lab2

July 25, 2025

[1]:
```
pip install 'qiskit[visualization]'
```

```
Requirement already satisfied: qiskit[visualization] in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (2.1.1)
Requirement already satisfied: rustworkx>=0.15.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.16.0)
Requirement already satisfied: numpy<3,>=1.17 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (2.3.1)
Requirement already satisfied: scipy>=1.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (1.16.0)
Requirement already satisfied: dill>=0.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.4.0)
Requirement already satisfied: stevedore>=3.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (5.4.1)
Requirement already satisfied: typing-extensions in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (4.14.1)
Requirement already satisfied: matplotlib>=3.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (3.10.3)
Requirement already satisfied: pydot in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (4.0.1)
Requirement already satisfied: Pillow>=4.2.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (11.3.0)
Requirement already satisfied: pylatexenc>=1.4 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (2.10)
Requirement already satisfied: seaborn>=0.9.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (0.13.2)
Requirement already satisfied: sympy>=1.3 in
```

```
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]) (1.14.0)
Requirement already satisfied: contourpy>=1.0.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (1.3.2)
Requirement already satisfied: cycler>=0.10 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (4.59.0)
Requirement already satisfied: kiwisolver>=1.3.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (1.4.8)
Requirement already satisfied: packaging>=20.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (25.0)
Requirement already satisfied: pyparsing>=2.3.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (3.2.3)
Requirement already satisfied: python-dateutil>=2.7 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]) (2.9.0.post0)
Requirement already satisfied: six>=1.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
python-dateutil>=2.7->matplotlib>=3.3->qiskit[visualization]) (1.17.0)
Requirement already satisfied: pandas>=1.2 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
seaborn>=0.9.0->qiskit[visualization]) (2.3.1)
Requirement already satisfied: pytz>=2020.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pandas>=1.2->seaborn>=0.9.0->qiskit[visualization]) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pandas>=1.2->seaborn>=0.9.0->qiskit[visualization]) (2025.2)
Requirement already satisfied: pbr>=2.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
stevedore>=3.0.0->qiskit[visualization]) (6.1.1)
Requirement already satisfied: setuptools in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pbr>=2.0.0->stevedore>=3.0.0->qiskit[visualization]) (65.5.0)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
sympy>=1.3->qiskit[visualization]) (1.3.0)
Note: you may need to restart the kernel to use updated packages.
```

[2]:
```
pip install qiskit-ibm-runtime
```

```
Requirement already satisfied: qiskit-ibm-runtime in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages
(0.40.1)
Requirement already satisfied: requests>=2.19 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (2.32.3)
Requirement already satisfied: requests-ntlm>=1.1.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (1.3.0)
Requirement already satisfied: numpy>=1.13 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (2.3.1)
Requirement already satisfied: urllib3>=1.21.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (2.5.0)
Requirement already satisfied: python-dateutil>=2.8.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (2.9.0.post0)
Requirement already satisfied: ibm-platform-services>=0.22.6 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (0.66.1)
Requirement already satisfied: pydantic>=2.5.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (2.11.7)
Requirement already satisfied: qiskit>=1.4.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (2.1.1)
Requirement already satisfied: packaging in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime) (25.0)
Requirement already satisfied: ibm_cloud_sdk_core<4.0.0,>=3.24.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ibm-platform-services>=0.22.6->qiskit-ibm-runtime) (3.24.1)
Requirement already satisfied: PyJWT<3.0.0,>=2.8.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ibm_cloud_sdk_core<4.0.0,>=3.24.1->ibm-platform-services>=0.22.6->qiskit-ibm-
runtime) (2.10.1)
Requirement already satisfied: six>=1.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
python-dateutil>=2.8.0->qiskit-ibm-runtime) (1.17.0)
Requirement already satisfied: charset-normalizer<4,>=2 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests>=2.19->qiskit-ibm-runtime) (3.4.2)
Requirement already satisfied: idna<4,>=2.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests>=2.19->qiskit-ibm-runtime) (3.10)
Requirement already satisfied: certifi>=2017.4.17 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
```

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requests>=2.19->qiskit-ibm-runtime) (2024.7.4)
Requirement already satisfied: annotated-types>=0.6.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pydantic>=2.5.0->qiskit-ibm-runtime) (0.7.0)
Requirement already satisfied: pydantic-core==2.33.2 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pydantic>=2.5.0->qiskit-ibm-runtime) (2.33.2)
Requirement already satisfied: typing-extensions>=4.12.2 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pydantic>=2.5.0->qiskit-ibm-runtime) (4.14.1)
Requirement already satisfied: typing-inspection>=0.4.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pydantic>=2.5.0->qiskit-ibm-runtime) (0.4.1)
Requirement already satisfied: rustworkx>=0.15.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit>=1.4.1->qiskit-ibm-runtime) (0.16.0)
Requirement already satisfied: scipy>=1.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit>=1.4.1->qiskit-ibm-runtime) (1.16.0)
Requirement already satisfied: dill>=0.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit>=1.4.1->qiskit-ibm-runtime) (0.4.0)
Requirement already satisfied: stevedore>=3.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit>=1.4.1->qiskit-ibm-runtime) (5.4.1)
Requirement already satisfied: cryptography>=1.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests-ntlm>=1.1.0->qiskit-ibm-runtime) (45.0.5)
Requirement already satisfied: pyspnego>=0.4.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests-ntlm>=1.1.0->qiskit-ibm-runtime) (0.11.2)
Requirement already satisfied: cffi>=1.14 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
cryptography>=1.3->requests-ntlm>=1.1.0->qiskit-ibm-runtime) (1.17.1)
Requirement already satisfied: pycparser in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
cffi>=1.14->cryptography>=1.3->requests-ntlm>=1.1.0->qiskit-ibm-runtime) (2.22)
Requirement already satisfied: pbr>=2.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
stevedore>=3.0.0->qiskit>=1.4.1->qiskit-ibm-runtime) (6.1.1)
Requirement already satisfied: setuptools in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pbr>=2.0.0->stevedore>=3.0.0->qiskit>=1.4.1->qiskit-ibm-runtime) (65.5.0)
Note: you may need to restart the kernel to use updated packages.
```

[3]:
```
pip install rustworkx
```

```
Requirement already satisfied: rustworkx in
```

```
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages
(0.16.0)
Requirement already satisfied: numpy<3,>=1.16.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
rustworkx) (2.3.1)
Note: you may need to restart the kernel to use updated packages.
```

[4]:
```
pip install -U qiskit "qc-grader[qiskit,jupyter] @ git+https://github.com/
↪qiskit-community/Quantum-Challenge-Grader.git"
```

```
Collecting qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git (from qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git)
  Cloning https://github.com/qiskit-community/Quantum-Challenge-Grader.git to
/tmp/pip-install-4wrkf1pn/qc-grader_56fe4f25037e408ca03a44ce33a74c92
  Running command git clone --filter=blob:none --quiet
https://github.com/qiskit-community/Quantum-Challenge-Grader.git /tmp/pip-
install-4wrkf1pn/qc-grader_56fe4f25037e408ca03a44ce33a74c92
  Resolved https://github.com/qiskit-community/Quantum-Challenge-Grader.git to
commit 1d7a6915623b0cfeac4c114391c279e9d98eb7f9
  Preparing metadata (setup.py) … done
Requirement already satisfied: qiskit in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (2.1.1)
Requirement already satisfied: typeguard in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (4.4.4)
Requirement already satisfied: jsonpickle==3.0.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (3.0.3)
Requirement already satisfied: requests==2.32.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (2.32.3)
Requirement already satisfied: ipycytoscape in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.3.3)
Requirement already satisfied: plotly in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (6.2.0)
```

```
Requirement already satisfied: networkx==3.2.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (3.2.1)
Requirement already satisfied: graphviz in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.21)
Requirement already satisfied: ibm-platform-services==0.66.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.66.1)
Requirement already satisfied: jupyterlab in /opt/conda/lib/python3.11/site-
packages (from qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (4.2.0)
Requirement already satisfied: ipykernel in /opt/conda/lib/python3.11/site-
packages (from qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (6.29.3)
Requirement already satisfied: qiskit-ibm-runtime in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.40.1)
Requirement already satisfied: qiskit-aer in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.17.1)
Requirement already satisfied: qiskit_serverless in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.25.1)
Requirement already satisfied: ibm_cloud_sdk_core<4.0.0,>=3.24.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ibm-platform-services==0.66.1->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (3.24.1)
Requirement already satisfied: charset-normalizer<4,>=2 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests==2.32.3->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (3.4.2)
```

```
Requirement already satisfied: idna<4,>=2.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests==2.32.3->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (3.10)
Requirement already satisfied: urllib3<3,>=1.21.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests==2.32.3->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (2.5.0)
Requirement already satisfied: certifi>=2017.4.17 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests==2.32.3->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (2024.7.4)
Requirement already satisfied: rustworkx>=0.15.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit) (0.16.0)
Requirement already satisfied: numpy<3,>=1.17 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit) (2.3.1)
Requirement already satisfied: scipy>=1.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit) (1.16.0)
Requirement already satisfied: dill>=0.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit) (0.4.0)
Requirement already satisfied: stevedore>=3.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit) (5.4.1)
Requirement already satisfied: typing-extensions in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit) (4.14.1)
Requirement already satisfied: python_dateutil<3.0.0,>=2.8.2 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ibm_cloud_sdk_core<4.0.0,>=3.24.1->ibm-platform-services==0.66.1->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.9.0.post0)
Requirement already satisfied: PyJWT<3.0.0,>=2.8.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ibm_cloud_sdk_core<4.0.0,>=3.24.1->ibm-platform-services==0.66.1->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.10.1)
Requirement already satisfied: six>=1.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
python_dateutil<3.0.0,>=2.8.2->ibm_cloud_sdk_core<4.0.0,>=3.24.1->ibm-platform-
```

