

IP ADDRESS CLASSES

IP ADDRESS CLASSES					
CLASS A	Range: 1-127 Total: 128	Total: 16,777,216 - 2			
0	NETWORK (7 Bits)	HOST (24 Bits)			
CLASS B	Range: 128 - 191 Total: 16,384	Total: 65,536 - 2			
1	0	NETWORK (14 Bits)	HOST (16 Bits)		
CLASS C	Range: 192 - 223 Total: 2,097,152	Total: 256 - 2			
1	1	0	NETWORK (21 Bits)	HOST (8 Bits)	
CLASS D	Range: 224 - 239 (Broadcast)				
1	1	1	0	NETWORK (28 Bits)	
CLASS E	Range: 240 - 247 (Research)				
1	1	1	1	0	NETWORK (27 Bits)

IP ADDRESS CLASS RANGES	
CLASS A	Total Range: 1.0.0.0 to 126.0.0.0
	Private Range: 10.0.0.0 to 10.255.255.255
CLASS B	Total Range: 128.0.0.0 to 192.255.0.0
	Private Range: 172.16.0.0 to 172.31.255.255
CLASS C	Total Range: 192.0.0.0 to 223.255.255.0
	Private Range: 192.168.0.0 to 192.168.255.255
CLASS D	Range: 224.0.0.0 to 239.255.255.255
CLASS E	Range: 240.0.0.0 to 247.255.255.255

BASIC SUBNETTING STEPS	
STEP NUMBER	DESCRIPTION
STEP 1	Determine the number of host bits to be used (borrowed) for the subnetting.
STEP 2	Enumerate one subnet mask for entire network (determined by Step 1).
STEP 3	Enumerate the new subnetted network ID's (a unique subnet ID for each physical segment).
STEP 4	Enumerate the IP addresses for each new subnetted network ID.

**SUBNETTING STEP 1
DETERMINE NUMBER OF HOST BITS TO BORROW**

STEP NUMBER	DESCRIPTION					
STEP 1	Determine the number of physical segments (subnets) needed on the network plus the number of segments required for the future.					
STEP 2	Determine the number of required hosts needed for each physical segment (subnet) plus number of hosts per segment required for future.					
STEP 3	Calculate the number of subnets (and the number of hosts per subnet) using the formula $2^n - 2$, where n = the number of binary bits in either field.					
Example Class B Network	172.16.3.0 255.255.0.0	Borrow 3 bits for subnet mask	11111111	11111111	11100000	00000000
Calculations	Number of Subnets = $2^3 - 2 = 6$			Hosts per Subnet = $2^{13} - 2 = 8,190$		
STEP 4	Multiply the number of subnets by the number of hosts on each subnet to gget the total number of hosts on network.					
Calculation	Total Number of Hosts on Network = $6 \times 8,190 = 49,140$					

SUBNETTING STEP 2 ENUMERATE SUBNET MASK

STEP NUMBER	DESCRIPTION			
STEP 1	Convert the number of physical segments (subnets) needed to binary format.			
STEP 2	Count the number of bits required to represent the number of physical segments (subnets) in binary.			
STEP 3	Convert the required number of bits to decimal format in high order (from left to right).			
STEP 4	Obtain subnet mask.			
Example Class B Network	172.16.3.0 255.255.0.0	Number of Subnets = 6		
Binary Value of 6	11111 110	3 bits		
Convert To High Order Decimal	11111111	11111111	11100000	00000000
Obtain Subnet Mask	255	255	224	0

DECIMAL EQUIVALENTS FOR NETMASKING

Bits Barrowed	Bit Totals	Address	Bit 1	Bit 2	Bit 3	Bit4	Bit 5	Bit 6	Bit 7	Bit 8
1	128	128	1	0	0	0	0	0	0	0
2	128 + 64	192	1	1	0	0	0	0	0	0
3	128 + 64 + 32	224	1	1	1	0	0	0	0	0
4	128 + 64 + 32 + 16	240	1	1	1	1	0	0	0	0
5	128 + 64 + 32 + 16 + 8	248	1	1	1	1	1	0	0	0
6	128 + 64 + 32 + 16 + 8 + 4	252	1	1	1	1	1	1	0	0
7	128 + 64 + 32 + 16 + 8 + 4 + 2	254	1	1	1	1	1	1	1	0
8	128 + 64 + 32 + 16 + 8 + 4 + 2 + 1	255	1	1	1	1	1	1	1	1

