

#QML-HEP GSoC 2023 Task Solutions

##Installing Required Package

```
!pip install cirq
!pip install qiskit
!pip install pylatexenc
!pip install pennylane
```

Looking in indexes: <https://pypi.org/simple>, <https://us-python.pkg.dev/colab-wheels/public/simple/>

Collecting cirq

Downloading cirq-1.1.0-py3-none-any.whl (7.7 kB)

Collecting cirq-aqt==1.1.0

Downloading cirq_aqt-1.1.0-py3-none-any.whl (27 kB)

Collecting cirq-rigetti==1.1.0

Downloading cirq_rigetti-1.1.0-py3-none-any.whl (66 kB)

66.4/66.4 KB 3.9 MB/s eta

0:00:00

577.4/577.4 KB 17.7 MB/s eta

0:00:00

57.6/57.6 KB 7.0 MB/s eta

0:00:00

594.6/594.6 KB 48.4 MB/s eta

0:00:00

1.8/1.8 MB 66.9 MB/s eta

0:00:00

Requirement already satisfied: requests~=2.18 in

/usr/local/lib/python3.9/dist-packages (from cirq-aqt==1.1.0->cirq) (2.27.1)

Requirement already satisfied: numpy<1.24,>=1.16 in

/usr/local/lib/python3.9/dist-packages (from cirq-core==1.1.0->cirq) (1.22.4)

Requirement already satisfied: sortedcontainers~=2.0 in

/usr/local/lib/python3.9/dist-packages (from cirq-core==1.1.0->cirq) (2.4.0)

Requirement already satisfied: matplotlib~=3.0 in

/usr/local/lib/python3.9/dist-packages (from cirq-core==1.1.0->cirq) (3.7.1)

Requirement already satisfied: tqdm in /usr/local/lib/python3.9/dist-packages (from cirq-core==1.1.0->cirq) (4.65.0)

Collecting duet~=0.2.7

Downloading duet-0.2.7-py3-none-any.whl (28 kB)

Requirement already satisfied: pandas in

/usr/local/lib/python3.9/dist-packages (from cirq-core==1.1.0->cirq) (1.4.4)

Requirement already satisfied: sympy in /usr/local/lib/python3.9/dist-packages (from cirq-core==1.1.0->cirq) (1.11.1)

Collecting networkx~=2.4

Downloading networkx-2.8.8-py3-none-any.whl (2.0 MB)

