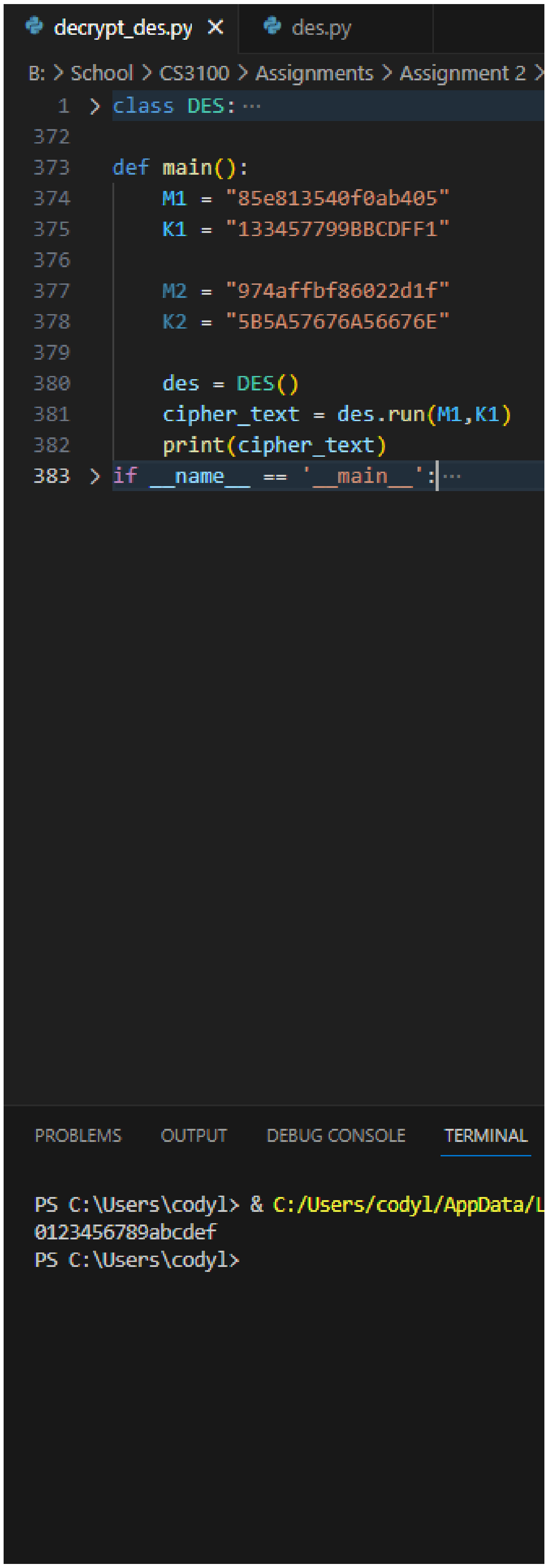
```
class DES:

  def final_permutation(self, plain_text):
    """
    inputs: str
    output: str
    """
    table = [40, 8, 48, 16, 56, 24, 64, 32,
      39, 7, 47, 15, 55, 23, 63, 31,
      38, 6, 46, 14, 54, 22, 62, 30,
      37, 5, 45, 13, 53, 21, 61, 29,
      36, 4, 44, 12, 52, 20, 60, 28,
      35, 3, 43, 11, 51, 19, 59, 27,
      34, 2, 42, 10, 50, 18, 58, 26,
      33, 1, 41, 9,  49, 17, 57, 25]
    return self.r_permutation(plain_text, table, 64)

  def key_permutation_2(self, key):
    """
    inputs: str
    outputs: str
    """
    table =  [14, 17, 11, 24, 1, 5,
    3, 28, 15, 6, 21, 10,
    23, 19, 12, 4, 26, 8,
    16, 7, 27, 20, 13, 2,
    41, 52, 31, 37, 47, 55,
    30, 40, 51, 45, 33, 48,
    44, 49, 39, 56, 34, 53,
    46, 42, 50, 36, 29, 32
]
    return self.permutation(key, table, 56)

def rotate_key_bits_1(self, key):
    """
    inputs: str
    output: str
    """
    binary_value = self.hex_to_binary(key, 56)
    left = binary_value[:28]
    right = binary_value[28:]

    left_rotated = self.rotate_left(left)
    right_rotated = self.rotate_left(right)

    rotated_binary_value = left_rotated + right_rotated

    hex_str = self.binary_to_hex(rotated_binary_value,14)

    return hex_str

def rotate_key_bits_2(self, key):
    """
    inputs: str
    output: str
    """
    binary_value = self.hex_to_binary(key, 56)
    left = binary_value[:28]
    right = binary_value[28:]

    left_rotated_1 = self.rotate_left(left)
    left_rotated_2 = self.rotate_left(left_rotated_1)
    right_rotated_1 = self.rotate_left(right)
    right_rotated_2 = self.rotate_left(right_rotated_1)

    rotated_binary_value = left_rotated_2 + right_rotated_2

    hex_str = self.binary_to_hex(rotated_binary_value, 14)

    return hex_str

def rounds(self, plain_text, key):
    """
    inputs: str, str, int
    output: str
    """
    left1 = plain_text[8:]
    right1 = plain_text[:8]

    left2 = left1
    right2 = right1
    key_list = self.key(key)

    for i in range(16, 0, -1):
        f = self.f_function(left1,key_list[i-1])
        # right1 = self.xor_hex(left2, f)
        # left1 = right2
```

```
            left1 = self.xor_hex(right2, f)
            right1 = left2

            right2 = right1.zfill(8)
