

Simon Final

June 12, 2020

```
[1]: import numpy as np
import inspect

def f_0(a, b): #s = 10
    no_args = 2
    string_ = str(a)+str(b)
    dict_={}
    dict_['00'] = dict_['10'] = format(1, '#0'+str(no_args+2)+'b')
    dict_['01'] = dict_['11'] = format(2, '#0'+str(no_args+2)+'b')
    return dict_[string_]

def f_1(a, b): #s = 01
    no_args = 2
    string_ = str(a)+str(b)
    dict_={}
    dict_['00'] = dict_['01'] = format(1, '#0'+str(no_args+2)+'b')
    dict_['10'] = dict_['11'] = format(2, '#0'+str(no_args+2)+'b')
    return dict_[string_]

def f_3(a, b, c): #s = 001
    no_args = 3
    string_ = str(a)+str(b)+str(c)
    dict_={}
    dict_['000'] = dict_['001'] = format(1, '#0'+str(no_args+2)+'b')
    dict_['010'] = dict_['011'] = format(2, '#0'+str(no_args+2)+'b')
    dict_['100'] = dict_['101'] = format(3, '#0'+str(no_args+2)+'b')
    dict_['110'] = dict_['111'] = format(4, '#0'+str(no_args+2)+'b')
    return dict_[string_]

def f_4(a, b, c): #s = 010
    no_args = 3
    string_ = str(a)+str(b)+str(c)
    dict_={}
    dict_['000'] = dict_['010'] = format(1, '#0'+str(no_args+2)+'b')
    dict_['001'] = dict_['011'] = format(2, '#0'+str(no_args+2)+'b')
    dict_['100'] = dict_['110'] = format(3, '#0'+str(no_args+2)+'b')
    dict_['101'] = dict_['111'] = format(4, '#0'+str(no_args+2)+'b')
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    return dict_[string_]

def f_6(a, b, c, d): #s = 0001
    no_args = 4
    string_ = str(a)+str(b)+str(c)+str(d)
    dict_={}
    dict_['0000'] = dict_['0001'] = format(1, '#0'+str(no_args+2)+'b')
    dict_['0010'] = dict_['0011'] = format(2, '#0'+str(no_args+2)+'b')
    dict_['0100'] = dict_['0101'] = format(3, '#0'+str(no_args+2)+'b')
    dict_['0110'] = dict_['0111'] = format(4, '#0'+str(no_args+2)+'b')
    dict_['1000'] = dict_['1001'] = format(5, '#0'+str(no_args+2)+'b')
    dict_['1010'] = dict_['1011'] = format(6, '#0'+str(no_args+2)+'b')
    dict_['1100'] = dict_['1101'] = format(7, '#0'+str(no_args+2)+'b')
    dict_['1110'] = dict_['1111'] = format(8, '#0'+str(no_args+2)+'b')
    return dict_[string_]

def f_7(a, b, c, d): #s = 0010
    no_args = 4
    string_ = str(a)+str(b)+str(c)+str(d)
    dict_={}
    dict_['0000'] = dict_['0010'] = format(1, '#0'+str(no_args+2)+'b')
    dict_['0001'] = dict_['0011'] = format(2, '#0'+str(no_args+2)+'b')
    dict_['0100'] = dict_['0110'] = format(3, '#0'+str(no_args+2)+'b')
    dict_['0101'] = dict_['0111'] = format(4, '#0'+str(no_args+2)+'b')
    dict_['1000'] = dict_['1010'] = format(5, '#0'+str(no_args+2)+'b')
    dict_['1001'] = dict_['1011'] = format(6, '#0'+str(no_args+2)+'b')
    dict_['1100'] = dict_['1110'] = format(7, '#0'+str(no_args+2)+'b')
    dict_['1101'] = dict_['1111'] = format(8, '#0'+str(no_args+2)+'b')
    return dict_[string_]

def f_9(a, b, c, d, e): #s = 00010
    no_args = 5
    string_ = str(a)+str(b)+str(c)+str(d)+str(e)
    dict_={}
    dict_['00000'] = dict_['00010'] = format(1, '#0'+str(no_args+2)+'b')
    dict_['00001'] = dict_['00011'] = format(2, '#0'+str(no_args+2)+'b')
    dict_['00100'] = dict_['00110'] = format(3, '#0'+str(no_args+2)+'b')
    dict_['00101'] = dict_['00111'] = format(4, '#0'+str(no_args+2)+'b')
    dict_['01000'] = dict_['01010'] = format(5, '#0'+str(no_args+2)+'b')
    dict_['01001'] = dict_['01011'] = format(6, '#0'+str(no_args+2)+'b')
    dict_['01100'] = dict_['01110'] = format(7, '#0'+str(no_args+2)+'b')
    dict_['01101'] = dict_['01111'] = format(8, '#0'+str(no_args+2)+'b')
    dict_['10000'] = dict_['10010'] = format(9, '#0'+str(no_args+2)+'b')
    dict_['10001'] = dict_['10011'] = format(10, '#0'+str(no_args+2)+'b')
    dict_['10100'] = dict_['10110'] = format(11, '#0'+str(no_args+2)+'b')
    dict_['10101'] = dict_['10111'] = format(12, '#0'+str(no_args+2)+'b')
    dict_['11000'] = dict_['11010'] = format(13, '#0'+str(no_args+2)+'b')

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dict_['11001'] = dict_['11011'] = format(14, '#0'+str(no_args+2)+'b')
dict_['11100'] = dict_['11110'] = format(15, '#0'+str(no_args+2)+'b')
dict_['11101'] = dict_['11111'] = format(16, '#0'+str(no_args+2)+'b')
return dict_[string_]

def f_10(a, b, c, d, e, f): #s = 000010
    no_args = 6
    string_ = str(a)+str(b)+str(c)+str(d)+str(e)+str(f)
    dict_={}
    dict_['000000'] = dict_['000010'] = format(1, '#0'+str(no_args+2)+'b')
    dict_['000001'] = dict_['000011'] = format(2, '#0'+str(no_args+2)+'b')
    dict_['000100'] = dict_['000110'] = format(3, '#0'+str(no_args+2)+'b')
    dict_['000101'] = dict_['000111'] = format(4, '#0'+str(no_args+2)+'b')
    dict_['001000'] = dict_['001010'] = format(5, '#0'+str(no_args+2)+'b')
    dict_['001001'] = dict_['001011'] = format(6, '#0'+str(no_args+2)+'b')
    dict_['001100'] = dict_['001110'] = format(7, '#0'+str(no_args+2)+'b')
    dict_['001101'] = dict_['001111'] = format(8, '#0'+str(no_args+2)+'b')
    dict_['010000'] = dict_['010010'] = format(9, '#0'+str(no_args+2)+'b')
    dict_['010001'] = dict_['010011'] = format(10, '#0'+str(no_args+2)+'b')
    dict_['010100'] = dict_['010110'] = format(11, '#0'+str(no_args+2)+'b')
    dict_['010101'] = dict_['010111'] = format(12, '#0'+str(no_args+2)+'b')
    dict_['011000'] = dict_['011010'] = format(13, '#0'+str(no_args+2)+'b')
    dict_['011001'] = dict_['011011'] = format(14, '#0'+str(no_args+2)+'b')
    dict_['011100'] = dict_['011110'] = format(15, '#0'+str(no_args+2)+'b')
    dict_['011101'] = dict_['011111'] = format(16, '#0'+str(no_args+2)+'b')
    dict_['100000'] = dict_['100010'] = format(17, '#0'+str(no_args+2)+'b')
    dict_['100001'] = dict_['100011'] = format(18, '#0'+str(no_args+2)+'b')
    dict_['100100'] = dict_['100110'] = format(19, '#0'+str(no_args+2)+'b')
    dict_['100101'] = dict_['100111'] = format(20, '#0'+str(no_args+2)+'b')
    dict_['101000'] = dict_['101010'] = format(21, '#0'+str(no_args+2)+'b')
    dict_['101001'] = dict_['101011'] = format(22, '#0'+str(no_args+2)+'b')
    dict_['101100'] = dict_['101110'] = format(23, '#0'+str(no_args+2)+'b')
    dict_['101101'] = dict_['101111'] = format(24, '#0'+str(no_args+2)+'b')
    dict_['110000'] = dict_['110010'] = format(25, '#0'+str(no_args+2)+'b')
    dict_['110001'] = dict_['110011'] = format(26, '#0'+str(no_args+2)+'b')
    dict_['110100'] = dict_['110110'] = format(27, '#0'+str(no_args+2)+'b')
    dict_['110101'] = dict_['110111'] = format(28, '#0'+str(no_args+2)+'b')
    dict_['111000'] = dict_['111010'] = format(29, '#0'+str(no_args+2)+'b')
    dict_['111001'] = dict_['111011'] = format(30, '#0'+str(no_args+2)+'b')
    dict_['111100'] = dict_['111110'] = format(31, '#0'+str(no_args+2)+'b')
    dict_['111101'] = dict_['111111'] = format(32, '#0'+str(no_args+2)+'b')
    return dict_[string_]

def f_11(a, b, c, d, e, f, g): #s = 0000010
    no_args = 7
    string_ = str(a)+str(b)+str(c)+str(d)+str(e)+str(f)+str(g)
    dict_={}

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dict_['0000000'] = dict_['0000010'] = format(1, '#0'+str(no_args+2)+'b')
dict_['0000001'] = dict_['0000011'] = format(2, '#0'+str(no_args+2)+'b')
dict_['0000100'] = dict_['0000110'] = format(3, '#0'+str(no_args+2)+'b')
dict_['0000101'] = dict_['0000111'] = format(4, '#0'+str(no_args+2)+'b')
dict_['0001000'] = dict_['0001010'] = format(5, '#0'+str(no_args+2)+'b')
dict_['0001001'] = dict_['0001011'] = format(6, '#0'+str(no_args+2)+'b')
dict_['0001100'] = dict_['0001110'] = format(7, '#0'+str(no_args+2)+'b')
dict_['0001101'] = dict_['0001111'] = format(8, '#0'+str(no_args+2)+'b')
dict_['0010000'] = dict_['0010010'] = format(9, '#0'+str(no_args+2)+'b')
dict_['0010001'] = dict_['0010011'] = format(10, '#0'+str(no_args+2)+'b')
dict_['0010100'] = dict_['0010110'] = format(11, '#0'+str(no_args+2)+'b')
dict_['0010101'] = dict_['0010111'] = format(12, '#0'+str(no_args+2)+'b')
dict_['0011000'] = dict_['0011010'] = format(13, '#0'+str(no_args+2)+'b')
dict_['0011001'] = dict_['0011011'] = format(14, '#0'+str(no_args+2)+'b')
dict_['0011100'] = dict_['0011110'] = format(15, '#0'+str(no_args+2)+'b')
dict_['0011101'] = dict_['0011111'] = format(16, '#0'+str(no_args+2)+'b')
dict_['0100000'] = dict_['0100010'] = format(17, '#0'+str(no_args+2)+'b')
dict_['0100001'] = dict_['0100011'] = format(18, '#0'+str(no_args+2)+'b')
dict_['0100100'] = dict_['0100110'] = format(19, '#0'+str(no_args+2)+'b')
dict_['0100101'] = dict_['0100111'] = format(20, '#0'+str(no_args+2)+'b')
dict_['0101000'] = dict_['0101010'] = format(21, '#0'+str(no_args+2)+'b')
dict_['0101001'] = dict_['0101011'] = format(22, '#0'+str(no_args+2)+'b')
dict_['0101100'] = dict_['0101110'] = format(23, '#0'+str(no_args+2)+'b')
dict_['0101101'] = dict_['0101111'] = format(24, '#0'+str(no_args+2)+'b')
dict_['0110000'] = dict_['0110010'] = format(25, '#0'+str(no_args+2)+'b')
dict_['0110001'] = dict_['0110011'] = format(26, '#0'+str(no_args+2)+'b')
dict_['0110100'] = dict_['0110110'] = format(27, '#0'+str(no_args+2)+'b')
dict_['0110101'] = dict_['0110111'] = format(28, '#0'+str(no_args+2)+'b')
dict_['0111000'] = dict_['0111010'] = format(29, '#0'+str(no_args+2)+'b')
dict_['0111001'] = dict_['0111011'] = format(30, '#0'+str(no_args+2)+'b')
dict_['0111100'] = dict_['0111110'] = format(31, '#0'+str(no_args+2)+'b')
dict_['0111101'] = dict_['0111111'] = format(32, '#0'+str(no_args+2)+'b')
dict_['1000000'] = dict_['1000010'] = format(33, '#0'+str(no_args+2)+'b')
dict_['1000001'] = dict_['1000011'] = format(34, '#0'+str(no_args+2)+'b')
dict_['1000100'] = dict_['1000110'] = format(35, '#0'+str(no_args+2)+'b')
dict_['1000101'] = dict_['1000111'] = format(36, '#0'+str(no_args+2)+'b')
dict_['1001000'] = dict_['1001010'] = format(37, '#0'+str(no_args+2)+'b')
dict_['1001001'] = dict_['1001011'] = format(38, '#0'+str(no_args+2)+'b')
dict_['1001100'] = dict_['1001110'] = format(39, '#0'+str(no_args+2)+'b')
dict_['1001101'] = dict_['1001111'] = format(40, '#0'+str(no_args+2)+'b')
dict_['1010000'] = dict_['1010010'] = format(41, '#0'+str(no_args+2)+'b')
dict_['1010001'] = dict_['1010011'] = format(42, '#0'+str(no_args+2)+'b')
dict_['1010100'] = dict_['1010110'] = format(43, '#0'+str(no_args+2)+'b')
dict_['1010101'] = dict_['1010111'] = format(44, '#0'+str(no_args+2)+'b')
dict_['1011000'] = dict_['1011010'] = format(45, '#0'+str(no_args+2)+'b')
dict_['1011001'] = dict_['1011011'] = format(46, '#0'+str(no_args+2)+'b')
dict_['1011100'] = dict_['1011110'] = format(47, '#0'+str(no_args+2)+'b')

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dict_['1011101'] = dict_['1011111'] = format(48, '#0'+str(no_args+2)+'b')
dict_['1100000'] = dict_['1100010'] = format(49, '#0'+str(no_args+2)+'b')
dict_['1100001'] = dict_['1100011'] = format(50, '#0'+str(no_args+2)+'b')
dict_['1100100'] = dict_['1100110'] = format(51, '#0'+str(no_args+2)+'b')
dict_['1100101'] = dict_['1100111'] = format(52, '#0'+str(no_args+2)+'b')
dict_['1101000'] = dict_['1101010'] = format(53, '#0'+str(no_args+2)+'b')
dict_['1101001'] = dict_['1101011'] = format(54, '#0'+str(no_args+2)+'b')
dict_['1101100'] = dict_['1101110'] = format(55, '#0'+str(no_args+2)+'b')
dict_['1101101'] = dict_['1101111'] = format(56, '#0'+str(no_args+2)+'b')
dict_['1110000'] = dict_['1110010'] = format(57, '#0'+str(no_args+2)+'b')
dict_['1110001'] = dict_['1110011'] = format(58, '#0'+str(no_args+2)+'b')
dict_['1110100'] = dict_['1110110'] = format(59, '#0'+str(no_args+2)+'b')
dict_['1110101'] = dict_['1110111'] = format(60, '#0'+str(no_args+2)+'b')
dict_['1111000'] = dict_['1111010'] = format(61, '#0'+str(no_args+2)+'b')
dict_['1111001'] = dict_['1111011'] = format(62, '#0'+str(no_args+2)+'b')
dict_['1111100'] = dict_['1111110'] = format(63, '#0'+str(no_args+2)+'b')
dict_['1111101'] = dict_['1111111'] = format(64, '#0'+str(no_args+2)+'b')
return dict_[string_]

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[2]: def getDecimalNo(arr_1, arr_2):
    integer = 0
    n = 2*len(arr_1)
    final_arr = np.concatenate((arr_1,arr_2))
    for i in range(0,n):
        integer = integer + (2**i)*final_arr[n-1-i]
    return integer

