

# Python/Qiskit 入門

高中量子科技課程

2022 (C) 黃敦紀

# 課程安排

- Python 入門
- Qiskit 實作

# Python 入門

- 循序結構：
  - 函式 function
  - 物件 object
- 選擇結構：`if`
- 重複結構：迴圈 loop



# IBM Quantum



Graphically build circuits with  
**IBM Quantum Composer**

Launch Composer

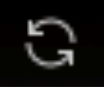
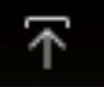
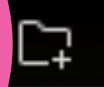


Develop quantum experiments in  
**IBM Quantum Lab**

Launch Lab

IBM Quantum Lab

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Launcher


Notebook



Qiskit v0.34.2  
(ipykernel)



Getting started  
with Qiskit




Qiskit v0.34.2  
(ipykernel)


Console

Qiskit v0.34.2  
(ipykernel)


Other




Text File



Markdown File



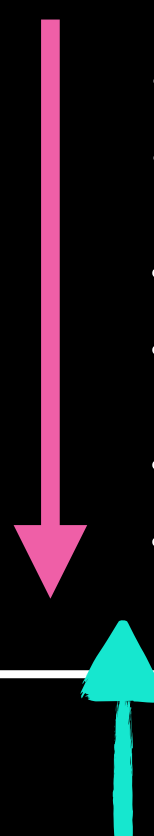
Python File



Show  
Contextual Help

# 循序結構

- 程式一行一行循序執行

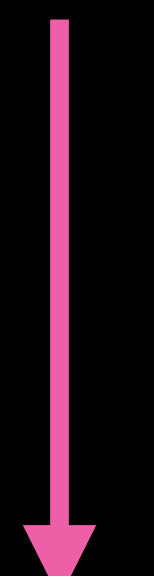


```
print ("Hello World")  
print ("123")  
print (34+25)
```

按照順序執行  
動作

程式

(請注意句首不可隨意空白)


$$\begin{aligned}x^2 - 5x + 6 &= 0 \\(x - 2)(x - 3) &= 0 \\x - 2 = 0 \text{ or } x - 3 &= 0 \\x = 2 \text{ or } x = 3\end{aligned}$$

等價、同義

數學演算



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20 hours ago



error.ipynb

10 days ago



errors.ipynb

10 days ago



funcs.py

5 days ago

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Untitled4.ipynb



Code



[1]: import numpy as np

# Importing standard Qiskit libraries

from qiskit import QuantumCircuit, transpile, Aer, IBMQ

from qiskit.tools.jupyter import \*

from qiskit.visualization import \*

from ibm\_quantum\_widgets import \*

from qiskit.providers.aer import QasmSimulator

# Loading your IBM Quantum account(s)

provider = IBMQ.load\_account()

<frozen importlib.\_bootstrap>:219: RuntimeWarning: scipy.\_lib.messag  
e binary incompatibility. Expected 56 from C header, got 64 from Py

[ ]: print ("hello world")



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5 days ago

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&lt;frozen importlib.\_bootstrap&gt;:219: RuntimeWarning: scipy.\_lib.message binary incompatibility. Expected 56 from C header, got 64 from Py

[ ]: print ("hello world")