```
services==0.66.1->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.17.0)
Requirement already satisfied: matplotlib>=3.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (3.10.3)
Requirement already satisfied: pydot in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (4.0.1)
Requirement already satisfied: Pillow>=4.2.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (11.3.0)
Requirement already satisfied: pylatexenc>=1.4 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.10)
Requirement already satisfied: seaborn>=0.9.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.13.2)
Requirement already satisfied: sympy>=1.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.14.0)
Requirement already satisfied: contourpy>=1.0.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.3.2)
Requirement already satisfied: cycler>=0.10 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
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git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.12.1)
Requirement already satisfied: fonttools>=4.22.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (4.59.0)
Requirement already satisfied: kiwisolver>=1.3.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.4.8)
Requirement already satisfied: packaging>=20.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (25.0)
Requirement already satisfied: pyparsing>=2.3.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
matplotlib>=3.3->qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (3.2.3)
Requirement already satisfied: pandas>=1.2 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
seaborn>=0.9.0->qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.3.1)
Requirement already satisfied: pytz>=2020.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pandas>=1.2->seaborn>=0.9.0->qiskit[visualization]~=2.1.0; extra ==
"qiskit"->qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (2025.2)
Requirement already satisfied: tzdata>=2022.7 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pandas>=1.2->seaborn>=0.9.0->qiskit[visualization]~=2.1.0; extra ==
"qiskit"->qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (2025.2)
Requirement already satisfied: pbr>=2.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
stevedore>=3.0.0->qiskit) (6.1.1)
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Requirement already satisfied: setuptools in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pbr>=2.0.0->stevedore>=3.0.0->qiskit) (65.5.0)
Requirement already satisfied: mpmath<1.4,>=1.1.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
sympy>=1.3->qiskit[visualization]~=2.1.0; extra == "qiskit"->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.3.0)
Requirement already satisfied: ipywidgets>=7.6.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipycytoscape->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (8.1.7)
Requirement already satisfied: spectate>=1.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipycytoscape->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.0.1)
Requirement already satisfied: comm>=0.1.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipywidgets>=7.6.0->ipycytoscape->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.2.2)
Requirement already satisfied: ipython>=6.1.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipywidgets>=7.6.0->ipycytoscape->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (8.37.0)
Requirement already satisfied: traitlets>=4.3.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipywidgets>=7.6.0->ipycytoscape->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (5.14.3)
Requirement already satisfied: widgetsnbextension~=4.0.14 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipywidgets>=7.6.0->ipycytoscape->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (4.0.14)
Requirement already satisfied: jupyterlab_widgets~=3.0.15 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipywidgets>=7.6.0->ipycytoscape->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (3.0.15)
Requirement already satisfied: decorator in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
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grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (5.2.1)
Requirement already satisfied: jedi>=0.16 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.19.2)
Requirement already satisfied: matplotlib-inline in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.1.7)
Requirement already satisfied: pexpect>4.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (4.9.0)
Requirement already satisfied: prompt_toolkit<3.1.0,>=3.0.41 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (3.0.51)
Requirement already satisfied: pygments>=2.4.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.19.2)
Requirement already satisfied: stack_data in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.6.3)
Requirement already satisfied: wcwidth in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from p
rompt_toolkit<3.1.0,>=3.0.41->ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape-
>qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.2.13)
Requirement already satisfied: parso<0.9.0,>=0.8.4 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jedi>=0.16->ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
```

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grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.8.4)
Requirement already satisfied: ptyprocess>=0.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pexpect>4.3->ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.7.0)
Requirement already satisfied: debugpy>=1.6.5 in /opt/conda/lib/python3.11/site-
packages (from ipykernel->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.8.1)
Requirement already satisfied: jupyter-client>=6.1.12 in
/opt/conda/lib/python3.11/site-packages (from ipykernel->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (8.6.1)
Requirement already satisfied: jupyter-core!=5.0.*,>=4.12 in
/opt/conda/lib/python3.11/site-packages (from ipykernel->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (5.7.2)
Requirement already satisfied: nest-asyncio in /opt/conda/lib/python3.11/site-
packages (from ipykernel->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.6.0)
Requirement already satisfied: psutil in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ipykernel->qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (7.0.0)
Requirement already satisfied: pyzmq>=24 in /opt/conda/lib/python3.11/site-
packages (from ipykernel->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (26.0.3)
Requirement already satisfied: tornado>=6.1 in /opt/conda/lib/python3.11/site-
packages (from ipykernel->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (6.4)
Requirement already satisfied: platformdirs>=2.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jupyter-core!=5.0.*,>=4.12->ipykernel->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (4.3.8)
Requirement already satisfied: async-lru>=1.0.0 in
/opt/conda/lib/python3.11/site-packages (from jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
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Challenge-Grader.git) (2.0.4)
Requirement already satisfied: httpx>=0.25.0 in /opt/conda/lib/python3.11/site-
packages (from jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.27.0)
Requirement already satisfied: jinja2>=3.0.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jupyterlab->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (3.1.6)
Requirement already satisfied: jupyter-lsp>=2.0.0 in
/opt/conda/lib/python3.11/site-packages (from jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.2.5)
Requirement already satisfied: jupyter-server<3,>=2.4.0 in
/opt/conda/lib/python3.11/site-packages (from jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.14.0)
Requirement already satisfied: jupyterlab-server<3,>=2.27.1 in
/opt/conda/lib/python3.11/site-packages (from jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.27.1)
Requirement already satisfied: notebook-shim>=0.2 in
/opt/conda/lib/python3.11/site-packages (from jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.2.4)
Requirement already satisfied: anyio>=3.1.0 in /opt/conda/lib/python3.11/site-
packages (from jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (4.3.0)
Requirement already satisfied: argon2-cffi>=21.1 in
/opt/conda/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (23.1.0)
Requirement already satisfied: jupyter-events>=0.9.0 in
/opt/conda/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.10.0)
Requirement already satisfied: jupyter-server-terminals>=0.4.4 in
/opt/conda/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
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community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.5.3)
Requirement already satisfied: nbconvert>=6.4.4 in
/opt/conda/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (7.16.4)
Requirement already satisfied: nbformat>=5.3.0 in
/opt/conda/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (5.10.4)
Requirement already satisfied: overrides>=5.0 in /opt/conda/lib/python3.11/site-
packages (from jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (7.7.0)
Requirement already satisfied: prometheus-client>=0.9 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.22.1)
Requirement already satisfied: send2trash>=1.8.2 in
/opt/conda/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.8.3)
Requirement already satisfied: terminado>=0.8.3 in
/opt/conda/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.18.1)
Requirement already satisfied: websocket-client>=1.7 in
/opt/conda/lib/python3.11/site-packages (from jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.8.0)
Requirement already satisfied: babel>=2.10 in /opt/conda/lib/python3.11/site-
packages (from jupyterlab-server<3,>=2.27.1->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.14.0)
Requirement already satisfied: json5>=0.9.0 in /opt/conda/lib/python3.11/site-
packages (from jupyterlab-server<3,>=2.27.1->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.9.25)
Requirement already satisfied: jsonschema>=4.18.0 in
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/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jupyterlab-server<3,>=2.27.1->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (4.25.0)
Requirement already satisfied: sniffio>=1.1 in /opt/conda/lib/python3.11/site-
packages (from anyio>=3.1.0->jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.3.1)
Requirement already satisfied: argon2-cffi-bindings in
/opt/conda/lib/python3.11/site-packages (from argon2-cffi>=21.1->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (21.2.0)
Requirement already satisfied: httpcore==1.* in /opt/conda/lib/python3.11/site-
packages (from httpx>=0.25.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.0.5)
Requirement already satisfied: h11<0.15,>=0.13 in
/opt/conda/lib/python3.11/site-packages (from
httpcore==1.*->httpx>=0.25.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.14.0)
Requirement already satisfied: MarkupSafe>=2.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jinja2>=3.0.3->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (3.0.2)
Requirement already satisfied: attrs>=22.2.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jsonschema>=4.18.0->jupyterlab-server<3,>=2.27.1->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (25.3.0)
Requirement already satisfied: jsonschema-specifications>=2023.03.6 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jsonschema>=4.18.0->jupyterlab-server<3,>=2.27.1->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2025.4.1)
Requirement already satisfied: referencing>=0.28.4 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jsonschema>=4.18.0->jupyterlab-server<3,>=2.27.1->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
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Challenge-Grader.git) (0.36.2)
Requirement already satisfied: rpds-py>=0.7.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jsonschema>=4.18.0->jupyterlab-server<3,>=2.27.1->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.26.0)
Requirement already satisfied: python-json-logger>=2.0.4 in
/opt/conda/lib/python3.11/site-packages (from jupyter-events>=0.9.0->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (2.0.7)
Requirement already satisfied: pyyaml>=5.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
jupyter-events>=0.9.0->jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (6.0.2)
Requirement already satisfied: rfc3339-validator in
/opt/conda/lib/python3.11/site-packages (from jupyter-events>=0.9.0->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.1.4)
Requirement already satisfied: rfc3986-validator>=0.1.1 in
/opt/conda/lib/python3.11/site-packages (from jupyter-events>=0.9.0->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.1.1)
Requirement already satisfied: fqdn in /opt/conda/lib/python3.11/site-packages
(from jsonschema[format-nongpl]>=4.18.0->jupyter-events>=0.9.0->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.5.1)
Requirement already satisfied: isoduration in /opt/conda/lib/python3.11/site-
packages (from jsonschema[format-nongpl]>=4.18.0->jupyter-
events>=0.9.0->jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (20.11.0)
Requirement already satisfied: jsonpointer>1.13 in
/opt/conda/lib/python3.11/site-packages (from jsonschema[format-
nongpl]>=4.18.0->jupyter-events>=0.9.0->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (2.4)
Collecting rfc3987-syntax>=1.1.0 (from jsonschema[format-
nongpl]>=4.18.0->jupyter-events>=0.9.0->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
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community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git)
  Using cached rfc3987_syntax-1.1.0-py3-none-any.whl.metadata (7.7 kB)
Requirement already satisfied: uri-template in /opt/conda/lib/python3.11/site-
packages (from jsonschema[format-nongpl]>=4.18.0->jupyter-
events>=0.9.0->jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.3.0)
Collecting webcolors>=24.6.0 (from jsonschema[format-nongpl]>=4.18.0->jupyter-
events>=0.9.0->jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git)
  Using cached webcolors-24.11.1-py3-none-any.whl.metadata (2.2 kB)
Requirement already satisfied: beautifulsoup4 in /opt/conda/lib/python3.11/site-
packages (from nbconvert>=6.4.4->jupyter-server<3,>=2.4.0->jupyterlab->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (4.12.3)
Requirement already satisfied: bleach!=5.0.0 in /opt/conda/lib/python3.11/site-
packages (from nbconvert>=6.4.4->jupyter-server<3,>=2.4.0->jupyterlab->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (6.1.0)
Requirement already satisfied: defusedxml in /opt/conda/lib/python3.11/site-
packages (from nbconvert>=6.4.4->jupyter-server<3,>=2.4.0->jupyterlab->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.7.1)
Requirement already satisfied: jupyterlab-pygments in
/opt/conda/lib/python3.11/site-packages (from nbconvert>=6.4.4->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.3.0)
Requirement already satisfied: mistune<4,>=2.0.3 in
/opt/conda/lib/python3.11/site-packages (from nbconvert>=6.4.4->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (3.0.2)
Requirement already satisfied: nbclient>=0.5.0 in
/opt/conda/lib/python3.11/site-packages (from nbconvert>=6.4.4->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.10.0)
Requirement already satisfied: pandocfilters>=1.4.1 in
/opt/conda/lib/python3.11/site-packages (from nbconvert>=6.4.4->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
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community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.5.0)
Requirement already satisfied: tinycss2 in /opt/conda/lib/python3.11/site-
packages (from nbconvert>=6.4.4->jupyter-server<3,>=2.4.0->jupyterlab->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.3.0)
Requirement already satisfied: webencodings in /opt/conda/lib/python3.11/site-
packages (from bleach!=5.0.0->nbconvert>=6.4.4->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.5.1)
Requirement already satisfied: fastjsonschema>=2.15 in
/opt/conda/lib/python3.11/site-packages (from nbformat>=5.3.0->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (2.19.1)
Collecting lark>=1.2.2 (from rfc3987-syntax>=1.1.0->jsonschema[format-
nongpl]>=4.18.0->jupyter-events>=0.9.0->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git)
  Using cached lark-1.2.2-py3-none-any.whl.metadata (1.8 kB)
Requirement already satisfied: cffi>=1.0.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
argon2-cffi-bindings->argon2-cffi>=21.1->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.17.1)
Requirement already satisfied: pycparser in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
cffi>=1.0.1->argon2-cffi-bindings->argon2-cffi>=21.1->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (2.22)
Requirement already satisfied: soupsieve>1.2 in /opt/conda/lib/python3.11/site-
packages (from beautifulsoup4->nbconvert>=6.4.4->jupyter-
server<3,>=2.4.0->jupyterlab->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (2.5)
Requirement already satisfied: arrow>=0.15.0 in /opt/conda/lib/python3.11/site-
packages (from isoduration->jsonschema[format-nongpl]>=4.18.0->jupyter-
events>=0.9.0->jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.3.0)
Requirement already satisfied: types-python-dateutil>=2.8.10 in
/opt/conda/lib/python3.11/site-packages (from
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arrow>=0.15.0->isoduration->jsonschema[format-nongpl]>=4.18.0->jupyter-
events>=0.9.0->jupyter-server<3,>=2.4.0->jupyterlab->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.9.0.20240316)
Requirement already satisfied: narwhals>=1.15.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
plotly->qc-grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.47.1)
Requirement already satisfied: requests-ntlm>=1.1.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.3.0)
Requirement already satisfied: pydantic>=2.5.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit-ibm-runtime->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (2.11.7)
Requirement already satisfied: annotated-types>=0.6.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pydantic>=2.5.0->qiskit-ibm-runtime->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.7.0)
Requirement already satisfied: pydantic-core==2.33.2 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pydantic>=2.5.0->qiskit-ibm-runtime->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (2.33.2)
Requirement already satisfied: typing-inspection>=0.4.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
pydantic>=2.5.0->qiskit-ibm-runtime->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.4.1)
Requirement already satisfied: cryptography>=1.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests-ntlm>=1.1.0->qiskit-ibm-runtime->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (45.0.5)
Requirement already satisfied: pyspnego>=0.4.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
requests-ntlm>=1.1.0->qiskit-ibm-runtime->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.11.2)
Requirement already satisfied: ray<3,>=2.30 in
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/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.47.1)
Requirement already satisfied: importlib-metadata<9,>=5.2.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (8.4.0)
Requirement already satisfied: cloudpickle==2.2.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (2.2.1)
Requirement already satisfied: tqdm<5,>=4.66.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (4.67.1)
Requirement already satisfied: opentelemetry-api<1.33.1,>=1.18.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.33.0)
Requirement already satisfied: opentelemetry-sdk<1.33.1,>=1.18.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.33.0)
Requirement already satisfied: opentelemetry-exporter-otlp-proto-
grpc<1.33.1,>=1.18.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.33.0)
Requirement already satisfied: s3fs>=2023.6.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (2025.7.0)
Requirement already satisfied: opentelemetry-instrumentation-requests>=0.40b0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.54b0)
Requirement already satisfied: pyarrow<19,>=16.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
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qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (18.1.0)
Requirement already satisfied: aiohttp<4,>=3.10.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (3.12.14)
Requirement already satisfied: zipp==3.19.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit_serverless->qc-grader@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (3.19.1)
Requirement already satisfied: aiohappyeyeballs>=2.5.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
aiohttp<4,>=3.10.0->qiskit_serverless->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (2.6.1)
Requirement already satisfied: aiosignal>=1.4.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
aiohttp<4,>=3.10.0->qiskit_serverless->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.4.0)
Requirement already satisfied: frozenlist>=1.1.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
aiohttp<4,>=3.10.0->qiskit_serverless->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.7.0)
Requirement already satisfied: multidict<7.0,>=4.5 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
aiohttp<4,>=3.10.0->qiskit_serverless->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (6.6.3)
Requirement already satisfied: propcache>=0.2.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
aiohttp<4,>=3.10.0->qiskit_serverless->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (0.3.2)
Requirement already satisfied: yarl<2.0,>=1.17.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
aiohttp<4,>=3.10.0->qiskit_serverless->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (1.20.1)
Requirement already satisfied: deprecated>=1.2.6 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opentelemetry-api<1.33.1,>=1.18.0->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
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Challenge-Grader.git) (1.2.18)
Requirement already satisfied: googleapis-common-protos~=1.52 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opentelemetry-exporter-otlp-proto-grpc<1.33.1,>=1.18.0->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.70.0)
Requirement already satisfied: grpcio<2.0.0,>=1.63.2 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opentelemetry-exporter-otlp-proto-grpc<1.33.1,>=1.18.0->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.73.1)
Requirement already satisfied: opentelemetry-exporter-otlp-proto-common==1.33.0
in /opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages
(from opentelemetry-exporter-otlp-proto-
grpc<1.33.1,>=1.18.0->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.33.0)
Requirement already satisfied: opentelemetry-proto==1.33.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opentelemetry-exporter-otlp-proto-grpc<1.33.1,>=1.18.0->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.33.0)
Requirement already satisfied: protobuf<6.0,>=5.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opentelemetry-proto==1.33.0->opentelemetry-exporter-otlp-proto-
grpc<1.33.1,>=1.18.0->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (5.29.5)
Requirement already satisfied: opentelemetry-semantic-conventions==0.54b0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opentelemetry-sdk<1.33.1,>=1.18.0->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.54b0)
Requirement already satisfied: symengine<0.14,>=0.11 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
qiskit) (0.13.0)
Requirement already satisfied: click>=7.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray<3,>=2.30->ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (8.2.1)
```

