

# Exercise - Qiskit 101 Overview

December 14, 2024

## 1 Qiskit 101

```
[111]: %pip install qiskit[visualization]
```

```
Requirement already satisfied: qiskit[visualization] in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages
(1.3.1)
Requirement already satisfied: rustworkx>=0.15.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.15.1)
Requirement already satisfied: numpy<3,>=1.17 in /opt/conda/lib/python3.11/site-
packages (from qiskit[visualization]) (1.26.4)
Requirement already satisfied: scipy>=1.5 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (1.14.1)
Requirement already satisfied: sympy>=1.3 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (1.13.3)
Requirement already satisfied: dill>=0.3 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.3.9)
Requirement already satisfied: python-dateutil>=2.8.0 in
/opt/conda/lib/python3.11/site-packages (from qiskit[visualization]) (2.9.0)
Requirement already satisfied: stevedore>=3.0.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (5.4.0)
Requirement already satisfied: typing-extensions in
/opt/conda/lib/python3.11/site-packages (from qiskit[visualization]) (4.12.2)
Requirement already satisfied: symengine<0.14,>=0.11 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.13.0)
Requirement already satisfied: matplotlib>=3.3 in
/opt/conda/lib/python3.11/site-packages (from qiskit[visualization]) (3.9.3)
Requirement already satisfied: pydot in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (3.0.3)
Requirement already satisfied: Pillow>=4.2.1 in /opt/conda/lib/python3.11/site-
packages (from qiskit[visualization]) (11.0.0)
```

Requirement already satisfied: pylatexenc>=1.4 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit[visualization]) (2.10)

Requirement already satisfied: seaborn>=0.9.0 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit[visualization]) (0.13.2)

Requirement already satisfied: contourpy>=1.0.1 in  
/opt/conda/lib/python3.11/site-packages (from  
matplotlib>=3.3->qiskit[visualization]) (1.3.1)

Requirement already satisfied: cycycler>=0.10 in /opt/conda/lib/python3.11/site-  
packages (from matplotlib>=3.3->qiskit[visualization]) (0.12.1)

Requirement already satisfied: fonttools>=4.22.0 in  
/opt/conda/lib/python3.11/site-packages (from  
matplotlib>=3.3->qiskit[visualization]) (4.55.2)

Requirement already satisfied: kiwisolver>=1.3.1 in  
/opt/conda/lib/python3.11/site-packages (from  
matplotlib>=3.3->qiskit[visualization]) (1.4.7)

Requirement already satisfied: packaging>=20.0 in  
/opt/conda/lib/python3.11/site-packages (from  
matplotlib>=3.3->qiskit[visualization]) (24.0)

Requirement already satisfied: pyparsing>=2.3.1 in  
/opt/conda/lib/python3.11/site-packages (from  
matplotlib>=3.3->qiskit[visualization]) (3.2.0)

Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.11/site-  
packages (from python-dateutil>=2.8.0->qiskit[visualization]) (1.16.0)

Requirement already satisfied: pandas>=1.2 in /opt/conda/lib/python3.11/site-  
packages (from seaborn>=0.9.0->qiskit[visualization]) (2.2.3)

Requirement already satisfied: pbr>=2.0.0 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
stevedore>=3.0.0->qiskit[visualization]) (6.1.0)

Requirement already satisfied: mpmath<1.4,>=1.1.0 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
sympy>=1.3->qiskit[visualization]) (1.3.0)

Requirement already satisfied: pytz>=2020.1 in /opt/conda/lib/python3.11/site-  
packages (from pandas>=1.2->seaborn>=0.9.0->qiskit[visualization]) (2024.1)

Requirement already satisfied: tzdata>=2022.7 in /opt/conda/lib/python3.11/site-  
packages (from pandas>=1.2->seaborn>=0.9.0->qiskit[visualization]) (2024.2)

Note: you may need to restart the kernel to use updated packages.

## 2 Build a Circuit with Qiskit

```
[112]: from qiskit import QuantumCircuit, QuantumRegister
```

```
[113]: qubits = QuantumRegister(2, name = "q")
```

```
[114]: circuit = QuantumCircuit(qubits)
```

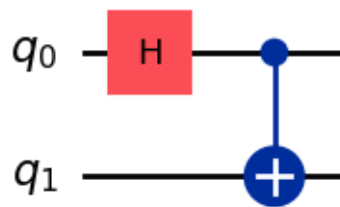
```
[115]: q0, q1 = qubits
```

```
[116]: # Create the First Bell State
# Replace the '?'
#####
circuit.h(q0)
circuit.cx(q0, q1)
```

```
[116]: <qiskit.circuit.instructionset.InstructionSet at 0x7cef9776fc10>
```

```
[117]: circuit.draw('mpl')
```

```
[117]:
```



