} power is 8; subtract two, and six valid subnet bits remain.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Default Network Mask 255.255.0.0	11111111	11111111	**000**00000	00000000
Subnet Mask 255.255.224.0	11111111	11111111	**111**00000	00000000

How many valid subnets exist on the 182.100.0.0 /27 network?

This is a Class B network, with a network mask of 255.255.0.0, or /16. The subnet mask is /27, indicating there are three subnet bits. 2 to the 11^{th} power is 2048; subtract two, and 2046 valid subnets remain.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Default Network Mask 255.255.0.0	11111111	11111111	**00000000**	**000**00000
Subnet Mask 255.255.255.224	11111111	11111111	**11111111**	**111**00000

How many valid subnets exist on the 231.23.19.0 /30 network?

This is a Class C network, with a network mask of 255.255.255.0, or /24. The subnet mask is /30, indicating there are six subnet bits. 2 to the 6^{th} power is 64; subtract two, and 62 valid subnets remain.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	**000000**00
Subnet Mask 255.255.255.252	11111111	11111111	11111111	**111111**00

How many valid subnets exist on the 17.0.0.0 255.240.0.0 network?

This is a Class A network, with a network mask of 255.0.0.0. The subnet mask here is 255.240.0.0, indicating there are four subnet bits. 2 to the 4^{th} power is 16; subtract two, and 14 valid subnets remain.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Default Network Mask 255.0.0.0	11111111	**0000**0000	00000000	00000000
Subnet Mask 255.240.0.0	11111111	**1111**0000	00000000	00000000

How many valid subnets exist on the 234.12.200.0 255.255.255.248 network?

This is a Class C network, with a network mask of 255.255.255.0. The subnet mask here is 255.255.255.248, indicating there are five subnet bits. 2 to the 5^{th} power is 32; subtract two, and 30 valid subnets remain.

	1^{st} Octet	2^{nd} Octet	3^{rd} Octet	4^{th} Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	00000000
Subnet Mask 255.255.255.248	11111111	11111111	11111111	**11111**000

How many valid subnets exist on the 155.200.0.0 255.255.255.128 network?

This is a Class B network, with a network mask of 255.255.0.0. The subnet mask here is 255.255.255.128, indicating there are nine subnet bits. 2 to the 9th power is 512; subtract two, and 510 valid subnets remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	**00000000**	**0**0000000
Subnet Mask 255.255.255.128	11111111	11111111	**11111111**	**1**0000000

At this point in your studies, you should have gotten each question correct. If you had difficulty with the last nine questions, review Section Four. If not, let's press on!

Determining The Number Of Valid Hosts

How many valid host addresses exist on the 211.24.12.0 /27 subnet?

This is a Class C network, with a network mask of /24. The subnet mask is /27, indicating that there are three subnet bits and five host bits. 2 to the 5th power is 32; subtract two, and 30 valid hosts remain.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	000**00000**
Subnet Mask 255.255.255.224	11111111	11111111	11111111	111**00000**

How many valid host addresses exist on the 12.0.0.0 /19 subnet?

This is a Class A network, with a network mask of /8. The subnet mask is /19, indicating that there are eleven subnet bits and 13 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	00000000	000**00000**	**00000000**
Subnet Mask 255.255.224.0	11111111	11111111	111**00000**	**00000000**

2 to the 13th power is 8192; subtract two, and 8190 valid hosts remain.

How many valid host addresses exist on the 178.34.0.0 /28 subnet?

This is a Class B network, with a network mask of /16. The subnet mask is /28, indicating there are twelve subnet bits and four host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	00000000	0000**0000**
Subnet Mask 255.255.255.240	11111111	11111111	11111111	1111**0000**

2 to the 4th power is 16; subtract two, and 14 valid host addresses remain.

How many valid host addresses exist on the 211.12.45.0 /30 subnet?

This is a Class C network, with a network mask of /24. The subnet mask is /30, indicating there are six subnet bits and two host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	000000**00**
Subnet Mask 255.255.255.252	11111111	11111111	11111111	111111**00**

2 to the 2nd power is 4; subtract two, and two valid host addresses remain.