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Requirement already satisfied: filelock in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray<3,>=2.30->ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (3.18.0)
Requirement already satisfied: msgpack<2.0.0,>=1.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray<3,>=2.30->ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.1.1)
Requirement already satisfied: aiohttp_cors in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.8.1)
Requirement already satisfied: colorful in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.5.7)
Requirement already satisfied: py-spy>=0.2.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.4.0)
Requirement already satisfied: opencensus in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.11.4)
Requirement already satisfied: opentelemetry-exporter-prometheus in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.54b0)
Requirement already satisfied: smart_open in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (7.3.0.post1)
```

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Requirement already satisfied: virtualenv!=20.21.1,>=20.0.24 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (20.31.2)
Requirement already satisfied: wrapt<2,>=1.10 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
deprecated>=1.2.6->opentelemetry-api<1.33.1,>=1.18.0->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.17.2)
Requirement already satisfied: opentelemetry-instrumentation==0.54b0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opentelemetry-instrumentation-requests>=0.40b0->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.54b0)
Requirement already satisfied: opentelemetry-util-http==0.54b0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opentelemetry-instrumentation-requests>=0.40b0->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.54b0)
Requirement already satisfied: aiobotocore<3.0.0,>=2.5.4 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
s3fs>=2023.6.0->qiskit_serverless->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (2.23.1)
Requirement already satisfied: fsspec==2025.7.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
s3fs>=2023.6.0->qiskit_serverless->qc-grader@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git->qc-grader[jupyter,qiskit]@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git) (2025.7.0)
Requirement already satisfied: aioitertools<1.0.0,>=0.5.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
aiobotocore<3.0.0,>=2.5.4->s3fs>=2023.6.0->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.12.0)
Requirement already satisfied: botocore<1.38.47,>=1.38.40 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
aiobotocore<3.0.0,>=2.5.4->s3fs>=2023.6.0->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.38.46)
Requirement already satisfied: jmespath<2.0.0,>=0.7.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
```

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aiobotocore<3.0.0,>=2.5.4->s3fs>=2023.6.0->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (1.0.1)
Requirement already satisfied: distlib<1,>=0.3.7 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
virtualenv!=20.21.1,>=20.0.24->ray[default]<3,>=2.30->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.4.0)
Requirement already satisfied: opencensus-context>=0.1.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opencensus->ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.1.3)
Requirement already satisfied: google-api-core<3.0.0,>=1.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
opencensus->ray[default]<3,>=2.30->qiskit_serverless->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.25.1)
Requirement already satisfied: proto-plus<2.0.0,>=1.22.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
google-api-
core<3.0.0,>=1.0.0->opencensus->ray[default]<3,>=2.30->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (1.26.1)
Requirement already satisfied: google-auth<3.0.0,>=2.14.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
google-api-
core<3.0.0,>=1.0.0->opencensus->ray[default]<3,>=2.30->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (2.40.3)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
google-auth<3.0.0,>=2.14.1->google-api-
core<3.0.0,>=1.0.0->opencensus->ray[default]<3,>=2.30->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (5.5.2)
Requirement already satisfied: pyasn1-modules>=0.2.1 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
google-auth<3.0.0,>=2.14.1->google-api-
core<3.0.0,>=1.0.0->opencensus->ray[default]<3,>=2.30->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
```

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Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.4.2)
Requirement already satisfied: rsa<5,>=3.1.4 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
google-auth<3.0.0,>=2.14.1->google-api-
core<3.0.0,>=1.0.0->opencensus->ray[default]<3,>=2.30->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (4.9.1)
Requirement already satisfied: pyasn1>=0.1.3 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
rsa<5,>=3.1.4->google-auth<3.0.0,>=2.14.1->google-api-
core<3.0.0,>=1.0.0->opencensus->ray[default]<3,>=2.30->qiskit_serverless->qc-
grader@ git+https://github.com/qiskit-community/Quantum-Challenge-
Grader.git->qc-grader[jupyter,qiskit]@ git+https://github.com/qiskit-
community/Quantum-Challenge-Grader.git) (0.6.1)
Requirement already satisfied: executing>=1.2.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
stack_data->ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (2.2.0)
Requirement already satisfied: asttokens>=2.1.0 in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
stack_data->ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (3.0.0)
Requirement already satisfied: pure-eval in
/opt/.qbraid/environments/qgss_000000/pyenv/lib/python3.11/site-packages (from
stack_data->ipython>=6.1.0->ipywidgets>=7.6.0->ipycytoscape->qc-grader@
git+https://github.com/qiskit-community/Quantum-Challenge-Grader.git->qc-
grader[jupyter,qiskit]@ git+https://github.com/qiskit-community/Quantum-
Challenge-Grader.git) (0.2.3)
Using cached rfc3987_syntax-1.1.0-py3-none-any.whl (8.0 kB)
Using cached lark-1.2.2-py3-none-any.whl (111 kB)
Using cached webcolors-24.11.1-py3-none-any.whl (14 kB)
Installing collected packages: webcolors, lark, rfc3987-syntax
  Attempting uninstall: webcolors
    Found existing installation: webcolors 1.13
    Not uninstalling webcolors at /opt/conda/lib/python3.11/site-packages,
outside environment /opt/.qbraid/environments/qgss_000000/pyenv
    Can't uninstall 'webcolors'. No files were found to uninstall.
                           3/3
[rfc3987-syntax]
Successfully installed lark-1.2.2 rfc3987-syntax-1.1.0 webcolors-24.11.1
Note: you may need to restart the kernel to use updated packages.
```

[5]:
```
import qiskit
import qc_grader

print(f"Qiskit version: {qiskit.__version__}")
print(f"Grader version: {qc_grader.__version__}")
```

```
Qiskit version: 2.1.1
Grader version: 0.22.12
```

[6]:
```
from qiskit_ibm_runtime import QiskitRuntimeService


service = QiskitRuntimeService(name="qgss-2025")
service.saved_accounts()
```

[6]:
```
{'qgss-2025': {'channel': 'ibm_quantum_platform',
  'url': 'https://cloud.ibm.com',
  'token': 'xi0nZf18SfBZn-P1f124QEWDywbHVDPldD9sjHLkYjNE',
  'instance': 'crn:v1:bluemix:public:quantum-computing:us-
east:a/28121048c51949f9a93006ccbc7b3faf:edce2be1-5f4f-4532-9d3d-72a7b8c6538d::',
  'verify': True,
  'private_endpoint': False}}
```

[7]:
```
import rustworkx as rx
import numpy as np
import matplotlib.pyplot as plt
from rustworkx.visualization import mpl_draw as draw_graph
from qiskit_ibm_runtime import QiskitRuntimeService
from scipy.optimize import minimize

from qiskit import QuantumCircuit
from qiskit.providers.fake_provider import GenericBackendV2
from qiskit.quantum_info import SparsePauliOp, Statevector, DensityMatrix,␣
 ↪Operator
from qiskit.circuit.library import QAOAAnsatz
from qiskit.transpiler.preset_passmanagers import generate_preset_pass_manager
from qiskit.visualization import plot_histogram
from qiskit.transpiler import Layout

from qiskit_ibm_runtime import (
    Session,
    EstimatorV2 as Estimator,
    SamplerV2 as Sampler,
    EstimatorOptions,
)
from qiskit_ibm_runtime.debug_tools import Neat
from qiskit_aer import AerSimulator
```

```
from utils import zne_method, plot_zne, plot_backend_errors_and_counts
from qc_grader.challenges.qgss_2025 import (
    grade_lab2_ex1,
    grade_lab2_ex2,
    grade_lab2_ex3,
    grade_lab2_ex4,
    grade_lab2_ex5,
    grade_lab2_ex6a,
    grade_lab2_ex6b,
)
```

[8]:
```
# Execute to make arrays of properties
service = QiskitRuntimeService(name="qgss-2025")
# We define a specific backend
brisbane_backend = service.backend("ibm_brisbane")
# We obtain the system properties, number of qubits and coupling map
properties = brisbane_backend.properties()
num_qubits = brisbane_backend.num_qubits
coupling_map = brisbane_backend.coupling_map

# We define various lists of metrics for all the qubits of the backend
t1, t2, gate_error_x, readout_error, gate_error_ecr = [], [], [], [], []
for i in range(num_qubits):
    t1.append(properties.t1(i))
    t2.append(properties.t2(i))
    gate_error_x.append(properties.gate_error(gate="x", qubits=i))
    readout_error.append(properties.readout_error(i))
for pair in coupling_map:
    gate_error_ecr.append(properties.gate_error(gate="ecr", qubits=pair))
```

[9]:
```
def find_best_metrics(backend) -> list[tuple[int or list, float]]:
    """Finds the best-performing qubits and qubit pair based on various␣
 ↪hardware metrics."""

    # ---- Task 0: Gather backend properties ----
    properties = backend.properties()
    num_qubits = backend.num_qubits
    coupling_map = backend.coupling_map

    t1, t2, gate_error_x, readout_error, gate_error_ecr = [], [], [], [], []

    for i in range(num_qubits):
        t1.append(properties.t1(i))
        t2.append(properties.t2(i))
        gate_error_x.append(properties.gate_error(gate="x", qubits=i))
        readout_error.append(properties.readout_error(i))
```

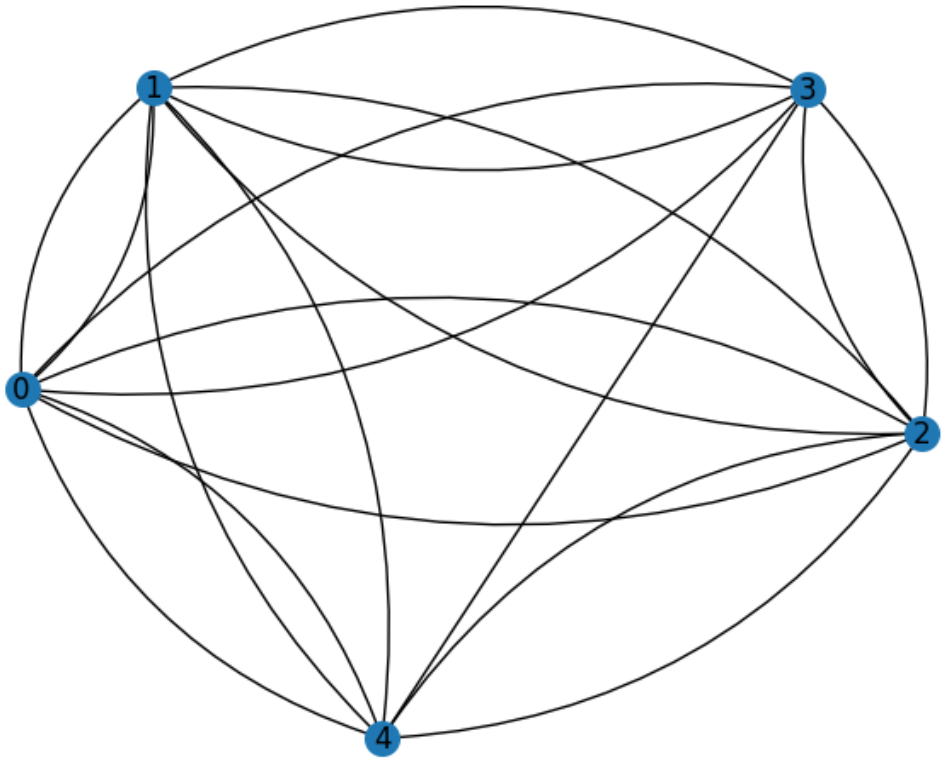
```
    for pair in coupling_map:
        gate_error_ecr.append((pair, properties.gate_error(gate="ecr",␣
↪qubits=pair)))

    # ---- Task 1: Extract best values and indices ----

    # Longest T1
    max_t1 = max(t1)
    index_t1_max = t1.index(max_t1)

    # Longest T2
    max_t2 = max(t2)
    index_t2_max = t2.index(max_t2)

    # Lowest single-qubit X gate error
    min_x_error = min(gate_error_x)
    index_min_x_error = gate_error_x.index(min_x_error)

    # Lowest readout error
    min_readout = min(readout_error)
    index_min_readout = readout_error.index(min_readout)

    # Lowest ECR error
    min_ecr_pair, min_ecr_error = min(gate_error_ecr, key=lambda x: x[1])

    # ---- Final return ----
    solutions = [
        [int(index_t1_max), max_t1],
        [int(index_t2_max), max_t2],
        [int(index_min_x_error), min_x_error],
        [int(index_min_readout), min_readout],
        [list(min_ecr_pair), min_ecr_error],
    ]
    return solutions
```

[10]:
```
# Submit your answer using the following code
grade_lab2_ex1(find_best_metrics)
```

```
Submitting your answer. Please wait…
Congratulations!  Your answer is correct.
```

[11]:
```
# We define the seed
seed = 43
# We define the number of nodes:
n = 5
# We define the graph
```

```
graph = rx.PyGraph()
graph.add_nodes_from(np.arange(0, n, 1))
generic_backend = GenericBackendV2(n, seed=seed)
weights = 1
# We make it explicitly asymmetrical to have a smaller set of solutions
graph.add_edges_from([(edge[0], edge[1], weights) for edge in generic_backend.
 ↪coupling_map][:-1])
draw_graph(graph, node_size=200, with_labels=True, width=1)
```



[12]:
```
def graph_to_Pauli(graph: rx.PyGraph) -> list[tuple[str, float]]:
    """Convert the graph into a Pauli list representing the Max-Cut cost␣
 ↪Hamiltonian."""
    n = graph.num_nodes()
    pauli_list = []

    for (i, j, weight) in graph.weighted_edge_list():
        # Create a Pauli string with 'Z' at positions i and j, 'I' elsewhere
        z_term = ["I"] * n
        z_term[i] = "Z"
        z_term[j] = "Z"
```

```
        pauli_str = "".join(reversed(z_term))  # Little-endian format
        pauli_list.append((pauli_str, weight))  # Just weight, no factor of 1/2

    return pauli_list



max_cut_paulis = graph_to_Pauli(graph)
cost_hamiltonian = SparsePauliOp.from_list(max_cut_paulis)
print("Cost Function Hamiltonian:", cost_hamiltonian)
```

