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APPENDIX E

Subnetting Reference Pages

This appendix features a set of subnetting reference pages (RP). Each reference page, a single printed page in length, outlines one of the many subnetting processes covered in various chapters of this book.

Although both the printed book and this appendix cover the same processes, the focus is much different. Chapter 12, "IP Addressing and Subnetting," in the *CCENT/CCNA ICND1 Official Exam Certification Guide* (which exists as Appendix H, "ICND1 Chapter 12: IP Addressing and Subnetting," on the CD-ROM of the *ICND2 Official Exam Certification Guide*) explains in detail most of the processes and math related to IP addressing and subnetting. This appendix takes the processes from Chapter 12 and puts all the details of each individual process onto one physical page. When practicing your subnetting math to build speed and accuracy, you can print and refer to these RPs rather than flip through pages in the book. You can also completely ignore this appendix if you like, because there is no new information here that was not already covered in Chapter 12.

This appendix and Appendix D, "Subnetting Practice," are identical elements in both the *CCENT/CCNA ICND1 Official Exam Certification Guide* and the *CCNA ICND2 Official Exam Certification Guide*. If you own both books, you can use either copy of these appendices as you study. If you own only the *CCENT/CCNA ICND1 Official Exam Certification Guide*, note that this appendix includes information about variable-length subnet masking (VLSM) in RP-8, which you can ignore when preparing for the ICND1 exam. If you own only the *CCNA ICND2 Official Exam Certification Guide*, the entire appendix will be useful, because subnetting can be covered in detail on any of the three CCNA exams, plus VLSM is specifically within the scope of the ICND2 and CCNA exams. However, if you have only the *CCNA ICND2 Official Exam Certification Guide* and want more explanation about the use of these RPs, you need to refer to Appendix H of ICND2, which contains a copy of Chapter 12, "IP Addressing and Subnetting," from the *CCENT/CCNA ICND1 Official Exam Certification Guide*.

The process described in each RP should help you learn and internalize the math used to find certain facts about IP addresses and subnets. *However, especially for the decimal* *processes listed here, you should not attempt to memorize each exact process listed in these reference pages.* Instead, by referring to and practicing these processes repeatedly, you should begin to internalize the processes. Just as most people do not really think about the process of multiplying, but instead just do it, the goal with subnetting for the CCNA exams is that you practice these processes to the point that you do not have to think about the process as much as think about the quick math required to get the answer.

The RPs in this appendix are as listed number and title in Table E-1.

Table E-1 *List of Reference Pages*

Reference Page Number	Title
1A	Converting Subnet Masks Between Dotted Decimal and Prefix Format: Binary Version
1B	Converting Subnet Masks Between Dotted Decimal and Prefix Format: Decimal Version
2	Analyzing Unsubnetted IP Addresses
3A	Analyzing an Existing Subnet Mask: Binary Version
3B	Analyzing an Existing Subnet Mask: Decimal Version
4	Choosing a Subnet Mask
5A	Finding the Subnet Number: Binary Version
5A-Shortcut	Finding the Subnet Number: Binary Shortcut
5B	Finding the Subnet Number: Decimal Version, Easy Masks
5C	Finding the Subnet Number: Decimal Version, Difficult Masks
6A	Finding the Broadcast Address and Range of Usable Addresses: Binary Version
6B	Finding the Broadcast Address and Range of Usable Addresses: Decimal Version, Easy Masks
6C	Finding the Broadcast Address and Range of Usable Addresses: Decimal Version, Difficult Masks
7A	Finding All Possible Subnets: Fewer than 8 Subnet Bits (Decimal)
7B	Finding All Possible Subnets: More than 8 Subnet Bits (Decimal)
8	Finding New Subnet Numbers When Using Variable-Length Subnet Masks

General Reference Information

In addition to the RPs, which list a specific process as described in this book, this appendix includes several references for other key information useful for performing subnetting tasks. The information in this section is included so that you can easily print a copy and keep it with you when practicing subnetting.

