Bit Tricks for Competitive Programming

In competitive programming or in general some problems seems difficult but can be solved very easily with little bit magic. We have discussed some tricks in below previous post.

Bitwise Hacks for Competitive Programming

We have considered below facts in this article –

- 0 based indexing of bits from left to right.
- Setting i-th bit means, turning i-th bit to 1
- Clearing i-th bit means, turning i-th bit to 0

1) Clear all bits from LSB to ith bit

```
mask = ~((1 << i+1 ) - 1);
x &= mask;
```

Logic: To clear all bits from LSB to i-th bit, we have to AND x with mask having LSB to i-th bit 0. To obtain such mask, first left shift 1 i times. Now if we minus 1 from that, all the bits from 0 to i-1 become 1 and remaining bits become 0. Now we can simply take complement of mask to get all first i bits to 0 and remaining to 1.
Example-
x = 29 (00011101) and we want to clear LSB to 3rd bit, total 4 bits
mask -> 1 << 4 -> 16(00010000)
mask -> 16 – 1 -> 15(00001111)
mask -> ~mask -> 11110000
x & mask -> 16 (00010000)

2) Clearing all bits from MSB to i-th bit

```
mask = (1 << i) - 1;
x &= mask;
```

Logic: To clear all bits from MSB to i-th bit, we have to AND x with mask having MSB to i-th bit 0. To obtain such mask, first left shift 1 i times. Now if we minus 1 from that, all the bits from 0 to i-1 become 1 and remaining bits become 0.

Example-
x = 215 (11010111) and we want to clear MSB to 4th bit, total 4 bits
mask -> 1 << 4 -> 16(00010000)
mask -> 16 – 1 -> 15(00001111)
x & mask -> 7(00000111)

3) Divide by 2

```
x >>= 1;
```

Logic: When we do arithmetic right shift, every bit is shifted to right and blank position is substituted with sign bit of number, 0 in case of positive and 1 in case of negative number. Since every bit is a power of 2, with each shift we are reducing the value of each bit by factor of 2 which is equivalent to division of x by 2.

Example-
x = 18(00010010)
x >> 1 = 9 (00001001)

4) Multiplying by 2

```
x <<= 1;
```

Logic: When we do arithmetic left shift, every bit is shifted to left and blank position is substituted with 0 . Since every bit is a power of 2, with each shift we are increasing the value of each bit by a factor of 2 which is equivalent to multiplication of x by 2.

Example-
x = 18(00010010)
x << 1 = 36 (00100100)

5) Upper case English alphabet to lower case

```
ch |= ' ';
```

Logic: The bit representation of upper case and lower case English alphabets are –

```
A -> 01000001          a -> 01100001
B -> 01000010          b -> 01100010
C -> 01000011          c -> 01100011
  .                              .
  .                              .
Z -> 01011010          z -> 01111010
```

As we can see if we set 5th bit of upper case characters, it will be converted into lower case character. We have to prepare a mask having 5th bit 1 and other 0 (00100000). This mask is bit representation of space character (‘ ‘). The character ‘ch’ then ORed with mask.

Example-

ch = ‘A’ (01000001)

mask = ‘ ‘ (00100000)

ch | mask = ‘a’ (01100001)

Please refer Case conversion (Lower to Upper and Vice Versa) for details.

6) Lower case English alphabet to upper case

```
ch &= '_' ;
```

Logic: The bit representation of upper case and lower case English alphabets are –

```
A -> 01000001                 a -> 01100001
B -> 01000010                 b -> 01100010
C -> 01000011                 c -> 01100011
.                                .
.                                .
Z -> 01011010                 z -> 01111010
```

As we can see if we clear 5th bit of lower case characters, it will be converted into upper case character. We have to prepare a mask having 5th bit 0 and other 1 (10111111). This mask is bit representation of underscore character (‘_‘). The character ‘ch’ then AND with mask.

Example-

ch = ‘a’ (01100001)

mask = ‘_ ‘ (11011111)

ch | mask = ‘A’ (01000001)

Please refer Case conversion (Lower to Upper and Vice Versa) for details.

7) Count set bits in integer

```
int countSetBits(int x)
{
    int count = 0;
    while (x)
    {
        x &= (x-1);
        count++;
    }
    return count;
}
```

Logic: This is **Brian Kernighan’s** algorithm.

8) Find log base 2 of 32 bit integer

```
int log2(int x)
{
    int res = 0;
    while (x >>= 1)
        res++;
    return res;
}
```

Logic: We right shift x repeatedly until it becomes 0, meanwhile we keep count on the shift operation. This count value is the log2(x).

9) Checking if given 32 bit integer is power of 2

```
int isPowerof2(int x)
{
    return (x && !(x & x-1));
}
```

Logic: All the power of 2 have only single bit set e.g. 16 (00010000). If we minus 1 from this, all the bits from LSB to set bit get toggled, i.e., 16-1 = 15 (00001111). Now if we AND x with (x-1) and the result is 0 then we can say that x is power of 2 otherwise not. We have to take extra care when x = 0.

Example

x = 16(000100000)

x – 1 = 15(00001111)

x & (x-1) = 0

so 16 is power of 2

Please refer this article for more bit hacks.

This article is contributed by **Atul Kumar**. If you like GeeksforGeeks and would like to contribute, you can also write an article using contribute.geeksforgeeks.org or mail your article to contribute@geeksforgeeks.org. See your article appearing on the GeeksforGeeks main page and help other Geeks.

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6) Lower case English alphabet to upper case

ch &= '_' ;
it should be ch &= ~' ';

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