### 3 Transpile a Circuit with Qiskit Presets

```
[118]: %pip install qiskit-ibm-runtime
```

```
Requirement already satisfied: qiskit-ibm-runtime in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages
(0.34.0)
Requirement already satisfied: requests>=2.19 in /opt/conda/lib/python3.11/site-
packages (from qiskit-ibm-runtime) (2.31.0)
Requirement already satisfied: requests-ntlm>=1.1.0 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (1.3.0)
Requirement already satisfied: numpy>=1.13 in /opt/conda/lib/python3.11/site-
packages (from qiskit-ibm-runtime) (1.26.4)
Requirement already satisfied: urllib3>=1.21.1 in
/opt/conda/lib/python3.11/site-packages (from qiskit-ibm-runtime) (2.2.1)
Requirement already satisfied: python-dateutil>=2.8.0 in
/opt/conda/lib/python3.11/site-packages (from qiskit-ibm-runtime) (2.9.0)
Requirement already satisfied: websocket-client>=1.5.1 in
/opt/conda/lib/python3.11/site-packages (from qiskit-ibm-runtime) (1.8.0)
Requirement already satisfied: ibm-platform-services>=0.22.6 in
/opt/.qbraided/environments/qbraided_000000/pyenv/lib/python3.11/site-packages (from
```

qiskit-ibm-runtime) (0.59.0)  
Requirement already satisfied: pydantic<2.10,>=2.5.0 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit-ibm-runtime) (2.9.2)  
Requirement already satisfied: qiskit>=1.1.0 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit-ibm-runtime) (1.3.1)  
Requirement already satisfied: ibm-cloud-sdk-core<4.0.0,>=3.22.0 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
ibm-platform-services>=0.22.6->qiskit-ibm-runtime) (3.22.0)  
Requirement already satisfied: annotated-types>=0.6.0 in  
/opt/conda/lib/python3.11/site-packages (from pydantic<2.10,>=2.5.0->qiskit-ibm-  
runtime) (0.7.0)  
Requirement already satisfied: pydantic-core==2.23.4 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
pydantic<2.10,>=2.5.0->qiskit-ibm-runtime) (2.23.4)  
Requirement already satisfied: typing-extensions>=4.6.1 in  
/opt/conda/lib/python3.11/site-packages (from pydantic<2.10,>=2.5.0->qiskit-ibm-  
runtime) (4.12.2)  
Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.11/site-  
packages (from python-dateutil>=2.8.0->qiskit-ibm-runtime) (1.16.0)  
Requirement already satisfied: rustworkx>=0.15.0 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit>=1.1.0->qiskit-ibm-runtime) (0.15.1)  
Requirement already satisfied: scipy>=1.5 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit>=1.1.0->qiskit-ibm-runtime) (1.14.1)  
Requirement already satisfied: sympy>=1.3 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit>=1.1.0->qiskit-ibm-runtime) (1.13.3)  
Requirement already satisfied: dill>=0.3 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit>=1.1.0->qiskit-ibm-runtime) (0.3.9)  
Requirement already satisfied: stevedore>=3.0.0 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit>=1.1.0->qiskit-ibm-runtime) (5.4.0)  
Requirement already satisfied: symengine<0.14,>=0.11 in  
/opt/.qbraidd/environments/qbraidd\_000000/pyenv/lib/python3.11/site-packages (from  
qiskit>=1.1.0->qiskit-ibm-runtime) (0.13.0)  
Requirement already satisfied: charset-normalizer<4,>=2 in  
/opt/conda/lib/python3.11/site-packages (from requests>=2.19->qiskit-ibm-  
runtime) (3.3.2)  
Requirement already satisfied: idna<4,>=2.5 in /opt/conda/lib/python3.11/site-  
packages (from requests>=2.19->qiskit-ibm-runtime) (3.7)  
Requirement already satisfied: certifi>=2017.4.17 in  
/opt/conda/lib/python3.11/site-packages (from requests>=2.19->qiskit-ibm-  
runtime) (2024.2.2)  
Requirement already satisfied: cryptography>=1.3 in

```

/opt/conda/lib/python3.11/site-packages (from requests-ntlm>=1.1.0->qiskit-ibm-
runtime) (42.0.7)
Requirement already satisfied: pypspnego>=0.4.0 in
/opt/.qibraid/environments/qibraid_000000/pyenv/lib/python3.11/site-packages (from
requests-ntlm>=1.1.0->qiskit-ibm-runtime) (0.11.2)
Requirement already satisfied: cffi>=1.12 in /opt/conda/lib/python3.11/site-
packages (from cryptography>=1.3->requests-ntlm>=1.1.0->qiskit-ibm-runtime)
(1.16.0)
Requirement already satisfied: PyJWT<3.0.0,>=2.8.0 in
/opt/conda/lib/python3.11/site-packages (from ibm-cloud-sdk-
core<4.0.0,>=3.22.0->ibm-platform-services>=0.22.6->qiskit-ibm-runtime) (2.8.0)
Requirement already satisfied: pbr>=2.0.0 in
/opt/.qibraid/environments/qibraid_000000/pyenv/lib/python3.11/site-packages (from
stevedore>=3.0.0->qiskit>=1.1.0->qiskit-ibm-runtime) (6.1.0)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in
/opt/.qibraid/environments/qibraid_000000/pyenv/lib/python3.11/site-packages (from
sympy>=1.3->qiskit>=1.1.0->qiskit-ibm-runtime) (1.3.0)
Requirement already satisfied: pycparser in /opt/conda/lib/python3.11/site-
packages (from cffi>=1.12->cryptography>=1.3->requests-ntlm>=1.1.0->qiskit-ibm-
runtime) (2.22)
Note: you may need to restart the kernel to use updated packages.