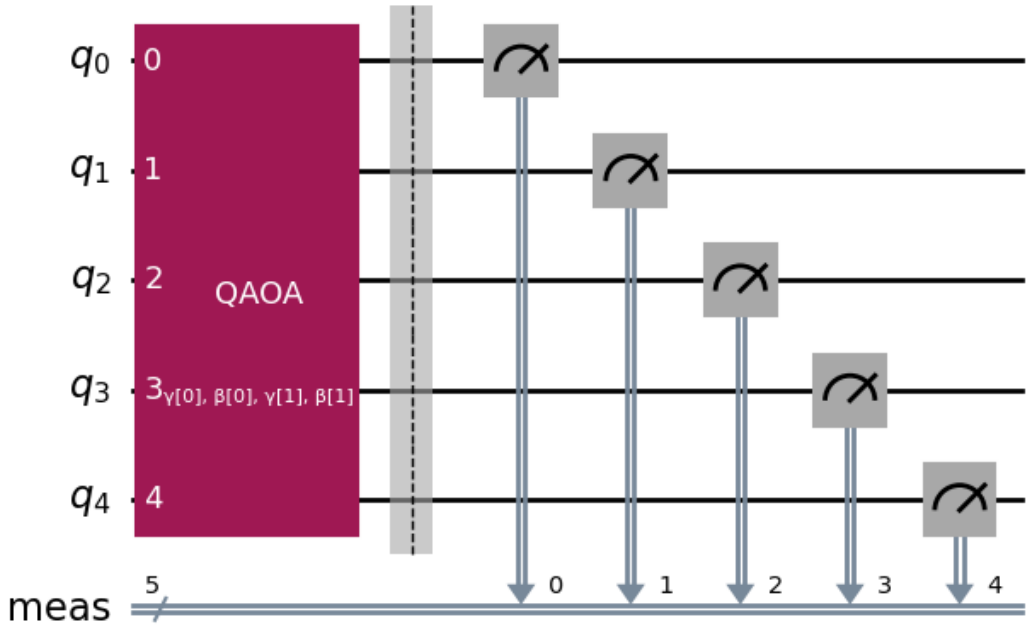
```
Cost Function Hamiltonian: SparsePauliOp(['IIIZZ', 'IIIZZ', 'IIZIZ', 'IIZIZ',
'IZIIZ', 'IZIIZ', 'ZIIIZ', 'ZIIIZ', 'IIZZI', 'IIZZI', 'IZIZI', 'IZIZI', 'ZIIZI',
'ZIIZI', 'IZZII', 'IZZII', 'ZIZII', 'ZIZII', 'ZZIII'],
              coeffs=[1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j,
1.+0.j, 1.+0.j,
 1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j, 1.+0.j,
 1.+0.j])
```

[13]:
```
# Submit your answer using the following code
grade_lab2_ex2(graph_to_Pauli)
```

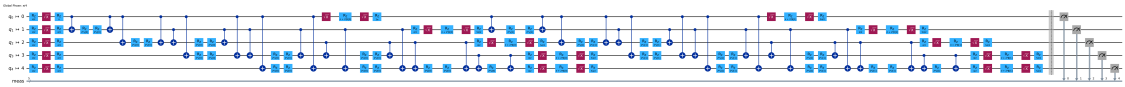
```
Submitting your answer. Please wait…
Congratulations!  Your answer is correct.
```

[14]:
```
layers = 2
qaoa_circuit = QAOAAnsatz(cost_operator=cost_hamiltonian, reps=layers)
qaoa_circuit.measure_all()
qaoa_circuit.draw("mpl")
```

[14]:



[15]:
```
# Create pass manager for transpilation

pm = generate_preset_pass_manager(
    optimization_level=3, backend=generic_backend, seed_transpiler=seed
)

qaoa_circuit_transpiled = pm.run(qaoa_circuit)
qaoa_circuit_transpiled.draw("mpl", fold=False, idle_wires=False)
```

[15]:


[16]:
```
init_params = np.zeros(2 * layers)
```

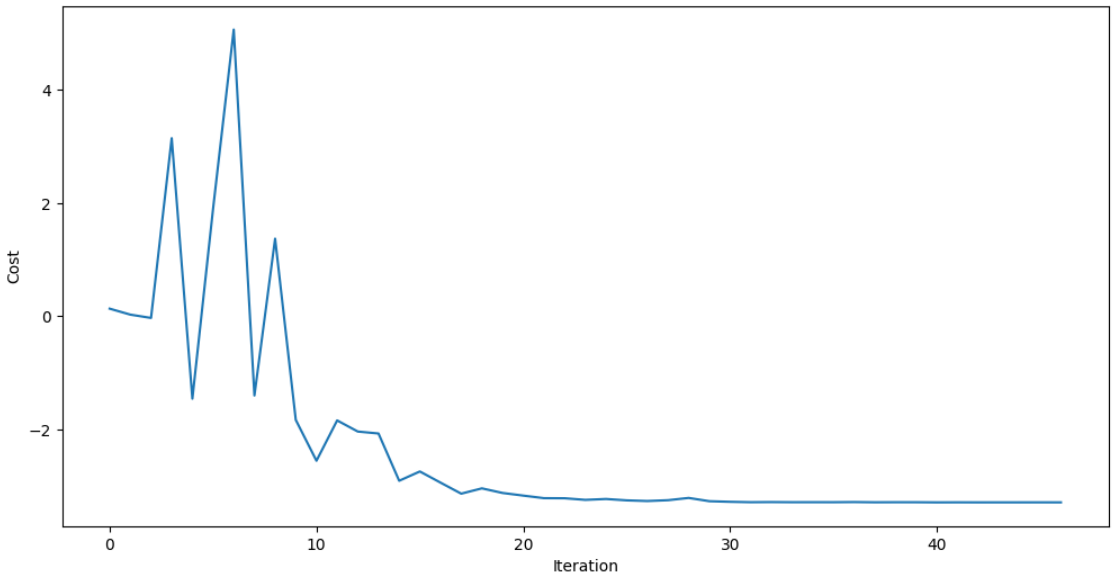
[17]:
```
objective_func_vals = []


def cost_func_estimator(
    params: list, ansatz: QuantumCircuit, isa_hamiltonian: SparsePauliOp,␣
 ↪estimator: Estimator
) -> float:
```

```
    """Compute the cost function value using a parameterized ansatz and an␣
 ↪estimator for a given Hamiltonian."""
    if isa_hamiltonian.num_qubits != ansatz.num_qubits:
        isa_hamiltonian = isa_hamiltonian.apply_layout(ansatz.layout)
    pub = (ansatz, isa_hamiltonian, params)
    job = estimator.run([pub])
    results = job.result()[0]
    cost = results.data.evs
    objective_func_vals.append(cost)
    return cost


def train_qaoa(
    params: list,
    circuit: QuantumCircuit,
    hamiltonian: SparsePauliOp,
    backend: QiskitRuntimeService.backend,
) -> tuple:
    """Optimize QAOA parameters using COBYLA and an estimator on a given␣
 ↪backend."""
    with Session(backend=backend) as session:
        options = {"simulator": {"seed_simulator": seed}}
        estimator = Estimator(mode=session, options=options)
        estimator.options.default_shots = 100000

        result = minimize(
            cost_func_estimator,
            params,
            args=(circuit, hamiltonian, estimator),
            method="COBYLA",
            options={"maxiter": 200, "rhobeg": 1, "catol": 1e-3, "tol": 0.0001},
        )
    print(result)
    return result, objective_func_vals


result_qaoa, objective_func_vals = train_qaoa(
    init_params, qaoa_circuit_transpiled, cost_hamiltonian, generic_backend
)
```

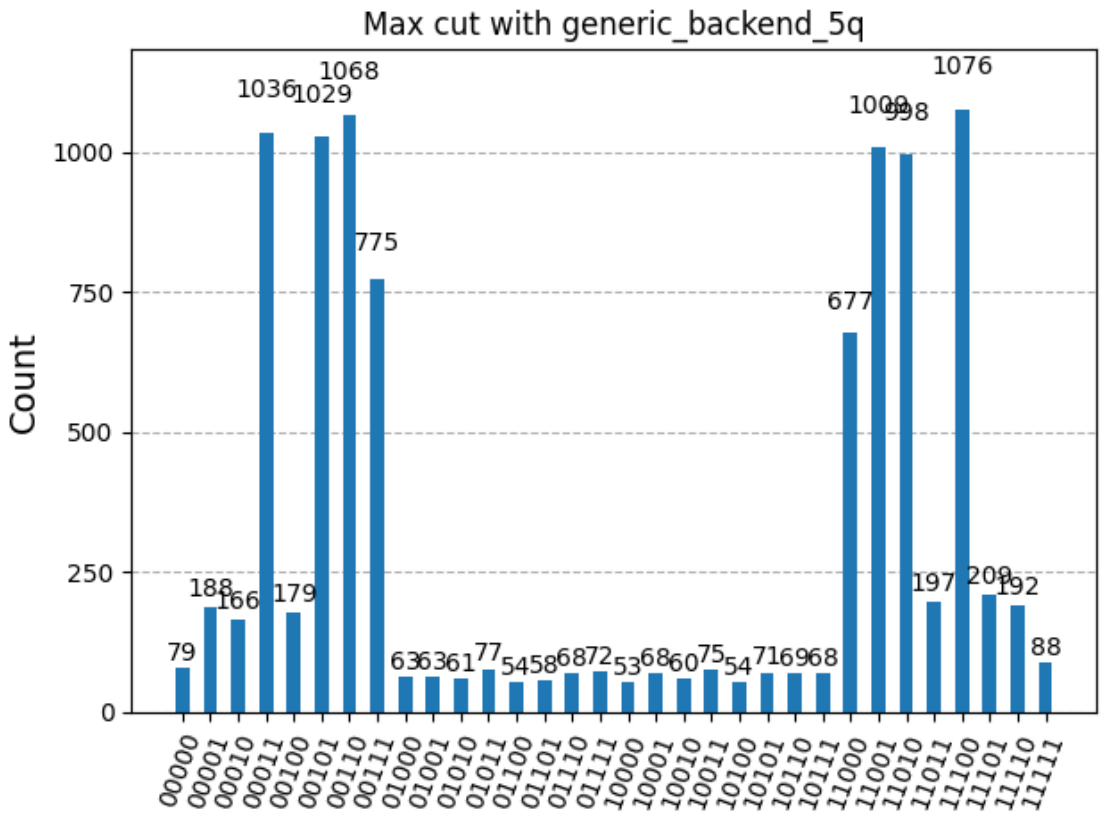
```
 message: Return from COBYLA because the trust region radius reaches its lower
bound.
 success: True
  status: 0
     fun: -3.2863771362286376
       x: [ 9.958e-01  1.181e+00  3.710e-02  9.495e-01]
    nfev: 47
```

```
   maxcv: 0.0
```

[18]:
```
plt.figure(figsize=(12, 6))
plt.plot(objective_func_vals)
plt.xlabel("Iteration")
plt.ylabel("Cost")
plt.show()
```



[19]:
```
# Get the optimized parameters from the result
opt_params = result_qaoa.x
SHOTS = 10000


def sample_qaoa(opt_params, circuit, backend):

    # Submit the circuit to Sampler
    options = {"simulator": {"seed_simulator": seed}}
    sampler = Sampler(mode=backend, options=options)
    job = sampler.run([(circuit, opt_params)], shots=SHOTS)
    results_sampler = job.result()
    counts_list = results_sampler[0].data.meas.get_counts()
    display(plot_histogram(counts_list, title=f"Max cut with {backend.name}"))

    return counts_list


counts_list = sample_qaoa(opt_params, qaoa_circuit_transpiled, generic_backend)
```



[20]:
```
eigenvalues, eigenvectors = np.linalg.eig(cost_hamiltonian)
ground_energy = min(eigenvalues).real
num_solutions = eigenvalues.tolist().count(ground_energy)
index_solutions = np.where(eigenvalues == ground_energy)[0].tolist()
print(f"The ground energy of the Hamiltonian is {ground_energy}")
print(f"The number of solutions of the problem is {num_solutions}")
print(f"The list of the solutions based on their index is {index_solutions}")
```

```
The ground energy of the Hamiltonian is -5.0
The number of solutions of the problem is 8
The list of the solutions based on their index is [3, 5, 6, 7, 24, 25, 26, 28]
```

[21]:
```
def decimal_to_binary(decimal_list, n):
    return [bin(num)[2:].zfill(n) for num in decimal_list]


# Convert the solutions to quantum states
states_solutions = decimal_to_binary(index_solutions, n)
# Sort the dictionary items by their counts in descending order
sorted_states = sorted(counts_list.items(), key=lambda item: item[1],␣
 ↪reverse=True)
```

```
# Take the top 'num_solutions' entries
top_states = sorted_states[:num_solutions]
# Extract only the states keys from the top entries
qaoa_ground_states = sorted([state for state, count in top_states])
print(f"The analytical solutions for the Max-cut problem are:␣
 ↪{states_solutions}")
print(f"The QAOA ground states solutions for the Max-cut are:␣
 ↪{qaoa_ground_states}")
```

```
The analytical solutions for the Max-cut problem are: ['00011', '00101',
'00110', '00111', '11000', '11001', '11010', '11100']
The QAOA ground states solutions for the Max-cut are: ['00011', '00101',
'00110', '00111', '11000', '11001', '11010', '11100']
```

[22]:
```
real_backends = service.backends()
print(f"The quantum computers available for you are {real_backends}")
```

```
The quantum computers available for you are [<IBMBackend('ibm_brisbane')>,
<IBMBackend('ibm_sherbrooke')>, <IBMBackend('ibm_torino')>]
```