How many valid host addresses exist on the 129.12.0.0 /20 subnet?

This is a Class B network, with a network mask of /16. The subnet mask is /20, indicating there are four subnet bits and twelve host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	0000**0000**	**00000000**
Subnet Mask 255.255.240.0	11111111	11111111	1111**0000**	**00000000**

2 to the 12th power is 4096; subtract two, and 4094 valid hosts remain.

How many valid host addresses exist on the 210.34.24.0 255.255.255.248 subnet?

This is a Class C network, with a network mask of 255.255.255.0. The subnet mask is five bits longer, indicating there are five subnet bits and three host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.255.0	11111111	11111111	11111111	00000**000**
Subnet Mask 255.255.255.248	11111111	11111111	11111111	11111**000**

2 to the 3rd power is 8; subtract two, and six valid hosts remain.

How many valid host addresses exist on the 145.100.0.0 255.255.254.0 subnet?

This is a Class B network, with a network mask of 255.255.0.0. The subnet mask is seven bits longer, indicating there are seven subnet bits and nine host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.255.0.0	11111111	11111111	0000000**0**	**00000000**
Subnet Mask 255.255.254.0	11111111	11111111	1111111**0**	**00000000**

2 to the 9th power is 512; subtract two, and 510 valid host addresses remain.

How many valid host addresses exist on the 23.0.0.0 255.255.240.0 subnet?

This is a Class A network, with a network mask of 255.0.0.0. The subnet mask is 12 bits longer, indicating there are 12 subnet bits and 12 host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Default Network Mask 255.0.0.0	11111111	00000000	0000**0000**	**00000000**
Subnet Mask 255.255.240.0	11111111	11111111	1111**0000**	**00000000**

2 to the 12th power is 4096; subtract two, and 4094 valid hosts remain.

Your skill set should have allowed you to answer each of the previous eight questions perfectly. If you had difficulty in either the approach or the execution, review Section Five.

Determining The Subnet Number Of A Given IP Address

On what subnet can the IP address 142.12.38.189 /25 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 142.12.38.189	10001110	00001100	00100110	10111101
Subnet Mask /25	11111111	11111111	11111111	10000000
Boolean AND Result	10001110	00001100	00100110	10000000

Convert the Boolean AND result to dotted decimal, and the resulting subnet is 142.12.38.128 /25.

On what subnet can the IP address 170.17.209.36 /19 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 170.17.209.36	10101010	00010001	11010001	00100100
Subnet Mask /19	11111111	11111111	11100000	00000000
Boolean AND Result	11001001	00010001	11000000	00000000

Convert the Boolean AND result to dotted decimal, and the resulting subnet is 170.17.192.0 /19.

On what subnet can the IP address 10.178.39.205 /29 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 10.178.39.205	00001010	10110010	00100111	11001101
Subnet Mask /29	11111111	11111111	11111111	11111000
Boolean AND Result	00001010	10110010	00100111	11001000

Convert the Boolean AND result to dotted decimal, and the resulting subnet is 10.178.39.200 /29.

On what subnet can the IP address 190.34.9.173 /22 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 190.34.9.173	10111110	00100010	00001001	10101101
Subnet Mask /22	11111111	11111111	11111100	00000000
Boolean AND Result	10111110	00100010	00001000	00000000

Convert the Boolean AND result to dotted decimal, and the resulting subnet is 190.34.8.0 /22.

On what subnet can the IP address 203.23.189.205 255.255.255.240 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 203.23.189.205	11001011	00010111	10111101	11001101
Subnet Mask 255.255.255.240 (/28)	11111111	11111111	11111111	11110000
Boolean AND Result	11001011	00010111	10111101	11000000

Convert the Boolean AND result to dotted decimal, and the resulting subnet is 203.23.189.192 255.255.255.240.

On what subnet can the IP address 109.89.45.204 255.255.224.0 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 109.89.45.204	01101101	01011001	00101101	11001100
Subnet Mask 255.255.224.0 (/19)	11111111	11111111	11100000	00000000
Boolean AND Result	01101101	01011001	00100000	00000000

Convert the Boolean AND result to dotted decimal, and the resulting subnet is 109.89.32.0 255.255.224.0.