2.0/2.0 MB 66.8 MB/s eta
0:00:00
Requirement already satisfied: typing-extensions in
/usr/local/lib/python3.9/dist-packages (from cirq-core==1.1.0->cirq)
(4.5.0)
Requirement already satisfied: scipy in /usr/local/lib/python3.9/dist-
packages (from cirq-core==1.1.0->cirq) (1.10.1)
Requirement already satisfied: protobuf<4,>=3.15.0 in
/usr/local/lib/python3.9/dist-packages (from cirq-google==1.1.0->cirq)
(3.20.3)
Collecting google-api-core[grpc]<2.0.0dev,>=1.14.0
 Downloading google_api_core-1.34.0-py3-none-any.whl (120 kB)
 220.2/220.2 KB 16.8 MB/s eta
0:00:00
Requirement already satisfied: proto-plus>=1.20.0 in
/usr/local/lib/python3.9/dist-packages (from cirq-google==1.1.0->cirq)
(1.22.2)
Collecting pyquil>=3.2.0
 Downloading pyquil-3.3.4-py3-none-any.whl (221 kB)
 221.6/221.6 KB 28.3 MB/s eta
0:00:00
Requirement already satisfied: googleapis-common-protos<2.0dev,>=1.56.2 in
/usr/local/lib/python3.9/dist-packages (from google-api-
core[grpc]<2.0.0dev,>=1.14.0->cirq-google==1.1.0->cirq) (1.59.0)
Requirement already satisfied: google-auth<3.0dev,>=1.25.0 in
/usr/local/lib/python3.9/dist-packages (from google-api-
core[grpc]<2.0.0dev,>=1.14.0->cirq-google==1.1.0->cirq) (2.17.0)
Requirement already satisfied: grpcio-status<2.0dev,>=1.33.2 in
/usr/local/lib/python3.9/dist-packages (from google-api-
core[grpc]<2.0.0dev,>=1.14.0->cirq-google==1.1.0->cirq) (1.48.2)
Requirement already satisfied: grpcio<2.0dev,>=1.33.2 in
/usr/local/lib/python3.9/dist-packages (from google-api-
core[grpc]<2.0.0dev,>=1.14.0->cirq-google==1.1.0->cirq) (1.53.0)
Requirement already satisfied: pillow>=6.2.0 in
/usr/local/lib/python3.9/dist-packages (from matplotlib~=3.0->cirq-
core==1.1.0->cirq) (8.4.0)
Requirement already satisfied: importlib-resources>=3.2.0 in
/usr/local/lib/python3.9/dist-packages (from matplotlib~=3.0->cirq-
core==1.1.0->cirq) (5.12.0)
Requirement already satisfied: python-dateutil>=2.7 in
/usr/local/lib/python3.9/dist-packages (from matplotlib~=3.0->cirq-
core==1.1.0->cirq) (2.8.2)
Requirement already satisfied: packaging>=20.0 in
/usr/local/lib/python3.9/dist-packages (from matplotlib~=3.0->cirq-
core==1.1.0->cirq) (23.0)
Requirement already satisfied: contourpy>=1.0.1 in
/usr/local/lib/python3.9/dist-packages (from matplotlib~=3.0->cirq-
core==1.1.0->cirq) (1.0.7)
Requirement already satisfied: pyparsing>=2.3.1 in
/usr/local/lib/python3.9/dist-packages (from matplotlib~=3.0->cirq-

```
core==1.1.0->cirq) (3.0.9)
Requirement already satisfied: fonttools>=4.22.0 in
/usr/local/lib/python3.9/dist-packages (from matplotlib~=3.0->cirq-
core==1.1.0->cirq) (4.39.3)
Requirement already satisfied: kiwisolver>=1.0.1 in
/usr/local/lib/python3.9/dist-packages (from matplotlib~=3.0->cirq-
core==1.1.0->cirq) (1.4.4)
Requirement already satisfied: cycler>=0.10 in
/usr/local/lib/python3.9/dist-packages (from matplotlib~=3.0->cirq-
core==1.1.0->cirq) (0.11.0)
Collecting lark<0.12.0,>=0.11.1
  Downloading lark-0.11.3.tar.gz (229 kB)
    _____ 229.9/229.9 KB 26.0 MB/s eta
0:00:00
etadata (setup.py) ... _____
147.4/147.4 KB 13.3 MB/s eta 0:00:00
    _____ 45.6/45.6 KB 4.8 MB/s eta
0:00:00
etadata (setup.py) ... ent already satisfied: idna<4,>=2.5 in
/usr/local/lib/python3.9/dist-packages (from requests~=2.18->cirq-
aqt==1.1.0->cirq) (3.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in
/usr/local/lib/python3.9/dist-packages (from requests~=2.18->cirq-
aqt==1.1.0->cirq) (1.26.15)
Requirement already satisfied: charset-normalizer~=2.0.0 in
/usr/local/lib/python3.9/dist-packages (from requests~=2.18->cirq-
aqt==1.1.0->cirq) (2.0.12)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.9/dist-packages (from requests~=2.18->cirq-
aqt==1.1.0->cirq) (2022.12.7)
Requirement already satisfied: pytz>=2020.1 in
/usr/local/lib/python3.9/dist-packages (from pandas->cirq-core==1.1.0-
>cirq) (2022.7.1)
Requirement already satisfied: mpmath>=0.19 in
/usr/local/lib/python3.9/dist-packages (from sympy->cirq-core==1.1.0-
>cirq) (1.3.0)
Requirement already satisfied: six>=1.9.0 in
/usr/local/lib/python3.9/dist-packages (from google-
auth<3.0dev,>=1.25.0->google-api-core[grpc]<2.0.0dev,>=1.14.0->cirq-
google==1.1.0->cirq) (1.16.0)
Requirement already satisfied: rsa<5,>=3.1.4 in
/usr/local/lib/python3.9/dist-packages (from google-
auth<3.0dev,>=1.25.0->google-api-core[grpc]<2.0.0dev,>=1.14.0->cirq-
google==1.1.0->cirq) (4.9)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in
/usr/local/lib/python3.9/dist-packages (from google-