SHORTENED NETMASK TABLE

Binary Bit Place	8	7	6	5	4	3	2	1
Binary Value	128	64	32	16	8	4	1	2
Decimal Mask	128	192	224	240	248	252	254	255

**SUBNETTING STEP 3
ENUMERATE SUBNETTED NETWORK ID'S
MICROSOFT METHOD**

STEP NUMBER	DESCRIPTION					
STEP 1	Using the same number of bits as are used in the subnet mask (barrowed bits) list all possible bit combinations.					
Example Class B Network	172.16.3.0 255.255.0.0	255 11111111	255 11111111	224 11100000	0 00000000	
STEP 2	Cross out values that use all 0's (reserved for network) or 1's (match subnet mask) as they invalid IP addresses and network ID's.					
STEP 3	Convert to decimal the subnet ID bits for each subnet. Each decimal value represents a single subnet and used to define range of host ID's for subnet.					
Cross Out Values & Convert	00000000 = 0					
Black Decimal Valid Subnet ID's	00100000 = 32					
	01000000 = 64					
	01100000 = 96					
	10000000 = 128					
	10100000 = 160					
	11000000 = 192					
	11100000 = 224					

SUBNETTING STEP 3 ENUMERATE SUBNETTED NETWORK ID'S CISCO METHOD					
STEP NUMBER	DESCRIPTION				
STEP 1	Given an IP address, write the 32 bit address in binary notation.				
STEP 2	For the IP address above, write the 32 bit subnet mask in binary notation.				
STEP 3	Draw a vertical line just after the last contiguous subnet mask 1 bit.				
STEP 4	In a row just below, place all 0's for the remaining free spaces (to the right of the line). This will be the subnet.				
STEP 5	In the next row, to the right of the line, place all 1's until you reach the 32 bit boundary. This will be the broadcast address.				
STEP 6	On the right side of the line in the next row, place all 0's free spaces (except last) and place a 1 in the last free space. This is the first usable address.				
STEP 7	On the right side of the line in the next row, place all 1's free spaces (except last) and place a 0 in the last free space. This is the last usable address.				
STEP 8	Copy down all bits you wrote in Step 1 for the bit fields to the left of the line for all four lines.				
STEP 9	Convert the bottom four rows back to dotted-decimal notation.				
Example Class B Network	172	16	2	160	
172.16.2.160	10101100	00010000	00000010	10 100000	HOST (1)
255.255.255.192	11111111	11111111	11111111	11 000000	MASK (2)
172.16.2.128	10101100	00010000	00000010	10 000000	Subnet (4)
172.16.2.191	10101100	00010000	00000010	10 111111	Broadcast (5)
172.16.2.129	10101100	00010000	00000010	11 100001	First (6)
172.16.2.190	10101100	00010000	00000010	10 000001	Last (7)

SUBNETTING STEP 3 ENUMERATE SUBNETTED NETWORK ID'S SHORTCUT METHOD				
STEP NUMBER	DESCRIPTION			
STEP 1	List the number of bits (in high order) that were used for the subnet mask.			
Example Class B Network	255 11111111	255 11111111	224 11100000	0 00000000
STEP 2	Convert the bit with the lowest value to decimal format. This is the increment value (magic number) used to determine each subnet ID (address).			
Convert Lowest Bit To Decimal	Increment Value = 32			
STEP 3	Determine the number of valid subnet by employing the formula $2^n - 2$, where n is the number of bits borrowed (used) for the subnet mask.			
Calculate Number Subnets	$2^3 - 2 = 6$			
STEP 4	Starting with 0, increment by the value calculated in Step 2 the same number of time as calculated in Step 3. These increment values are the subnet ID's.			
Determine Subnet ID's	Invalid	0 (network)		
	Subnet 1	32		
	Subnet 2	64		
	Subnet 3	96		
	Subnet 4	128		
	Subnet 5	160		
	Subnet 6	192		
	Invalid	240 (subnet mask)		

