1   Reversible Half Aadder

```
Half-Adder:
-----------

            +---------------+                +------------------+
            |               |                | a | b | a^b | a&b |
    a ---->|               |----> a ^ b      +---|---|-----------|
            |               |                | 0 | 0 |  0  |  0  |
            |      HA       |                | 0 | 1 |  1  |  0  |
            |               |                | 1 | 0 |  1  |  0  |
    b ---->|               |----> a & b      | 1 | 1 |  0  |  1  |
            |               |                +------------------+
            +---------------+


reversible:
-----------

          +---------------------+
          |                     |
  a ---->|                     |----> a
          |                     |
          |                     |
  b ---->|                     |----> b
          |                     |
          |       U             |
          |         HA          |
          |                     |
  c ---->|                     |----> c ^ (a ^ b)
          |                     |
          |                     |
  d ---->|                     |----> d ^ (a & b)
          |                     |
          +---------------------+
```
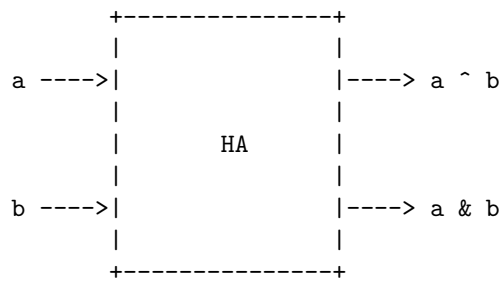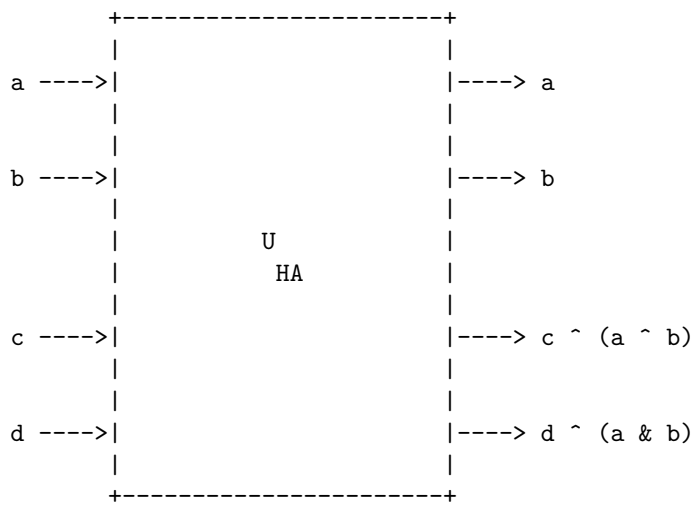
```
+---------------+ +---+---+------------------+
| a | b | c | d | | a | b | c^(a^b) | d^(a&b) |
+---+---+---+---+ +---+---+---------+---------+
| 0 | 0 | 0 | 0 | | 0 | 0 |    0    |    0    |
| 0 | 0 | 0 | 1 | | 0 | 0 |    0    |    1    |
| 0 | 0 | 1 | 0 | | 0 | 0 |    1    |    0    |
| 0 | 0 | 1 | 1 | | 0 | 0 |    1    |    1    |
| 0 | 1 | 0 | 0 | | 0 | 1 |    1    |    0    |
| 0 | 1 | 0 | 1 | | 0 | 1 |    1    |    1    |
| 0 | 1 | 1 | 0 | | 0 | 1 |    0    |    0    |
| 0 | 1 | 1 | 1 | | 0 | 1 |    0    |    1    |
| 1 | 0 | 0 | 0 | | 1 | 0 |    1    |    0    |
| 1 | 0 | 0 | 1 | | 1 | 0 |    1    |    1    |
| 1 | 0 | 1 | 0 | | 1 | 0 |    0    |    0    |
| 1 | 0 | 1 | 1 | | 1 | 0 |    0    |    1    |
| 1 | 1 | 0 | 0 | | 1 | 1 |    0    |    1    |
| 1 | 1 | 0 | 1 | | 1 | 1 |    0    |    0    |
| 1 | 1 | 1 | 0 | | 1 | 1 |    1    |    1    |
| 1 | 1 | 1 | 1 | | 1 | 1 |    1    |    0    |
+---------------+ +--------------------------+
          one-to-one
```

```
quantum-circuit:
----------------


  a -----#--------------------------------#------
         |                                |
         |                                |
  b -----------------#------------------#------
         |           |                  |
         |           |                  |
  c ----|+|---------|+|----------------------------
         c ^ a       (c ^ a)^ b          |
                                         |
  d ----------------------------------|+|-----
                                      d ^ (a & b)
```