auth<3.0dev,>=1.25.0->google-api-core[grpc]<2.0.0dev,>=1.14.0->cirq-
google==1.1.0->cirq) (5.3.0)
Requirement already satisfied: pyasn1-modules>=0.2.1 in
/usr/local/lib/python3.9/dist-packages (from google-
```

```
auth<3.0dev,>=1.25.0->google-api-core[grpc]<2.0.0dev,>=1.14.0->cirq-
google==1.1.0->cirq) (0.2.8)
Requirement already satisfied: zipp>=3.1.0 in
/usr/local/lib/python3.9/dist-packages (from importlib-
resources>=3.2.0->matplotlib~=3.0->cirq-core==1.1.0->cirq) (3.15.0)
Requirement already satisfied: toml<0.11.0,>=0.10.2 in
/usr/local/lib/python3.9/dist-packages (from qcs-api-
client<0.22.0,>=0.21.0->pyquil>=3.2.0->cirq-rigetti==1.1.0->cirq)
(0.10.2)
Collecting PyJWT<3.0.0,>=2.4.0
  Downloading PyJWT-2.6.0-py3-none-any.whl (20 kB)
Collecting attrs<22.0.0,>=21.3.0
  Downloading attrs-21.4.0-py2.py3-none-any.whl (60 kB)
  60.6/60.6 KB 8.2 MB/s eta
0:00:00
ent already satisfied: pydantic<2.0.0,>=1.7.2 in
/usr/local/lib/python3.9/dist-packages (from qcs-api-
client<0.22.0,>=0.21.0->pyquil>=3.2.0->cirq-rigetti==1.1.0->cirq)
(1.10.7)
Collecting rfc3339<7.0,>=6.2
  Downloading rfc3339-6.2-py3-none-any.whl (5.5 kB)
Collecting httpx<0.24.0,>=0.23.0
  Downloading httpx-0.23.3-py3-none-any.whl (71 kB)
  71.5/71.5 KB 10.7 MB/s eta
0:00:00
  98.7/98.7 KB 11.0 MB/s eta
0:00:00
ent already satisfied: decorator>=3.4.2 in
/usr/local/lib/python3.9/dist-packages (from retry<0.10.0,>=0.9.2-
>pyquil>=3.2.0->cirq-rigetti==1.1.0->cirq) (4.4.2)
Requirement already satisfied: msgpack<2.0,>=0.6 in
/usr/local/lib/python3.9/dist-packages (from rpcq<4.0.0,>=3.10.0-
>pyquil>=3.2.0->cirq-rigetti==1.1.0->cirq) (1.0.5)
Collecting python-rapidjson
  Downloading python_rapidjson-1.10-cp39-cp39-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl (1.7 MB)
  1.7/1.7 MB 68.0 MB/s eta
0:00:00
ent already satisfied: pyzmq>=17 in /usr/local/lib/python3.9/dist-
packages (from rpcq<4.0.0,>=3.10.0->pyquil>=3.2.0->cirq-
rigetti==1.1.0->cirq) (23.2.1)
Collecting ruamel.yaml
  Downloading ruamel.yaml-0.17.21-py3-none-any.whl (109 kB)
  109.5/109.5 KB 11.3 MB/s eta
0:00:00
  69.6/69.6 KB 8.8 MB/s eta
0:00:00
ent already satisfied: pyasn1<0.5.0,>=0.4.6 in
/usr/local/lib/python3.9/dist-packages (from pyasn1-modules>=0.2.1-
>google-auth<3.0dev,>=1.25.0->google-api-core[grpc]<2.0.0dev,>=1.14.0-
```

```

>cirq-google==1.1.0->cirq) (0.4.8)
Collecting ruamel.yaml.clib>=0.2.6
  Downloading ruamel.yaml.clib-0.2.7-cp39-cp39-
manylinux_2_17_x86_64.manylinux2014_x86_64.manylinux_2_24_x86_64.whl
(519 kB)
----- 519.4/519.4 KB 38.8 MB/s eta
0:00:00
----- 58.3/58.3 KB 5.4 MB/s eta
0:00:00
----- 80.6/80.6 KB 7.3 MB/s eta
0:00:00
e=lark-0.11.3-py2.py3-none-any.whl size=99646
sha256=3fbdf5a3c50fb279ede331680bb10c13be520ad53fc8a3f5d4fa94c64566a4c
3
  Stored in directory:
/root/.cache/pip/wheels/ec/6a/24/f8eeaf52fee56bfe54309621b59c41bb7f1df
56f4bfbcbdb0ce
  Building wheel for rpcq (setup.py) ... e=rpcq-3.11.0-py3-none-
any.whl size=45985
sha256=809c584a2b129cd3ca635d99b95ecbbfe80158d7c9f044bfb38492ef836c513
4
  Stored in directory:
/root/.cache/pip/wheels/a6/c4/42/34581dfe489802146924ad802b13aa7fe3820
f9e8c15f67afc
Successfully built lark rpcq
Installing collected packages: types-retry, types-python-dateutil,
rfc3986, rfc3339, lark, sniffio, ruamel.yaml.clib, retrying, python-
rapidjson, PyJWT, py, networkx, iso8601, h11, duet, attrs,
ruamel.yaml, retry, anyio, rpcq, httpcore, google-api-core, cirq-core,
httpx, cirq-web, cirq-pasqal, cirq-ionq, cirq-aqt, qcs-api-client,
cirq-google, pyquil, cirq-rigetti, cirq
  Attempting uninstall: networkx
    Found existing installation: networkx 3.0
    Uninstalling networkx-3.0:
      Successfully uninstalled networkx-3.0
  Attempting uninstall: attrs
    Found existing installation: attrs 22.2.0
    Uninstalling attrs-22.2.0:
      Successfully uninstalled attrs-22.2.0
  Attempting uninstall: google-api-core
    Found existing installation: google-api-core 2.11.0
    Uninstalling google-api-core-2.11.0:
      Successfully uninstalled google-api-core-2.11.0
Successfully installed PyJWT-2.6.0 anyio-3.6.2 attrs-21.4.0 cirq-1.1.0
cirq-aqt-1.1.0 cirq-core-1.1.0 cirq-google-1.1.0 cirq-ionq-1.1.0 cirq-
pasqal-1.1.0 cirq-rigetti-1.1.0 cirq-web-1.1.0 duet-0.2.7 google-api-
core-1.34.0 h11-0.14.0 httpcore-0.16.3 httpx-0.23.3 iso8601-1.1.0
lark-0.11.3 networkx-2.8.8 py-1.11.0 pyquil-3.3.4 python-rapidjson-
1.10 qcs-api-client-0.21.3 retry-0.9.2 retrying-1.3.4 rfc3339-6.2