Table E-2 lists decimal numbers 0 through 255, with their 8-bit binary equivalent values.

Table E-2 *Binary-Decimal Conversion Chart*

Decimal Value	Binary Value	Decimal Value	Binary Value	Decimal Value	Binary Value	Decimal Value	Binary Value
0	00000000	32	00100000	64	01000000	96	01100000
1	00000001	33	00100001	65	01000001	97	01100001
2	00000010	34	00100010	66	01000010	98	01100010
3	00000011	35	00100011	67	01000011	99	01100011
4	00000100	36	00100100	68	01000100	100	01100100
5	00000101	37	00100101	69	01000101	101	01100101
6	00000110	38	00100110	70	01000110	102	01100110
7	00000111	39	00100111	71	01000111	103	01100111
8	00001000	40	00101000	72	01001000	104	01101000
9	00001001	41	00101001	73	01001001	105	01101001
10	00001010	42	00101010	74	01001010	106	01101010
11	00001011	43	00101011	75	01001011	107	01101011
12	00001100	44	00101100	76	01001100	108	01101100
13	00001101	45	00101101	77	01001101	109	01101101
14	00001110	46	00101110	78	01001110	110	01101110
15	00001111	47	00101111	79	01001111	111	01101111
16	00010000	48	00110000	80	01010000	112	01110000
17	00010001	49	00110001	81	01010001	113	01110001
18	00010010	50	00110010	82	01010010	114	01110010
19	00010011	51	00110011	83	01010011	115	01110011
20	00010100	52	00110100	84	01010100	116	01110100
21	00010101	53	00110101	85	01010101	117	01110101
22	00010110	54	00110110	86	01010110	118	01110110
23	00010111	55	00110111	87	01010111	119	01110111
24	00011000	56	00111000	88	01011000	120	01111000
25	00011001	57	00111001	89	01011001	121	01111001
26	00011010	58	00111010	90	01011010	122	01111010
27	00011011	59	00111011	91	01011011	123	01111011
28	00011100	60	00111100	92	01011100	124	01111100
29	00011101	61	00111101	93	01011101	125	01111101
30	00011110	62	00111110	94	01011110	126	01111110
31	00011111	63	00111111	95	01011111	127	01111111

Table E-2 *Binary-Decimal Conversion Chart (Continued)*

Decimal Value	Binary Value	Decimal Value	Binary Value	Decimal Value	Binary Value	Decimal Value	Binary Value
128	10000000	160	10100000	192	11000000	224	11100000
129	10000001	161	10100001	193	11000001	225	11100001
130	10000010	162	10100010	194	11000010	226	11100010
131	10000011	163	10100011	195	11000011	227	11100011
132	10000100	164	10100100	196	11000100	228	11100100
133	10000101	165	10100101	197	11000101	229	11100101
134	10000110	166	10100110	198	11000110	230	11100110
135	10000111	167	10100111	199	11000111	231	11100111
136	10001000	168	10101000	200	11001000	232	11101000
137	10001001	169	10101001	201	11001001	233	11101001
138	10001010	170	10101010	202	11001010	234	11101010
139	10001011	171	10101011	203	11001011	235	11101011
140	10001100	172	10101100	204	11001100	236	11101100
141	10001101	173	10101101	205	11001101	237	11101101
142	10001110	174	10101110	206	11001110	238	11101110
143	10001111	175	10101111	207	11001111	239	11101111
144	10010000	176	10110000	208	11010000	240	11110000
145	10010001	177	10110001	209	11010001	241	11110001
146	10010010	178	10110010	210	11010010	242	11110010
147	10010011	179	10110011	211	11010011	243	11110011
148	10010100	180	10110100	212	11010100	244	11110100
149	10010101	181	10110101	213	11010101	245	11110101
150	10010110	182	10110110	214	11010110	246	11110110
151	10010111	183	10110111	215	11010111	247	11110111
152	10011000	184	10111000	216	11011000	248	11111000
153	10011001	185	10111001	217	11011001	249	11111001
154	10011010	186	10111010	218	11011010	250	11111010
155	10011011	187	10111011	219	11011011	251	11111011
156	10011100	188	10111100	220	11011100	252	11111100
157	10011101	189	10111101	221	11011101	253	11111101
158	10011110	190	10111110	222	11011110	254	11111110
159	10011111	191	10111111	223	11011111	255	11111111