2 Hamming Code

https://github.com/bchatterjee99/quantum/blob/master/hamming.c

3 qtrng

https://github.com/bchatterjee99/quantum/blob/master/qtrng.py

4 Entanglement

```
        +---------+
        |         |
  |0> --|    H    |----------------------#------
        |         |   |0>+|1>            |
        +---------+  ---------           |
                      sqrt(2)            |   |01> + |10>
                                         |   ----------
                                         |     sqrt(2)
        +---------+                      |
        |         |                      |
  |0> --|    X    |----------------------|+|-----
        |         |   |1>                |
        +---------+            |
                               |
                               v

                   |01> + |11>
                   ----------
                     sqrt(2)
```

https://github.com/bchatterjee99/quantum/blob/master/entangled.py
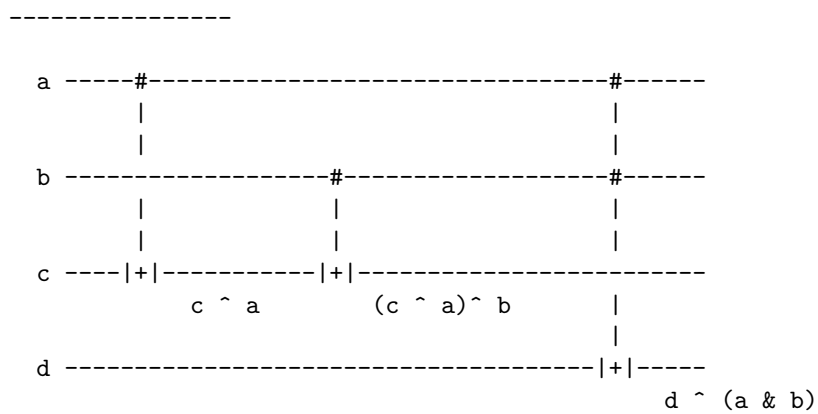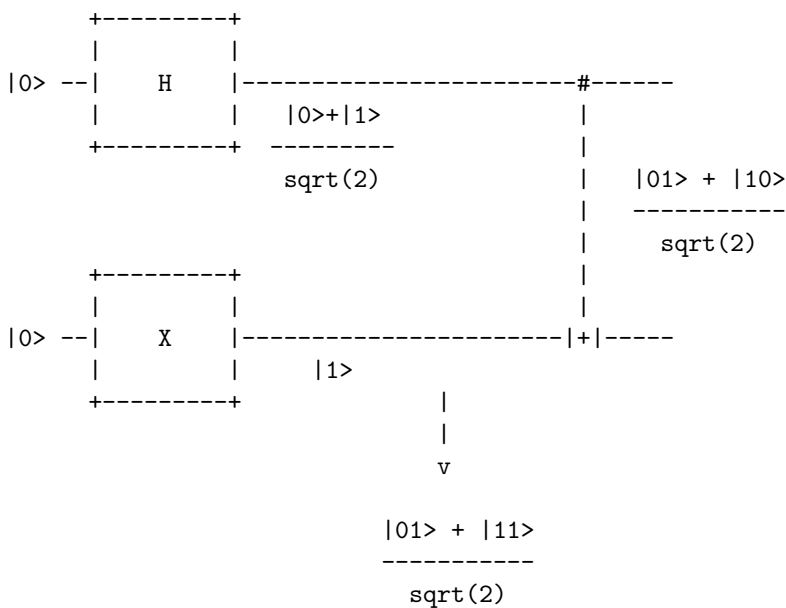
```python
from qiskit import QuantumRegister, ClassicalRegister
from qiskit import QuantumCircuit, Aer, execute

q1 = QuantumRegister(2);
c1 = ClassicalRegister(2);

qc = QuantumCircuit(q1, c1);
backend = Aer.get_backend("qasm_simulator");


#--------------------------------------------------
#
#          +----------+
```
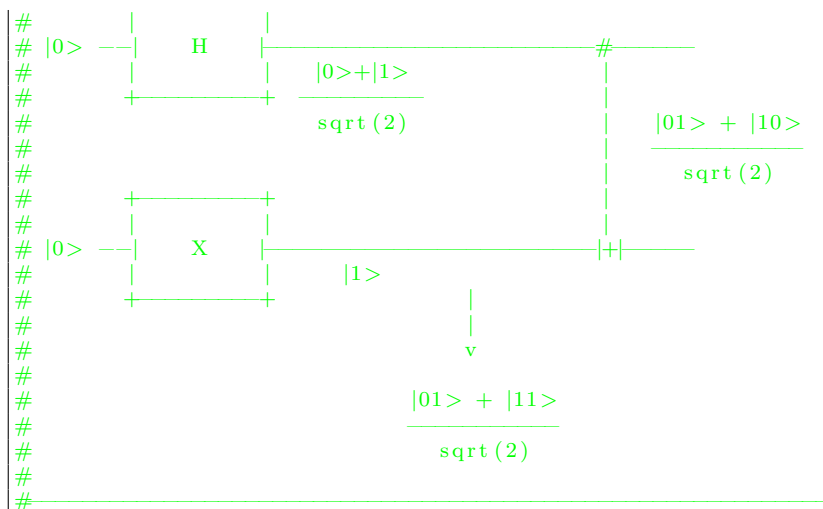
```
#        |        |
# |0> --|    H    |------------------------#----
#        |        |    |0>+|1>             |
#        +--------+    ---------           |
#                       sqrt(2)            |  |01> + |10>
#                                          |  -----------
#                                          |   sqrt(2)
#        +--------+                        |
#        |        |                        |
# |0> --|    X    |------------------------|+|----
#        |        |    |1>                  |
#        +--------+                         |
#                                           |
#                                           v
#
#                            |01> + |11>
#                            -----------
#                              sqrt(2)
#
#------------------------------------------------
```

```
qc.h(q1[0]);
qc.x(q1[1]);
qc.cx(q1[0], q1[1])
qc.measure(q1, c1);

qjob = execute(qc, backend, shots=100);
counts = qjob.result().get_counts();

print(counts)
```