```

rfc3986-1.5.0 rpcq-3.11.0 ruamel.yaml-0.17.21 ruamel.yaml.clib-0.2.7
sniffio-1.3.0 types-python-dateutil-2.8.19.11 types-retry-0.9.9.3

```
{"pip_warning":{"packages":["google"]}}
```

Looking in indexes: <https://pypi.org/simple>, <https://us-python.pkg.dev/colab-wheels/public/simple/>

Collecting qiskit

Downloading qiskit-0.42.1.tar.gz (14 kB)

Preparing metadata (setup.py) ...

anylinux_2_17_x86_64.manylinux2014_x86_64.whl (5.1 MB)

5.1/5.1 MB 33.8 MB/s eta

0:00:00

anylinux_2_17_x86_64.manylinux2014_x86_64.whl (12.8 MB)

12.8/12.8 MB 46.0 MB/s eta

0:00:00

q-provider==0.20.2

Downloading qiskit_ibmq_provider-0.20.2-py3-none-any.whl (241 kB)

241.5/241.5 KB 23.2 MB/s eta

0:00:00

Requirement already satisfied: scipy>=1.0 in /usr/local/lib/python3.9/dist-packages (from qiskit-aer==0.12.0->qiskit) (1.10.1)

Requirement already satisfied: numpy>=1.16.3 in

/usr/local/lib/python3.9/dist-packages (from qiskit-aer==0.12.0->qiskit) (1.22.4)

Requirement already satisfied: python-dateutil>=2.8.0 in /usr/local/lib/python3.9/dist-packages (from qiskit-ibmq-provider==0.20.2->qiskit) (2.8.2)

Requirement already satisfied: requests>=2.19 in

/usr/local/lib/python3.9/dist-packages (from qiskit-ibmq-provider==0.20.2->qiskit) (2.27.1)

