Write an Efficient Method to Check if a Number is Multiple of 3

The very first solution that comes to our mind is the one that we learned in school. If sum of digits in a number is multiple of 3 then number is multiple of 3 e.g., for 612 sum of digits is 9 so it's a multiple of 3. But this solution is not efficient. You have to get all decimal digits one by one, add them and then check if sum is multiple of 3.

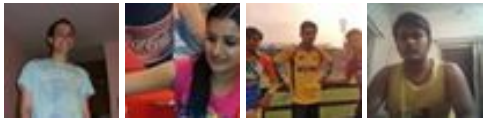
There is a pattern in binary representation of the number that can be used to find if number is a multiple of 3. If difference between count of odd set bits (Bits set at odd positions) and even set bits is multiple of 3 then is the number.

Example: 23 (00..10111)
1) Get count of all set bits at odd positions (For 23 it's 3).
2) Get count of all set bits at even positions (For 23 it's 1).
3) If difference of above two counts is a multiple of 3 then number is also a multiple of 3.

(For 23 it's 2 so 23 is not a multiple of 3)

Take some more examples like 21, 15, etc…

```
Algorithm: isMutlipleOf3(n)
1) Make n positive if n is negative.
2) If number is 0 then return 1
3) If number is 1 then return 0
4) Initialize: odd_count = 0, even_count = 0
5) Loop while n != 0
    a) If rightmost bit is set then increment odd count.
```

```
    b) Right-shift n by 1 bit
    c) If rightmost bit is set then increment even count.
    d) Right-shift n by 1 bit
6) return isMutlipleOf3(odd_count - even_count)
```

Proof:
Above can be proved by taking the example of 11 in decimal numbers. (In this context 11 in decimal numbers is same as 3 in binary numbers)
If difference between sum of odd digits and even digits is multiple of 11 then decimal number is multiple of 11. Let's see how.

Let's take the example of 2 digit numbers in decimal
AB = 11A -A + B = 11A + (B – A)
So if (B – A) is a multiple of 11 then is AB.

Let us take 3 digit numbers.

ABC = 99A + A + 11B – B + C = (99A + 11B) + (A + C – B)
So if (A + C – B) is a multiple of 11 then is (A+C-B)

Let us take 4 digit numbers now.
ABCD = 1001A + D + 11C – C + 999B + B – A
= (1001A – 999B + 11C) + (D + B – A -C)
So, if (B + D – A – C) is a multiple of 11 then is ABCD.

This can be continued for all decimal numbers.
Above concept can be proved for 3 in binary numbers in the same way.

Time Complexity: O(logn)

Program:

```
#include<stdio.h>

/* Fnction to check if n is a multiple of 3*/
int isMultipleOf3(int n)
{
    int odd_count = 0;
    int even_count = 0;
```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```
    /* Make no positive if +n is multiple of 3
       then is -n. We are doing this to avoid
       stack overflow in recursion*/
    if(n < 0)    n = -n;
    if(n == 0) return 1;
    if(n == 1) return 0;

    while(n)
    {
        /* If odd bit is set then
           increment odd counter */
        if(n & 1)
           odd_count++;
        n = n>>1;

        /* If even bit is set then
           increment even counter */
        if(n & 1)
            even_count++;
        n = n>>1;
    }

     return isMultipleOf3(abs(odd_count - even_count));
}

/* Program to test function isMultipleOf3 */
int main()
{
    int num = 23;
    if (isMultipleOf3(num))
        printf("num is multiple of 3");
    else
        printf("num is not a multiple of 3");
    getchar();
    return 0;
}
```

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iamcoded • 2 months ago

can any one explain how is complexity o(log n)?

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Rohan • 9 months ago

```
#include <stdio.h>
#include <math.h>
int main()
{
int i=0,n, p = 0, d, n_original;
printf("Enter number : ");
scanf("%d",&n)
printf("Enter Diviser : ");
scanf("%d",&d)

n_original = n;

while(n>1) {
i++;
n>>=1;
}
n=pow(2,i);