# 循序結構

- 練習：用 Python 程式輸出

```
I enjoy the class.
```

```
456
```

```
121212
```

# 函式 function

```
def fun():  
    print("hi")  
    return
```

```
fun()  
fun()  
fun()
```

... 定義 define

... 呼叫 (執行) call

... 呼叫 (執行) call

... 呼叫 (執行) call

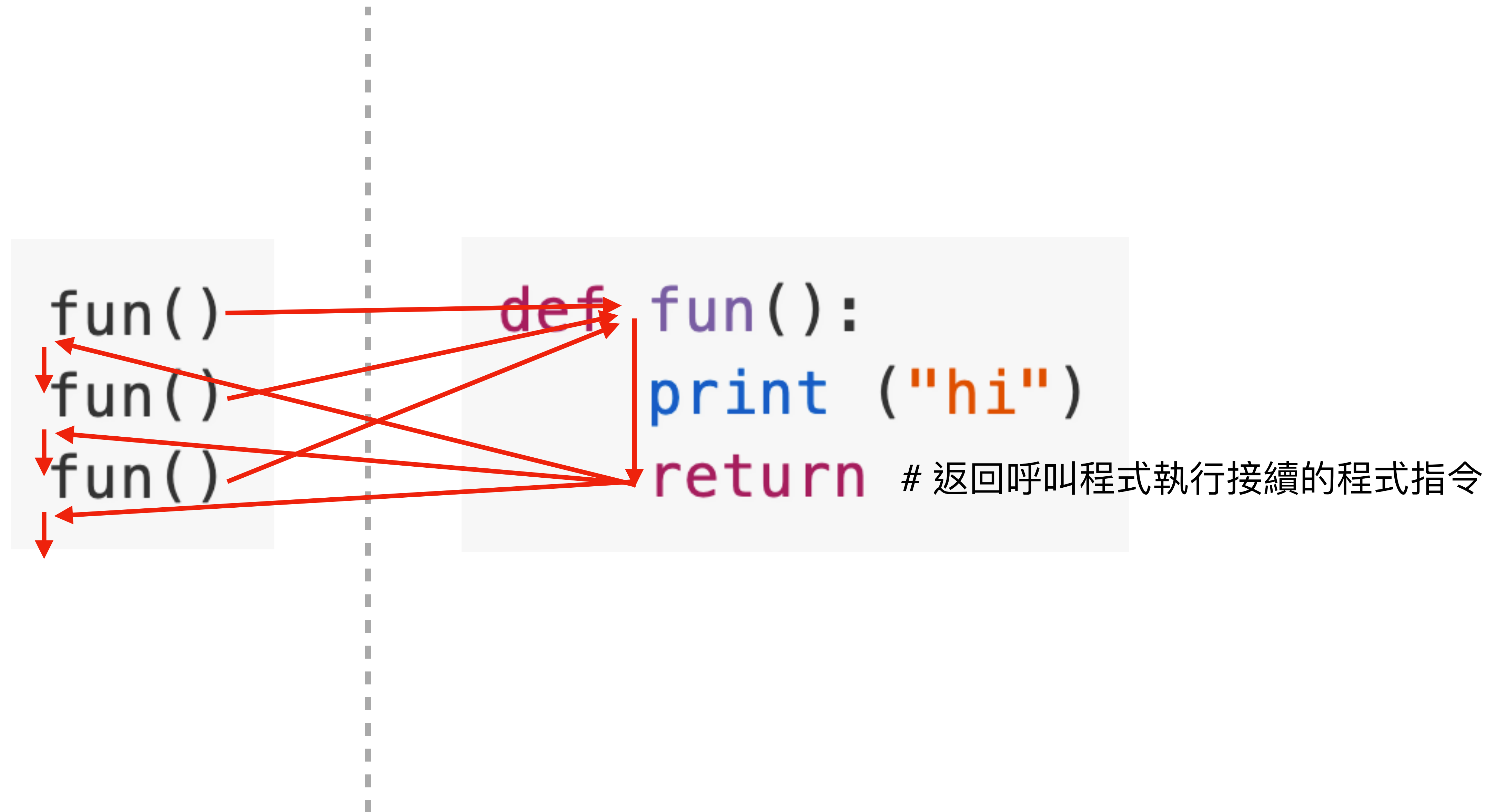
```
def fun():  
    print ("hi")  
    return
```

-----

```
fun()  
fun()  
fun()
```

```
fun()  
fun()  
fun()
```

```
def fun():  
    print ("hi")  
    return
```



- 參數

- 回傳值

... 函式：填表要求完成某個動作

- import (匯入) module (模組)

提供的功能： 量子計算 機器學習 數學工具 ...

modules/套件：

qiskit

tensorflow

numpy

...

語言/環境：

Python



開始建構一個 quantum circuit ...

(circuit 名稱可以自己取)

指定參數 (1 個 qubit, 1 個 classical bit)

qc = QuantumCircuit (1, 1)

