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DAA LAB 04 – B

1. AIM:

To use Divide and Conquer Technique for Large integer multiplication

2. PROGRAM:

```
def intMultiplication(a,b):  
    """  
    This function calculates product of 2 integers by Brute Force  
  
    Arguments:  
    a (int) : The first integer that needs to be multiplied  
    b (int) : The second integer that needs to be multiplied  
  
    Returns:  
    res (int) : The product of the given two integers  
    """  
    a, b = str(x), str(y)  
    result = 0  
    for i in range(len(b)):  
        digB = int(b[-(i + 1)])  
  
        row_result = 0  
        carry = 0  
        for j in range(len(a)):  
            digA = int(a[-(j + 1)])  
  
            product = digA * digB + carry  
            carry = product // 10  
            product = product % 10  
  
            row_result += product * (10 ** j)  
  
        if carry > 0:  
            row_result += carry * (10 ** len(a))  
  
    row_result *= (10 ** i)
```

```

        result += row_result

    return result

def karatsuba(a, b):
    """
    This function calculates product by Divide and Conquer Technique, using
    Karatsuba's Algorithm
    Arguments:
    a (int) : The first integer that needs to be multiplied
    b (int) : The second integer that needs to be multiplied

    Returns:
    res (int) : The product of the given two integers
    """

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

    n = max(len(str(a)), len(str(b)))
    m = n // 2

    pow10m = 10 ** m
    aH, aL = divmod(a, pow10m)
    bH, bL = divmod(b, pow10m)

    z0 = karatsuba(aL, bL)
    z1 = karatsuba(aL + aH, bL + bH)
    z2 = karatsuba(aH, bH)

    return (z2 * 10**(2*m)) + ((z1 - z2 - z0) * 10**m) + z0

x = 1234
y = 5678
try:
    x, y = int(x), int(y)
except (ValueError, TypeError):
    raise ValueError("Both inputs must be valid integers")
res=intMultiplcation(x,y)
print(f"Using Regular Approach: {x} * {y} = {res}")

```

```
res = karatsuba(x, y)
print(f"Using Karatsuba's Algorithm: {x} * {y} = {res}")
```

3. TESTCASES:

1. a=1234 b=5678

```
Using Regular Approach: 1234 * 5678 = 7006652
Using Karatsuba's Algorithm: 1234 * 5678 = 7006652
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

2. a=123456789012345 b=987654321098765

```
Using Regular Approach: 123456789012345 * 987654321098765 = 121932631137021071359549253925
Using Karatsuba's Algorithm: 123456789012345 * 987654321098765 = 121932631137021071359549253925
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

Ln 45, Col 20 Spaces: 4

3. a=987654321012345 b=123456789098765

```
Using Regular Approach: 987654321012345 * 123456789098765 = 121932631211705022074989253925
Using Karatsuba's Algorithm: 987654321012345 * 123456789098765 = 121932631211705022074989253925
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

Ln 45, Col 20 Spaces: 4

4. a=12345678976543 b=987654321234567

```
Using Regular Approach: 12345678976543 * 987654321234567 = 12193263189757440472793761881
Using Karatsuba's Algorithm: 12345678976543 * 987654321234567 = 12193263189757440472793761881
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

Ln 45, Col 20 Spaces: 4

5. a=12345678 b=98765432

```
Using Regular Approach: 12345678 * 98765432 = 1219326221002896
Using Karatsuba's Algorithm: 12345678 * 98765432 = 1219326221002896
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

6. a=12345678909 b=98765432101

```
Using Regular Approach: 12345678909 * 98765432101 = 1219326312027587257809
Using Karatsuba's Algorithm: 12345678909 * 98765432101 = 1219326312027587257809
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

Ln 45, Co

7. One of the numbers is zero

a=123456 b=0

```
Using Regular Approach: 123456 * 0 = 0
Using Karatsuba's Algorithm: 123456 * 0 = 0
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

8. One of the input is a string

a=123456 b=""

```
ValueError: Both inputs must be valid integers
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

9. Number is negative

a= -1234 b=4567

```
Using Regular Approach: -1234 * 4567 = -5635678
Using Karatsuba's Algorithm: -1234 * 4567 = -5635678
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

10. One of the number is of type float

a= 12.3 b=1234

```
ValueError: Both inputs must be integers
PS C:\Users\Chaitra\OneDrive\Desktop\Programs>
```

11. For 50 Digits

```
For 50 digits
Using Regular Approach: 12345678901234567890123456789012345678901234567890 * 98765432109876543210987654321098765432109876543210 = 121
9326311370217952261850327338667885945115073915611949397448712086533622923332237463801111263526900
Using Karatsuba's Algorithm: 12345678901234567890123456789012345678901234567890 * 98765432109876543210987654321098765432109876543210
= 1219326311370217952261850327338667885945115073915611949397448712086533622923332237463801111263526900
```

Hence, we implemented Divide and Conquer technique for Large Integer Multiplication using Karatsuba Algorithm. We divided the number into smaller subproblems and recursively called the function thrice to achieve this. Making our time complexity $O(n^{\log_2 3}) = O(n^{1.585})$ which is better than the normal brute force approach. We also learnt about Git and Github and how it can be used as a Version Control System