```

```
[119]: from qiskit import QuantumCircuit, QuantumRegister
```

```
[120]: from qiskit.transpiler.preset_passmanagers import generate_preset_pass_manager
```

```
[121]: from qiskit_ibm_runtime import QiskitRuntimeService
```

```
[122]: qubits = QuantumRegister(2, name="q")
```

```
[123]: circuit = QuantumCircuit(qubits)
```

```
[124]: q0, q1 = qubits
```

```
[125]: # Create again the First Bell State
# Replace the ?
#####
circuit.h(q0)
circuit.cx(q0, q1)
```

```
[125]: <qiskit.circuit.instructionset.InstructionSet at 0x7cef97667250>
```

```
[126]: from qiskit_ibm_runtime import QiskitRuntimeService
```

```

service = QiskitRuntimeService(
    channel='ibm_quantum',
    instance='ibm-q/open/main',

```

```

    token='ca510ffa26e7cab3a62660e5dfc40269bcec1b1e369333737ff46892bc37b489d6538948eac6fd55a43f
')

```

```

[127]: # Select a Backend
# Replace the ?
#####
backend = service.least_busy(simulator=False)

```

```

[128]: # Replace the ?
pass_manager = generate_preset_pass_manager(1, backend=backend)
### Light Optimization (levels are between 0 and 3)

```

```

[129]: # Replace the ?
transpiled = pass_manager.run(circuit)

```

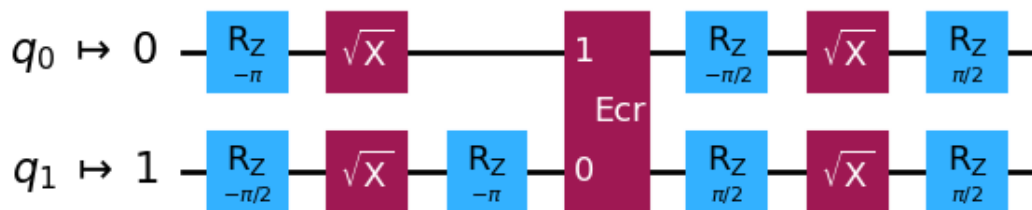
```

[130]: transpiled.draw("mpl", idle_wires=False)

```

[130]:

Global Phase:  $7\pi/4$



## 4 The Esitmator Primitive

```

[131]: %pip install qiskit-aer

```

```

Requirement already satisfied: qiskit-aer in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.11/site-packages
(0.15.1)
Requirement already satisfied: qiskit>=1.1.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.11/site-packages (from
qiskit-aer) (1.3.1)
Requirement already satisfied: numpy>=1.16.3 in /opt/conda/lib/python3.11/site-
packages (from qiskit-aer) (1.26.4)
Requirement already satisfied: scipy>=1.0 in
/opt/.qbraid/environments/qbraid_000000/pyenv/lib/python3.11/site-packages (from
qiskit-aer) (1.14.1)

```

Requirement already satisfied: psutil>=5 in /opt/conda/lib/python3.11/site-packages (from qiskit-aer) (5.9.8)