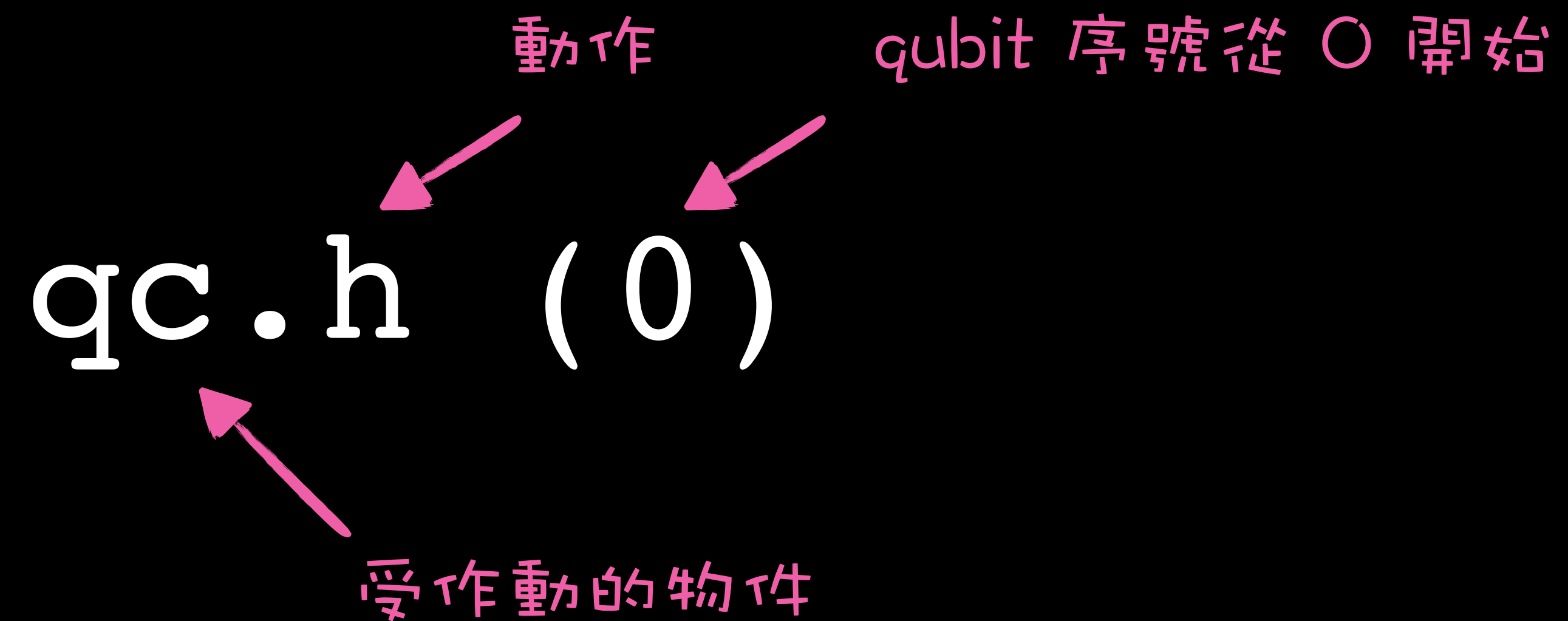
指定為回傳值

qubit 0 接上 hadamard gate ...

動作      qubit 序號從 0 開始

qc.h (0)

受作動的物件



先將目前的 circuit 畫出來看看 ...

qc.draw ()

動作

受作動的物件

# 接下來你可以做 2 (3) 件事

1. 用模擬器後端模擬執行 (量測)
2. 用實機執行 (量測)
3. 看狀態向量 (理論，狀態不塌縮)

在要量測的 qubit 上接上 measurements ...