**SUBNETTING STEP 4
ENUMERATE IP ADDRESSES FOR EACH SUBNET**

STEP NUMBER	DESCRIPTION			
STEP 1	By defining subnet IDs you automatically define host IDs for each subnet. The result of each incremental value indicates the beginning of a range of host IDs for a subnet. If you increment the value one extra time, you can determine the end of the range (one less than the subnet mask).			
STEP 2	Fill in the host ID ranges based on the identified subnet ID's.			
Example Class B Network	255 11111111	255 11111111	224 11100000	0 00000000
Determine Host ID's	Subnet	Beginning Value	Ending Value	
	Subnet 1	w.x.32.1	w.x.63.254	
	Subnet 2	w.x.64.1	w.x.95.254	
	Subnet 3	w.x.96.1	w.x.127.254	
	Subnet 4	w.x.128.1	w.x.159.254	
	Subnet 5	w.x.160.1	w.x.191.254	
	Subnet 6	w.x.192.1	w.x.223.254	
Example Class C Network	255 11111111	255 11111111	255 11111111	224 11100000
Determine Host ID's	Subnet	Beginning Value	Ending Value	
	Subnet 1	w.x.y.33	w.x.y.63	
	Subnet 2	w.x.y.65	w.x.y.95	
	Subnet 3	w.x.y.97	w.x.y.127	
	Subnet 4	w.x.y.129	w.x.y.159	
	Subnet 5	w.x.y.161	w.x.y.191	
	Subnet 6	w.x.y.193	w.x.y.223	

ANDing
(Determine Network ID By Performing a Logical AND Operation)

IP ADDRESS	10000001	00111000	10111101	00101001	129.56.189.41
SUBNET MASK	11111111	11111111	11110000	00000000	255.255.240.0
SUBNET ADDRESS	10000001	00111000	10110000	00000000	129.56.176.0
BROADCAST ADDRESS	10000001	00111000	10111111	11111111	129.56.15.255
IP ADDRESS	00111000	00111000	01000101	00010100	140.179.65.20
SUBNET MASK	00111000	00111000	11100000	00000000	255.255.240.0
SUBNET ADDRESS	00111000	00111000	01000000	00000000	140.56.64.0
BROADCAST ADDRESS	00111000	00111000	01011111	11111111	140.56.95.255

CLASS A SUBNETS

# BITS	MAGIC # (Increment Value)	SUBNET MASKS	CIDR	# SUBNETS (2 ⁿ - 2)	# HOSTS (2 ⁿ - 2)	TOTAL HOSTS (Subnets x Hosts)
1	128	Invalid	/9	Invalid	Invalid	Invalid
2	64	255.192.0.0	/10	2	4,194,302	8,388,604
3	32	255.224.0.0	/11	6	2,097,150	12,582,900
4	16	255.240.0.0	/12	14	1,048,574	14,680,036
5	8	255.248.0.0	/13	30	524,286	15,728,580
6	4	255.252.0.0	/14	62	262,142	16,252,804
7	2	255.254.0.0	/15	126	131,070	16,514,820
8	1	255.255.0.0	/16	254	65,534	16,645,636
9	128	255.255.128.0	/17	510	32,766	16,710,660
10	64	255.255.192.0	/18	1,022	16,382	16,742,404
11	32	255.255.224.0	/19	2,046	8,190	16,756,740
12	16	255.255.240.0	/20	4,094	4,094	16,760,836
13	8	255.255.248.0	/21	8,190	2,046	16,756,740
14	4	255.255.252.0	/22	16,382	1,022	16,742,404
15	2	255.255.254.0	/23	32,766	510	16,710,660
16	1	255.255.255.0	/24	65,534	254	16,645,636
17	128	255.255.255.128	/25	131,070	126	16,514,820
18	64	255.255.255.192	/26	262,142	62	16,252,804
19	32	255.255.255.224	/27	524,286	30	15,728,580
20	16	255.255.255.240	/28	1,048,574	14	14,680,036
21	8	255.255.255.248	/29	2,097,150	6	12,582,900
22	4	255.255.255.252	/30	4,194,302	2	8,388,604
23	2	Invalid	/31	Invalid	Invalid	Invalid
24	1	Invalid	/32	Invalid	Invalid	Invalid