[23]:
```
# backends=[service.backend("alt_brisbane"),service.
 ↪backend("alt_kawasaki"),service.backend("alt_torino")]
real_backends = [
    service.backend("ibm_brisbane"),
    service.backend("ibm_sherbrooke"),
    service.backend("ibm_torino"),
]
```

[24]:
```
noisy_fake_backends = []
for backend in real_backends:
    noisy_fake_backends.append(AerSimulator.from_backend(backend,␣
 ↪seed_simulator=seed))
print(f"The noisy simulators are {noisy_fake_backends}")
```

```
The noisy simulators are [AerSimulator('aer_simulator_from(ibm_brisbane)'
             noise_model=<NoiseModel on ['reset', 'sx', 'measure', 'x', 'id',
'ecr']>), AerSimulator('aer_simulator_from(ibm_sherbrooke)'
             noise_model=<NoiseModel on ['reset', 'sx', 'measure', 'x', 'id',
'ecr']>), AerSimulator('aer_simulator_from(ibm_torino)'
             noise_model=<NoiseModel on ['reset', 'sx', 'measure', 'x', 'id',
'cz']>)]
```

[25]:
```
def accumulated_errors(backend: QiskitRuntimeService.backend, circuit:␣
 ↪QuantumCircuit) -> list:
    """Compute accumulated gate and readout errors for a given circuit on a␣
 ↪specific backend."""
```

```
    # Initializing quantities
    acc_single_qubit_error = 0
    acc_two_qubit_error = 0
    single_qubit_gate_count = 0
    two_qubit_gate_count = 0
    acc_readout_error = 0

    # Defining useful variables
    properties = backend.properties()
    qubit_layout = list(circuit.layout.initial_layout.get_physical_bits().
↪keys())[:n]

    # Define readout error (only for qubits in layout)
    for q in qubit_layout:
        acc_readout_error += properties.readout_error(q)

    # Identify which two-qubit gate is used
    basis_gates = backend.configuration().basis_gates
    if "ecr" in basis_gates:
        two_qubit_gate = "ecr"
    elif "cz" in basis_gates:
        two_qubit_gate = "cz"
    elif "cx" in basis_gates:
        two_qubit_gate = "cx"
    else:
        raise ValueError("No supported two-qubit gate found in backend basis␣
↪gates.")

    # Loop over the instructions in the circuit
    for instruction in circuit.data:
        name = instruction.operation.name
        qubits = [circuit.find_bit(q).index for q in instruction.qubits]

        # Skip measure (readout already included)
        if name == "measure":
            continue

        # Single-qubit gate
        if len(qubits) == 1:
            single_qubit_gate_count += 1
            q = qubits[0]
            acc_single_qubit_error += properties.gate_error(name, [q])

        # Two-qubit gate
        elif len(qubits) == 2 and name == two_qubit_gate:
            two_qubit_gate_count += 1
            acc_two_qubit_error += properties.gate_error(name, qubits)
```

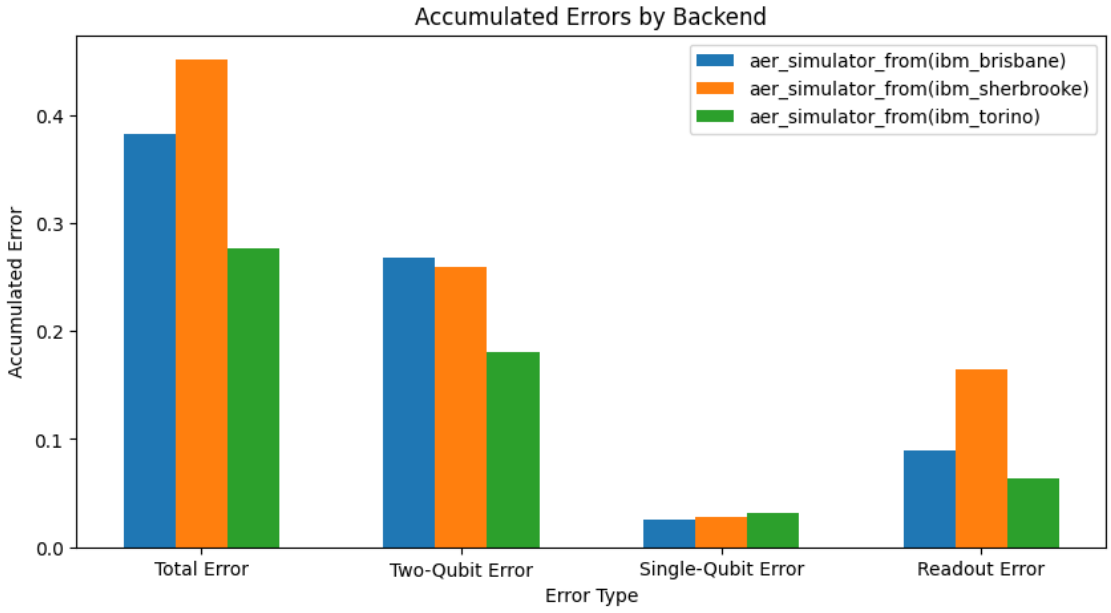
```
    acc_total_error = acc_two_qubit_error + acc_single_qubit_error +␣
 ↪acc_readout_error

    results = [
        acc_total_error,
        acc_two_qubit_error,
        acc_single_qubit_error,
        acc_readout_error,
        single_qubit_gate_count,
        two_qubit_gate_count,
    ]
    return results
```

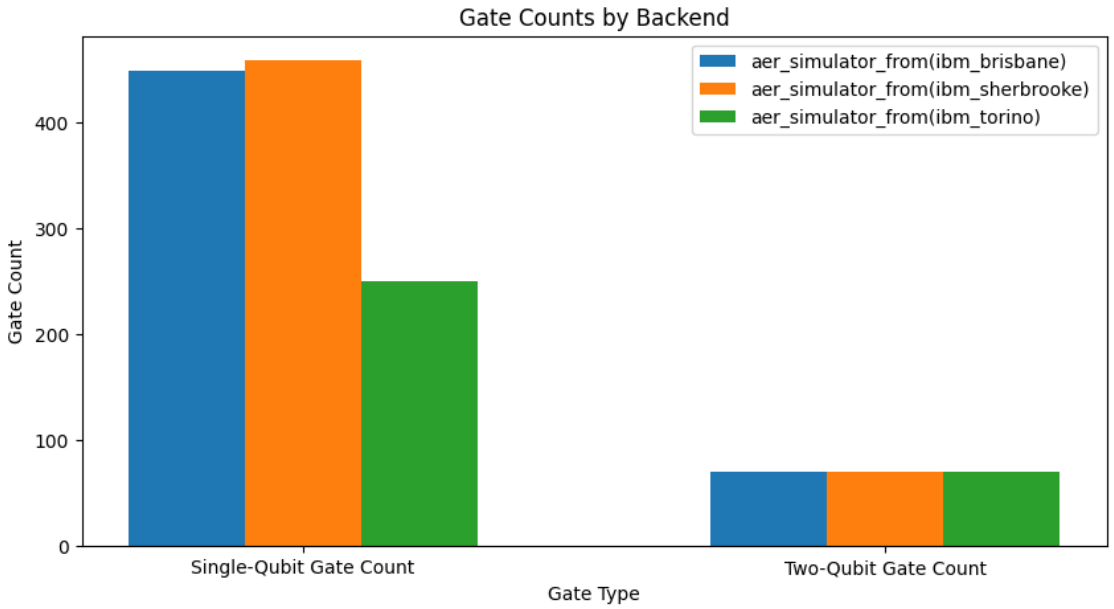
[26]:
```
qaoa_transpiled_list = []
errors_and_counts_list = []
for noisy_fake_backend in noisy_fake_backends:
    pm = generate_preset_pass_manager(
        backend=noisy_fake_backend,
        optimization_level=3,
        seed_transpiler=seed,
    )
    circuit = pm.run(qaoa_circuit)
    qaoa_transpiled_list.append(circuit)

    errors_and_counts = accumulated_errors(noisy_fake_backend, circuit)
    errors_and_counts_list.append(errors_and_counts)
# You can print your results to visualize if they are correct
for backend, (
    acc_total_error,
    acc_two_qubit_error,
    acc_single_qubit_error,
    acc_readout_error,
    single_qubit_gate_count,
    two_qubit_gate_count,
) in zip(noisy_fake_backends, errors_and_counts_list):
    print(f"Backend {backend.name}")
    print(f"Accumulated two-qubit error of {two_qubit_gate_count} gates:␣
 ↪{acc_two_qubit_error:.3f}")
    print(
        f"Accumulated one-qubit error of {single_qubit_gate_count} gates:␣
 ↪{acc_single_qubit_error:.3f}"
    )
    print(f"Accumulated readout error: {acc_readout_error:.3f}")
    print(f"Accumulated total error: {acc_total_error:.3f}\n")
```

```
Backend aer_simulator_from(ibm_brisbane)
```

```
Accumulated two-qubit error of 70 gates: 0.268
Accumulated one-qubit error of 449 gates: 0.025
Accumulated readout error: 0.090
Accumulated total error: 0.383

Backend aer_simulator_from(ibm_sherbrooke)
Accumulated two-qubit error of 70 gates: 0.259
Accumulated one-qubit error of 459 gates: 0.027
Accumulated readout error: 0.165
Accumulated total error: 0.451

Backend aer_simulator_from(ibm_torino)
Accumulated two-qubit error of 70 gates: 0.181
Accumulated one-qubit error of 250 gates: 0.032
Accumulated readout error: 0.063
Accumulated total error: 0.276
```

[27]:
```
plot_backend_errors_and_counts(noisy_fake_backends, errors_and_counts_list)
```



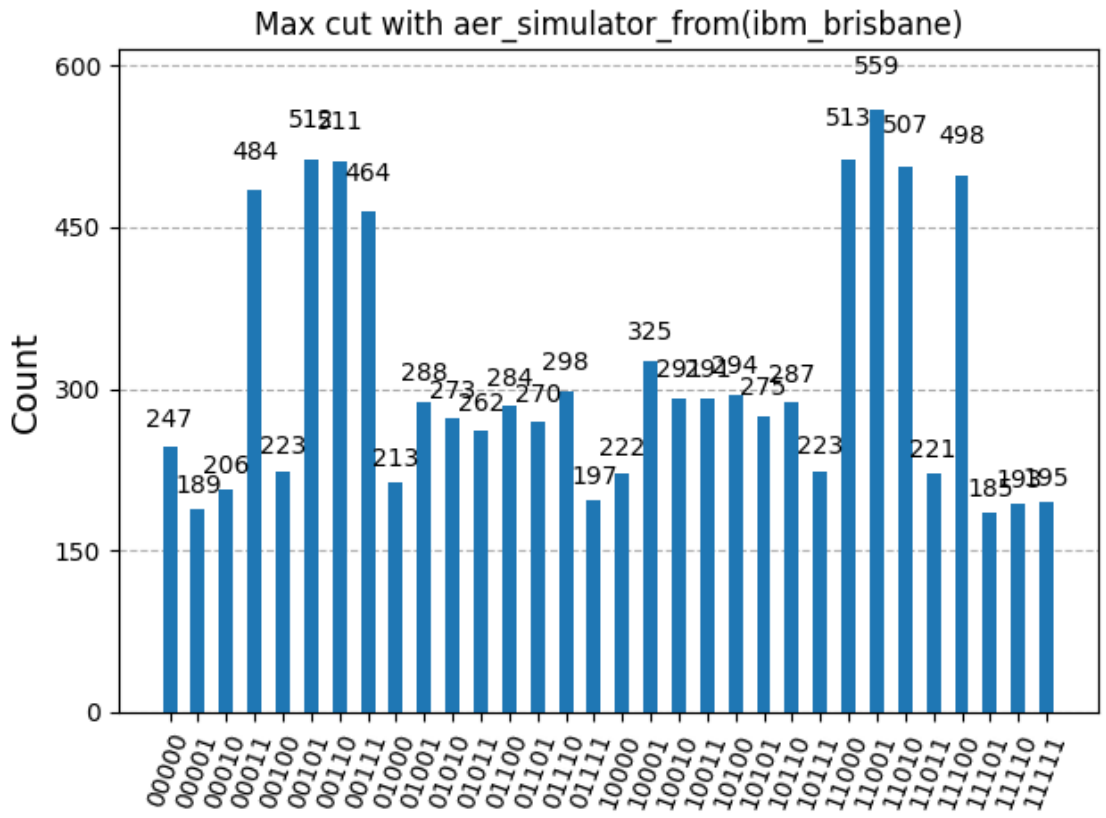


[28]:
```
# Submit your answer using the following code
grade_lab2_ex3(accumulated_errors)
```

```
Submitting your answer. Please wait…
Congratulations!  Your answer is correct.
```