動作  
qc.measure\_all ()  
受作動的物件

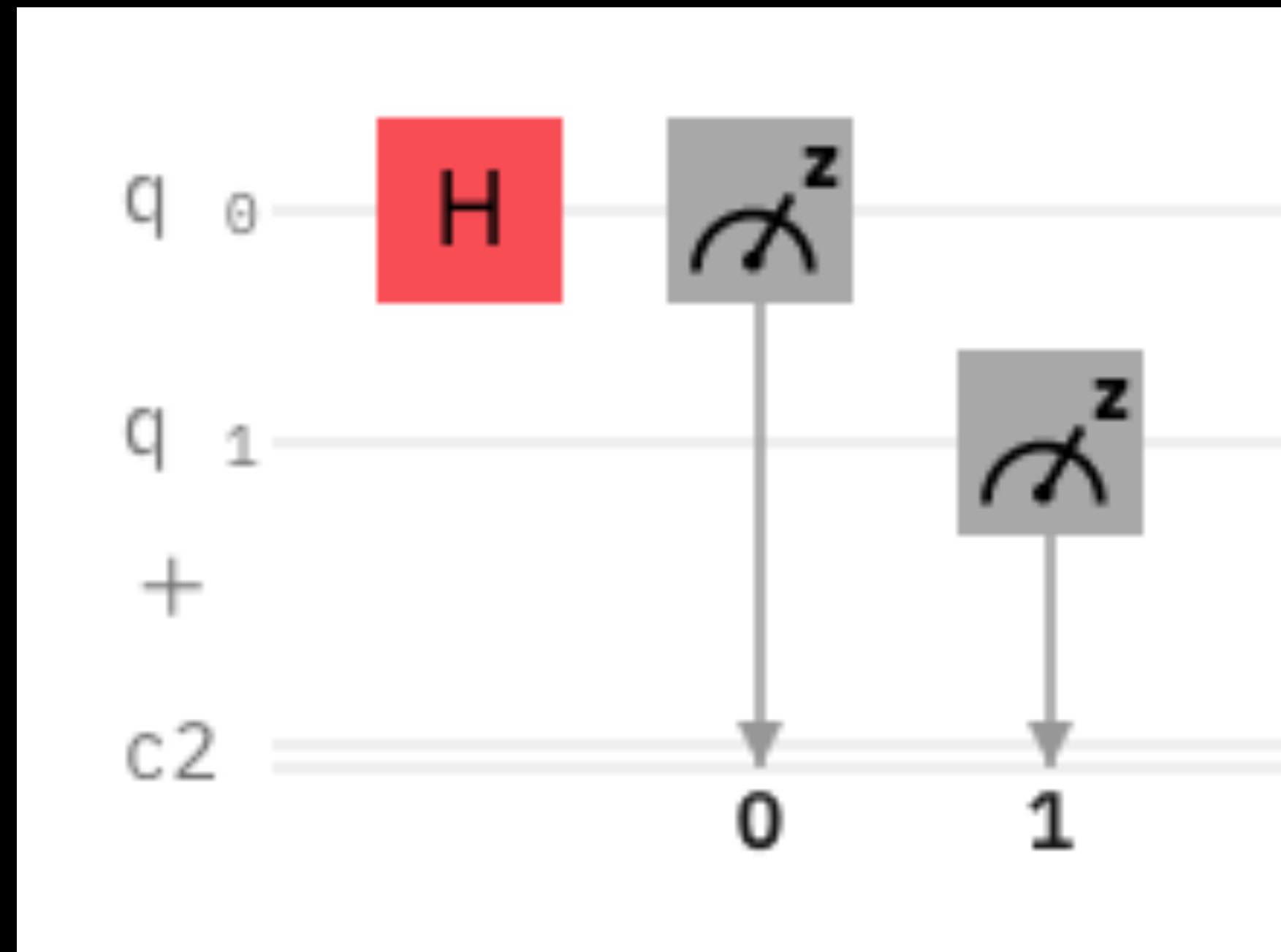
# 1. 用模擬器後端模擬執行

```
sim = QasmSimulator()  
comp = transpile (qc, sim)  
sres = sim.run (comp, 1024).result().get_counts (qc)
```

看結果 ...

```
print (sres) # 文字  
plot_histogram(sres) # 統計 (直方) 圖
```

- 練習：在 IBM Quantum Lab 建構並模擬執行以下之 quantum circuit



## 2. 用實機執行

```
from qiskit import execute
from qiskit.tools.monitor import job_monitor
```

```
backend = IBMQ.get_provider('ibm-q').get_backend('ibmq_lima')
job = execute(qc, backend = backend, shots = 1024)
job_monitor(job, interval = 5)
rres = job.result().get_counts(qc)
```

(找 5/7 qubits, Online, pending jobs 的)

看結果 ...

```
print(rres) # 文字
plot_histogram(rres) # 統計 (直方) 圖
```



## 2. 用實機執行 (續)

實機雜訊圖 ... (也可以直接在網頁上看)

```
plot_error_map(backend)
```

挑戰題：

如何用實機執行得到更接近理論的結果？

# 重複結構 (迴圈 loop)

```
print (1)  
print (2)  
print (3)
```

```
for i in range (3):  
    print (i)
```

(縮排：空四格)