Many of the processes outlined in the RPs require that you find the multiples of a value called the magic number. Table E-3 lists the multiples of most of the possible values of the magic number for reference. Note that the magic number can also be decimal 1 or decimal 2, but the multiples of those values are not in the table. Also, note that the top row of the table lists the values of the magic number, and that for a magic number of 4, two columns were used to reduce the length of the table.

Table E-3 *Integer Multiples of Common Magic Numbers 4, 8, 16, 32, 64, and 128*

4	4 (Continued)	8	16	32	64	128
0	128	0	0	0	0	0
4	132	8	16	32	64	128
8	136	16	32	64	128	256
12	140	24	48	96	192	
16	144	32	64	128	256	
20	148	40	80	160		
24	152	48	96	192		
28	156	56	112	224		
32	160	64	128	256		
36	164	72	144			
40	168	80	160			
44	172	88	176			
48	176	96	192			
52	180	104	208			
56	184	112	224			
60	188	120	240			
64	192	128	256			
68	196	136				
72	200	144				
76	204	152				
80	208	160				
84	212	168				
88	216	176				
92	220	184				
96	224	192				
100	228	200				
104	232	208				
108	236	216				
112	240	224				
116	244	232				
120	248	240				
124	252	248				
	256	256				

Table E-4 lists the key information required to determine the classful IP network in which an address resides, the default subnet mask (used when no subnetting is performed), and the two-part structure of IP addresses when no subnetting is performed.

Table E-4 *Key Facts About Unsubnetted IP Networks*

Class	Range of First Octet Values (Inclusive)	Default Mask/Prefix	Number of Network Octets	Number of Host Octets
A	1–126	255.0.0.0 (/8)	1	3
B	128–191	255.255.0.0 (/16)	2	2
C	192–223	255.255.255.0 (/24)	3	1

An octet of a subnet mask can use only nine specific decimal values. Table E-5 lists those nine values, the binary equivalents, and the number of binary 1s and 0s in each mask. This information can be very useful for quickly analyzing IP addresses.

Table E-5 *Nine Possible Values in a Subnet Mask*

Value of an Octet of a Subnet Mask	Binary Equivalent	Number of Binary 1s	Number of Binary 0s
0	00000000	0	8
128	10000000	1	7
192	11000000	2	6
224	11100000	3	5
240	11110000	4	4
248	11111000	5	3
252	11111100	6	2
254	11111110	7	1
255	11111111	8	0

A classful analysis of a subnetted IP address includes three parts:

1. A network part (as defined by class rules)
2. A host part (as defined by the number of 0s in the subnet mask)
3. A subnet part (the leftover bit positions) between the network and host parts

The number of subnet bits and the number of host bits define the number of possible subnets of that classful network, and the number of hosts per subnet. Table E-6 lists the values, as calculated with a formula that uses powers of 2. Note that the last column assumes that the zero subnet and broadcast subnet are usable.

Table E-6 *Calculations Related to the Number of Subnets and Hosts*

Number of Bits in the Host or Subnet Field	Maximum Number of Hosts (2^h-2)	Maximum Number of Subnets (2^s)
1	0	2
2	2	4
3	6	8
4	14	16
5	30	32
6	62	64
7	126	128
8	254	256
9	510	512
10	1022	1024
11	2046	2048
12	4094	4096
13	8190	8192
14	16,382	16,384

The remainder of this appendix includes the various RPs.