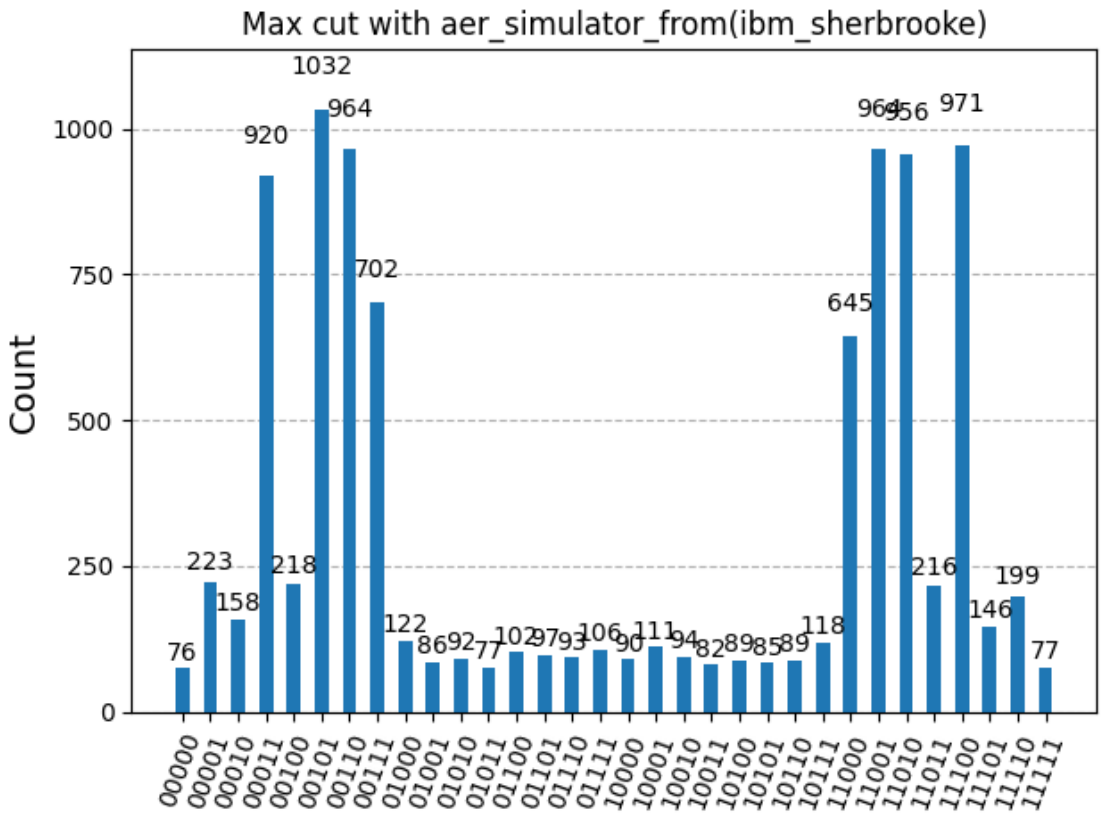
[29]:
```
opt_params_list = []
counts_list_backends = []
for noisy_fake_backend, circuit in zip(noisy_fake_backends[:1],␣
 ↪qaoa_transpiled_list[:1]):
    result_backend, _ = train_qaoa(init_params, circuit, cost_hamiltonian,␣
 ↪noisy_fake_backend)
    opt_params = result_backend.x
    opt_params_list.append(opt_params)
    counts_list_backend = sample_qaoa(opt_params, circuit, noisy_fake_backend)
    counts_list_backends.append(counts_list_backend)
```

```
 message: Return from COBYLA because the trust region radius reaches its lower
bound.
 success: True
  status: 0
     fun: -1.4464355356446434
       x: [ 1.654e-01  1.017e+00  2.059e+00 -2.635e-01]
    nfev: 83
   maxcv: 0.0
```

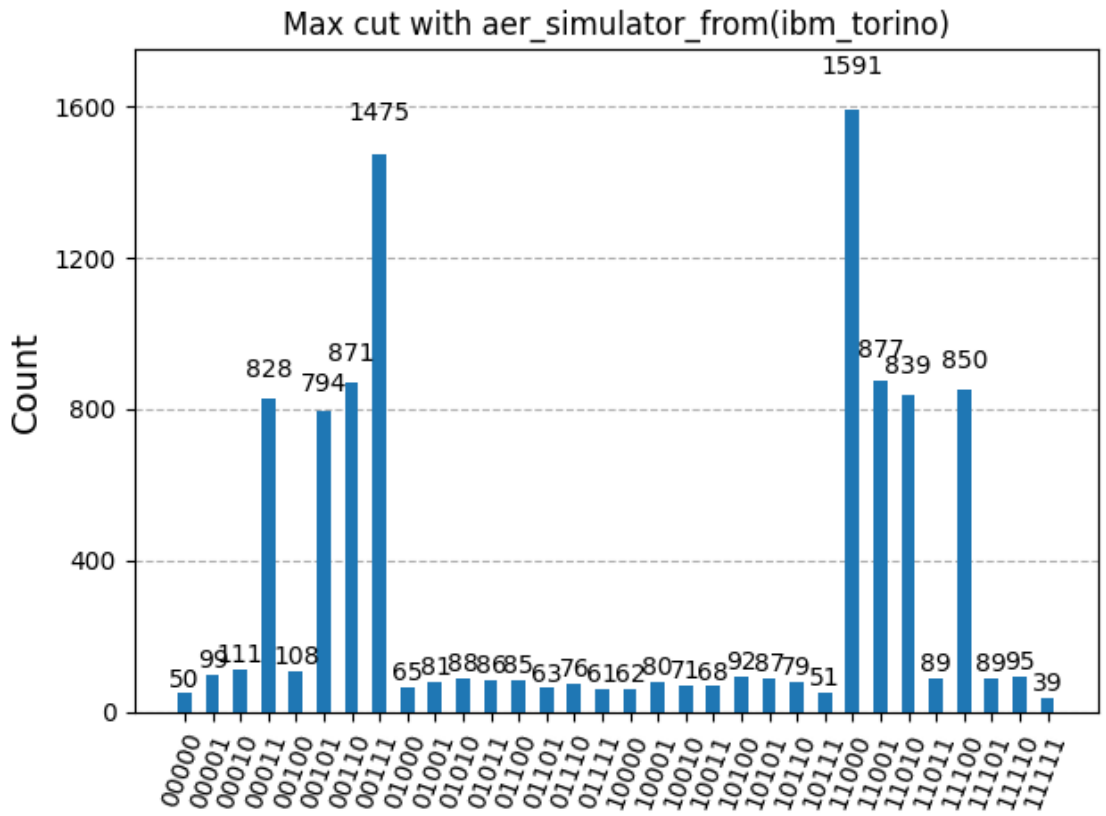


[32]:
```
for noisy_fake_backend, circuit in zip(noisy_fake_backends[1:],␣
↪qaoa_transpiled_list[1:]):
    result_backend, _ = train_qaoa(init_params, circuit, cost_hamiltonian,␣
↪noisy_fake_backend)
    opt_params = result_backend.x
    opt_params_list.append(opt_params)
    counts_list_backend = sample_qaoa(opt_params, circuit, noisy_fake_backend)
    counts_list_backends.append(counts_list_backend)
```

```
 message: Return from COBYLA because the trust region radius reaches its lower
bound.
 success: True
  status: 0
     fun: -3.078339216607834
       x: [ 4.767e-01  7.016e-01  9.628e-01 -5.173e-02]
    nfev: 48
   maxcv: 0.0
```




```
 message: Return from COBYLA because the trust region radius reaches its lower
bound.
 success: True
  status: 0
     fun: -3.9087109128908706
       x: [ 1.090e+00 -2.094e-01  8.817e-01  9.587e-01]
    nfev: 71
   maxcv: 0.0
```



[31]:
```
solutions_counts_noiseless = [counts_list[key] for key in states_solutions]
print(
    f"Probability of measuring a solution for {generic_backend.name} is␣
 ↪{float(sum(solutions_counts_noiseless)/SHOTS)}"
)
```

```
Probability of measuring a solution for generic_backend_5q is 0.7668
```

[33]:
```
# We select the `ibm_brisbane` backend
num_backend = 0
noisy_fake_backend = noisy_fake_backends[num_backend]

pm = generate_preset_pass_manager(
    backend=noisy_fake_backend,
    optimization_level=3,
    seed_transpiler=seed,
    layout_method="sabre",
)
circuit_transpiled = pm.run(qaoa_circuit)
```

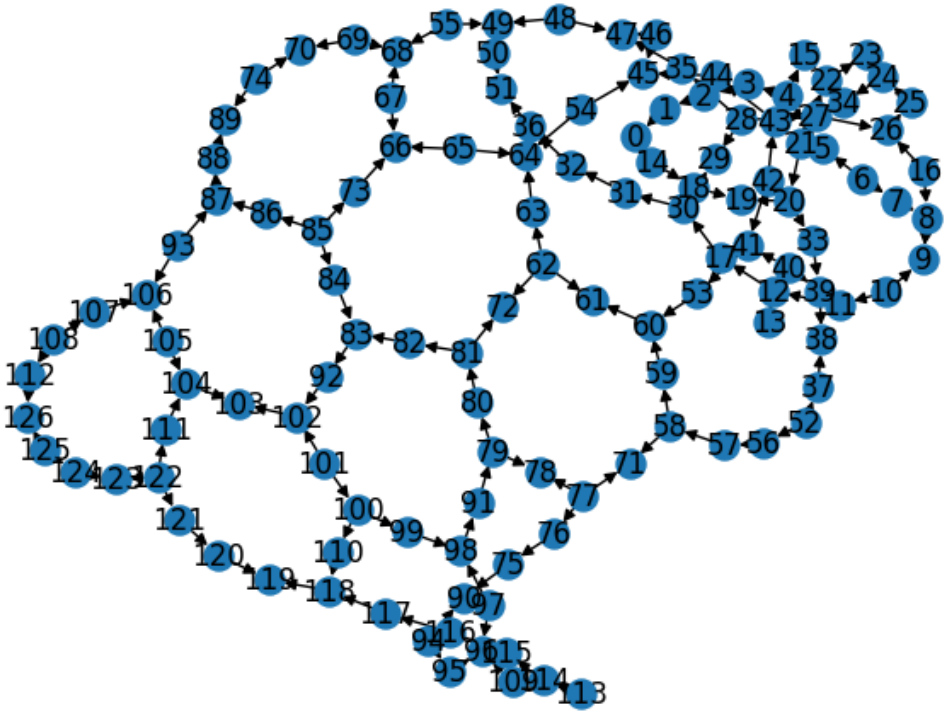
```python
def two_qubit_gate_errors_per_circuit_layout(
    circuit: QuantumCircuit, backend: QiskitRuntimeService.backend
) -> tuple:
    """Calculate accumulated two-qubit gate errors and related metrics for a␣
 ↪given circuit layout."""
    pair_list = []
    error_pair_list = []
    error_acc_pair_list = []
    two_qubit_gate_count = 0
    properties = backend.properties()
    if "ecr" in (backend.configuration().basis_gates):
        two_qubit_gate = "ecr"
    elif "cz" in (backend.configuration().basis_gates):
        two_qubit_gate = "cz"
    for instruction in circuit.data:
        if instruction.operation.num_qubits == 2:
            two_qubit_gate_count += 1
            pair = [instruction.qubits[0]._index, instruction.qubits[1]._index]
            error_pair = properties.gate_error(gate=two_qubit_gate, qubits=pair)
            if pair not in (pair_list):
                pair_list.append(pair)
                error_pair_list.append(error_pair)
                error_acc_pair_list.append(error_pair)
            else:
                pos = pair_list.index(pair)
                error_acc_pair_list[pos] += error_pair

    acc_two_qubit_error = sum(error_acc_pair_list)
    return (
        acc_two_qubit_error,
        two_qubit_gate_count,
        pair_list,
        error_pair_list,
        error_acc_pair_list,
    )


(
    acc_two_qubit_error,
    two_qubit_gate_count,
    pair_list,
    error_pair_list,
    error_acc_pair_list,
) = two_qubit_gate_errors_per_circuit_layout(circuit_transpiled,␣
 ↪noisy_fake_backend)
two_qubit_ops_list = [int(a / b) for a, b in zip(error_acc_pair_list,␣
 ↪error_pair_list)]
```

```
# We print the results
print(f"The pairs of qubits that need to perform two-qubit operations are:\n␣
 ↪{pair_list}")
print(
    f"The errors introduced by each of the two-qubit operations are:\n␣
 ↪{[round(err,3) for err in error_pair_list]}"
)
print(
    f"The accumulated errors introduced by each of the two-qubit operations are:
 ↪\n {[round(err,3) for err in error_acc_pair_list]}"
)
print(f"The repetitions of each one of the two-qubit operations is:\n␣
 ↪{two_qubit_ops_list}")
print(f"The number of two-qubit operations in total:\n {two_qubit_gate_count}")
print(f"The total accumulated error by two-qubit operations is:\n␣
 ↪{acc_two_qubit_error:.3f}")
```

```
The pairs of qubits that need to perform two-qubit operations are:
 [[62, 72], [81, 72], [62, 61], [62, 63]]
The errors introduced by each of the two-qubit operations are:
 [0.007, 0.005, 0.006, 0.008]
The accumulated errors introduced by each of the two-qubit operations are:
 [0.2, 0.062, 0.083, 0.117]
The repetitions of each one of the two-qubit operations is:
 [29, 13, 13, 15]
The number of two-qubit operations in total:
 70
The total accumulated error by two-qubit operations is:
 0.463
```

[34]:
```
# We build a graph with the connectivity constraints of our backend that␣
 ↪includes the two-qubit gate errors as weights in the edges
graph = rx.PyDiGraph()
graph.add_nodes_from(np.arange(0, noisy_fake_backend.num_qubits, 1))
two_qubit_gate = "ecr"
graph.add_edges_from(
    [
        (
            edge[0],
            edge[1],
            noisy_fake_backend.properties().gate_error(
                gate=two_qubit_gate, qubits=(edge[0], edge[1])
            ),
        )
        for edge in noisy_fake_backend.coupling_map
    ]
)
```

```
draw_graph(graph, node_size=150, with_labels=True, width=1)
```



[35]:
```
def remap_nodes(original_labels: list, edge_list: list[list]) ->␣
↪list[list[int]]:
    """Remap node labels to a new sequence starting from 0 based on their order␣
↪in original_labels."""
    label_mapping = {label: idx for idx, label in enumerate(original_labels)}
    remapped = [[label_mapping[src], label_mapping[dst]] for src, dst in␣
↪edge_list]
    return remapped


layout_list = list(circuit_transpiled.layout.initial_layout.get_physical_bits().
↪keys())[:5]
logical_pair_list = remap_nodes(layout_list, pair_list)
print(f"Physical qubit layout list:\n {layout_list}")
print(f"\nOriginal two-qubit gates list:\n {pair_list}")
print(f"\nRemapped two-qubit gates list (in logical qubits):\n␣
↪{logical_pair_list}")
```

```
Physical qubit layout list:
 [72, 62, 81, 61, 63]

Original two-qubit gates list:
 [[62, 72], [81, 72], [62, 61], [62, 63]]

Remapped two-qubit gates list (in logical qubits):
 [[1, 0], [2, 0], [1, 3], [1, 4]]
```