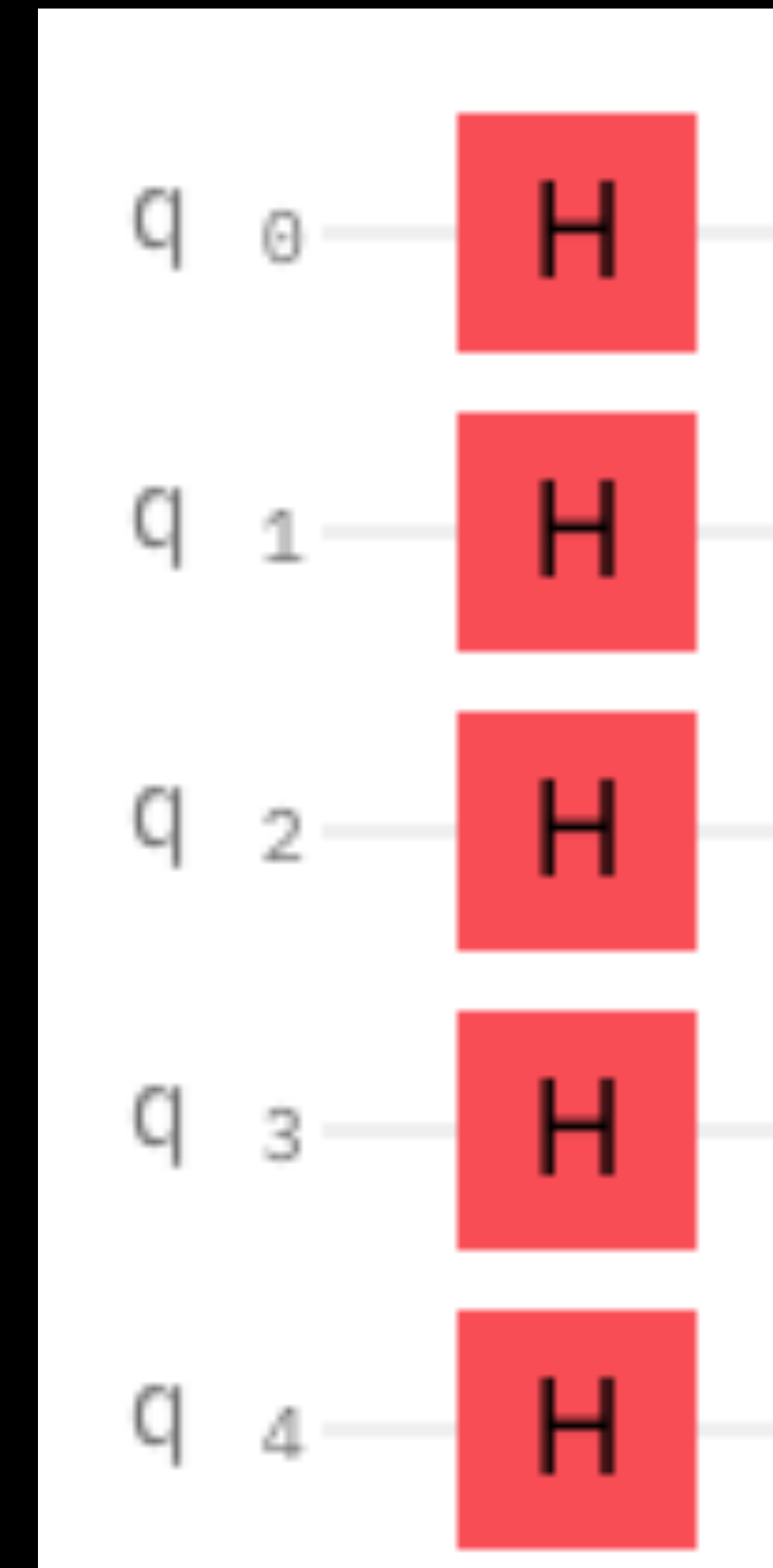
# 重複結構

- 練習：用 Python 迴圈輸出

```
0  
1  
2  
3  
4  
5  
6  
7  
8  
9
```

# 重複結構

- 練習：用迴圈建構如右的 quantum circuit (另開新檔 New File 或用不同的名字)