while(n)
```

see more

1 • Reply • Share ›

Pankaj Goyal • 10 months ago

I don&#039t understand why it is more efficient....for a thousand digit no...by fi

and checking if it is divisible by 3, in that if I would take 1000 iterations to solve
log(9999.....1000 times) iterations to solve it...
so how is it more efficient?

1 ^ | v • Reply • Share ›

jugal • 10 months ago

complexity of method 4 is not log(n). because we are performing constant ope
time. please check.

^ | v • Reply • Share ›

jugal ➚ jugal • 10 months ago

sorry misplaced previous comment as it is for next-power-of-2 post.

^ | v • Reply • Share ›

abhishek08aug • a year ago

Why can't we just take modulo of number with 3 and if it comes out to be a ze
multiple of 3?

Why so much of unnecessary extra mind work?

^ | v • Reply • Share ›

abhishek08aug ➚ abhishek08aug • a year ago

Probably because taking modulo is O(n/3)?

^ | v • Reply • Share ›

lakshay ➚ abhishek08aug • 11 months ago

Modulo involves division which takes O(m)(atleast theoretically)
When a no is a power of 2, the modulo internally does it by bitw
efficient!
correct me if i am wrong.

^ | v • Reply • Share ›

Kushagra Sinha • a year ago

@admin Correct me if I am wrong but the complexity of the posted solution is

In the first step of recursion, we need log(n) steps (since there are log2(n) nun
Then further down the recursion chain, the complexity in *worst* case will be l
log2(log2(n)) digits) and then log(log (log n)) and so on. Therefore the comple

Let us be sloppy for a second and assume the complexity is O(log n) which is

Now, let us consider the "school" algorithm. It sums the digits of n in its decim
above, its complexity will be log10(n).

Since, log10(n) < log2(n) as n tends to infinity, the "school" algorithm is more e

Common sense explanation: Since we are looking at each digit anyhow, it mal
base so that the number of digits considered is less. Therefore a solution in ba

Please clarify.

1 ▲ | ▼ • Reply • Share ›

Akhil ➦ Kushagra Sinha • 11 months ago

base 2 solution involves checking bits of the number only.
If we find the digits and sum them, it will take much more time.

```
/* Paste your code here (You may delete these lines if not wri
```

▲ | ▼ • Reply • Share ›

HLS.nirma • 2 years ago

The code can be optimized here:

```
 if(n == 0) return 1;
if(n == 1) return 0;
```

```
/*Improvement */
if(n == 0) return 1;
if(n <= 2) return 0;
/* One function call will be less. */
```

1 ▲ | ▼ • Reply • Share ›

Amit ➦ HLS.nirma • 8 days ago

then it ll return 0 if n=0 .

▲ | ▼ • Reply • Share ›

Arpitha • 2 years ago

The simple way of doing that will be , convert the given number into string usin given number, check whether sum is 3 6 or 9 , if yes then its divisible :)

▲ | ▼ • Reply • Share ›

AG ➦ Arpitha • a year ago

Brilliant !

▲ | ▼ • Reply • Share ›

pritybhudolia ➦ AG • a year ago

@Arpita
I am not sure whether i got u or not. But if u mean
42= 4+2=6 hence divisible by 3
12=1+2=3 hence divisible by 3
then wat about 39 as 3+9=12
if u ask again to add until it becomes single digit, then i think sin

▲ | ▼ • Reply • Share ›

Prateek • 2 years ago

There is a small error in explanation:

Instead of:
Let us take 4 digit numbers now.
ABCD = 1001A + D + 11C – C + 999B + B – A
= (1001A – 999B + 11C) + (D + B – A -C)
So, if (B + D – A – C) is a multiple of 11 then is ABCD.

it should be:
ABCD = 1001A + 99B + 11C - A + B - C + D
ABCD = (1001A + 99B + 11C) + (D + B - A - C)

```
/* Paste your code here (You may delete these lines if not writing c
```


Dhaval Patel • 2 years ago

[sourcecode language="java"]
public static void main(String[] args) {
int number = 23;
int andOperation = 0;
int oddCount = 0;
int evenCount = 0;

while (number != 0) {
andOperation = number & 1;

if (andOperation == 1) {
oddCount++;
}

number = number >>> 1;

andOperation = number & 1;
if (andOperation == 1) {

evenCount++;

see more

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Red Lv • 2 years ago

I think the idea DFA would work perfectly here with the time complexity O(lgn),

int rem=0;

while(n)
{
int bit=n&1;

rem=(rem*2+bit)%3;

n=n>>1;
}

return (rem==0);

```
/* Paste your code here (You may delete these lines if not writing c
```

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shal Red Lv • 2 years ago

like it

```
/* Paste your code here (You may delete these lines if not wri
```

Reply • Share ›

praveen Raj • 3 years ago

```
int checkdiv(int num)
```

```
{
  int n;
  aim:
     while(num!=0)
      { n=+(num&0x0f);
          num>>=4;
      }
     if((n>>4)!=0)
         {num=n;
          goto aim;
         }
       else
        {
            if((n==0)||(n==3)||(n==6)||(n==9))
                return 1;
            else
             return 0;
         }
}
```


KK123 • 3 years ago

Here's a clean and working code:

```
 #include<iostream>
using namespace std;

int bitCount(int n)
{
    int count = 0;
    while(n)
```

```
    {
            count++;
            n = n & (n - 1);
    }
    return count;
}

int main()
{
```

see more

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MD03 ➦ KK123 • 11 months ago

liked it!!

Reply • Share ›

john • 3 years ago

```
boolean isMultipleOfThree(int n) {

        boolean oddBit = true;
        int diff = 0;
        for (; n > 0; n >>= 1, oddBit = !oddBit) {
                diff += oddBit ? n & 1 : -(n & 1);
        }
        return diff % 3 == 0;
}
```

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john ➦ john • 3 years ago

```
boolean isMultipleOfThree(int n) {
```

```
        n = Math.abs(n);
        boolean oddBit = true;
        int diff = 0;
        for (; n > 0; n >>= 1, oddBit = !oddBit) {
                diff += oddBit ? n & 1 : -(n & 1);
        }
        return diff % 3 == 0;
}
```

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varnika • 3 years ago

can you generalize divisibility by any no.?

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atiq varnika • a year ago

Not possible...

```
/* Paste your code here (You may delete these lines if not wri
```

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atiq atiq • a year ago

I mean no better method.....

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Frank • 3 years ago

can someone explain (In this context 11 in decimal numbers is same as 3 in b

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arnav.agarwal • 4 years ago

Also:

Also.

```
#include<stdio.h>
int remainderby3(unsigned int i) { /* good for 32-bit unsigned int */
  i = (i & 65535) + (i >> 16);
  i = (i & 65535) + (i >> 16);
  i = (i & 255) + (i >> 8);
  i = (i & 255) + (i >> 8);
  i = (i & 15) + (i >> 4);
  i = (i & 15) + (i >> 4);
  i = (i & 3) + (i >> 2);
  i = (i & 3) + (i >> 2);
  return (i != 3)? i : 0;
}

void main()
{
     int n;
     scanf("%d", &n);
     int a= remainderby3(n);
     if(a==0)
          printf("Divisible by 3");
     else
          printf("not divisible by 3");
}
```


tech.login.id2 • 4 years ago

@Geeks4Geeks:
Please provide a proof of this theory too.
A derivation showing why a number would be divisible by 3 if diff in its odd and
there before we accept its correctness

there before we accept its correctness.

@game:
Please elaborate a little what you mean. I could not understand anything.

Reply • Share ›

pennypecker • 4 years ago

The quotient for 'B' should be 99 in:

"ABCD = 1001A + D + 11C – C + 999B + B – A
= (1001A – 999B + 11C) + (D + B – A -C)"

Reply • Share ›

sunny321 • 4 years ago

please comment on soln of "game"..

Reply • Share ›

game • 4 years ago

Hello, I would like to extend the question to finding the divisibility of any number operator (its VERY costly).
The following code does the same, hope u enjoy the beauty of the algorithm :)

```
#include<stdio.h>
int main()
{
   int n, p = 0, d, t;
   scanf("%d%d",&n,&d); /* n is number and d is divisor */
   t = n;
   n--;
   n |= n>>1;
   n |= n>>2;
   n |= n>>4;
   n |= n>>8;
```

```
n |= n>>16;
n++;
if ( (t&(t-1) ) != 0)
```

see more

• Reply • Share ›

Rohan game • 9 months ago

Perhaps a more straight forward way to point at MSB.

```
 #include <stdio.h>
#include <math.h>
int main()
{
   int i=0,n, p = 0, d, n_original;
   printf("Enter number : ");
   scanf("%d",&n);
   printf("Enter Diviser : ");
   scanf("%d",&d);

   n_original = n;

   while(n>1) {
           i++;
           n>>=1;
   }
```

see more

• Reply • Share ›

kas game • 3 years ago

Great work :)

• Reply • Share ›

Surabhi game • 3 years ago

A slight correction to the code.

while(n) is an infinite loop here.

it should be:

```
 while ( n )
{
   p = (n&t)?( (p<<1) + 1):(p<<=1);
   p = p>=d?p-d:p;
   n>>=1;
}
```

• Reply • Share ›

mannirulz game • 4 years ago

this doesnt seems to be working... can u check with values(27 4)

• Reply • Share ›

geeksforgeeks • 5 years ago

@Arun: Your solution is correct. While you are using a construct provided by p
implemented an algorithm for multiple of 3.
Time complexity of % operator will also be O(logn) as it is also dependent on t
n.

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tiger geeksforgeeks • 2 years ago

Could you please explain me how it is O(logn) in the method you have
Please...

• Reply • Share ›

candis ➚ geeksforgeeks • 3 years ago

i prbably m not getting how is it working for the cases lyk, 1000(8)
even count=1
odd count=0

remainder -1 absolute(-1)=1
but the expected answer was 2....

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Arun • 5 years ago

I am not sure i am right

if Num%3==0 {print("Num is multiple of 3")}
else{print("Num is not multiple of 3")}

Time complexity : O(1)

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Devender Rao ➚ Arun • 2 months ago

missed the whole point. here we are not taking just about the % operat

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vishal.mnnit ➚ Arun • 4 years ago

u r rt

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geeksforgeeks • 5 years ago

@Joe: It works for 6 and 9 also. For 6 (110), difference of set bit count at even
of 3). Same is true for 9. You can verify it by replacing 23 with 3 or 6 in the abc

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kg1020 ➚ geeksforgeeks • 2 years ago

binary of 21 is 00...010101
so how it will work for 21 ?
plse explain...

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joe blow • 5 years ago

Does that algorithm work? It doesn't work for numbers like 6 or 9

  • Reply • Share ›

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