Requirement already satisfied: rustworkx>=0.15.0 in /opt/.qbraided/environments/qbraided\_000000/pyenv/lib/python3.11/site-packages (from qiskit>=1.1.0->qiskit-aer) (0.15.1)

Requirement already satisfied: sympy>=1.3 in /opt/.qbraided/environments/qbraided\_000000/pyenv/lib/python3.11/site-packages (from qiskit>=1.1.0->qiskit-aer) (1.13.3)

Requirement already satisfied: dill>=0.3 in /opt/.qbraided/environments/qbraided\_000000/pyenv/lib/python3.11/site-packages (from qiskit>=1.1.0->qiskit-aer) (0.3.9)

Requirement already satisfied: python-dateutil>=2.8.0 in /opt/conda/lib/python3.11/site-packages (from qiskit>=1.1.0->qiskit-aer) (2.9.0)

Requirement already satisfied: stevedore>=3.0.0 in /opt/.qbraided/environments/qbraided\_000000/pyenv/lib/python3.11/site-packages (from qiskit>=1.1.0->qiskit-aer) (5.4.0)

Requirement already satisfied: typing-extensions in /opt/conda/lib/python3.11/site-packages (from qiskit>=1.1.0->qiskit-aer) (4.12.2)

Requirement already satisfied: symengine<0.14,>=0.11 in /opt/.qbraided/environments/qbraided\_000000/pyenv/lib/python3.11/site-packages (from qiskit>=1.1.0->qiskit-aer) (0.13.0)

Requirement already satisfied: six>=1.5 in /opt/conda/lib/python3.11/site-packages (from python-dateutil>=2.8.0->qiskit>=1.1.0->qiskit-aer) (1.16.0)

Requirement already satisfied: pbr>=2.0.0 in /opt/.qbraided/environments/qbraided\_000000/pyenv/lib/python3.11/site-packages (from stevedore>=3.0.0->qiskit>=1.1.0->qiskit-aer) (6.1.0)

Requirement already satisfied: mpmath<1.4,>=1.1.0 in /opt/.qbraided/environments/qbraided\_000000/pyenv/lib/python3.11/site-packages (from sympy>=1.3->qiskit>=1.1.0->qiskit-aer) (1.3.0)

Note: you may need to restart the kernel to use updated packages.

```
[132]: from qiskit_ibm_runtime import QiskitRuntimeService, EstimatorV2 as Estimator
```

```
[133]: from qiskit import QuantumCircuit, QuantumRegister
```

```
[134]: from qiskit.quantum_info import SparsePauliOp
```

```
[135]: from qiskit_aer.primitives import Estimator
```

```
[136]: qubits = QuantumRegister(2, name="q")
```

```
[137]: circuit = QuantumCircuit(qubits)
```

```
[138]: q0, q1 = qubits
```

```
[139]: # Create the First Bell State
# Replace the ?
circuit.h(q0)
circuit.cx(q0, q1)
```

```
[139]: <qiskit.circuit.instructionset.InstructionSet at 0x7cef73a94850>
```

```
[140]: observable = SparsePauliOp("ZZ")
```

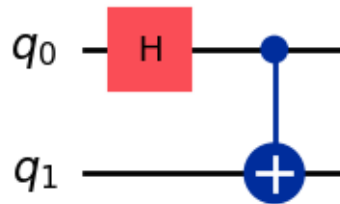
```
[141]: estimator = Estimator()
```

```
[142]: # Replace the ?
job = estimator.run([circuit], [observable])
exact_value = job.result().values[0]
print(f"Exact Expectation Value: {exact_value}")
```

Exact Expectation Value: 1.0

```
[143]: circuit.draw("mpl")
```

```
[143]:
```



## 5 Build a Noise Model

### 5.0.1 From Real Backend

```
[144]: from qiskit_aer.noise import NoiseModel
```

```
[145]: from qiskit_aer.primitives import Estimator
```

```
[146]: from qiskit_ibm_runtime import QiskitRuntimeService
```

```
[147]: from qiskit_ibm_runtime import QiskitRuntimeService

service = QiskitRuntimeService(
    channel='ibm_quantum',
```



```

        instance='ibm-q/open/main',
        ↵
        ↪token='ca510ffa26e7cab3a62660e5dfc40269bcec1b1e369333737ff46892bc37b489d6538948eac6fd55a43f
    )