            left2 = left1.zfill(8)
        return left2 + right2

    def key(self, key):
        key_list = []
        rotated_key = key
        for i in range(1, 17):
            if i in (1,2,9,16):
                rotated_key = self.rotate_key_bits_1(rotated_key)
                k = self.key_permutation_2(rotated_key)
            else:
                rotated_key = self.rotate_key_bits_2(rotated_key)
                k = self.key_permutation_2(rotated_key)
            key_list.append(k)
        return key_list

    def xor_hex(self, hex_value_1, hex_value_2):
        """
        inputs: str, str
        output: str
        """
        int_value_1 = int(hex_value_1, 16)
        int_value_2 = int(hex_value_2, 16)
        result_int = int_value_1 ^ int_value_2


        hex_value = hex(result_int)[2:]

        return hex_value


    def p_permutation(self, plain_text):

        """

        inputs: str

        output: str

        """


        table = [16,7,20,21,29,12,28,17,1,15,23,

                26,5,18,31,10,2,8,24,14,32,27,3

                ,9,19,13,30,6,22,11,4,25]

        return self.permutation(plain_text,table,32)


    def f_function(self, plain_text,key):

        """

        inputs: str, str

        output: str

        """

        e = self.expansion_32_48(plain_text)

        new_key = self.xor_hex(e, key)

        binary_value = self.hex_to_binary(new_key, 48)

        s_box_substitution = self.s1(binary_value[:6]) + self.s2(binary_value[6:12]) +
self.s3(binary_value[12:18]) + self.s4(binary_value[18:24]) + self.s5(binary_value[24:30]) +
self.s6(binary_value[30:36]) + self.s7(binary_value[36:42]) + self.s8(binary_value[42:48])

        return self.p_permutation(s_box_substitution)
```

```
def s_box(self, binary_value, table):
  """
  inputs: str, int list list
  output: str
  """

  row = int(binary_value[0] + binary_value[5],2)
  column = int(binary_value[1:5],2)

  # Convert int to hex
  int_value = table[row][column]
  hex_value = hex(int_value)[2:]

  return hex_value

def s1(self, plain_text):
  """
  inputs: str
  output: str
  """
  table = [
  [14, 4, 13, 1, 2, 15, 11, 8, 3, 10, 6, 12, 5, 9, 0, 7],
  [0, 15, 7, 4, 14, 2, 13, 1, 10, 6, 12, 11, 9, 5, 3, 8],
  [4, 1, 14, 8, 13, 6, 2, 11, 15, 12, 9, 7, 3, 10, 5, 0],