[37]:
```python
def find_paths_with_weight_sum_below_threshold(
    graph: rx.PyDiGraph,
    threshold: float,
    two_qubit_ops_list: list[int],
    logical_pair_list: list[list[int]],
) -> tuple[list[list[int]], list[float]]:
    """Find all valid paths through a graph whose weighted sum is below a given␣
 ↪threshold."""
    valid_paths = []
    valid_weights = []

    for start_node in range(graph.num_nodes()):
        paths = [[start_node]]
        weights = [0]

        for i in range(len(two_qubit_ops_list)):
            new_paths = []
            new_weights = []

            for path, weight in zip(paths, weights):
                if logical_pair_list[i][0] < logical_pair_list[i][1]:
                    index_of_expanding_node = logical_pair_list[i][0]  #␣
 ↪control qubit
                    node_to_expand_from = path[index_of_expanding_node]

                    for neighbor in graph.neighbors(node_to_expand_from):
                        if neighbor not in path and graph.
 ↪has_edge(node_to_expand_from, neighbor):
                            # Get the edge error and scale it
                            edge_error = graph.
 ↪get_edge_data(node_to_expand_from, neighbor)
                            edge_weight = edge_error * two_qubit_ops_list[i]

                            new_paths.append(path + [neighbor])
                            new_weights.append(weight + edge_weight)
                else:
                    index_of_expanding_node = logical_pair_list[i][1]  # target␣
 ↪qubit
```

```
                    node_to_expand_from = path[index_of_expanding_node]

                    for neighbor in graph.
 ↪neighbors_undirected(node_to_expand_from):
                        if neighbor not in path and graph.has_edge(neighbor,␣
 ↪node_to_expand_from):
                            # Get the edge error and scale it
                            edge_error = graph.get_edge_data(neighbor,␣
 ↪node_to_expand_from)
                            edge_weight = edge_error * two_qubit_ops_list[i]

                            new_paths.append(path + [neighbor])
                            new_weights.append(weight + edge_weight)

            paths = new_paths
            weights = new_weights

        for path, weight in zip(paths, weights):
            if weight < threshold:
                valid_paths.append(path)
                valid_weights.append(weight)

    return valid_paths, valid_weights

threshold = acc_two_qubit_error

valid_paths, valid_weights = find_paths_with_weight_sum_below_threshold(
    graph, threshold, two_qubit_ops_list, logical_pair_list
)

if valid_weights:
    minimum_weight_index = valid_weights.index(min(valid_weights))
    opt_layout = valid_paths[minimum_weight_index]
else:
    minimum_weight_index = None
    opt_layout = layout_list

print(f"We found {len(valid_paths)} valid paths")
```

```
We found 5 valid paths
```

[38]:
```
init_layout = Layout({q: phys for q, phys in zip(qaoa_circuit.qubits,␣
 ↪opt_layout)})
pm = generate_preset_pass_manager(
    backend=noisy_fake_backend,
    optimization_level=3,
    seed_transpiler=seed,
```

```
    initial_layout=init_layout,
    layout_method="sabre",
)

circuit_opt = pm.run(qaoa_circuit)

(
    acc_total_error_opt,
    two_qubit_gate_count,
    pair_list,
    error_pair_list,
    error_acc_pair_list,
) = two_qubit_gate_errors_per_circuit_layout(circuit_opt, noisy_fake_backend)

print(
    f"The path with smaller errors in its two-qubit gates is: {opt_layout} \n",
    f"With total accumulated error of {acc_total_error_opt:.3f}",
)
```

```
The path with smaller errors in its two-qubit gates is: [5, 4, 6, 3, 15]
 With total accumulated error of 0.291
```

[39]:
```
# Submit your answer using the following code
grade_lab2_ex4(find_paths_with_weight_sum_below_threshold)
```

```
Submitting your answer. Please wait…
Congratulations!  Your answer is correct.
```

[40]:
```
def finding_best_seed(
    circuit: QuantumCircuit, backend: QiskitRuntimeService.backend
) -> tuple[QuantumCircuit, int, float, int]:
    """Find the transpiler seed that minimizes two-qubit gate error for a given␣
 ↪circuit and backend."""

    min_err_acc_seed_loop = 100  # Start with a large number
    circuit_opt_best_seed = None
    best_seed_transpiler = None
    two_qubit_gate_count_seed_loop = 0

    for seed_transpiler in range(0, 500):
        pm = generate_preset_pass_manager(
            backend=backend,
            optimization_level=3,
            seed_transpiler=seed_transpiler,
            layout_method="sabre",
        )
        circuit_opt_seed = pm.run([circuit])[0]
```

```
        # Fix: unpack properly
        result = two_qubit_gate_errors_per_circuit_layout(circuit_opt_seed,␣
 ↪backend)
        acc_two_qubit_error = result[0]
        two_qubit_gate_count = result[1]

        if acc_two_qubit_error < min_err_acc_seed_loop:
            min_err_acc_seed_loop = acc_two_qubit_error
            best_seed_transpiler = seed_transpiler
            circuit_opt_best_seed = circuit_opt_seed
            two_qubit_gate_count_seed_loop = two_qubit_gate_count

    return (
        circuit_opt_best_seed,
        best_seed_transpiler,
        min_err_acc_seed_loop,
        two_qubit_gate_count_seed_loop,
    )
```

[41]:
```
(
    circuit_opt_seed_loop,
    best_seed_transpiler,
    min_err_acc_seed_loop,
    two_qubit_gate_count_seed_loop,
) = finding_best_seed(qaoa_circuit, noisy_fake_backend)

best_layout = list(circuit_opt_seed_loop.layout.initial_layout.
 ↪get_physical_bits().keys())[:n]
print(f"Best transpiler seed: {best_seed_transpiler}")
print(f"Minimum accumulated two-qubit gate error: {min_err_acc_seed_loop:.5f}")
print(f"Two-qubit gate count for best seed: {two_qubit_gate_count_seed_loop}")
print(f"Best layout (first n logical qubits mapped to physical qubits):\n␣
 ↪{best_layout}")
```

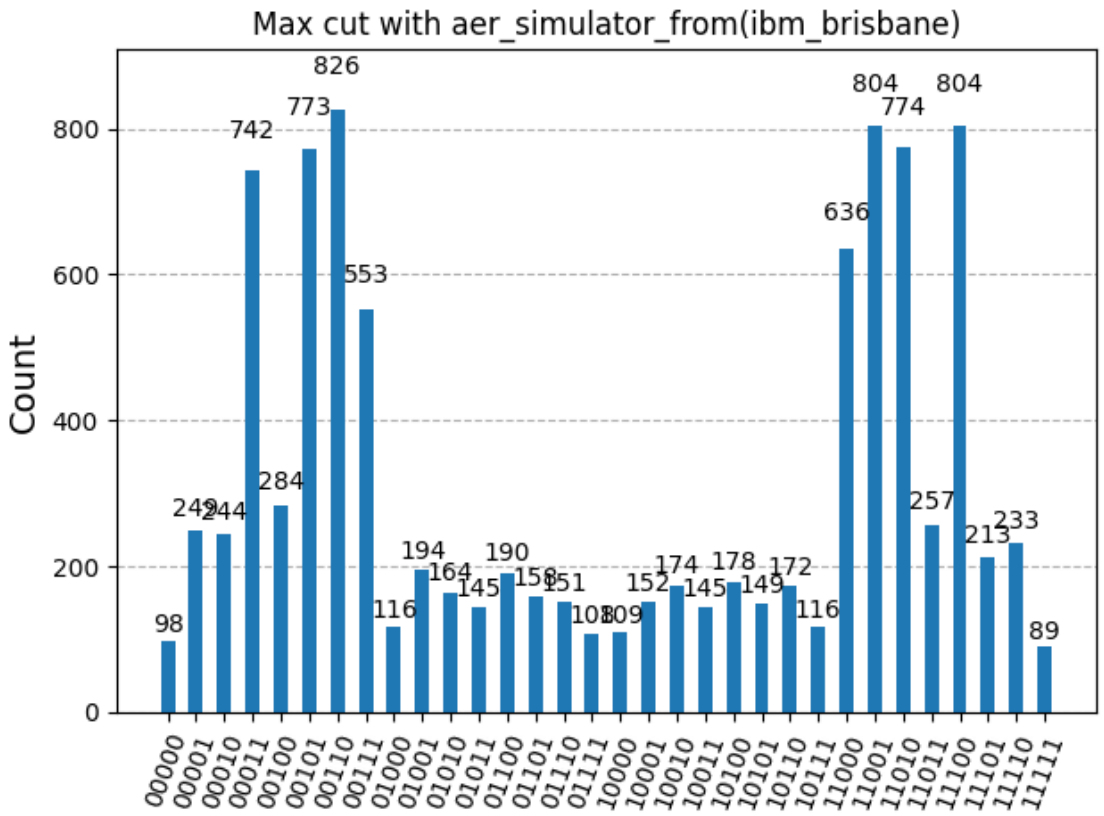
```
Best transpiler seed: 169
Minimum accumulated two-qubit gate error: 0.26785
Two-qubit gate count for best seed: 70
Best layout (first n logical qubits mapped to physical qubits):
 [22, 21, 23, 15, 20]
```

[42]:
```
# Submit your answer using the following code
grade_lab2_ex5(finding_best_seed)
```

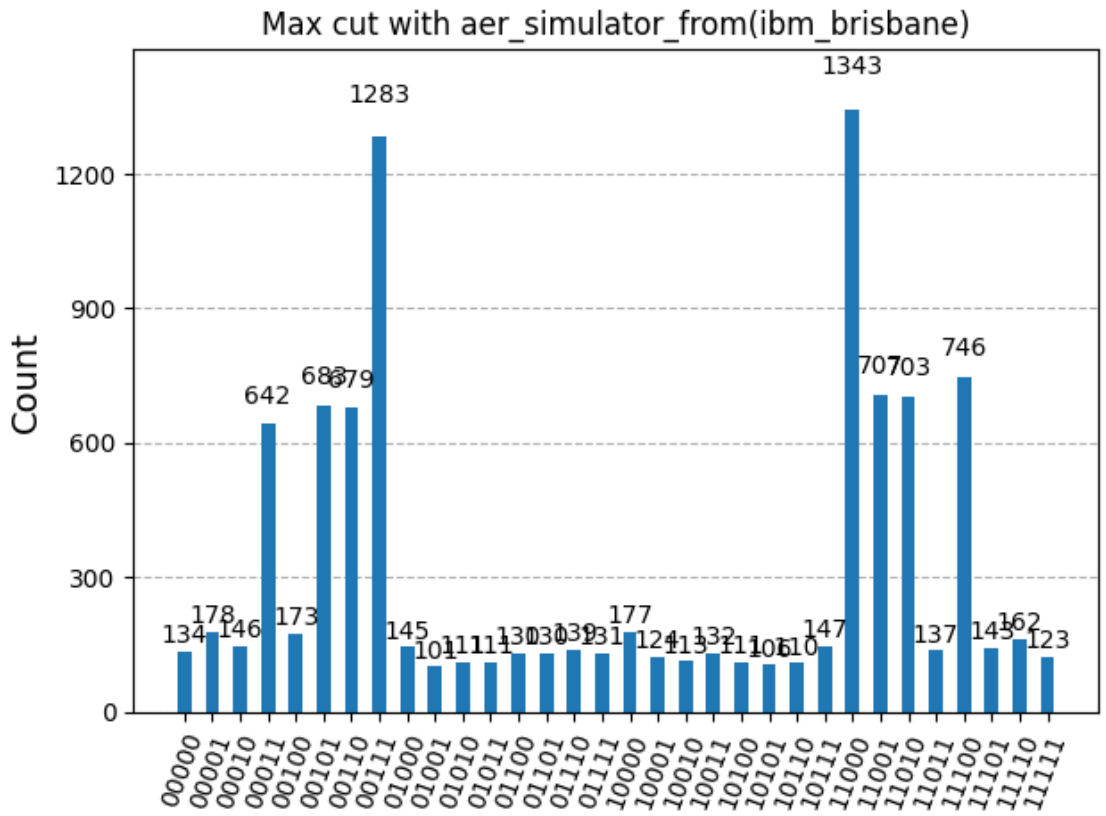
```
Submitting your answer. Please wait…
Congratulations!  Your answer is correct.
```

[43]:
```
counts_list_transpiled_circuits = []
circuit_transpiled_list = [circuit_transpiled, circuit_opt_seed_loop]
opt_params_list_transpiled_circuits = []
for circuit in circuit_transpiled_list:
    result_backend, _ = train_qaoa(init_params, circuit, cost_hamiltonian,␣
 ↪noisy_fake_backend)
    opt_params = result_backend.x
    opt_params_list_transpiled_circuits.append(opt_params)
    counts_list_transpiled_circuit = sample_qaoa(opt_params, circuit,␣
 ↪noisy_fake_backend)
    counts_list_transpiled_circuits.append(counts_list_transpiled_circuits)
    solutions_counts = [counts_list_transpiled_circuit[key] for key in␣
 ↪states_solutions]
    print(f"Probability of measuring a solution for is␣
 ↪{float(sum(solutions_counts)/SHOTS)}")
```

```
 message: Return from COBYLA because the trust region radius reaches its lower
bound.
 success: True
  status: 0
     fun: -2.50550494495055
       x: [ 1.055e+00  1.245e+00  4.564e-02  9.677e-01]
    nfev: 97
   maxcv: 0.0
```




```
Probability of measuring a solution for is 0.5912
 message: Return from COBYLA because the trust region radius reaches its lower
bound.
 success: True
  status: 0
     fun: -2.767162328376716
       x: [-3.037e-01 -9.393e-01 -4.988e-01 -6.961e-01]
    nfev: 135
   maxcv: 0.0
```