```

```
[148]: backend = service.backend("ibm_sherbrooke")
```

```
[149]: # Replace the ?
noise_model = NoiseModel.from_backend(backend)
```

```
[150]: # Replace the ?
estimator = Estimator(backend_options=dict(noise_model=noise_model))
```

```
[151]: print(estimator,noise_model)
```

```

<qiskit_aer.primitives.estimator.Estimator object at 0x7cef704e8890> NoiseModel:
  Basis gates: ['delay', 'ecr', 'for_loop', 'id', 'if_else', 'measure', 'reset',
'rz', 'switch_case', 'sx', 'x']
  Instructions with noise: ['x', 'ecr', 'sx', 'id', 'measure', 'reset']
  Qubits with noise: [0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16,
17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36,
37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56,
57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76,
77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96,
97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107, 108, 109, 110, 111, 112,
113, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 126]
  Specific qubit errors: [('x', (0,)), ('x', (1,)), ('x', (2,)), ('x', (3,)),
('x', (4,)), ('x', (5,)), ('x', (6,)), ('x', (7,)), ('x', (8,)), ('x', (9,)),
('x', (10,)), ('x', (11,)), ('x', (12,)), ('x', (13,)), ('x', (14,)), ('x',
(15,)), ('x', (16,)), ('x', (17,)), ('x', (18,)), ('x', (19,)), ('x', (20,)),
('x', (21,)), ('x', (22,)), ('x', (23,)), ('x', (24,)), ('x', (25,)), ('x',
(26,)), ('x', (27,)), ('x', (28,)), ('x', (29,)), ('x', (30,)), ('x', (31,)),
('x', (32,)), ('x', (33,)), ('x', (34,)), ('x', (35,)), ('x', (36,)), ('x',
(37,)), ('x', (38,)), ('x', (39,)), ('x', (40,)), ('x', (41,)), ('x', (42,)),
('x', (43,)), ('x', (44,)), ('x', (45,)), ('x', (46,)), ('x', (47,)), ('x',
(48,)), ('x', (49,)), ('x', (50,)), ('x', (51,)), ('x', (52,)), ('x', (53,)),
('x', (54,)), ('x', (55,)), ('x', (56,)), ('x', (57,)), ('x', (58,)), ('x',
(59,)), ('x', (60,)), ('x', (61,)), ('x', (62,)), ('x', (63,)), ('x', (64,)),
('x', (65,)), ('x', (66,)), ('x', (67,)), ('x', (68,)), ('x', (69,)), ('x',
(70,)), ('x', (71,)), ('x', (72,)), ('x', (73,)), ('x', (74,)), ('x', (75,)),
('x', (76,)), ('x', (77,)), ('x', (78,)), ('x', (79,)), ('x', (80,)), ('x',
(81,)), ('x', (82,)), ('x', (83,)), ('x', (84,)), ('x', (85,)), ('x', (86,)),
('x', (87,)), ('x', (88,)), ('x', (89,)), ('x', (90,)), ('x', (91,)), ('x',
(92,)), ('x', (93,)), ('x', (94,)), ('x', (95,)), ('x', (96,)), ('x', (97,)),
('x', (98,)), ('x', (99,)), ('x', (100,)), ('x', (101,)), ('x', (102,)), ('x',
(103,)), ('x', (104,)), ('x', (105,)), ('x', (106,)), ('x', (107,)), ('x',
(108,)), ('x', (109,)), ('x', (110,)), ('x', (111,)), ('x', (112,)), ('x',

```

(113,)), ('x', (114,)), ('x', (115,)), ('x', (116,)), ('x', (117,)), ('x',  
 (118,)), ('x', (119,)), ('x', (120,)), ('x', (121,)), ('x', (122,)), ('x',  
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```

## 5.0.2 From scratch

```
[152]: from qiskit_aer.noise import ReadoutError, depolarizing_error
```

```
[153]: noise_model = NoiseModel()
```

```
[154]: cx_depolarizing_prob = 0.02
```

```
[155]: bit_flip_prob = 0.05
```

```
[156]: # Replace the ?
noise_model.add_all_qubit_quantum_error(
    depolarizing_error(cx_depolarizing_prob, 2), ["cx"]
)
```

```
[157]: # Replace the ?
noise_model.add_all_qubit_readout_error(
    ReadoutError(
        [
            [1 - bit_flip_prob, bit_flip_prob],
            [bit_flip_prob, 1 - bit_flip_prob],
        ]
    )
)
```

```
[158]: ##### A readable interpretation of the previous cell:
##### Measurement misassignment probabilities
p0given1 = 0.1
p1given0 = 0.05
ReadoutError([[1 - p1given0, p1given0], [p0given1, 1 - p0given1]])
```

```
[158]: ReadoutError([[0.95 0.05]
[0.1 0.9 ]])
```

## **6 End of Notebook**

### **6.0.1 Author**

Gaius Ocatvianus Augustus