RP-1A: Converting Subnet Masks Between Dotted Decimal and Prefix Format: Binary Version

Subnet masks can be shown in two separate formats: dotted decimal and prefix. The process listed here defines how to convert between the two formats, using binary math. To aid in the conversion process, Table E-7 lists the nine possible decimal values in a mask using dotted decimal format, as well as the binary equivalent.

Table E-7 *Nine Possible Values in a Subnet Mask*

Value of an Octet of a Subnet Mask	Binary Equivalent	Number of Binary 1s	Number of Binary 0s
0	00000000	0	8
128	10000000	1	7
192	11000000	2	6
224	11100000	3	5
240	11110000	4	4
248	11111000	5	3
252	11111100	6	2
254	11111110	7	1
255	11111111	8	0

Process:

To convert from dotted decimal format to prefix format:

Step 1 Convert the dotted decimal mask to binary.

Step 2 Count the number of binary 1s in the 32-bit binary mask; this is the value of the prefix notation mask.

To convert from prefix format to dotted decimal format:

Step 1 Write down *x* binary 1s, where *x* is the value listed in the prefix version of the mask.

Step 2 Write down binary 0s after the binary 1s until the combined 1s and 0s form a 32-bit number.

Step 3 Convert this binary number, 8 bits at a time, to decimal, to create a dotted decimal number; this value is the dotted decimal version of the subnet mask.

RP-1B: Converting Subnet Masks Between Dotted Decimal and Prefix Format: Decimal Version

Subnet masks can be shown in two separate formats: dotted decimal and prefix. The process listed here defines how to convert between the two formats, using binary math. To aid in the conversion process, Table E-8 lists the nine possible decimal values in a mask using dotted decimal format, as well as its binary equivalent.

Table E-8 *Nine Possible Values in a Subnet Mask*

Value of an Octet of a Subnet Mask	Binary Equivalent	Number of Binary 1s	Number of Binary 0s
0	00000000	0	8
128	10000000	1	7
192	11000000	2	6
224	11100000	3	5
240	11110000	4	4
248	11111000	5	3
252	11111100	6	2
254	11111110	7	1
255	11111111	8	0

Process:

To convert from dotted decimal format to prefix format:

Step 1 Start with a prefix value of 0.

Step 2 For each dotted decimal octet, add the number of binary 1s listed for that decimal value in Table E-8.

Step 3 The prefix length is /*x*, where *x* is the sum calculated at Step 2.

To convert from prefix format to dotted decimal format:

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

Step 2 Write down *d* octets of value 255. (This in effect begins the mask with 8, 16, or 24 binary 1s.)

Step 3 For the next octet, find the decimal number that begins with *r* binary 1s, followed by all binary 0s, per Table E-8.

Step 4 For any remaining octets, write down a decimal 0.

RP-2: Analyzing Unsubnetted IP Addresses

The process listed defines how to determine the classful IP network number, network broadcast address, the number of network octets, and the number of host octets, given a unicast IPv4 address. Table E-9 lists some important reference information, and Table E-10 provides a convenient place to record your answers when using the process.

Table E-9 *Key Facts About Unsubnetted IP Networks*

Class	Range of First Octet Values (Inclusive)	Default Mask/Prefix	Number of Network Octets	Number of Host Octets
A	1–126	255.0.0.0 (/8)	1	3
B	128–191	255.255.0.0 (/16)	2	2
C	192–223	255.255.255.0 (/24)	3	1

Table E-10 *RP-2 Answer Table*

IP Address	Number of Network Octets in the Address	Number of Host Octets in the Address	Network Number	Network Broadcast Address

Process:

Step 1 Compare the first octet of the address to the second column of Table E-9 to determine the address class.

Step 2 Write down the number of network octets depending on the address class, again based on the information in Table E-9.

Step 3 Write down the number of host octets depending on the address class, again based on the information in Table E-9.

Step 4 To find the network number:

a) For the network octets, copy the IP address's network octets.

b) For the host octets, write down 0s.

Step 5 To find the network broadcast address:

a) For the network octets, copy the IP address's network octets.

b) For the host octets, write down 255s.

RP-3A: Analyzing an Existing Subnet Mask: Binary Version

You can determine several useful facts about a classful network when using a single mask throughout the classful network. In particular, you can find the number of possible subnets and the number of host addresses in each subnet. This RP guides you through a binary process to find both facts. For reference, Table E-11 lists some key information that you should memorize for the exam. Table E-12 provides a convenient place to record your answers when practicing.

Table E-11 *First Octet Values for Class A, B, and C Networks*

Class	Range of First Octet	Number of Network Bits
A	1–126	8
B	128–191	16
C	192–223	24

Table E-12 *RP-3A Answer Table*

IP Address	Mask	Number of Network Bits	Number of Subnet Bits	Number of Host Bits

Process:

Step 1 Compare the first octet of the address to the table of Class A, B, C addresses; write down the number of network bits (8, 16, or 24) depending on the address class.

Step 2 Find the number of hosts bits by:

a) Converting the subnet mask to binary.

b) Counting the number of binary 0s in the mask.

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

Step 4 Calculate the number of subnets as either 2^s or 2^s-2, where s is the number of subnet bits.

Step 5 Calculate the number of hosts per subnet as 2^h-2, where h is the number of host bits.

RP-3B: Analyzing an Existing Subnet Mask: Decimal Version

Like RP-3A, this RP defines how to find the number of subnets, and the number of hosts per subnet, in a classful network that uses a single mask. This process, however, uses only decimal math—but it relies on the memorization of the nine decimal values that can be used in a subnet mask, as listed in Table E-13.

Table E-13 *Nine Possible Values in a Subnet Mask*

Value of an Octet of a Subnet Mask	Binary Equivalent	Number of Binary 1s	Number of Binary 0s
0	00000000	0	8
128	10000000	1	7
192	11000000	2	6
224	11100000	3	5
240	11110000	4	4
248	11111000	5	3
252	11111100	6	2
254	11111110	7	1
255	11111111	8	0

Process:

Step 1 (Same as Step 1 in the binary process.) Compare the first octet of the address to the table of Class A, B, C addresses; write down the number of network bits depending on the address class.

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

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

Step 4 (Same as Step 4 in the binary process.) Calculate the number of subnet bits by subtracting the number of combined network and host bits from 32.

Step 5 Calculate the number of subnets as either 2^s or $2^s–2$, where s is the number of subnet bits.

Step 6 Calculate the number of hosts per subnet as $2^h–2$, where h is the number of host bits.

RP-4: Choosing a Subnet Mask

RP-4 summarizes the process for finding the correct subnet mask(s), given some design requirements.

Process:

Step 1 Find the number of network bits (N) based on Class A, B, C rules.

Step 2 Find the number of subnet bits (S) based on the formula 2^s, such that 2^s => the required number of subnets.

Step 3 Find the number of host bits (H) based on the formula 2^h–2, such that 2^h–2 => the required number of hosts per subnet.

Step 4 Write down, starting on the left, N + S binary 1s.

Step 5 Write down, starting on the right, H binary 0s.

Step 6 If the number of binary 1s and 0s together adds up to less than 32:

a) Fill in the remaining "wildcard" bit positions—between the binary 1s and 0s—with the letter X.

b) Find all combinations of bits for the wildcard bit positions that meet the requirements for only having one consecutive string of binary 1s in the binary mask.

Step 7 Convert the mask(s) to decimal or prefix format as appropriate.

Step 8 To find the mask that maximizes the number of subnets, pick the mask that has the most binary 1s in it. To find the mask that maximizes the number of hosts per subnet, pick the mask that has the largest number of binary 0s in it.

RP-5A: Finding the Subnet Number: Binary Version

The subnet number in which an IP address resides can be calculated by performing a bitwise Boolean AND operation of the IP address and subnet mask. This RP describes the process for ANDing the IP address and mask to find the subnet number. Table E-14 matches the process steps, providing a convenient place to record your answers.

> **TIP** An AND of two binary 1s yields a 1; all other combinations of 2 bits ANDed together yields a 0.

Table E-14 *RP-5A Answer Table*

	Octet 1	Octet 2	Octet 3	Octet 4
IP Address				
Mask				
Subnet Number (Binary)				
Decimal Subnet Number				

Process:

Step 1 Convert the IP address to binary and list the values of each octet in Table E-14.

Step 2 Convert the subnet mask to binary and record it in the table as well.

Step 3 Perform a bitwise Boolean AND of the two numbers. To do so:

a) AND the first bit of the address with the first bit of the subnet mask, recording the result below those numbers.

b) AND the second bit of each number, recording the result below those numbers.

c) Repeat for each pair of bits, resulting in a 32-bit binary number.

Step 4 Convert the resulting binary number, *8 bits at a time*, back to decimal. This value is the subnet number.

RP-5A-Shortcut: Finding the Subnet Number: Binary Shortcut

In the *CCENT/CCNA ICND1 Official Exam Certification Guide*, Chapter 12, "IP Addressing and Subnetting," suggests a shorter way to use a Boolean AND to find the subnet number. RP-5A-Shortcut summarizes the process. Table E-15 matches the process steps, providing a convenient place to record your answers.

Table E-15 *RP-5A-Shortcut Answer Table*

	Octet 1	Octet 2	Octet 3	Octet 4
Mask				
IP Address				
Subnet Number (Binary)				
Decimal Subnet Number				

Process:

Step 1 Record the decimal mask in the first row of Table E-15, and the decimal IP address in the second row.

Step 2 For any mask octets of value decimal 255, copy the IP address's octet value for the same octet of the decimal subnet number.

Step 3 Similarly, for any mask octets of value decimal 0, write down a decimal 0 for the same octet of the subnet number.

Step 4 If the subnet number still has one remaining octet to be filled in, use the RP-5A process, but just for that one octet, as follows:

a) Convert that one remaining octet of the IP address to binary.

b) Convert that one remaining octet of the mask to binary.

c) AND the two 8-bit numbers together.

d) Convert the 8-bit number to decimal, and place that value in the one remaining octet of the subnet number.

RP-5B: Finding the Subnet Number: Decimal Version, Easy Masks

This RP lists a process for finding a subnet number, based on an IP address and an easy subnet mask, without using any binary math. An easy mask is a subnet mask with only 255s and 0s—a fact that makes the decimal shortcut relatively simple. Use Table E-16 to record your work as you practice the process.

Table E-16 *RP-5B Answer Table*

	Octet 1	Octet 2	Octet 3	Octet 4
Mask				
IP Address				
Decimal Subnet Number				

Process:

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

Step 2 For each *subnet mask octet* of value 255, copy the *IP address* octet value.

Step 3 For the remaining octets, write down a 0.

RP-5C: Finding the Subnet Number: Decimal Version, Difficult Masks

This RP lists a process for finding a subnet number, based on an IP address and mask, without using any binary math. As written, this process assumes that a difficult mask—a mask with one octet that is neither a 255 nor a 0—is used. Use Table E-17 (subnet chart) to record your work as you practice the process.

Table E-17 *RP-5C Answer Table*

	Octet 1	Octet 2	Octet 3	Octet 4
Mask				
IP Address				
Decimal Subnet Number				

Process:

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

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

Step 3 Record the subnet number's value for the uninteresting octets, as follows:

a) For each octet to the left of the rectangle drawn in Step 2: copy the *IP address's* value in that same octet.

b) For each octet to the right of the rectangle: write down a decimal 0.