```

```

[3]: def create_Uf(f, n):
    binary1 = format(1, '#0'+str(n+2)+'b') #results in a binary string
    ↪ representing 1 with adequate number of 0s given by arity of f
    binary2 = format(0, '#0'+str(n+2)+'b') #results in a binary string
    ↪ representing 0 with adequate number of 0s given by arity of f
    result = {}
    query_list = [int(d) for d in str(binary2)[2:]] #bitstring to send function
    for i in range(pow(2,n)):
        result[binary2] = f(*query_list)
        integer_sum = int(binary1, 2) + int(binary2, 2)
        binary2 = format(integer_sum, '#0'+str(n+2)+'b') #updating the second
        ↪ binary string by adding 1 to get the next input sequence to send f
        query_list = [int(d) for d in str(binary2)[2:]]
        #with the above code we obtained the results of f for all 2**N bitstrings,
        ↪ now we proceed to get Uf for 2**2N bitstrings

    U_f = np.zeros((2**(2*n), 2**(2*n)))
    binary1 = format(1, '#0'+str(n+2)+'b') #results in a binary string
    ↪ representing 1 with adequate number of 0s given by arity of f

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    binary2 = format(0, '#0'+str(n+2)+'b') #results in a binary string
    →representing 0 with adequate number of 0s given by arity of f
    for i in range(pow(2,n)):
        b = format(0, '#0'+str(n+2)+'b')
        bin_num1_arr = np.array([int(d) for d in str(result[binary2])[2:]])
        →#f(x)

        for i in range(pow(2,n)):
            bin_num2_arr = np.array([int(d) for d in str(b)[2:]]) #b
            f_x_b = np.add(bin_num1_arr,bin_num2_arr) %2

            column = getDecimalNo(np.array([int(d) for d in str(binary2)[2:]])
            →f_x_b)

            row = getDecimalNo(np.array([int(d) for d in str(binary2)[2:]])
            →array([int(d) for d in str(b)[2:]]))

            U_f[row][column] = 1

            integer_sum = int(binary1, 2) + int(b, 2)
            b = format(integer_sum, '#0'+str(n+2)+'b')
            integer_sum = int(binary1, 2) + int(binary2, 2)
            binary2 = format(integer_sum, '#0'+str(n+2)+'b')
    return U_f

```

```

[11]: from qiskit import QuantumCircuit, execute, Aer
from qiskit.quantum_info.operators import Operator
from qiskit import assemble, transpile, IBMQ
from qiskit.circuit.library.standard_gates import XGate

provider = IBMQ.
    →save_account('e6634bf2340dd5d1cbf56a01ae9ebc74e1976dfb36f5b353a1185e6f32708fdc971ee1a0b1c21')

def run_program(f, n):
    U_f = create_Uf(f, n)
    N = n*2

    qubit_list=[]

    for i in range(0,int(N)):
        qubit_list.append(i)

    qc = QuantumCircuit(N,N) #create qc with the number of qubits required

    #adding Hadamard gates to all main qubits
    qc.h(range(n,N))

    #create the UF gate

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#uf_gate = Operator(U_f)
#qc.unitary(uf_gate, qubit_list, label = 'uf')

#adding the remaining Hadamards to the main qubits

"""
#for f_6
qc.x(0)

qc.cx(5,0)
qc.cx(5,1)

qc.cx(6,1)

qc.ccx(5,6,2)

qc.cx(7,2)

custom = XGate().control(3)
qc.append(custom, [5,6,7,3])
"""
#for f_7
qc.x(0)

qc.cx(4,0)
qc.cx(4,1)

qc.cx(6,1)

qc.ccx(4,6,2)

qc.cx(7,2)

custom = XGate().control(3)
qc.append(custom, [4,6,7,3])
"""
#for f_9
qc.x(0)

qc.cx(5,0)
qc.cx(5,1)

qc.cx(7,1)

qc.ccx(5,7,2)

qc.cx(8,2)

```

```

custom = XGate().control(3)
qc.append(custom, [5,7,8,3])

qc.cx(9,3)

custom_1 = XGate().control(4)
qc.append(custom_1, [5,7,8,9,4])

#for f_10
qc.x(0)

qc.cx(6,0)
qc.cx(6,1)

qc.cx(8,1)

qc.ccx(6,8,2)

qc.cx(9,2)

custom = XGate().control(3)
qc.append(custom, [6,8,9,3])

qc.cx(10,3)

custom_1 = XGate().control(4)
qc.append(custom_1, [6,8,9,10,4])

qc.cx(11,4)

custom_2 = XGate().control(5)
qc.append(custom_2, [6,8,9,10,11,5])

#for f_11
qc.x(0)

qc.cx(7,0)
qc.cx(7,1)

qc.cx(9,1)

qc.ccx(7,9,2)

qc.cx(10,2)

custom = XGate().control(3)

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qc.append(custom, [7,9,10,3])

qc.cx(11,3)

custom_1 = XGate().control(4)
qc.append(custom_1, [7,9,10,11,4])

qc.cx(12,4)

custom_2 = XGate().control(5)
qc.append(custom_2, [7,9,10,11,12,5])

qc.cx(13,5)

custom_3 = XGate().control(6)
qc.append(custom_3, [7,9,10,11,12,13,6])
"""

qc.h(range(n,N))

qc.measure(qubit_list,qubit_list)

print(qc.draw())

provider = IBMQ.load_account()
backend = provider.backends.ibmq_16_melbourne
qobj = assemble(transpile(qc, backend) , backend, shots=8000)
job = backend.run(qobj)

try:
    result = job.result()
    counts=result.get_counts(qc)
except TimeoutError:
    print("Could not obtain results for N: {}".format(N/2))
    return []

return counts, result.time_taken

```

configrc.store_credentials:WARNING:2020-06-09 20:45:31,077: Credentials already present. Set overwrite=True to overwrite.

```

[5]: import time

#had difficulty coding this section on solving the linear equations,
#took help from a friend who did the course the previous quarter to understand
→the functions and implement them

```

#also referenced book on solving linear equations with mod 2 using gaussian
→ elimination and back substitution

```

def isAllZeros(list_):
    for i in list_:
        if i!=0:
            return False
    return True

def addRow(vectors, z, MSBDict):
    while isAllZeros(z) is False:
        msbOne = z.index(1)
        if msbOne in MSBDict.keys():
            otherRow = MSBDict[msbOne]
            z = list(np.add(np.array(vectors[otherRow]),np.array(z))%2) #update
            →z (adding those two rows with same msb to get reduced row echolon form)
        else:
            break

    if(isAllZeros(z)):
        return vectors, MSBDict
    else:
        msbOne = z.index(1)
        keysList = list(MSBDict.keys())
        row = 0
        for row in range(len(keysList)):
            if keysList[row] > msbOne:
                break
        row+=1
        vectors.insert(row,z)
        MSBDict[z.index(1)]=row

        return vectors, MSBDict

def addLastVector(vectors):
    lastRow = [0 for i in range(len(vectors[0]))]
    lastOne = 0
    for i in range(len(vectors)):
        if vectors[i][i]==1:
            lastOne = i+1
        else:
            break
    lastRow[lastOne]=1 #insert 1 at appropriate msb position
    vectors.insert(lastOne, lastRow) #insert the lastRow in the proper index
    →corresponding to lastOne+1
    return lastRow, vectors

```

```

def getS(f):
    MSBDict = {}
    vectors = []
    n = len(inspect.signature(f).parameters)

    start = time.time()

    results_dict, run_time = run_program(f, n)
    print(results_dict)

    while(len(vectors) != n-1):
        results=[]
        max_key = max(results_dict, key=results_dict.get)
        for val in max_key[0:n]:
            results.append(int(val))
        vectors, MSBDict = addRow(vectors, results, MSBDict)
        del results_dict[max_key]

    end = time.time()
    total_time = end - start

    newRow, vectors = addLastVector(vectors)
    arr_1 = np.array(vectors)
    arr_2 = np.zeros(n)
    arr_2[newRow.index(1)] = 1
    y = np.linalg.solve(arr_1, arr_2)
    y = [i%2 for i in y]
    s = ''
    for i in range(len(y)):
        s+=str(int(y[i]))
    return s, total_time, run_time

```

```
[53]: print(getS(f_0))
```

```
q_0:  X  X  M
```

```
q_1:      X  M
```

```
q_2:  H      H  M
```

```
q_3:  H  H  M
```

```
c_0:
```

```
c_1:
```

c_2:

c_3:

ibmqfactory.load_account:WARNING:2020-06-09 12:40:34,181: Credentials are already in use. The existing account in the session will be replaced.

```
{'0001': 226, '0011': 19, '1101': 1, '0000': 50, '1111': 1, '0111': 7, '0100': 44, '0010': 212, '1001': 5, '0101': 261, '0110': 171, '1110': 3} ('10', 99.0167818069458, 6.21413254737854)
```

```
[54]: print(getS(f_0))
```

q_0: X X M

q_1: X M

q_2: H H M

q_3: H H M

c_0:

c_1:

c_2:

c_3:

ibmqfactory.load_account:WARNING:2020-06-09 12:42:28,665: Credentials are already in use. The existing account in the session will be replaced.

```
{'0001': 214, '0011': 27, '1000': 1, '1101': 3, '0000': 54, '1010': 3, '0111': 20, '0100': 62, '0010': 193, '1001': 2, '0101': 208, '0110': 208, '1110': 5} ('10', 100.06292986869812, 6.574207544326782)
```

```
[55]: print(getS(f_0))
```

q_0: X X M

q_1: X M

q_2: H H M

q_3: H H M

c_0:

c_1:

c_2:

c_3:

ibmqfactory.load_account:WARNING:2020-06-09 12:44:08,815: Credentials are already in use. The existing account in the session will be replaced.

```
{'0001': 250, '0011': 21, '1100': 1, '1101': 2, '0000': 55, '1010': 3, '0111': 20, '0100': 52, '0010': 197, '1001': 4, '0101': 227, '0110': 164, '1110': 4} ('10', 100.9611508846283, 6.274722099304199)
```

```
[27]: print(getS(f_1))
```

q_0: X X M

q_1: X M

q_2: H H M

q_3: H H M

c_0:

c_1:

c_2:

c_3:

ibmqfactory.load_account:WARNING:2020-06-09 12:11:21,996: Credentials are already in use. The existing account in the session will be replaced.

```
{'1011': 31, '0001': 81, '0011': 30, '1000': 25, '1100': 36, '1101': 90, '0000': 32, '1010': 92, '1111': 39, '0100': 33, '0101': 118, '1110': 87, '1001': 70, '0010': 99, '0110': 86, '0111': 51} ('01', 28.360081911087036, 7.659609079360962)
```

```
[28]: print(getS(f_1))
```

q_0: X X M

```

q_1:          X          M
q_2:  H        H        M
q_3:  H                H    M
c_0:
c_1:
c_2:
c_3:

```

```
ibmqfactory.load_account:WARNING:2020-06-09 12:11:50,251: Credentials are
already in use. The existing account in the session will be replaced.
```

```
{'1011': 30, '0001': 71, '0011': 45, '1000': 30, '1100': 32, '1101': 88, '0000':
41, '1010': 94, '1111': 44, '0100': 38, '0101': 118, '1110': 90, '1001': 56,
'0010': 76, '0110': 92, '0111': 55}
('01', 40.26495909690857, 7.399591445922852)
```

```
[29]: print(getS(f_1))
```

```

q_0:  X   X          M
q_1:          X          M
q_2:  H        H        M
q_3:  H                H    M
c_0:
c_1:
c_2:
c_3:

```

```
ibmqfactory.load_account:WARNING:2020-06-09 12:12:30,604: Credentials are
already in use. The existing account in the session will be replaced.
```

```
{'1011': 34, '0001': 76, '0011': 55, '1000': 31, '1100': 20, '1101': 78, '0000':
44, '1010': 90, '1111': 42, '0100': 28, '0101': 111, '1110': 82, '1001': 64,
'0010': 81, '0110': 100, '0111': 64}
('01', 48.61923789978027, 8.128834962844849)
```

```
[60]: print(getS(f_4))
```

```
q_0:  X  X    X      X    M
q_1:      X    X    M
q_2:          X    M
q_3:  H              H    M
q_4:  H  H  M
q_5:  H              H    M
c_0:
c_1:
c_2:
c_3:
c_4:
c_5:
```

```
ibmqfactory.load_account:WARNING:2020-06-09 13:45:16,672: Credentials are
already in use. The existing account in the session will be replaced.
```

```
{'010110': 1, '011000': 4, '000001': 44, '101111': 12, '000011': 16, '001100':
36, '010111': 2, '001101': 33, '100100': 40, '100010': 12, '100011': 20,
'111010': 3, '111000': 2, '101110': 17, '010011': 2, '101000': 48, '010000': 2,
'010101': 1, '111101': 3, '101010': 22, '011100': 4, '011010': 2, '011011': 4,
'101011': 21, '101101': 30, '001001': 39, '011110': 1, '101001': 45, '000111':
13, '001011': 16, '001000': 56, '100001': 45, '110010': 1, '010001': 5,
'000000': 55, '101100': 37, '010100': 1, '110100': 1, '000100': 42, '001010':
26, '001111': 19, '010010': 1, '111100': 3, '100101': 29, '100110': 14,
'111011': 1, '100000': 43, '000101': 38, '001110': 21, '110001': 3, '100111':
13, '011101': 2, '110101': 1, '111001': 1, '110000': 1, '000010': 28, '000110':
16, '111110': 2}
('010', 348.18765592575073, 6.6683619022369385)
```

```
[61]: print(getS(f_4))
```

```
q_0:  X  X    X      X    M
```

```

q_1:      X      X      M

q_2:              X      M

q_3:  H                      H      M

q_4:  H      H      M

q_5:  H                      H      M

c_0:

c_1:

c_2:

c_3:

c_4:

c_5:

```

```
ibmqfactory.load_account:WARNING:2020-06-09 13:51:04,812: Credentials are
already in use. The existing account in the session will be replaced.
```

```

{'010110': 2, '011000': 3, '000001': 36, '011001': 1, '101111': 18, '000011':
21, '001100': 43, '001101': 37, '100100': 31, '100010': 21, '100011': 21,
'111010': 2, '111000': 3, '101110': 22, '111111': 1, '010011': 2, '101000': 46,
'110011': 2, '010000': 2, '010101': 1, '101010': 29, '011100': 2, '011010': 2,
'101011': 29, '101101': 23, '001001': 42, '011110': 1, '101001': 51, '000111':
14, '001011': 25, '110110': 1, '100001': 41, '110010': 1, '001000': 36,
'000000': 43, '101100': 34, '010100': 1, '110100': 1, '000100': 41, '001010':
25, '001111': 11, '010010': 2, '111100': 2, '100101': 38, '100110': 17,
'111011': 1, '100000': 48, '000101': 26, '001110': 24, '110001': 2, '100111':
12, '011101': 4, '110101': 4, '111001': 3, '000010': 27, '000110': 20, '111110':
2}
('010', 353.38071274757385, 6.902806282043457)

```

```
[62]: print(getS(f_4))
```

```

q_0:  X      X      X              X      M

q_1:      X      X      M

q_2:              X      M

q_3:  H                      H      M

```


q_4: H H M

q_5: H H M

c_0:

c_1:

c_2:

c_3:

c_4:

c_5:

ibmqfactory.load_account:WARNING:2020-06-09 13:56:58,223: Credentials are already in use. The existing account in the session will be replaced.

```
{'010110': 1, '011000': 4, '000001': 49, '011001': 5, '101111': 25, '000011': 40, '001100': 16, '010111': 6, '001101': 31, '100100': 19, '100010': 22, '100011': 27, '111010': 1, '111000': 1, '101110': 17, '111111': 2, '010011': 6, '101000': 28, '110011': 3, '010000': 3, '010101': 3, '111101': 1, '101010': 19, '011100': 2, '011010': 3, '011011': 4, '101011': 24, '101101': 34, '001001': 43, '110111': 2, '101001': 38, '000111': 49, '001011': 41, '110110': 1, '100001': 32, '110010': 4, '001000': 38, '010001': 6, '000000': 27, '101100': 26, '010100': 1, '110100': 3, '000100': 22, '011111': 5, '001010': 23, '001111': 29, '010010': 4, '111100': 2, '100101': 30, '100110': 15, '111011': 6, '100000': 24, '000101': 46, '001110': 15, '110001': 7, '100111': 16, '011101': 3, '110101': 2, '111001': 2, '110000': 1, '000010': 16, '000110': 22, '111110': 3}
('010', 261.1162357330322, 6.710815668106079)
```

[64]: `print(getS(f_3))`

q_0: X X X X M

q_1: X X M

q_2: X M

q_3: H H M

q_4: H H M

q_5: H H M

c_0:

c_1:

c_2:

c_3:

c_4:

c_5:

ibmqfactory.load_account:WARNING:2020-06-09 14:04:01,345: Credentials are already in use. The existing account in the session will be replaced.

```
{'010110': 13, '011000': 3, '000001': 49, '011001': 1, '101111': 1, '000011': 35, '001100': 2, '010111': 16, '001101': 1, '100100': 35, '100010': 19, '100011': 27, '111000': 1, '101110': 1, '010011': 26, '101000': 1, '110011': 24, '010000': 44, '010101': 33, '101010': 2, '011100': 3, '101011': 1, '001001': 3, '011110': 1, '110111': 18, '101001': 1, '000111': 18, '001011': 2, '110110': 19, '100001': 49, '110010': 12, '010001': 60, '000000': 53, '101100': 2, '010100': 27, '110100': 29, '000100': 31, '011111': 3, '001010': 2, '001111': 1, '010010': 34, '100101': 34, '100110': 15, '000101': 30, '100000': 38, '110001': 53, '100111': 17, '110101': 39, '111001': 1, '110000': 32, '000010': 22, '000110': 15, '111110': 1}
('001', 211.52648901939392, 6.7166907787323)
```

```
[65]: print(getS(f_3))
```

q_0: X X X X M

q_1: X X M

q_2: X M

q_3: H H M

q_4: H H M

q_5: H H M

c_0:

c_1:

c_2:

c_3:

c_4:

c_5:

ibmqfactory.load_account:WARNING:2020-06-09 14:07:32,907: Credentials are already in use. The existing account in the session will be replaced.

```
{'010110': 34, '011000': 2, '000001': 39, '011001': 2, '101111': 1, '000011': 18, '010111': 22, '001101': 1, '100100': 29, '100010': 31, '100011': 20, '111010': 1, '101110': 1, '010011': 24, '101000': 1, '110011': 23, '010000': 45, '010101': 35, '111101': 2, '101010': 1, '011010': 1, '011011': 1, '101011': 2, '101101': 1, '001001': 3, '011110': 2, '110111': 15, '101001': 2, '000111': 25, '001011': 2, '110110': 21, '100001': 37, '110010': 25, '001000': 1, '010001': 33, '000000': 50, '101100': 1, '010100': 33, '110100': 33, '000100': 42, '011111': 1, '001010': 1, '010010': 31, '100101': 14, '100110': 21, '111011': 1, '100000': 64, '000101': 29, '001110': 2, '110001': 26, '100111': 14, '110101': 27, '111001': 1, '110000': 44, '000010': 42, '000110': 20}
('001', 158.92324900627136, 6.829826831817627)
```

```
[66]: print(getS(f_3))
```

q_0: X X X X M

q_1: X X M

q_2: X M

q_3: H H M

q_4: H H M

q_5: H H M

c_0:

c_1:

c_2:

c_3:

c_4:

c_5:

ibmqfactory.load_account:WARNING:2020-06-09 14:10:11,831: Credentials are already in use. The existing account in the session will be replaced.

```
{'010110': 17, '011000': 2, '000001': 43, '011001': 1, '101111': 2, '000011': 26, '001100': 3, '010111': 23, '001101': 3, '100100': 46, '100010': 23, '100011': 20, '111010': 6, '111000': 2, '111111': 1, '010011': 16, '101000': 3, '110011': 22, '010000': 37, '010101': 26, '111101': 4, '011010': 2, '101011': 1, '101101': 1, '001001': 5, '011110': 2, '110111': 22, '101001': 4, '000111': 23, '001011': 3, '110110': 19, '100001': 28, '110010': 25, '001000': 3, '010001': 24, '000000': 36, '101100': 1, '010100': 37, '110100': 42, '000100': 49, '010010': 21, '111100': 1, '100101': 42, '100110': 21, '111011': 1, '100000': 40, '000101': 35, '110001': 24, '100111': 23, '011101': 2, '110101': 31, '110000': 39, '000010': 41, '000110': 26}
('001', 310.71233320236206, 6.591018915176392)
```

```
[11]: print(getS(f_6))
```

```
q_0:  X  X      M
q_1:      X      X  M
q_2:      X      X  M
q_3:      X      M
q_4:  H      H      M
q_5:  H      H      M
q_6:  H      H      M
q_7:  H      H      M
c_0:
c_1:
c_2:
c_3:
c_4:
c_5:
c_6:
```

c_7:

ibmqfactory.load_account:WARNING:2020-06-09 17:20:16,271: Credentials are already in use. The existing account in the session will be replaced.

```
{'11100011': 1, '01111000': 2, '01010110': 1, '00001111': 1, '11101011': 2,
'00011101': 1, '11000100': 12, '01110010': 1, '00000001': 9, '01100101': 2,
'00001110': 1, '10000010': 11, '10001111': 1, '01100010': 8, '01001011': 4,
'11000001': 7, '01000101': 2, '10000001': 7, '01100001': 6, '11001100': 12,
'00111010': 3, '10101111': 1, '01001000': 25, '01011110': 2, '01010001': 1,
'10000011': 2, '10011100': 2, '11011100': 1, '01000110': 4, '10111000': 3,
'00110001': 1, '10001110': 3, '10101000': 20, '11100001': 1, '10111001': 1,
'11100110': 2, '10001010': 12, '00000100': 15, '10101010': 10, '00000101': 3,
'10110000': 6, '00100010': 5, '11001001': 4, '01011000': 4, '10101101': 1,
'10110110': 1, '10101100': 13, '01110100': 2, '01100110': 1, '00110000': 2,
'10001100': 11, '10101001': 4, '10111100': 2, '11001010': 10, '00010010': 4,
'01000111': 5, '11100010': 2, '01011010': 1, '11111100': 2, '11011001': 1,
'01101110': 2, '10001000': 22, '00010001': 3, '10111010': 1, '01011011': 1,
'01110000': 6, '11000000': 23, '01100100': 7, '10000000': 23, '00001101': 1,
'01111100': 1, '11000010': 12, '10100110': 4, '01011100': 1, '00011100': 2,
'11101101': 2, '00100111': 1, '01000010': 5, '01001101': 1, '11001101': 3,
'01110001': 1, '11100100': 11, '00001010': 3, '11111000': 3, '00100110': 1,
'00010000': 4, '10001011': 1, '10010000': 3, '00111000': 5, '01000011': 1,
'01000100': 12, '01000001': 2, '10000101': 1, '11101110': 1, '01100000': 28,
'10100011': 1, '11001110': 5, '11101001': 2, '10100001': 5, '10111011': 2,
'00100000': 30, '01101101': 2, '11010010': 2, '10011101': 1, '10100101': 1,
'10100100': 8, '11000111': 1, '11110010': 1, '00101000': 30, '10110011': 1,
'11101100': 15, '00000000': 30, '01011111': 1, '11011110': 1, '00100001': 4,
'10011110': 3, '01101000': 25, '01001110': 1, '01101010': 4, '10010100': 1,
'11000110': 5, '00000010': 11, '01001001': 2, '11101000': 15, '00110010': 1,
'00010011': 1, '11110000': 6, '00001001': 6, '00100100': 8, '11010110': 1,
'00100011': 4, '01010000': 1, '11100111': 1, '00000110': 6, '10110100': 4,
'11001000': 14, '01100011': 4, '11010000': 2, '10011001': 1, '00101101': 4,
'10000110': 2, '01001100': 17, '11101010': 9, '00001011': 1, '11111010': 1,
'00001100': 4, '11010100': 2, '00010100': 1, '10100000': 26, '00101100': 14,
'10000100': 16, '11011000': 1, '11000101': 2, '00100101': 1, '00111100': 3,
'00010110': 1, '01101001': 4, '00101001': 7, '10101110': 1, '11010011': 1,
'11100000': 27, '01001010': 5, '11110100': 2, '11110001': 1, '01111011': 1,
'01000000': 26, '10101011': 3, '00001000': 27, '01101011': 1, '01101100': 10,
'10111111': 2, '11010001': 1, '11101111': 1, '00010101': 1, '10011000': 2,
'10100010': 7, '10001001': 2, '01101111': 1, '00000011': 2, '00011001': 1,
'00101010': 7}
```

('0001', 36.11853003501892, 6.915039777755737)

```
[12]: print(getS(f_6))
```

q_0: X X M

q_1: X X M
 q_2: X X M
 q_3: X M
 q_4: H H M
 q_5: H H M
 q_6: H H M
 q_7: H H M
 c_0:
 c_1:
 c_2:
 c_3:
 c_4:
 c_5:
 c_6:
 c_7:

ibmqfactory.load_account:WARNING:2020-06-09 17:21:58,368: Credentials are already in use. The existing account in the session will be replaced.

```
{'11001111': 4, '01111000': 7, '01010110': 3, '11101011': 1, '00110100': 1,
'00111001': 4, '00011101': 1, '11000100': 8, '01110010': 3, '00011011': 1,
'00000001': 5, '01100101': 3, '01010111': 1, '10010010': 2, '00001110': 3,
'10110111': 1, '10000010': 7, '10001111': 1, '01100010': 5, '00111110': 2,
'01001011': 2, '11000001': 4, '11110110': 3, '01000101': 2, '10000001': 6,
'01100001': 6, '11001100': 6, '00111010': 3, '10101111': 1, '10000111': 2,
'11110011': 2, '01001000': 12, '01011110': 1, '01010001': 4, '01011001': 1,
'10011100': 1, '11011100': 3, '01000110': 1, '10111000': 9, '00110001': 3,
'10001110': 5, '10101000': 15, '11100001': 8, '10111001': 2, '11100110': 2,
'10001010': 3, '11111101': 2, '00000100': 9, '10101010': 6, '00000101': 7,
'10110000': 10, '00100010': 6, '11001001': 6, '10110001': 1, '01011000': 8,
'10101101': 3, '00011010': 3, '10110010': 3, '00111101': 2, '10101100': 3,
'01111001': 3, '01110100': 4, '01100110': 3, '00110000': 7, '10001100': 10,
'10101001': 10, '00011000': 4, '10111100': 4, '00010010': 1, '01000111': 2,
```

```

'11001010': 3, '11100010': 4, '01011010': 2, '11111100': 4, '01101110': 1,
'10001000': 13, '00010001': 4, '10111010': 2, '01011011': 1, '01110000': 8,
'11000000': 9, '10010001': 2, '01100100': 10, '00110101': 1, '10000000': 11,
'00001101': 4, '01111100': 4, '11000010': 4, '11111110': 3, '01011100': 1,
'00110111': 1, '00011100': 3, '11101101': 1, '00100111': 1, '00011111': 1,
'01000010': 3, '10111101': 1, '01001101': 2, '11001101': 4, '01110001': 5,
'11100100': 5, '00001010': 1, '11111000': 6, '00100110': 7, '00010000': 11,
'10010000': 5, '11001011': 3, '00111000': 11, '01010100': 4, '01110011': 1,
'01000100': 8, '11111011': 1, '01000001': 9, '10000101': 3, '11101110': 1,
'01100000': 19, '10100011': 2, '11001110': 2, '11101001': 6, '10100001': 9,
'11111001': 4, '11110101': 2, '00100000': 26, '01101101': 3, '11010010': 1,
'11000111': 1, '10100101': 5, '10100100': 10, '11110010': 4, '00101000': 15,
'01010011': 1, '11101100': 4, '11100101': 3, '00000000': 14, '10111110': 3,
'00101110': 4, '11011110': 2, '00101011': 2, '01001111': 1, '00100001': 13,
'10011110': 2, '01101000': 15, '11011101': 1, '00111111': 1, '01101010': 8,
'10010100': 5, '11000110': 4, '00000010': 7, '01001001': 3, '11010111': 1,
'00110010': 2, '00010011': 1, '11101000': 11, '11110000': 6, '00001001': 9,
'00100100': 12, '00100011': 2, '10001101': 2, '01010000': 4, '10010110': 3,
'11100111': 1, '00000110': 4, '10110100': 1, '11001000': 16, '11010000': 8,
'10011001': 1, '00101101': 4, '10000110': 2, '01111111': 1, '01001100': 8,
'11101010': 5, '00001011': 2, '11111010': 1, '00001100': 6, '00000111': 3,
'11010100': 3, '00010100': 3, '10100000': 16, '00101100': 8, '11011010': 1,
'10000100': 4, '11011000': 7, '11000101': 2, '00010111': 2, '10011010': 1,
'00100101': 3, '00111100': 3, '01101001': 11, '01010010': 3, '00101001': 6,
'10101110': 4, '11010011': 1, '01111101': 2, '01001010': 8, '11100000': 17,
'11110001': 2, '01111011': 1, '11011011': 1, '11110100': 8, '01000000': 13,
'10101011': 1, '00001000': 23, '01101011': 1, '01101100': 10, '11010001': 3,
'00110011': 3, '01111010': 2, '11101111': 2, '00010101': 2, '10011000': 8,
'10010011': 1, '10100010': 5, '10011111': 1, '10001001': 3, '01101111': 2,
'00000011': 1, '00011001': 2, '00101010': 6}
('0001', 35.780829191207886, 6.919490575790405)

```

```
[13]: print(getS(f_6))
```

```

q_0:  X  X      M

q_1:      X      X  M

q_2:      X      X  M

q_3:      X      M

q_4:  H      H      M

q_5:  H      H      M

q_6:  H      H      M

```

H	M
---	---

$c_0:$

c_1:

c_2:

c_3:

c_4:

c_5:

c_6:

c_7:

```
ibmqfactory.load_account:WARNING:2020-06-09 17:23:02,573: Credentials are
already in use. The existing account in the session will be replaced.
```

```
{
  '11100011': 3, '01111000': 10, '01010110': 1, '01010101': 1, '11101011': 1,
  '00110100': 4, '00111001': 2, '00011101': 2, '11000100': 6, '01110010': 2,
  '00011011': 1, '00000001': 4, '01100101': 1, '10010010': 2, '00001110': 3,
  '10000010': 3, '10001111': 2, '01100010': 9, '11110110': 2, '01001011': 1,
  '11000001': 7, '01000101': 1, '10000001': 6, '01100001': 6, '11001100': 10,
  '00111010': 3, '01001000': 18, '01011110': 1, '10000011': 3, '10011100': 4,
  '11011100': 3, '01000110': 3, '10111000': 5, '00110001': 2, '10001110': 3,
  '10101000': 18, '11100001': 8, '10111001': 2, '10001010': 8, '00000100': 10,
  '10101010': 9, '00000101': 4, '10110000': 7, '11000011': 1, '00100010': 4,
  '11001001': 9, '10110001': 1, '01011000': 7, '10101101': 2, '00011010': 1,
  '10110010': 2, '00111101': 1, '10101100': 1, '10110110': 1, '01110100': 6,
  '01100110': 4, '00110000': 8, '10001100': 10, '10101001': 7, '00011000': 5,
  '10111100': 5, '00010010': 3, '11001010': 6, '11100010': 10, '01011010': 3,
  '11111100': 4, '11011001': 2, '01101110': 1, '10001000': 25, '00010001': 2,
  '10111010': 3, '01011011': 1, '01110000': 6, '11000000': 13, '10010001': 4,
  '01100100': 9, '10000000': 27, '00001101': 3, '01111100': 3, '11000010': 4,
  '10100110': 2, '11111110': 2, '01011100': 1, '00110111': 1, '00011100': 4,
  '11101101': 4, '00100111': 2, '10111101': 2, '01000010': 1, '01001101': 1,
  '11001101': 1, '11100100': 6, '00001010': 8, '11111000': 6, '00100110': 1,
  '00010000': 6, '10001011': 2, '10010000': 8, '11001011': 1, '00111000': 13,
  '01010100': 1, '00111011': 1, '01000100': 7, '01000001': 6, '10000101': 2,
  '01100000': 15, '10100011': 1, '11001110': 4, '11101001': 5, '10100001': 7,
  '11111001': 3, '00100000': 21, '01101101': 2, '11010010': 2, '10011101': 2,
  '00101111': 2, '10100100': 9, '10100101': 2, '11000111': 1, '11110010': 1,
  '00101000': 12, '11010101': 2, '11101100': 10, '00000000': 28, '01011111': 1,
  '00101110': 2, '10111110': 1, '11011110': 1, '00101011': 1, '01001111': 1,
}
```



```
'00100001': 4, '10011110': 1, '01101000': 19, '01001110': 3, '01101010': 6,
'10010100': 5, '11000110': 1, '00000010': 11, '01001001': 4, '11101000': 17,
'11110000': 4, '00001001': 3, '00100100': 11, '01110101': 2, '11010110': 2,
'10100111': 1, '00100011': 4, '10001101': 1, '01010000': 5, '10010110': 1,
'10110101': 2, '00000110': 1, '10110100': 5, '11001000': 17, '01100011': 1,
'11010000': 12, '00101101': 3, '10000110': 2, '01001100': 3, '11101010': 6,
'00001011': 1, '00001100': 14, '00000111': 3, '11010100': 2, '00010100': 6,
'10100000': 15, '00101100': 7, '11011010': 1, '10000100': 6, '11011000': 8,
'11000101': 2, '00011110': 1, '10011010': 5, '00100101': 4, '00010110': 3,
'01101001': 6, '01010010': 3, '00101001': 3, '10101110': 1, '11010011': 1,
'11100000': 15, '01001010': 7, '11110100': 4, '11110001': 2, '01111011': 1,
'01000000': 13, '10101011': 1, '00001000': 28, '01101100': 8, '11010001': 1,
'01111010': 4, '11101111': 1, '00010101': 3, '10011000': 9, '10100010': 5,
'10011111': 1, '10001001': 4, '00000011': 3, '00011001': 5, '00101010': 6}
('0001', 33.51577425003052, 6.975473403930664)
```

```
[16]: print(getS(f_7))
```

```
q_0:  X  X  M
```

```
q_1:      X  X  M
```

```
q_2:          X  X  M
```

```
q_3:              X  M
```

```
q_4:  H              H  M
```

```
q_5:  H  H  M
```

```
q_6:  H              H  M
```

```
q_7:  H              H  M
```

```
c_0:
```

```
c_1:
```

```
c_2:
```

```
c_3:
```

```
c_4:
```

```
c_5:
```

```
c_6:
```

c_7:

ibmqfactory.load_account:WARNING:2020-06-09 17:24:33,506: Credentials are already in use. The existing account in the session will be replaced.

```
{'01111110': 1, '01111000': 9, '01010110': 2, '00001111': 1, '01010101': 3,
'11101011': 1, '00110100': 3, '00011101': 2, '11000100': 7, '01110010': 1,
'00011011': 4, '00000001': 6, '10010010': 4, '00001110': 2, '01011101': 1,
'10000010': 8, '01100010': 3, '11110110': 1, '11000001': 4, '01000101': 1,
'10000001': 4, '01100001': 3, '11001100': 6, '00111010': 2, '11110011': 1,
'01001000': 22, '01011110': 1, '01010001': 5, '01011001': 5, '10011100': 6,
'11011100': 8, '01000110': 5, '10111000': 8, '00110001': 1, '10101000': 10,
'11100001': 1, '10111001': 1, '11111101': 1, '10001010': 5, '00000100': 8,
'10101010': 2, '00000101': 1, '10110000': 13, '11000011': 1, '00100010': 2,
'10110001': 1, '01011000': 18, '00011010': 5, '10110010': 3, '10110110': 2,
'10101100': 6, '01111001': 2, '01110100': 2, '10001100': 4, '00110000': 11,
'10101001': 1, '10111100': 3, '00011000': 16, '11001010': 5, '00010010': 7,
'01000111': 1, '11100010': 1, '01011010': 7, '11111100': 7, '10001000': 20,
'00010001': 6, '10010101': 2, '10111010': 3, '01011011': 1, '01110000': 15,
'10010111': 1, '11000000': 20, '10010001': 7, '01100100': 2, '00110101': 2,
'10000000': 16, '01111100': 1, '11000010': 9, '10100110': 1, '01011100': 4,
'00011100': 10, '00011111': 1, '01000010': 4, '10111101': 2, '01001101': 2,
'01110001': 2, '11100100': 3, '00001010': 3, '11111000': 4, '00010000': 28,
'10001011': 1, '10010000': 25, '00111000': 10, '01010100': 7, '01000100': 8,
'11111011': 1, '01000001': 4, '11101110': 1, '01100000': 11, '11111001': 1,
'11001110': 1, '11101001': 3, '10100001': 4, '11110101': 1, '10111011': 1,
'00100000': 7, '01101101': 1, '11010010': 6, '10011101': 1, '11000111': 1,
'10100100': 2, '11110010': 1, '00101000': 9, '11010101': 1, '11101100': 2,
'01110110': 1, '00000000': 26, '10111110': 1, '11011110': 3, '00101011': 2,
'01001111': 1, '00100001': 2, '10011110': 4, '01101000': 12, '01001110': 2,
'11011101': 2, '01101010': 3, '10010100': 8, '11000110': 3, '00000010': 12,
'01001001': 5, '11101000': 7, '00110010': 2, '00010011': 2, '11110000': 3,
'00001001': 10, '00100100': 3, '11010110': 3, '10100111': 1, '00100011': 1,
'01010000': 20, '00000110': 1, '10110100': 5, '11001000': 17, '11010000': 17,
'10011001': 1, '00101101': 2, '10000110': 1, '01001100': 7, '11101010': 6,
'00001011': 2, '11111010': 2, '00001100': 12, '00000111': 1, '11010100': 6,
'00010100': 9, '10100000': 5, '00101100': 5, '11011010': 3, '10000100': 1,
'11011000': 15, '11000101': 2, '00010111': 1, '00011110': 2, '10011010': 5,
'00100101': 1, '00111100': 2, '00010110': 3, '01101001': 1, '01010010': 5,
'00101001': 2, '11100000': 10, '01111101': 2, '01001010': 8, '11110100': 2,
'11110001': 1, '01111011': 1, '11011011': 2, '01000000': 38, '10101011': 2,
'00001000': 22, '01101100': 2, '11010001': 4, '00110011': 3, '01111010': 4,
'00010101': 2, '10011000': 30, '10100010': 3, '10001001': 7, '00000011': 2,
'00011001': 3, '00101010': 4}
```

('0010', 34.428749084472656, 7.037915945053101)

```
[17]: print(getS(f_7))
```

q_0: X X M

q_1: X X M

q_2: X X M

q_3: X M

q_4: H H M

q_5: H H M

q_6: H H M

q_7: H H M

c_0:

c_1:

c_2:

c_3:

c_4:

c_5:

c_6:

c_7:

ibmqfactory.load_account:WARNING:2020-06-09 17:25:11,600: Credentials are already in use. The existing account in the session will be replaced.

```
{'11001111': 1, '01111000': 4, '11100011': 3, '00001111': 1, '01010101': 2,
'00110100': 3, '00111001': 1, '00011101': 1, '11000100': 6, '01110010': 2,
'01100111': 2, '00011011': 2, '00000001': 3, '01100101': 2, '01010111': 1,
'10010010': 9, '00001110': 2, '01011101': 2, '10110111': 1, '10000010': 4,
'01100010': 3, '11110110': 2, '01001011': 2, '11000001': 2, '01000101': 2,
'11001100': 6, '01100001': 3, '10011011': 1, '01001000': 22, '01011110': 1,
'01010001': 6, '01011001': 5, '10000011': 3, '10011100': 9, '11011100': 8,
'01000110': 3, '10111000': 12, '00110001': 4, '10001110': 1, '10101000': 8,
'11100001': 3, '10111001': 3, '11100110': 2, '10001010': 4, '00000100': 9,
```

```

'10101010': 2, '00000101': 2, '10110000': 9, '00100010': 2, '11001001': 4,
'01110111': 2, '10110001': 1, '01011000': 10, '00011010': 7, '10110010': 2,
'00111101': 3, '10101100': 6, '10110110': 2, '01111001': 2, '01110100': 6,
'01100110': 3, '00110000': 5, '10001100': 4, '10101001': 1, '00011000': 26,
'10111100': 5, '00010010': 7, '01000111': 2, '11001010': 5, '11100010': 2,
'01011010': 3, '11111100': 7, '11011001': 4, '01101110': 2, '10001000': 8,
'00010001': 7, '10010101': 4, '10111010': 2, '01011011': 1, '01110000': 12,
'10010111': 2, '11000000': 8, '10010001': 3, '01100100': 3, '10000000': 13,
'00001101': 1, '01111100': 3, '11000010': 3, '10100110': 3, '11111110': 1,
'01011100': 8, '00011100': 14, '10111101': 1, '01000010': 4, '01110001': 1,
'11100100': 6, '00001010': 4, '11111000': 11, '00010000': 14, '10001011': 1,
'10010000': 21, '11001011': 1, '00111000': 6, '01010100': 5, '00111011': 1,
'01110011': 2, '01000100': 9, '01000001': 2, '10000101': 2, '11101110': 2,
'01100000': 13, '11111001': 1, '11001110': 2, '00110110': 2, '10100001': 2,
'11101001': 7, '00100000': 16, '01101101': 1, '11010010': 3, '10011101': 3,
'10100101': 1, '10100100': 4, '11110010': 3, '00101000': 18, '01010011': 3,
'11010101': 2, '10110011': 2, '11101100': 6, '01110110': 1, '00000000': 22,
'01011111': 1, '00101110': 1, '10111110': 2, '11011110': 2, '00101011': 1,
'00100001': 3, '10011110': 3, '01101000': 11, '01001110': 1, '11011101': 1,
'01101010': 6, '10010100': 12, '11000110': 2, '00000010': 3, '01001001': 1,
'11101000': 9, '00110010': 5, '11110000': 11, '00001001': 5, '00100100': 6,
'01110101': 1, '11010110': 5, '00100011': 1, '10001101': 1, '01010000': 19,
'10010110': 3, '10110101': 1, '00000110': 1, '10110100': 6, '11100111': 1,
'11001000': 14, '01100011': 1, '11010000': 18, '10011001': 4, '00101101': 1,
'10000110': 4, '01001100': 6, '11101010': 3, '00001011': 2, '11111010': 2,
'00001100': 7, '11010100': 7, '00010100': 5, '10100000': 12, '00101100': 8,
'11011010': 6, '10000100': 14, '11011000': 14, '00010111': 2, '00011110': 2,
'10011010': 3, '00100101': 1, '00111100': 6, '00010110': 4, '01101001': 3,
'11111111': 1, '01010010': 4, '00101001': 4, '10101110': 2, '11010011': 2,
'01111101': 1, '01001010': 2, '11100000': 6, '11110001': 5, '01111011': 1,
'11110100': 8, '01000000': 15, '10101011': 1, '00001000': 23, '01101100': 4,
'11010001': 3, '00110011': 2, '01111010': 2, '11101111': 2, '00010101': 1,
'10011000': 9, '10100010': 5, '10011111': 1, '10001001': 2, '00011001': 2,
'00101010': 5}
('0010', 34.77624583244324, 6.8556599617004395)

```

```
[7]: print(getS(f_7))
```

ibmqfactory.load_account:WARNING:2020-06-09 17:44:30,906: Credentials are already in use. The existing account in the session will be replaced.

```
q_0:  X  X  M
```

```
q_1:      X  X  M
```

```
q_2:          X  X  M
```

q_3: X M

q_4: H H M

q_5: H H M

q_6: H H M

q_7: H H M

c_0:

c_1:

c_2:

c_3:

c_4:

c_5:

c_6:

c_7:

```
{'10011110': 4, '01011001': 4, '01100001': 1, '11001000': 15, '10101010': 2,
'11010010': 6, '11010100': 13, '01011010': 2, '11100010': 3, '11111100': 4,
'10000100': 17, '01011110': 3, '10110000': 5, '10000001': 2, '01100100': 1,
'00001001': 3, '10000101': 2, '11000110': 4, '01110100': 4, '00100000': 3,
'10010101': 2, '00011110': 1, '00000111': 1, '11111010': 2, '11000000': 35,
'11111000': 4, '11111110': 1, '00000010': 6, '00011101': 4, '10011111': 1,
'11011010': 2, '01010000': 27, '10010001': 2, '00010000': 17, '10011100': 12,
'01101010': 1, '11011101': 2, '01110110': 2, '01110000': 6, '01010010': 5,
'00111000': 5, '01101001': 1, '11000101': 3, '10001001': 5, '10111101': 1,
'00100100': 3, '00001110': 6, '00001010': 8, '11011100': 10, '01111010': 2,
'00110100': 3, '10000111': 2, '10011101': 1, '10001010': 4, '01001001': 4,
'10010000': 26, '00101100': 3, '10111100': 2, '11110001': 1, '00101110': 1,
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'11010110': 4, '10010111': 1, '11011000': 17, '01000001': 7, '10001000': 15,
'11000001': 4, '10000000': 38, '01011100': 5, '00010110': 3, '00101111': 2,
'00000011': 1, '00000100': 18, '01010101': 1, '11001001': 4, '10011001': 3,
'10100000': 8, '01001101': 2, '10100001': 1, '11111011': 1, '10011010': 5,
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'01101011': 1, '00001000': 23, '10110110': 1, '00000110': 2, '00011100': 12,
```

```
'01001000': 22, '10100100': 3, '01001110': 1, '01000110': 5, '11110000': 6,
'00011000': 10, '01101100': 6, '00011111': 1, '01010100': 17, '01111000': 4,
'01100010': 1, '10000011': 1, '11100100': 4, '11011110': 1, '11100101': 1,
'00001100': 13, '10001100': 7, '10110010': 1, '00100101': 1, '10010011': 2,
'10011000': 23, '00110001': 1, '11001010': 6, '00110000': 5, '00111100': 3,
'01001100': 9, '10001111': 1, '10100110': 1, '01010110': 4, '00101010': 2,
'11110001': 1, '11100000': 5, '11101010': 1, '00010001': 3, '01010001': 7,
'10110001': 2, '11101000': 4, '11001101': 1, '10111000': 8, '11110110': 1,
'00101000': 3, '00000000': 34, '11010101': 4, '01100000': 4, '01101110': 1,
'10010100': 13, '10100010': 1, '11010001': 1, '01110010': 1, '11001100': 9,
'00011010': 4, '00010010': 5, '01000100': 21, '01001111': 1, '00110110': 1,
'10000110': 5, '01000010': 11, '01001010': 7, '00010101': 1, '11001110': 1,
'10110100': 2, '10101100': 4, '11011001': 2, '01000000': 23, '10111001': 1,
'11000100': 6, '10001101': 1, '00000001': 6, '10010110': 3}
('0010', 28.634033203125, 6.97238826751709)
```

```
[6]: print(getS(f_9))
```

```
q_0:  X  X  M                                »
q_1:      X  X  M                                »
q_2:          X  X  M                                »
q_3:              X  X  M                                »
q_4:                  X  M                                »
q_5:  H                                H  M  »
q_6:  H  H  M                                »
q_7:  H                                H  M  »
q_8:  H                                H  M  »
q_9:  H                                H  »
c_0:                                »
c_1:                                »
c_2:                                »
c_3:                                »
c_4:                                »
```

			»
c_5:	»		
			»
c_6:	»		
			»
c_7:	»		
			»
c_8:	»		
			»
c_9:	»		
			»
«			
«q_0:			
«			
«q_1:			
«			
«q_2:			
«			
«q_3:			
«			
«q_4:			
«			
«q_5:			
«			
«q_6:			
«			
«q_7:			
«			
«q_8:			
«			
«q_9: M			
«			
«c_0:			
«			
«c_1:			
«			
«c_2:			
«			
«c_3:			
«			
«c_4:			
«			
«c_5:			
«			
«c_6:			
«			
«c_7:			
«			

«c_8:

«

«c_9:

«

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```
[8]: print(getS(f_9))
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q_1:      X  X  M  »
q_2:          X  X  M  »
q_3:              X  X  M  »
q_4:                  X  M  »
```

q_5:	H	H	M	»	
					»
q_6:	H	H	M	»	
					»
q_7:	H		M	»	
					»
q_8:	H		M	»	
					»
q_9:	H			»	
					»
c_0:				»	
					»
c_1:				»	
					»
c_2:				»	
					»
c_3:				»	
					»
c_4:				»	
					»
c_5:				»	
					»
c_6:				»	
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c_7:				»	
					»
c_8:				»	
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c_9:				»	
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«q_0:					
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«q_1:					
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«q_2:					
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«q_3:					
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«q_4:					
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«q_6:					
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«q_7:					
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«q_8:					

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«q_9: M
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«c_0:
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«c_1:
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«c_2:
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«c_3:
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«c_4:
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«c_9:
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ibmqfactory.load_account:WARNING:2020-06-09 19:23:56,479: Credentials are already in use. The existing account in the session will be replaced.

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```

```
[9]: print(getS(f_9))
```

q_0: X X M

q_1:	X	X	M		»		
						»	
q_2:		X	X	M	»		
						»	
q_3:			X	X	M	»	
						»	
q_4:				X	M	»	
						»	
q_5:	H				H	M	»
							»
q_6:	H	H	M				»
							»
q_7:	H				H	M	»
							»
q_8:	H				H	M	»
							»
q_9:	H				H		»
							»
c_0:							»
							»
c_1:							»
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c_2:							»
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c_3:							»
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c_4:							»
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c_5:							»
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ibmqfactory.load_account:WARNING:2020-06-09 19:25:03,654: Credentials are already in use. The existing account in the session will be replaced.

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```
[8]: print(getS(f_10))
      #did not get good distribution
```

```
q_0:  X  X  M                                »
                                           »
q_1:      X  X  M                                »
                                           »
q_2:      X  X  M                                »
                                           »
q_3:      X  X  M                                »
                                           »
q_4:      X  X  M                                »
                                           »
q_5:      X                                »
                                           »
q_6:  H                                »
                                           »
q_7:  H  H  M                                »
                                           »
q_8:  H                                »
```


			»
q_9:	H	»	
			»
q_10:	H	»	
			»
q_11:	H	»	
			»
c_0:		»	
			»
c_1:		»	
			»
c_2:		»	
			»
c_3:		»	
			»
c_4:		»	
			»
c_5:		»	
			»
c_6:		»	
			»
c_7:		»	
			»
c_8:		»	
			»
c_9:		»	
			»
c_10:		»	
			»
c_11:		»	
			»
«			
« q_0:			
«			
« q_1:			
«			
« q_2:			
«			
« q_3:			
«			
« q_4:			
«			
« q_5:	M		
«			
« q_6:	H	M	
«			
« q_7:			
«			

```

« q_8:  H      M
«
« q_9:  H      M
«
«q_10:  H      M
«
«q_11:  H      M
«
« c_0:
«
« c_1:
«
« c_2:
«
« c_3:
«
« c_4:
«
« c_5:
«
« c_6:
«
« c_7:
«
« c_8:
«
« c_9:
«
«c_10:
«
«c_11:
«

```

ibmqfactory.load_account:WARNING:2020-06-09 20:27:30,617: Credentials are already in use. The existing account in the session will be replaced.

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```

KeyboardInterrupt                                Traceback (most recent call
↳last)

<ipython-input-8-cb447f3001f4> in <module>
----> 1 print(getS(f_10))

<ipython-input-5-dc520c8d6396> in getS(f)
    62         for val in max_key[0:n]:
    63             results.append(int(val))
---> 64         vectors, MSBDict = addRow(vectors, results, MSBDict)
    65         del results_dict[max_key]
    66

<ipython-input-5-dc520c8d6396> in addRow(vectors, z, MSBDict)
    16         if msbOne in MSBDict.keys():
    17             otherRow = MSBDict[msbOne]
---> 18             z = list(np.add(np.array(vectors[otherRow]),np.
↳array(z))%2) #update z (adding those two rows with same msb to get reduced row
↳echolon form)
    19         else:
    20             break

```

KeyboardInterrupt:

```

[10]: print(getS(f_11))
      #stack size exceeded

```

```

q_0:  X  X  M  »
q_1:      X  X  M  »
q_2:      X  X  M  »
q_3:      X  X  M  »
q_4:      X  X  M  »
q_5:      X  »
q_6:      »
q_7:  H  »

```

q_8:	H	H	M	»	»
q_9:	H			»	»
q_10:	H			»	»
q_11:	H			»	»
q_12:	H			»	»
q_13:	H			»	»
c_0:				»	»
c_1:				»	»
c_2:				»	»
c_3:				»	»
c_4:				»	»
c_5:				»	»
c_6:				»	»
c_7:				»	»
c_8:				»	»
c_9:				»	»
c_10:				»	»
c_11:				»	»
c_12:				»	»
c_13:				»	»
«					
« q_0:					
«					
« q_1:					
«					
« q_2:					
«					
« q_3:					


```

«
« q_4:
«
« q_5:   X       M
«
« q_6:       X       M
«
« q_7:           H       M
«
« q_8:
«
« q_9:           H       M
«
«q_10:           H       M
«
«q_11:           H       M
«
«q_12:           H       M
«
«q_13:           H       M
«
« c_0:
«
« c_1:
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« c_2:
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« c_3:
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« c_4:
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«c_10:
«
«c_11:
«
«c_12:
«
«c_13:

```

«

ibmqfactory.load_account:WARNING:2020-06-09 20:40:42,474: Credentials are already in use. The existing account in the session will be replaced.

```

↳ -----
      IBMQJobFailureError                                Traceback (most recent call↳
↳ last)

      <ipython-input-10-ccd7d55c18b2> in <module>
      ----> 1 print(getS(f_11))

      <ipython-input-5-dc520c8d6396> in getS(f)
      54     start = time.time()
      55
      ---> 56     results_dict, run_time = run_program(f, n)
      57     print(results_dict)
      58

      <ipython-input-9-c4d989730f82> in run_program(f, n)
      148
      149     try:
      --> 150         result = job.result()
      151         counts=result.get_counts(qc)
      152     except TimeoutError:

      /usr/local/anaconda3/lib/python3.7/site-packages/qiskit/providers/ibmq/
↳ job/ibmqjob.py in result(self, timeout, wait, partial, refresh)
      272         raise IBMQJobFailureError(
      273             'Unable to retrieve result for job {}'. Job has↳
↳ failed. '
      --> 274             'Use job.error_message() to get more details.'.
↳ format(self.job_id()))
      275
      276         return self._retrieve_result(refresh=refresh)

      IBMQJobFailureError: 'Unable to retrieve result for job↳
↳ 5ee0563fbb3a8700133deae4. Job has failed. Use job.error_message() to get more↳
↳ details.'
```