CLASS B SUBNETS

# BITS	MAGIC # (Increment Value)	SUBNET MASKS	CIDR	# SUBNETS (2 ⁿ - 2)	# HOSTS (2 ⁿ - 2)	TOTAL HOSTS (Subnets x Hosts)
1	128	Invalid	/17	Invalid	Invalid	Invalid
2	64	255.255.192.0	/18	2	16,382	32,764
3	32	255.255.224.0	/19	6	8,190	49,140
4	16	255.255.240.0	/20	14	4,094	57,316
5	8	255.255.248.0	/21	30	2,046	61,380
6	4	255.255.252.0	/22	62	1,022	63,364
7	2	255.255.254.0	/23	126	510	64,260
8	1	255.255.255.0	/24	254	254	64,516
9	128	255.255.255.128	/25	510	126	64,260
10	64	255.255.255.192	/26	1,022	62	63,364
11	32	255.255.255.224	/27	2,046	30	61,380
12	16	255.255.255.240	/28	4,094	14	57,316
13	8	255.255.255.248	/29	8,190	6	49,140
14	4	255.255.255.252	/30	16,382	2	32,764
15	2	Invalid	/31	Invalid	Invalid	Invalid
16	1	Invalid	/32	Invalid	Invalid	Invalid

CLASS C SUBNETS						
# BITS	MAGIC # (Increment Value)	SUBNET MASKS	CIDR	# SUBNETS (2 ⁿ - 2)	# HOSTS (2 ⁿ - 2)	TOTAL HOSTS (Subnets x Hosts)
1	128	Invalid	/25	Invalid	Invalid	Invalid
2	64	255.255.255.192	/26	2	62	124
3	32	255.255.255.224	/27	6	30	180
4	16	255.255.255.240	/28	14	14	196
5	8	255.255.255.248	/29	30	6	180
6	4	255.255.255.252	/30	62	2	124
7	2	Invalid	/31	Invalid	Invalid	Invalid
8	1	Invalid	/32	Invalid	Invalid	Invalid

BINARY BIT PLACES TO DECIMAL COMBINATIONS

Binary Bit Places	1	2	3	4	5
Decimal Combinations	1	4	8	16	32
Binary Bit Places	6	7	8	9	10
Decimal Combinations	64	128	256	512	1,024
Binary Bit Places	11	12	13	14	15
Decimal Combinations	2,046	4,096	8,192	16,384	32,768
Binary Bit Places	16	17	18	19	20
Decimal Combinations	65,536	131,072	262,144	524,288	1,048,576
Binary Bit Places	21	22	23	24	25
Decimal Combinations	2,097,152	4,194,304	8,388,608	16,777,216	33,554,432
Binary Bit Places	26	27	28	29	30
Decimal Combinations	67,108,864	134,217,728	368,435,456	536,870,912	1,073,741,824
Binary Bit Places	31	32	33	34	35
Decimal Combinations	2,147,483,648	4,294,967,296	8,589,934,592	17,179,869,184	34,359,738,368
Binary Bit Places	36	37	38	39	40
Decimal Combinations	68,719,476,736	137,438,953,472	274,877,906,944	549,755,813,888	1,099,511,627,776
Binary Bit Places	41	42	43	44	45
Decimal Combinations	2,199,023,255,552	4,398,046,511,104	8,796,093,022,208	17,592,186,044,416	35,184,372,088,832