# Bit Manipulation - II

**Prerequisites:** knowledge of binary number system

## Count set bits
n & (n - 1) sets the first set-bit to zero.
Explanation: n = XXX100

         n - 1 = XXX011

   n & ( n - 1 ) = XXX000

```cpp
int numberofones(int n) {
    int count = 0;
    while (n) {
        n = n & (n - 1);
        count++;
    }
    return count;
}
```

## Power of two
From our past knowledge of the binary number system,

Numbers of the type $2^n$ have only 1 set bit.

Explanation: n = 000100

        n - 1 = 000011

   n & ( n - 1 ) = 000000

!( n & ( n - 1 ) ) = 000001

If the number only had one set bit, then n & ( n - 1 ) would be zero.

```cpp
bool ispowerof2(int n) {
    return (n && !(n & n - 1));
}
```

**Generate Subset**

Explanation: if the $j^{th}$ bit is set, then we take the $j^{th}$ element.

There are a total of $2^n$ subsets.

```cpp
void subsets(int arr[], int n) {
    for (int i = 0; i < (1 << n); i++) {
        for (int j = 0; j < n; j++) {
            if ( i & (1 << j)) {
                cout << arr[j] << " ";
            }
        } cout << endl;
    }
}
```

Practice Questions:
1. Counting bits
2. Power of four

**Q** Write a program to count the number of ones in binary representation of a number

(n & n-1) has same bits as n except the rightmost set bit

$n = 19 = (01011)_2$
$n-1 = 18 = (01010)_2$

$n = n \& n-1$
$= 01011 \& 01010$
$= 01010 = (18)_{10}$

$n = 18 = (01010)_2$
$n-1 = 17 = (01001)_2$

$n = n \& n-1$
$= 01010 \& 01001$
$= 01000 = (16)_{10}$

$n = 16 = (01000)_2$
$n-1 = 15 = (00111)_2$

$n = n \& n-1$
$= 01000 \& 00111$
$= 00000 = (0)_{10}$

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**Q** Write a program to generate all possible subsets of a set

{a, b, c}   $2^3$

| | a b c | |
|---|---|---|
| {} | 000 | 0 |
| {c} | 001 | 1 |
| {b} | 010 | 2 |
| {b, c} | 011 | 3 |
| {a} | 100 | 4 |
| {a, c} | 101 | 5 |
| {a, b} | 110 | 6 |
| {a, b, c} | 111 | 7 |

$2^3 - 1$

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