# 3. 看狀態向量

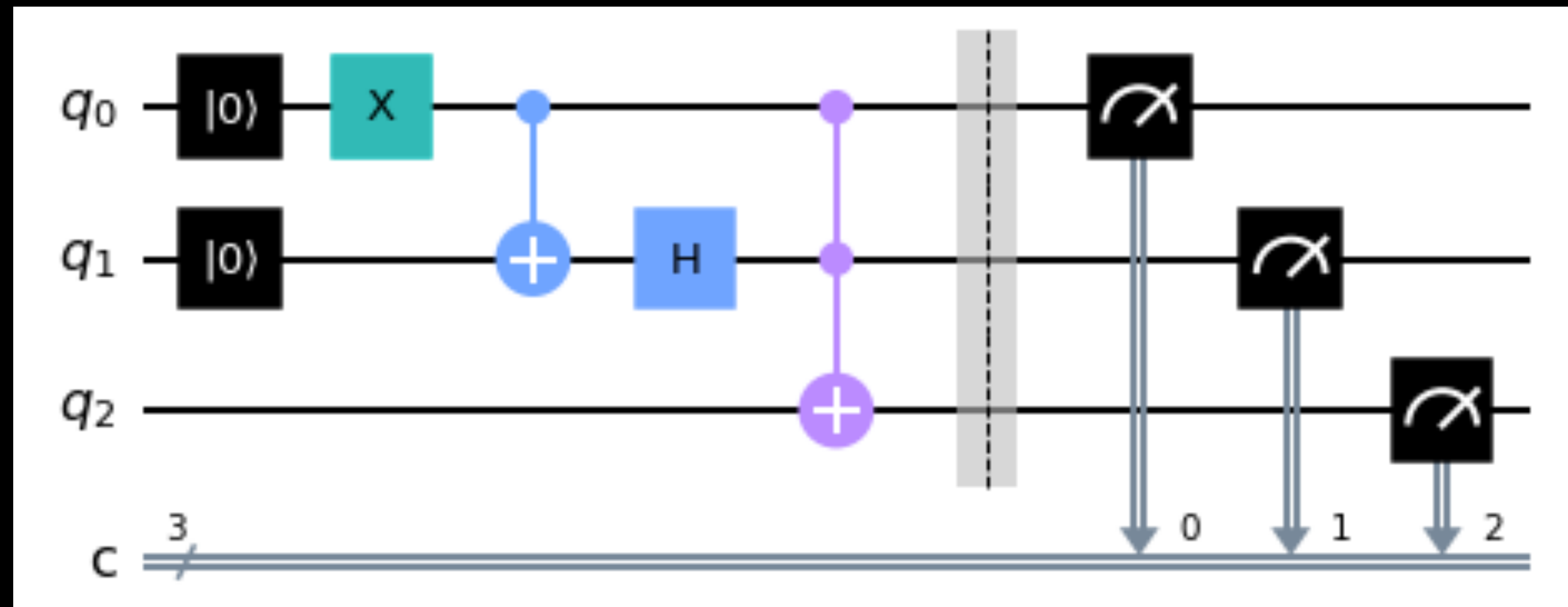
```
from qiskit.quantum_info import Statevector
```

```
Statevector.from_instruction(qc).draw("latex", prefix=" ")
```

```
plot_bloch_multivector(Statevector.from_instruction(qc))
```

# 初學 Quantum Gates

```
sg = QuantumCircuit (3, 3)
sg.reset (0)
sg.reset (1)
sg.x (0)
sg.cx (0, 1)
sg.h (1)
sg.ccx (0, 1, 2)
sg.barrier ()
sg.measure_all ()
sg.draw ()
```



# 初學 Quantum Gates

```
sg.reset (0)
sg.reset (1)

sg.x (0)

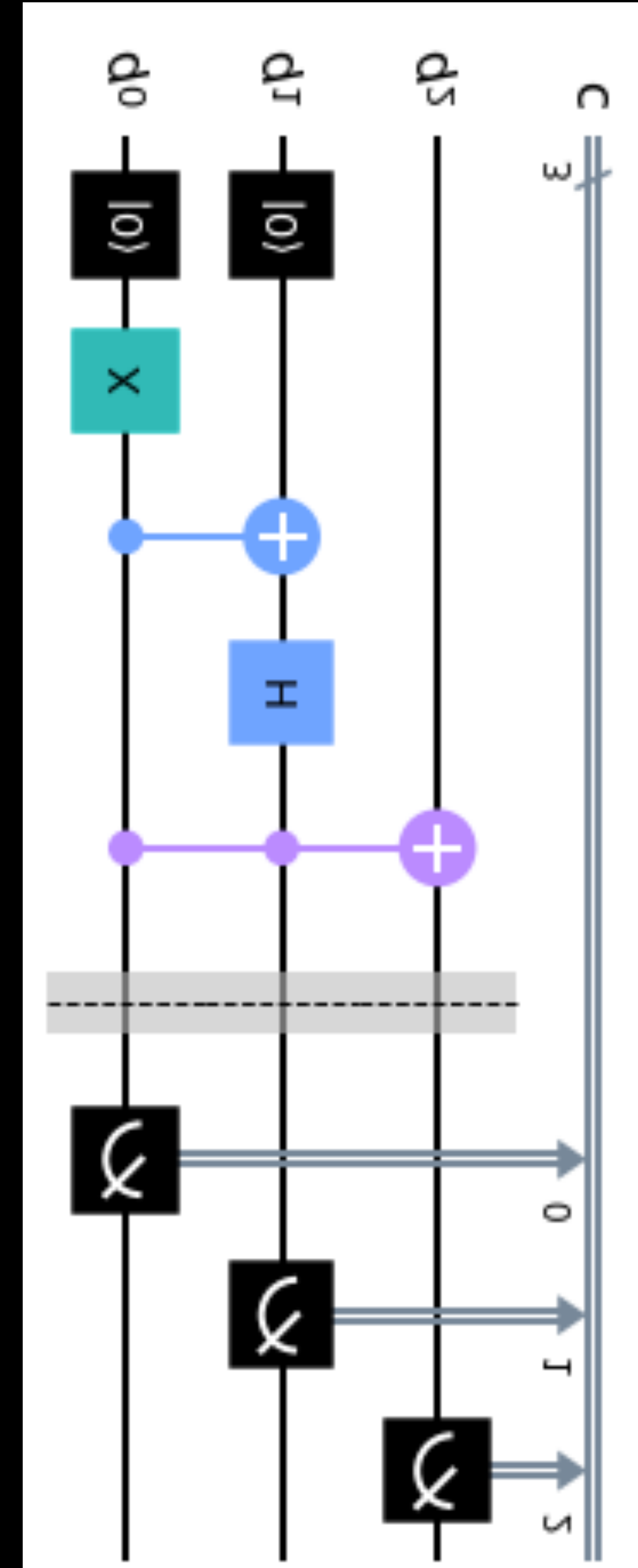
sg.cx (0, 1)

sg.h (1)

sg.ccx (0, 1, 2)

sg.barrier ()

sg.measure_all ()
```