Step 4 To find the subnet number's value for this interesting octet:

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

b) Calculate the multiples of the magic number, starting at 0, up through 256.

c) Write down the interesting octet's value, calculated as follows: find the multiple of the magic number that is *closest to, but not greater than*, the IP address's interesting octet value.

RP-6A: Finding the Broadcast Address and Range of Usable Addresses: Binary Version

Every subnet has a subnet number, a subnet broadcast address, and a range of usable IP addresses that happen to be the numbers between the subnet number and broadcast address. The binary process listed here assumes that you have already found the subnet number, and that you know the subnet mask. Use Table E-18 to record your work as you practice each problem.

Table E-18 *RP-6A Answer Table*

Step	Values
1) Subnet number (binary)	
1) Subnet mask (binary)	
3) Broadcast address (binary)	
4) Broadcast address (decimal)	
5) Smallest IP address (decimal)	
6) Largest IP address (decimal)	

Process:

Step 1 Write down the subnet number (or IP address) and subnet mask, in binary form. Make sure that the binary digits line up directly on top of each other.

Step 2 Separate the host part of these numbers from the network/subnet part by drawing a vertical line. Place this line between the rightmost binary 1 in the mask and the leftmost binary 0. Extend this line up and down an inch or two.

Step 3 To find the subnet broadcast address, in binary:

a) Copy the bits of the subnet number (or IP address) that are to the left of the vertical line.

b) Write down binary 1s for the bits to the right of the vertical line.

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

Step 5 To find the first IP address, copy the decimal subnet number, but add 1 to the fourth octet.

Step 6 To find the last IP address, copy the decimal subnet broadcast address, but subtract 1 from the fourth octet.

RP-6B: Finding the Broadcast Address and Range of Usable Addresses: Decimal Version, Easy Masks

Every subnet has a subnet number, a subnet broadcast address, and a range of usable IP addresses that happen to be the numbers between the subnet number and broadcast address. The decimal process listed here assumes that you used the process in RP-5B to find the subnet number—meaning that you already organized your answer using the subnet chart as shown in Table E-19, and you have drawn a rectangle around the interesting octet.

Table E-19 *RP-6B Answer Table*

	Octet 1	Octet 2	Octet 3	Octet 4
Mask				
IP Address				
Decimal Subnet Number				
First IP Address				
Last IP Address				
Broadcast Address				

Process:

Begin where RP-5B stopped, with the subnet mask, IP address, and subnet number (all in decimal) recorded. To match the step numbering in RP-5B, which has three steps, this RP starts with Step 4:

Step 4 For each *subnet mask octet* of value 255, copy the *IP address* octet value into the same octet of the broadcast address.

Step 5 For the remaining octets, write down 255 in the broadcast address.

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

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

RP-6C: Finding the Broadcast Address and Range of Usable Addresses: Decimal Version, Difficult Masks

Every subnet has a subnet number, a subnet broadcast address, and a range of usable IP addresses that happen to be the numbers between the subnet number and broadcast address. The decimal process listed here assumes that you used the process in RP-5C to find the subnet number, meaning that you have already organized your answer using the first three rows of the subnet chart shown in Table E-20, and you have drawn a rectangle around the interesting octet.

Table E-20 *RP-6C Answer Table*

	Octet 1	Octet 2	Octet 3	Octet 4
Mask				
IP Address				
Decimal Subnet Number				
First IP Address				
Last IP Address				
Broadcast Address				

Process:

Begin where RP-5C stopped, with the subnet mask, IP address, and subnet number (all in decimal) recorded. To match the step number of RP-5C, which has four steps, this RP starts with Step 5:

Step 5 Find the subnet broadcast address, as follows:

a) For each *subnet mask octet* to the left of the rectangle: copy the *IP address* octet value.

b) For each *subnet mask octet* to the right of the rectangle: write down 255.

c) Find the value for the interesting octet by adding the *subnet number's* value in the interesting octet to the *magic number, and subtract 1*.