  [15, 12, 8, 2, 4, 9, 1, 7, 5, 11, 3, 14, 10, 0, 6, 13]
]
  return self.s_box(plain_text, table)

def s2(self, plain_text):
    """
    inputs: str
    output: str
    """
    table = [
    [15, 1, 8, 14, 6, 11, 3, 4, 9, 7, 2, 13, 12, 0, 5, 10],
    [3, 13, 4, 7, 15, 2, 8, 14, 12, 0, 1, 10, 6, 9, 11, 5],
    [0, 14, 7, 11, 10, 4, 13, 1, 5, 8, 12, 6, 9, 3, 2, 15],
    [13, 8, 10, 1, 3, 15, 4, 2, 11, 6, 7, 12, 0, 5, 14, 9]
]
    return self.s_box(plain_text, table)

def s3(self, plain_text):
    """
    inputs: str
    output: str
    """
    table = [
    [10, 0, 9, 14, 6, 3, 15, 5, 1, 13, 12, 7, 11, 4, 2, 8],
    [13, 7, 0, 9, 3, 4, 6, 10, 2, 8, 5, 14, 12, 11, 15, 1],
    [13, 6, 4, 9, 8, 15, 3, 0, 11, 1, 2, 12, 5, 10, 14, 7],
    [1, 10, 13, 0, 6, 9, 8, 7, 4, 15, 14, 3, 11, 5, 2, 12]
]
    return self.s_box(plain_text, table)

def s4(self, plain_text):
    """
    inputs: str
    output: str
    """
    table = [
    [7, 13, 14, 3, 0, 6, 9, 10, 1, 2, 8, 5, 11, 12, 4, 15],
    [13, 8, 11, 5, 6, 15, 0, 3, 4, 7, 2, 12, 1, 10, 14, 9],
    [10, 6, 9, 0, 12, 11, 7, 13, 15, 1, 3, 14, 5, 2, 8, 4],
    [3, 15, 0, 6, 10, 1, 13, 8, 9, 4, 5, 11, 12, 7, 2, 14],
]
    return self.s_box(plain_text, table)

def s5(self, plain_text):
    """
    inputs: str
    output: str
    """
    table = [
    [2, 12, 4, 1, 7, 10, 11, 6, 8, 5, 3, 15, 13, 0, 14, 9],
    [14, 11, 2, 12, 4, 7, 13, 1, 5, 0, 15, 10, 3, 9, 8, 6],
    [4, 2, 1, 11, 10, 13, 7, 8, 15, 9, 12, 5, 6, 3, 0, 14],
    [11, 8, 12, 7, 1, 14, 2, 13, 6, 15, 0, 9, 10, 4, 5, 3],
]
    return self.s_box(plain_text, table)

def s6(self, plain_text):
    """
    inputs: str
    output: str
    """
    table = [
    [12, 1, 10, 15, 9, 2, 6, 8, 0, 13, 3, 4, 14, 7, 5, 11],
    [10, 15, 4, 2, 7, 12, 9, 5, 6, 1, 13, 14, 0, 11, 3, 8],
    [9, 14, 15, 5, 2, 8, 12, 3, 7, 0, 4, 10, 1, 13, 11, 6],
    [4, 3, 2, 12, 9, 5, 15, 10, 11, 14, 1, 7, 6, 0, 8, 13],
]
    return self.s_box(plain_text, table)

def s7(self, plain_text):
    """
    inputs: str
    output: str
    """
    table = [
    [4, 11, 2, 14, 15, 0, 8, 13, 3, 12, 9, 7, 5, 10, 6, 1],
    [13, 0, 11, 7, 4, 9, 1, 10, 14, 3, 5, 12, 2, 15, 8, 6],
    [1, 4, 11, 13, 12, 3, 7, 14, 10, 15, 6, 8, 0, 5, 9, 2],
    [6, 11, 13, 8, 1, 4, 10, 7, 9, 5, 0, 15, 14, 2, 3, 12],
]
    return self.s_box(plain_text, table)

def s8(self, plain_text):
    """
    inputs: str
    output: str
    """
    table = [
    [13, 2, 8, 4, 6, 15, 11, 1, 10, 9, 3, 14, 5, 0, 12, 7],
    [1, 15, 13, 8, 10, 3, 7, 4, 12, 5, 6, 11, 0, 14, 9, 2],
    [7, 11, 4, 1, 9, 12, 14, 2, 0, 6, 10, 13, 15, 3, 5, 8],
    [2, 1, 14, 7, 4, 10, 8, 13, 15, 12, 9, 0, 3, 5, 6, 11],
 ]
    return self.s_box(plain_text, table)


 def expansion_32_48(self, plain_text):
    """
    inputs: str
    output: str
    """
    table =
[32,1,2,3,4,5,4,5,6,7,8,9,8,9,10,11,12,13,12,13,14,15,16,17,16,17,18,19,20,21,20,21,22,23,24,25,
24,25,26,27,28,29,28,29,30,31,32,1]
    return self.permutation(plain_text, table, 32)


 def key_permutation_1(self, key):
    """
    inputs: str
    output: str
    """


    table = [57, 49, 41, 33, 25, 17, 9,
    1, 58, 50, 42, 34, 26, 18,
    10, 2, 59, 51, 43, 35, 27,
    19, 11, 3, 60, 52, 44, 36,
    63, 55, 47, 39, 31, 23, 15,
    7, 62, 54, 46, 38, 30, 22,
    14, 6, 61, 53, 45, 37, 29,
    21, 13, 5, 28, 20, 12, 4]
    return self.permutation(key,table,64)
```

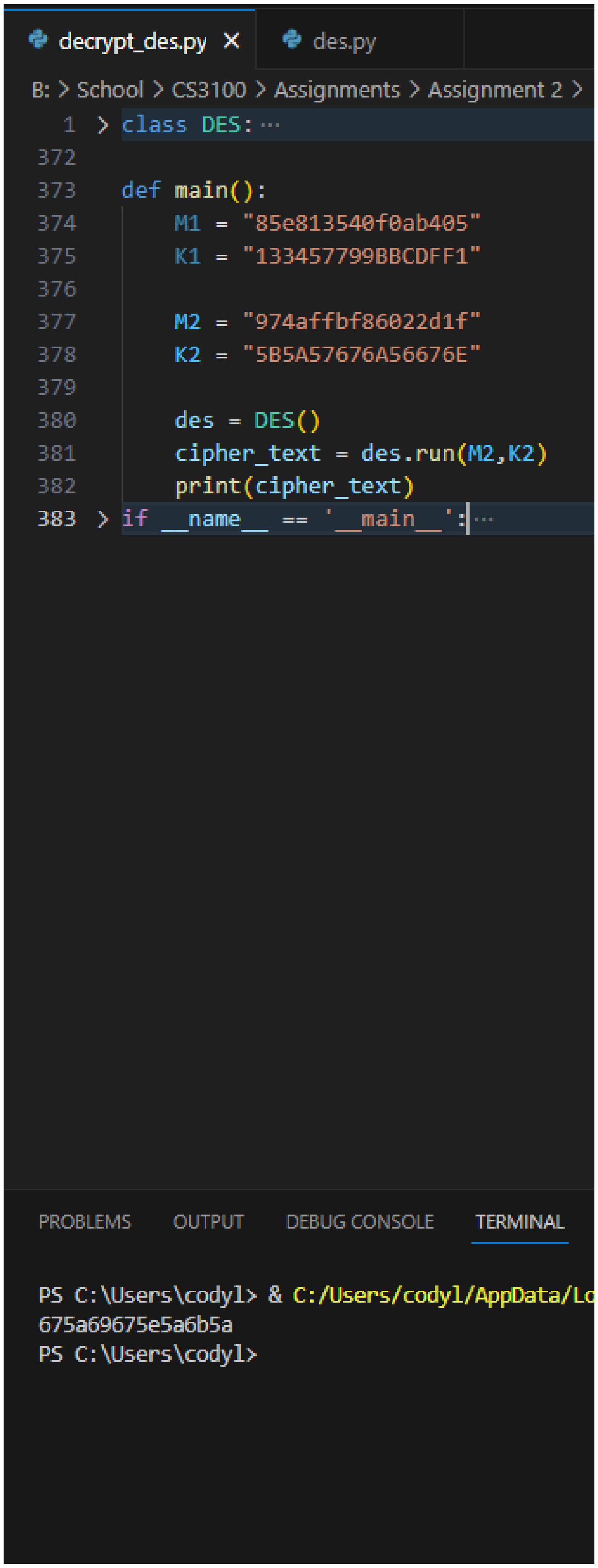
```
def rotate_left(self, binary_str):
    """
    inputs: str
    output: str
    """
    binary_list = list(binary_str)

    first_bit = binary_list.pop(0)
    binary_list.append(first_bit)

    rotated_binary_str = ''.join(binary_list)

    return rotated_binary_str

def hex_to_binary(self, hex_str, bit):
    """
    input type: str
    output type: binary
    """
    int_value = int(hex_str, 16)  # Convert hex to integer
    binary_value = bin(int_value)[2:].zfill(bit) # Convert integer to binary
    return binary_value

def binary_to_hex(self, binary_string, bit):
    """
    input type: int list
    output type: str
    """
    int_value = int(binary_string, 2)

    hex_value = hex(int_value)[2:].zfill(bit)

    return hex_value


  def r_permutation(self, plain_text, table, bit_size):

    """

    inputs: str, int list, int

    output: str

    """

    cipher_text = [0]*bit_size


    binary_value = self.hex_to_binary(plain_text, bit_size) # make it 64bit

    for i in range(len(table)):

      cipher_text[int(table[i]) - 1] = binary_value[i]


    binary_string = ''.join(str(bit) for bit in cipher_text)


    hex_value = self.binary_to_hex(binary_string, int(len(table)/4))

    return hex_value


  def permutation(self, plain_text, table, bit_size, ):

    """

    inputs: str, int list, int

    output: str

    """

    cipher_text = []


    binary_value = self.hex_to_binary(plain_text, bit_size) # make it 64bit

    for i in range(len(table)):
            cipher_text.append(binary_value[table[i]-1])

        binary_string = ''.join(str(bit) for bit in cipher_text)

        hex_value = self.binary_to_hex(binary_string, int(len(table)/4))
        return hex_value

    def initial_permutation(self, plain_text):
        """
        inputs: str
        output: str
        """
        table =
[58,50,42,34,26,18,10,2,60,52,44,36,28,20,12,4,62,54,46,38,30,22,14,6,64,56,48,40,32,24,16,8,5
7,49,41,33,25,17,9,1,59,51,43,35,27,19,11,3,61,53,45,37,29,21,13,5,63,55,47,39,31,23,15,7]
        return self.r_permutation(plain_text, table, 64)

    def run(self, plain_text, key):
        """
        inputs: str, str
        output: str
        """
        fp = self.final_permutation(plain_text)
        k = self.key_permutation_1(key).zfill(14)
        rnds = self.rounds(fp,k)

        ip = self.initial_permutation(rnds)
        return ip
```

```
def main():
   M1 = "85e813540f0ab405"
   K1 = "133457799BBCDFF1"

   M2 = "974affbf86022d1f"
   K2 = "5B5A57676A56676E"

   des = DES()
   cipher_text = des.run(M1,K1)
   print(cipher_text)
if __name__ == '__main__':
   main()
```



```python
class DES:···

def main():
    M1 = "85e813540f0ab405"
    K1 = "133457799BBCDFF1"

    M2 = "974affbf86022d1f"
    K2 = "5B5A57676A56676E"

    des = DES()
    cipher_text = des.run(M1,K1)
    print(cipher_text)
if __name__ == '__main__':···
```

```
PS C:\Users\codyl> & C:/Users/codyl/AppData/L
0123456789abcdef
PS C:\Users\codyl>
```



decrypt_des.py ✕ | des.py

B: > School > CS3100 > Assignments > Assignment 2 >

```
class DES:···

def main():
    M1 = "85e813540f0ab405"
    K1 = "133457799BBCDFF1"

    M2 = "974affbf86022d1f"
    K2 = "5B5A57676A56676E"

    des = DES()
    cipher_text = des.run(M2,K2)
    print(cipher_text)
if __name__ == '__main__':···
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

```
PS C:\Users\codyl> & C:/Users/codyl/AppData/Lo
675a69675e5a6b5a
PS C:\Users\codyl>
```