Probability of measuring a solution for is 0.6786

[44]:
```
def fold_global_circuit(circuit: QuantumCircuit, scale_factor: int) ->␣
↪QuantumCircuit:
    """Apply global circuit folding for Zero Noise Extrapolation (ZNE)."""
    if scale_factor % 2 == 0 or scale_factor < 1:
        raise ValueError("scale_factor must be an odd positive integer (1, 3,␣
↪5, ...)")

    # we define the number of times we are going to "fold" the circuit
    n_repeat = (scale_factor - 1) // 2
    folded_circuit = QuantumCircuit(circuit.qubits, circuit.clbits)

    def remove_all_measurements(qc: QuantumCircuit) -> QuantumCircuit:
        """Remove all measurements from a quantum circuit."""
        clean_qc = QuantumCircuit(qc.num_qubits)
        for instr in qc.data:
            if instr.operation.name != "measure":
                clean_qc.append(instr.operation, instr.qubits)
        return clean_qc
```

```
    # Remove measurements to obtain a clean unitary
    clean_circuit = remove_all_measurements(circuit)
    folded_circuit.append(clean_circuit,clean_circuit.qubits)

    # Apply (U† U)^n_repeat
    for _ in range(n_repeat):
        folded_circuit.append(clean_circuit.inverse(), clean_circuit.qubits)
        folded_circuit.append(clean_circuit, clean_circuit.qubits)

    return folded_circuit
```

[45]:
```
# Submit your answer using the following code
grade_lab2_ex6a(fold_global_circuit)
```

```
Submitting your answer. Please wait…
Congratulations!  Your answer is correct.
```

[46]:
```
def fold_local_circuit(circuit: QuantumCircuit, scale_factor: int) ->␣
↪QuantumCircuit:
    """Performs Zero-Noise Folding at the level of individual circuit␣
↪instructions."""

    if scale_factor % 2 == 0:
        raise ValueError("scale must be an odd positive integer (1, 3, 5, ...)")

    # We define the number of times we are going to "fold" each instruction
    n_repeat = (scale_factor - 1) // 2
    qc_folded = QuantumCircuit(circuit.qubits, circuit.clbits)

    if scale_factor == 1:
        return circuit
    else:
        for instruction in circuit.data:
            gate = instruction.operation
            qubits = instruction.qubits
            clbits = instruction.clbits

            # --- Task 6b ---
            # Skip measurement gates
            if gate.name == "measure":
                qc_folded.append(gate, qubits, clbits)
            else:
                # Apply original gate
                qc_folded.append(gate, qubits, clbits)

                # Apply folding (U† U)^n
                for _ in range(n_repeat):
```

```
                    # Apply inverse of the gate
                    qc_folded.append(gate.inverse(), qubits)
                    # Apply original gate again
                    qc_folded.append(gate, qubits)

    return qc_folded
```

[47]:
```
# Submit your answer using the following code
grade_lab2_ex6b(fold_local_circuit)
```

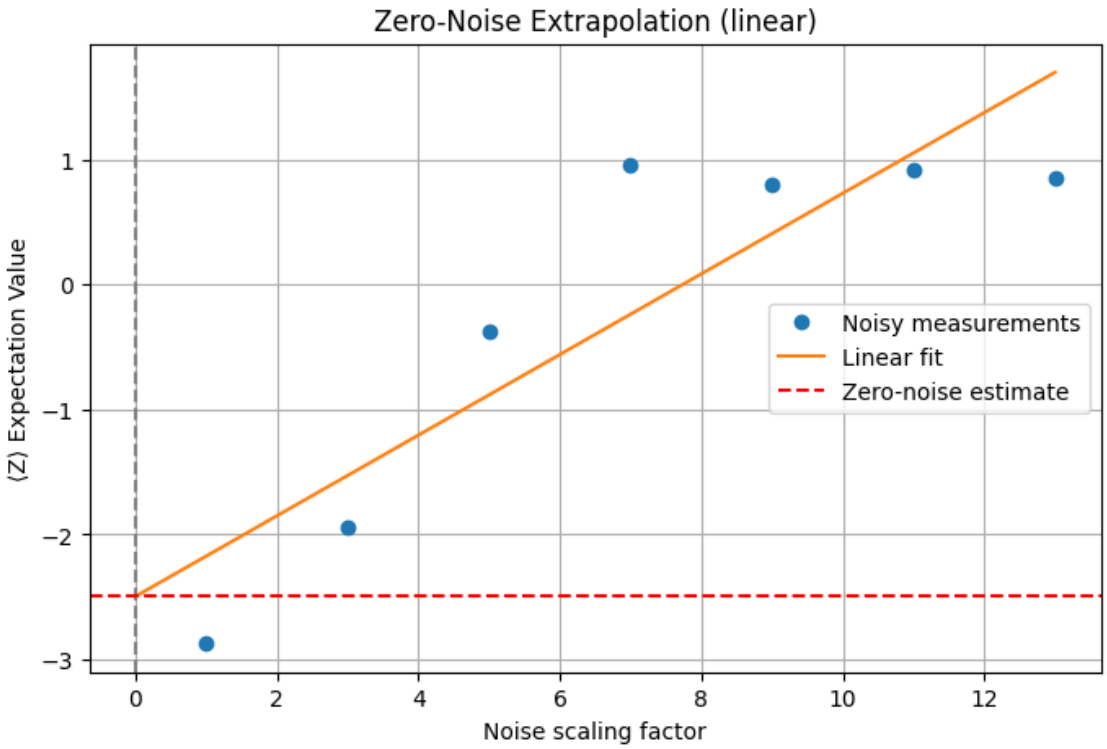
```
Submitting your answer. Please wait…
Congratulations!  Your answer is correct.
```

[48]:
```
def basic_zne(
    circuit,
    scales,
    backend,
    opt_params,
    observable,
):
    """Basic Zero Noise Extrapolation (ZNE) loop using local folding."""

    exp_vals = []
    xdata = np.array(scales)
    estimator = Estimator(mode=backend)

    for scale in scales:
        # Apply local folding
        folded = fold_local_circuit(circuit, scale)

        # Transpile for the backend
        basis_gates = backend.target.operation_names
        transpiled_folded = generate_preset_pass_manager(
            basis_gates=basis_gates, optimization_level=0, seed_transpiler=seed
        ).run(folded)
        pub = (
            transpiled_folded,
            observable.apply_layout(circuit.layout),
            opt_params,
        )
        # Evaluate the expectation value
        job = estimator.run([pub])
        results = job.result()[0]
        exp_vals.append(results.data.evs)

    return xdata, exp_vals, pub
```

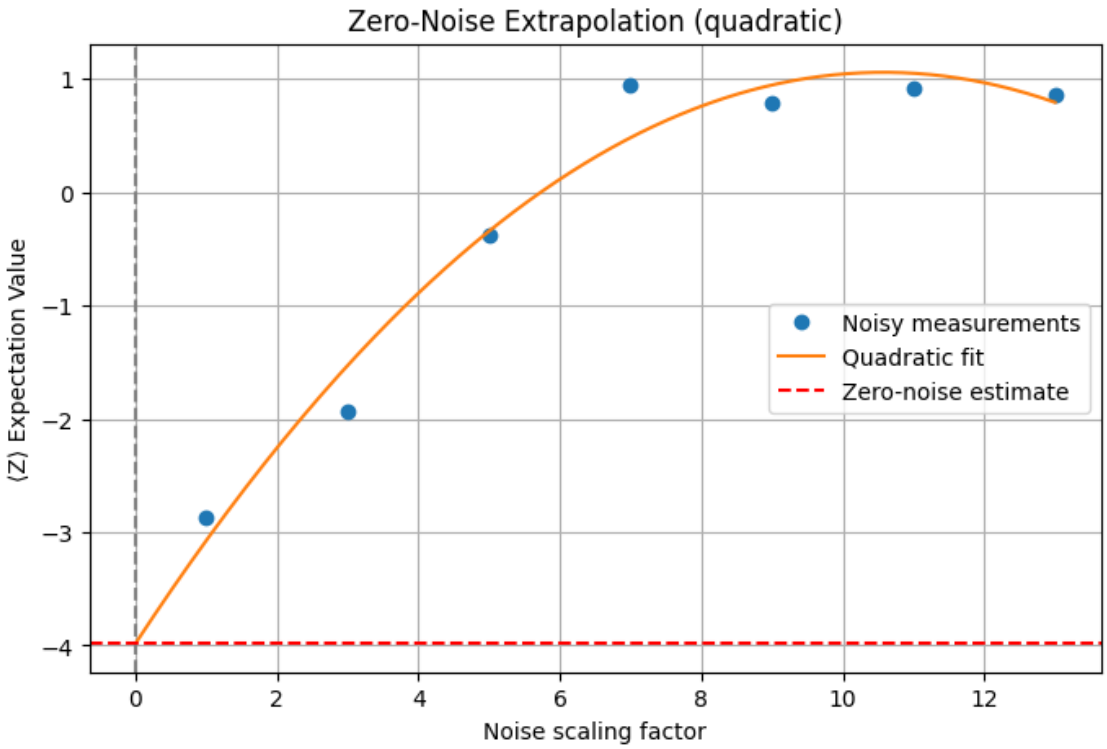
[49]:
```
scales = [1, 3, 5, 7, 9, 11, 13]
xdata, ydata, pub = basic_zne(
    qaoa_circuit_transpiled,
    scales,
    noisy_fake_backend,
    opt_params_list[num_backend],
    cost_hamiltonian,
)
```

[50]:
```
methods = ["linear", "quadratic", "exponential"]

for method in methods:
    print(f"\n Extrapolation Method: {method.upper()}")

    # Perform the extrapolation
    zero_val, fitted_vals, fit_params, fit_fn = zne_method(method=method,␣
 ↪xdata=xdata, ydata=ydata)

    # Print the extrapolated expectation value
    print(f" Z  (ZNE Estimate): {zero_val:.3f}")

    # Plot the results
    plot_zne(xdata, fitted_vals, zero_val, fit_fn, fit_params, method)
```

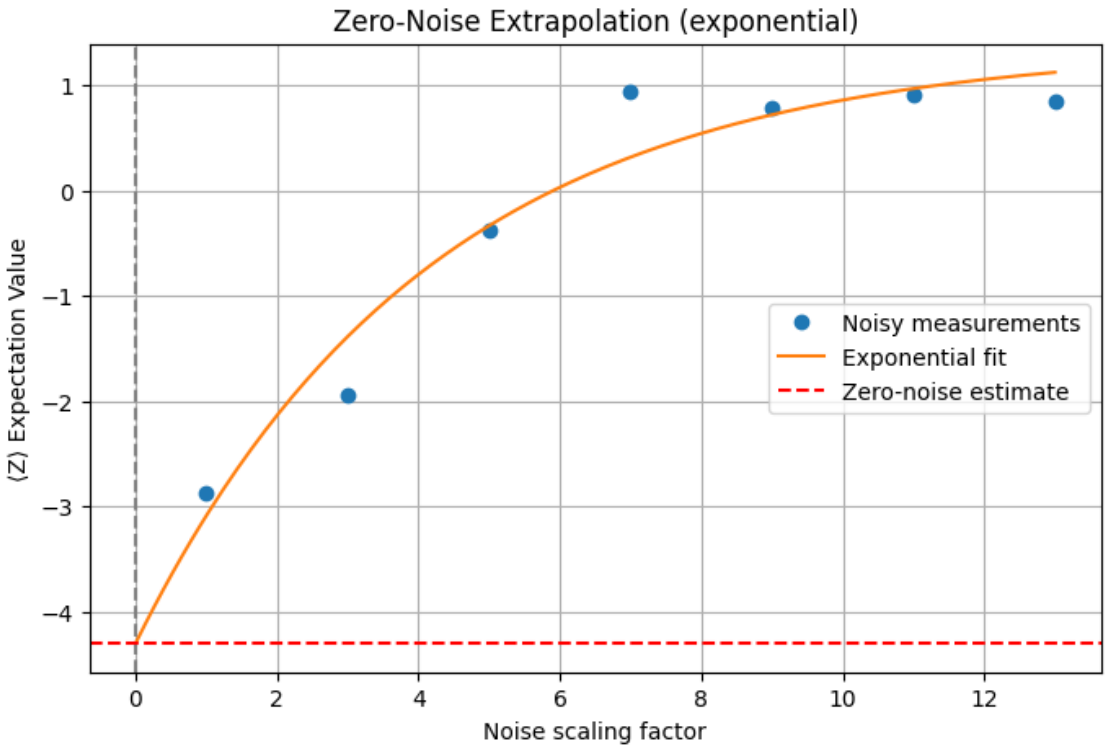
```
 Extrapolation Method: LINEAR
Z  (ZNE Estimate): -2.495
```




```
Extrapolation Method: QUADRATIC
Z  (ZNE Estimate): -3.983
```




```
Extrapolation Method: EXPONENTIAL
Z  (ZNE Estimate): -4.303
```



[51]:
```
# Check your submission status with the code below
from qc_grader.grader.grade import check_lab_completion_status

check_lab_completion_status("qgss_2025")
```

```
Lab 0: 2/2 exercises completed (100%)
     2508 participants have completed this lab
Lab 1: 9/9 exercises completed (100%)
     2114 participants have completed this lab
Lab 2: 7/7 exercises completed (100%)
     1410 participants have completed this lab
Lab 3: 0/5 exercises completed (0%)
     1254 participants have completed this lab
Lab 4: 0/6 exercises completed (0%)
     1218 participants have completed this lab
Functions Labs: 0/8 exercises completed (0%)
     6 participants have completed this lab
```

[ ]: