

DAA Assignment 4

Ishaan Shaikh

231070063

SY CE

Q. Write integer multiplication program.

Write integer multiplication program using divide and conquer technique.

Algorithm:

```
multiply (a, b):  
// Input: Two integers a and b  
// Output: Product of the integers
```

```
    res ← 0  
    for i = 1 to absolute(b):  
        res += a
```

```
    if b < 0  
        res = -res
```

```
    return res
```

Karatsuba (a,b):

//Input: Two ~~se~~ integers a and b

//Output: Product of the integers

if $a < 10$ or $b < 10$:
return $a * b$

$n = \max(a.\text{length}, b.\text{length})$
 $half = n/2$

$x1, x2 = x[0 \dots half], x[half+1 \dots]$
 $y1, y2 = y[0 \dots half], y[half+1 \dots]$

$z0 = \text{karatsuba}(x2, y2)$

$z1 = \text{karatsuba}(x2 + x1, y2 + y1)$

$z2 = \text{karatsuba}(x1, y1)$

return $z2 * 10^n + (z1 - z2 - z0) * 10^{n/2} + z0$

Test cases:

Test cases:

1) Input: 35435, 235345
Output: ~~96819492869~~ — 8339450075

2) Input: a, b
Output: Please enter valid integers

3) Input: (Blank Input)
Output: Please enter valid integers

4) Input: 233567, 865432
Output: 202136355944

5) Input: 756393234, 29828759
Output: 22562271486216606

6) Input: 1543378, a
Output: Please enter valid integers

Time Complexity:

Linear multiplication:

Input: Two integers a and b

Basic operation: add a to result iteratively

Let $C_{\text{worst}}(n)$ denote the time complexity of the algorithm

$$C_{\text{worst}}(n) = \sum_{i=1}^b 1$$

$$= b - 1 + 1$$

$$= b$$

$$\therefore T.C = O(b)$$

Can be generalised as $O(\text{num})$.

Karatsuba:

Input: Two integers x and y of length n

Basic operation: compute multiplication of parts of x and y

Let $T(n)$ be the time complexity of the algorithm:

$$T(n) = 3T\left(\frac{n}{2}\right) + O(1)$$

Using master's th^m

$$T(n) = aT\left(\frac{n}{b}\right) + f(n^d)$$

Comparing

$$a = 3, b = 2, f(n^d) = O(1), d = 0$$

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$$b^d = 2^0 = 1$$

$$3 > 1$$

$$\therefore a > b^d$$

$$T(n) = O\left(n^{\log_b a}\right)$$

$$= O\left(n^{\log_2 3}\right)$$

$$T(n) = O\left(n^{1.59}\right)$$

Program: PEP 08 Coding style for python is used

```
def multiply(a, b):
    """Multiply two integers using a for loop."""
    result = 0
    for _ in range(abs(b)): # Repeat for the absolute value of b
        result += a # Add a to the result for each iteration

    # If b is negative, negate the result
    if b < 0:
        result = -result

    return result

def main():
    """Main function to execute the multiplication."""
    try:
        # Input: Get two integers from the user
        num1 = int(input("Enter the first integer: "))
        num2 = int(input("Enter the second integer: "))

        # Process: Multiply the two integers
        result = multiply(num1, num2)
```



```

        # Output: Display the result
        print(f"The result of {num1} * {num2} is: {result}")

    except ValueError:
        print("Please enter valid integers.")

if __name__ == "__main__":
    main()

```

```

def karatsuba(x, y):
    """Recursive Karatsuba multiplication algorithm."""
    # Base case for recursion
    if x < 10 or y < 10:
        return x * y

    # Calculate the size of the numbers
    max_len = max(len(str(x)), len(str(y)))
    half_len = max_len // 2

    # Split the digit sequences about the half_len
    x_high = x // (10 ** half_len)
    x_low = x % (10 ** half_len)
    y_high = y // (10 ** half_len)
    y_low = y % (10 ** half_len)

    # 3 recursive calls
    z0 = karatsuba(x_low, y_low) # Low parts
    z1 = karatsuba(x_low + x_high, y_low + y_high) # Cross parts
    z2 = karatsuba(x_high, y_high) # High parts

    # Combine the results using the Karatsuba formula
    return (z2 * (10 ** (2 * half_len))) + \
        ((z1 - z2 - z0) * (10 ** half_len)) + z0

if __name__ == "__main__":
    while True:
        try:
            num1 = input("Enter the first integer: ")

```

```

        num2 = input("Enter the second integer: ")

        # Convert inputs to integers
        num1 = int(num1)
        num2 = int(num2)

        result = karatsuba(num1, num2)
        print(result)
        break # Exit loop after successful calculation

except ValueError as ve:
    print("Please enter valid integers")
except Exception as e:
    print(f"An error occurred: {e}. Please try again.")

```

Output:

```

Enter the first integer: 35435
Enter the second integer: 235345
8339450075

```

```

Enter the first integer: a
Enter the second integer: b
Please enter valid integers

```

```

Enter the first integer:
Enter the second integer:
Please enter valid integers

```

```

Enter the first integer: 233567
Enter the second integer: 865432
202136355944

```

```
PS C:\Users\Ishaan\Desktop\ok> & C:.
Enter the first integer: 756393234
Enter the second integer: 29828759
22562271486216606
```

```
Enter the first integer: 1543378
Enter the second integer: a
Please enter valid integers
```

Conclusion: Hence, we have studied the program to multiply two integers by linear and divide and conquer algorithm. Karatsuba's algorithm for multiplication was used in divide and conquer as it reduces the time complexity of the multiplication algorithm to a certain extent.