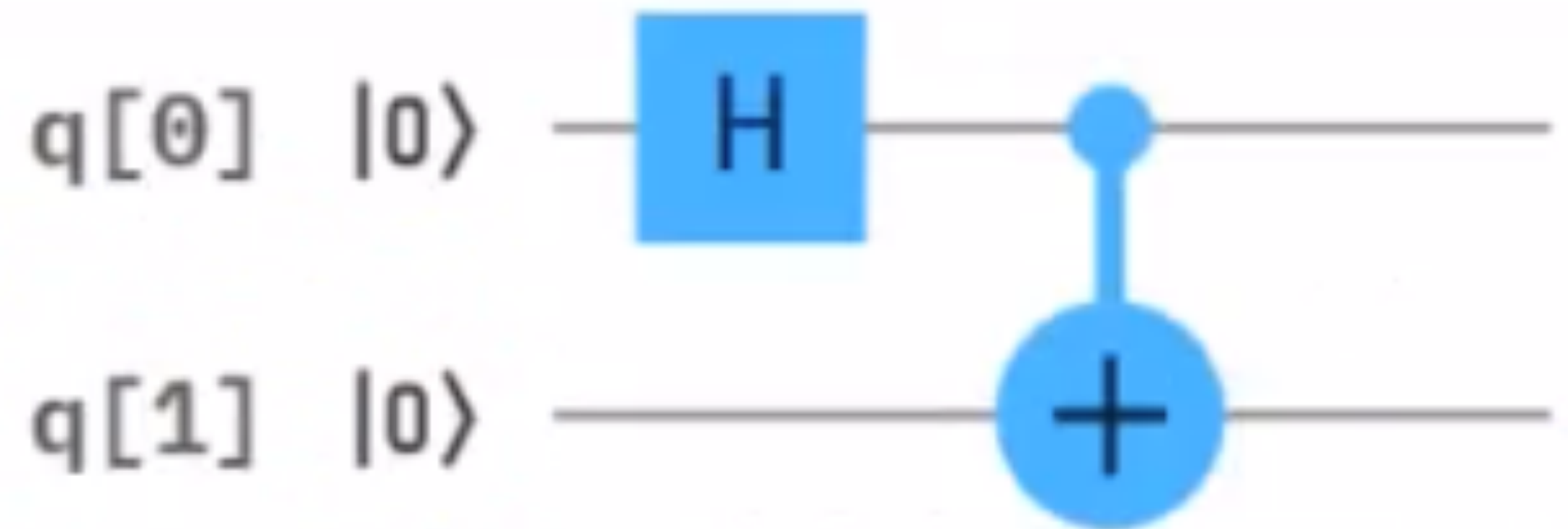
Bell state

$$\frac{1}{\sqrt{2}}(|00\rangle + |11\rangle)$$

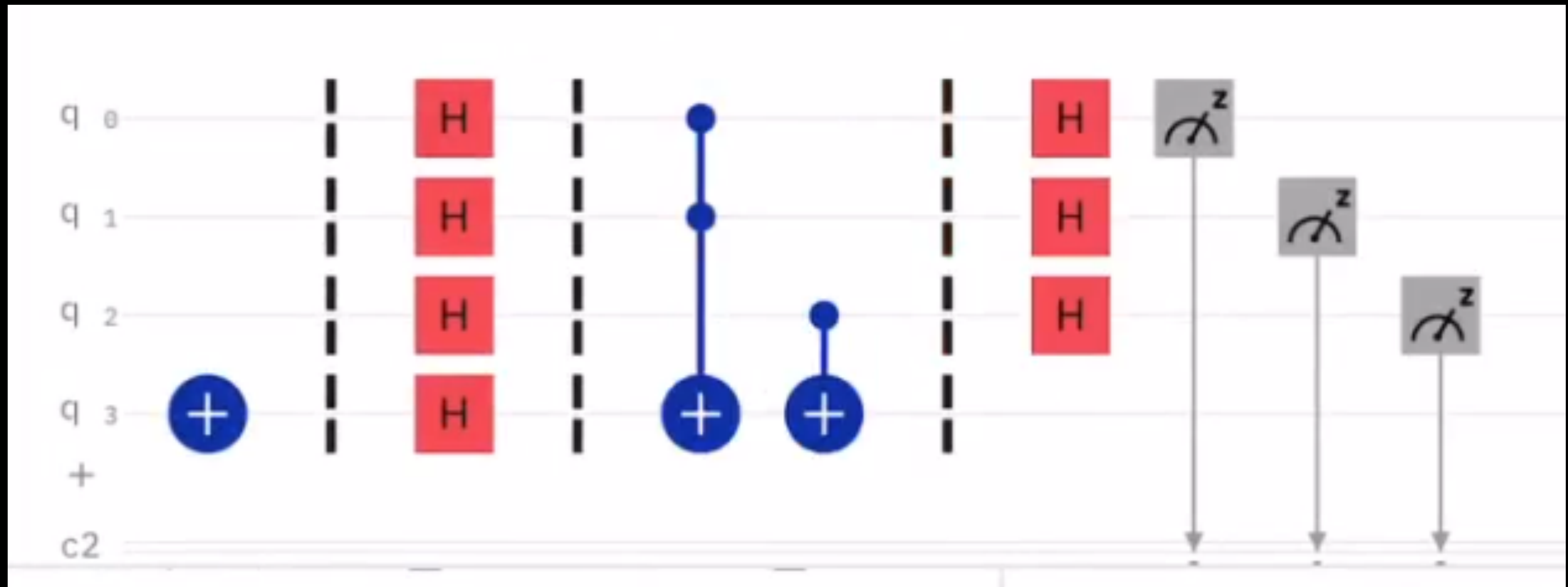
$$\frac{1}{\sqrt{2}}(|01\rangle + |10\rangle)$$

$$\frac{1}{\sqrt{2}}(|00\rangle - |11\rangle)$$

$$\frac{1}{\sqrt{2}}(|01\rangle - |10\rangle)$$







Deutsch-Josza (2022/2/26 黃琮暉老師課程截圖)

# The Atoms of Computation

AND

q <sub>1</sub> q <sub>0</sub>	q <sub>2</sub>
0 0	0
0 1	0
1 1	1
1 0	0

OR

q <sub>1</sub> q <sub>0</sub>	q <sub>2</sub>
0 0	0
0 1	1
1 1	1
1 0	1

XOR

q <sub>1</sub> q <sub>0</sub>	q <sub>2</sub>
0 0	0
0 1	1
1 1	0
1 0	1

# Qiskit Applications

IBM Quantum Challenge Africa 2021

IBM Quantum Challenge Fall 2021