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

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

RP-7A: Finding All Possible Subnets: Fewer than 8 Subnet Bits (Decimal)

This process describes how to find all possible subnets of a single classful network, under two assumptions: a single subnet mask is used throughout the network, and fewer than 8 subnet bits are used. In particular, the second assumption makes the process much cleaner and easier to master. Use Table E-21 to record your work as you practice this process.

Table E-21 *RP-7A Answer Table*

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Mask				
Magic Number				
Classful Network Number/ Zero Subnet Number				
Next Subnet				
(You may need many more such rows…)				
Next Subnet				
Next Subnet				
Broadcast Subnet				
Out of Range (Used by Process)				

Process:

Step 1 Write down the subnet mask, in decimal, in the first row of Table E-21.

Step 2 Identify the interesting octet, which is the one octet of the mask with a value other than 255 or 0. Draw a rectangle around the column of the interesting octet.

Step 3 Calculate the magic number by subtracting the *subnet mask's interesting octet* from 256. Record this value in the second row of the table.

Step 4 Write down the classful network number, which is the same number as the zero subnet, in the third row of the table.

Step 5 To find each successive subnet number:

a) For the three uninteresting octets, copy the previous subnet number's values.

b) For the interesting octet, add the magic number to the previous subnet number's interesting octet.

Step 6 Once the sum calculated in Step 5b reaches 256, stop the process. The number with the 256 in it is out of range, and the previous subnet number is the broadcast subnet.

RP-7B: Finding All Possible Subnets: More than 8 Subnet Bits (Decimal)

The process in RP-7B must be used in conjunction with RP-7A. RP-7B also describes how to find all possible subnets of a single classful network, but with the assumption that the subnet portion of the subnets is more than 8 bits. The process listed here modifies and expands the process defined in RP-7A. Table E-22 shows the same table as in RP-7A, again for convenience when recording your answers.

Table E-22 *RP-7B Answer Table*

	Octet 1	Octet 2	Octet 3	Octet 4
Subnet Mask				
Magic Number				
Classful Network Number/Zero Subnet Number				
Next Subnet				
(You may need many more such rows…)				
Next Subnet				
Next Subnet				
Broadcast Subnet				
Out of Range (Used by Process)				

Step 6 Beginning with the network number and mask, use process RP-7A until one of the steps results in a sum of 256. At that point, use the substeps listed here to find and record the next subnet number:

a) For the octet whose sum would have been 256, write down a 0.

b) For the octet to the left, add 1 to the previous subnet's value in that octet.

c) For the other two octets, copy the values of the same octets in the previous subnet number.

d) Start again with RP-7A Step 5.

Step 7 Each time process RP-7A results in a sum of 256, repeat Step 6 of this RP-7B process.

Step 8 Repeat until Step 6b would actually change the value of the network portion of the subnet number. The previously created subnet is the broadcast subnet.

RP-8: Finding New Subnet Numbers When Using VLSM

By performing the steps that follow, you can find new subnet numbers to use when adding a subnet to an existing internetwork—specifically one that uses VLSM.

Step 1 Analyze the existing subnets in the design, listing the subnet numbers, broadcast addresses, and range of IP addresses in each subnet.

Step 2 If not already listed as part of the question, pick the subnet mask (prefix length) to be used for the new subnet, based on the number of hosts required for the new subnet.

Step 3 Calculate a list of potentially usable subnet numbers of the classful network by using the processes listed in RP-7A and RP-7B, assuming the mask from Step 2. (If the exam question asks for the numerically largest or smallest subnet number, you might choose to only do this math for the first few or last few subnets.)

Step 4 For the subnets found at Step 3, calculate the subnet broadcast address and range of addresses for each assumed subnet.

Step 5 Compare the list of potential new subnets created at Steps 3 and 4 to the list of existing subnets from Step 1. Draw a line through any of the potential new subnets whose IP address range overlaps with an existing subnet.

Step 6 Pick one of the potential subnets that was not crossed out at Step 5.