On what subnet can the IP address 49.210.83.201 255.255.255.248 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 49.210.83.201	00110001	11010010	01010011	11001001
Subnet Mask 255.255.255.248 (/29)	11111111	11111111	11111111	11111000
Boolean AND Result	00110001	11010010	01010011	11001000

Convert the Boolean AND result to dotted decimal, and the resulting subnet is 49.210.83.200 255.255.255.248.

On what subnet can the IP address 31.189.234.245 /17 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 31.189.234.245	00011111	10111101	11101010	11110101
Subnet Mask /17	11111111	11111111	10000000	00000000
Boolean AND Result	00011111	10111101	10000000	00000000

Convert the Boolean AND result to dotted decimal, and the resulting subnet is 31.189.128.0 /17.

On what subnet can the IP address 100.10.13.176 /21 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 100.10.13.176	01100100	00001010	00001101	10110000
Subnet Mask /21	11111111	11111111	11111000	00000000
Boolean AND Result	01100100	00001010	00001000	00000000

Convert the Boolean AND result into dotted decimal, and the resulting subnet is 100.10.8.0 /21.

On what subnet can the IP address 190.98.35.17 /27 be found?

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address 190.98.35.17	10111110	01100010	00100011	00010001
Subnet Mask /27	11111111	11111111	11111111	11100000
Boolean AND Result	10111110	01100010	00100011	00000000

Convert the Boolean AND result to dotted decimal, and the resulting subnet is 190.98.35.0 /27.

You should have gotten each of these questions correct. If you had trouble, review Section Six. If you answered each one correctly, lets move on!

Determining Broadcast Addresses and Valid IP Address Ranges

What is the valid range of IP addresses for the subnet 100.100.45.32 /28?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 100.100.45.32	01100100	01100100	00101101	0010**0000**
Subnet Mask /28	11111111	11111111	11111111	1111**0000**

We know that the last four bits are the host bits. If these are all zeroes, this is the subnet address itself, and is not valid. If there are all ones, this is the broadcast address for this subnet, and is not valid. All addresses between the two are valid.

"All-Zeroes" Subnet Address: 100.100.45.32
"All-Ones" Broadcast Address: 100.100.45.47
Valid IP Addresses: 100.100.45.33 – 46

What is the valid range of IP addresses for the subnet 208.72.109.8 /29?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 208.72.109.8	11010000	01001000	01101101	00001**000**
Subnet Mask /29	11111111	11111111	11111111	11111**000**

"All-Zeroes" Subnet Address: 208.72.109.8
"All-Ones" Broadcast Address: 208.72.109.15
Valid IP Addresses: 208.72.109.9 – 208.72.109.14

What is the valid range of IP addresses for the subnet 190.89.192.0 255.255.240.0?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 190.89.192.0	10111110	01011001	1100**0000**	**00000000**
Subnet Mask 255.255.240.0	11111111	11111111	1111**0000**	**00000000**

"All-Zeroes" Subnet Address: 190.89.192.0
"All-Ones" Broadcast Address: 190.89.207.255
Valid IP Addresses: 190.89.192.1 – 190.89.207.254

What is the broadcast address of the subnet 101.45.210.52 /30?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 101.45.210.52	01100101	00101101	11010010	001101**00**
Subnet Mask /30	11111111	11111111	11111111	111111**00**

"All-Zeroes" Subnet Address: 101.45.210.52
"All-Ones" Broadcast Address: 101.45.210.55
Valid IP Addresses: 101.45.210.53, 101.45.210.54

What is the broadcast address of the subnet 90.34.128.0 /18?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 90.34.192.0	01011010	00100010	10**000000**	**00000000**
Subnet Mask /18	11111111	11111111	11**000000**	**00000000**

"All-Zeroes" Subnet Address: 90.34.128.0
"All-Ones" Broadcast Address: 90.34.191.255
Valid IP Addresses: 90.34.128.1 – 90.34.191.254

What is the valid range of IP addresses for the subnet 205.186.34.64 /27?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 205.186.34.64	11001101	10111010	00100010	01**000000**
Subnet Mask /27	11111111	11111111	11111111	111**00000**

"All-Zeroes" Subnet Address: 205.186.34.64
"All-Ones" Broadcast Address: 205.186.34.95
Valid IP Addresses: 205.186.34.65 – 94

What is the valid range of IP addresses for the subnet 175.24.36.0 255.255.252.0?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 175.24.36.0	10101111	00011000	001001**00**	**00000000**
Subnet Mask 255.255.252.0 (/22)	11111111	11111111	111111**00**	**00000000**

"All-Zeroes" Subnet Address: 175.24.36.0
"All-Ones" Broadcast Address: 175.24.39.255
Valid IP Addresses: 175.24.36.1 – 175.24.39.254

What is the broadcast address for the subnet 10.10.44.0 /25?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 10.10.44.0	00001010	00001010	00101100	0**0000000**
Subnet Mask /25	11111111	11111111	11111111	1**0000000**

"All-Zeroes" Subnet Address: 10.10.44.0
"All-Ones" Broadcast Address: 10.10.44.127
Valid IP Addresses: 10.10.44.1 – 10.10.44.126

What is the broadcast address for the subnet 120.20.240.0 /21?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 120.20.240.0	01111000	00010100	11110**000**	**00000000**
Subnet Mask /21	11111111	11111111	11111**000**	**00000000**

"All-Zeroes" Subnet Address: 120.20.240.0
"All-Ones" Broadcast Address: 120.20.247.255
Valid IP Addresses: 120.20.240.1 – 120.20.247.254

What is the range of valid IP addresses for the subnet 200.18.198.192 /26?

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Address 200.18.198.192	11001000	00010010	11000110	11**000000**
Subnet Mask /26	11111111	11111111	11111111	11**000000**

"All-Zeroes" Subnet Address: 200.18.198.192
"All-Ones" Broadcast Address: 200.18.198.255
Valid IP Addresses: 200.18.198.193 – 200.18.198.254

Exam Tip

A single operation – the one you've used to answer the last ten questions, and that you first learned in Section Seven – gives us the subnet address, the broadcast address, and the valid IP addresses of a given subnet. Make sure you give the correct answer when you're presented with multiple choice. Don't give a subnet address for an answer when a broadcast address has been asked for.

You should have the methodology down cold for determining subnet addresses, broadcast addresses, and valid IP address ranges. If you had any trouble with this section, review Section Seven. If not, let's head to the last part of your exam!

Meeting The Stated Design Requirements

You're working with the network address 135.13.0.0. Your network manager requests that you create a subnetting scheme that allows for at least 500 valid subnets, while each subnet should contain as many hosts as possible without exceeding 100. What is the best subnet mask to use?

A. 255.255.0.0
B. 255.255.192.0
C. 255.255.254.0
D. 255.255.255.128
E. 255.255.255.192
F. 255.255.255.224

This is a Class B network, with 16 network bits and 16 host bits.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Subnet Bits				
Host Bits				

The first requirement is that we have at least 500 subnets. Using the same formula we've used throughout this book, we see that nine subnet bits would give us 510 valid subnets:

2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 x 2 = 512 – 2 = 510

This would leave seven host bits, though. That would result in 128 valid host addresses, which violates the second requirement. (2 to the 7th power is 256; subtract two, and 254 valid host addresses remain.)

What about six host bits? That would yield 62 valid host addresses, which meets the second requirement. A combination of ten subnet bits and six host bits gives us 1022 valid subnets and 62 valid host addresses, meeting both requirements.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Subnet Bits			11111111	11
Host Bits				000000

The resulting mask is 255.255.255.192. (Note that a mask of 255.255.255.224 would work, but it does not yield the maximum number of host addresses without going over 100.)

You are working with the network 160.10.0.0. Your network manager has requested you develop a subnetting scheme that allows for at least 230 subnets, but no fewer than 200. At present, each subnet will contain no more than 20 hosts, but that's expected to grow by 20 hosts per year for the next five years. What is the best subnet mask to use?

- **A. 255.255.192.0**
- **B. 255.255.224.0**
- **C. 255.255.240.0**
- **D. 255.255.248.0**
- **E. 255.255.255.0**
- **F. None of the above.**

This is a Class B network, with a mask of 16 network bits, and 16 host bits that can be borrowed for subnetting.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Subnet Bits				
Host Bits				

The only number of subnet bits that results in between 200 and 230 subnets is eight, resulting in 254 valid subnets. That leaves eight host bits. Is this enough for the second requirement? Yes. If a subnet has 20 hosts now, and will grow by 20 hosts per year for the next five years, that's a total of 120 host addresses. Eight host bits is plenty.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Subnet Bits			11111111	
Host Bits				00000000

The resulting mask is 255.255.255.0.

You're working with the network number 223.12.23.0. Your network manager has asked you to develop a subnetting scheme that allows at least 30 valid hosts per subnet, but yields no more than five valid subnets. Which of the following is the appropriate network mask to use?

A. **/17**
B. **/24**
C. **/25**
D. **/26**
E. **/27**
F. **/28**
G. **/29**
H. **/30**

This Class C network's network mask is /24, leaving eight host bits:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111	11111111	
Subnet Bits				
Host Bits				

Using the formulas we've used throughout the book, we know that we need five host bits for at least 30 hosts per subnet. (2 to the 5th power, minus two, equals exactly 30.) Does this meet the second requirement?

No. That would leave three bits for subnetting, which yields six valid subnets. To meet the second requirement, you can have only two subnet bits, which yields only two valid subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111	11111111	
Subnet Bits				11
Host Bits				000000

This yields a mask of 255.255.255.192, which in prefix notation is expressed as /26.

You're working with the network number 90.0.0.0. Your network manager has directed you to develop a subnetting scheme that will allow for at least 5000 subnets while allowing the maximum number of hosts per subnet. What is the appropriate subnet mask?

A. 255.255.0.0
B. 255.255.128.0
C. 255.255.192.0
D. 255.255.224.0
E. 255.255.240.0
F. 255.255.248.0
G. 255.255.252.0

This Class A network has eight network bits, and 24 host bits that can be borrowed for subnetting:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111			
Subnet Bits				
Host Bits				

For this question, we simply need to decide the minimum number of subnet bits that will yield at least 5000 subnets. Using a calculator or pencil and paper, you find that it takes 13 subnet bits to come up with at least that many subnets; in this case, 8190 usable subnets.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111			
Subnet Bits		11111111	11111	
Host Bits			000	00000000

The resulting mask is 255.255.248.0.

You're working with the network number 131.10.0.0. Your network manager has requested that you develop a subnetting scheme that allows at least fifty subnets. No subnet should contain more than 1000 hosts. What is the best subnet mask to use?

A. 255.255.255.0
B. 255.255.254.0
C. 255.255.224.0
D. 255.255.192.0
E. 255.255.128.0
F. 255.255.64.0
G. None of the above.

This Class B network has 16 network bits, and 16 host bits that can be borrowed for subnetting:

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Subnet Bits				
Host Bits				

You quickly determine that for fifty subnets, you only need six subnet bits. That gives you 62 valid subnets. Does this meet the second requirement?

No. That would leave 10 host bits, which yields 1022 valid host addresses. (2 to the 10^{th} power equals 1024; subtract two, and 1022 remain.) But by borrowing one more bit for subnetting, giving us seven subnet bits and nine host bits, both requirements are met. Seven subnet bits yield 126 valid subnets; nine host bits yield 510 valid host addresses. The appropriate mask is 255.255.254.0.

	1st Octet	2nd Octet	3rd Octet	4th Octet
Network Bits	11111111	11111111		
Subnet Bits			1111111	
Host Bits			0	00000000

Congratulations! You've completed this 65-question final exam. If you had any difficulty with the final section, please review Section Eight. If you nailed all five of the final questions – great work!

Thanks !

Thank you for choosing ***The Bryant Advantage Mastery Series*** to help you on your way to your next Cisco certification.

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To your success,

Chris Bryant
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