Collecting websockets>=10.0

Downloading websockets-11.0-cp39-cp39-

manylinux_2_5_x86_64.manylinux1_x86_64.manylinux_2_17_x86_64.manylinux2014_x86_64.whl (129 kB)

129.5/129.5 KB 6.6 MB/s eta

0:00:00

Requirement already satisfied: urllib3>=1.21.1 in

/usr/local/lib/python3.9/dist-packages (from qiskit-ibmq-provider==0.20.2->qiskit) (1.26.15)

Collecting websocket-client>=1.5.1

Downloading websocket_client-1.5.1-py3-none-any.whl (55 kB)

55.9/55.9 KB 6.4 MB/s eta

0:00:00

<=1.1.0

Downloading requests_ntlm-1.1.0-py2.py3-none-any.whl (5.7 kB)

Collecting symengine>=0.9

Downloading symengine-0.10.0-cp39-cp39-

manylinux_2_12_x86_64.manylinux2010_x86_64.whl (37.5 MB)

37.5/37.5 MB 12.0 MB/s eta

0:00:00

```

anylinux_2_17_x86_64.manylinux2014_x86_64.whl (1.9 MB)
----- 1.9/1.9 MB 13.7 MB/s eta
0:00:00
Requirement already satisfied: sympy>=1.3 in /usr/local/lib/python3.9/dist-
packages (from qiskit-terra==0.23.3->qiskit) (1.11.1)
Collecting dill>=0.3
  Downloading dill-0.3.6-py3-none-any.whl (110 kB)
----- 110.5/110.5 KB 7.7 MB/s eta
0:00:00
----- 49.6/49.6 KB 5.4 MB/s eta
0:00:00
Requirement already satisfied: psutil>=5 in /usr/local/lib/python3.9/dist-
packages (from qiskit-terra==0.23.3->qiskit) (5.9.4)
Collecting ply>=3.10
  Downloading ply-3.11-py2.py3-none-any.whl (49 kB)
----- 49.6/49.6 KB 2.1 MB/s eta
0:00:00
Requirement already satisfied: six>=1.5 in /usr/local/lib/python3.9/dist-
packages (from python-dateutil>=2.8.0->qiskit-ibmq-provider==0.20.2-
>qiskit) (1.16.0)
Requirement already satisfied: charset-normalizer~=2.0.0 in
/usr/local/lib/python3.9/dist-packages (from requests>=2.19->qiskit-
ibmq-provider==0.20.2->qiskit) (2.0.12)
Requirement already satisfied: idna<4,>=2.5 in
/usr/local/lib/python3.9/dist-packages (from requests>=2.19->qiskit-
ibmq-provider==0.20.2->qiskit) (3.4)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.9/dist-packages (from requests>=2.19->qiskit-
ibmq-provider==0.20.2->qiskit) (2022.12.7)
Requirement already satisfied: cryptography>=1.3 in
/usr/local/lib/python3.9/dist-packages (from requests-ntlm<=1.1.0-
>qiskit-ibmq-provider==0.20.2->qiskit) (40.0.1)
Collecting ntlm-auth>=1.0.2
  Downloading ntlm_auth-1.5.0-py2.py3-none-any.whl (29 kB)
Collecting pbr!=2.1.0,>=2.0.0
  Downloading pbr-5.11.1-py2.py3-none-any.whl (112 kB)
----- 112.7/112.7 KB 14.1 MB/s eta
0:00:00
Requirement already satisfied: mpmath>=0.19 in /usr/local/lib/python3.9/dist-
packages (from sympy>=1.3->qiskit-terra==0.23.3->qiskit) (1.3.0)
Requirement already satisfied: cffi>=1.12 in
/usr/local/lib/python3.9/dist-packages (from cryptography>=1.3-
>requests-ntlm<=1.1.0->qiskit-ibmq-provider==0.20.2->qiskit) (1.15.1)
Requirement already satisfied: pycparser in
/usr/local/lib/python3.9/dist-packages (from cffi>=1.12-
>cryptography>=1.3->requests-ntlm<=1.1.0->qiskit-ibmq-
provider==0.20.2->qiskit) (2.21)
Building wheels for collected packages: qiskit
  Building wheel for qiskit (setup.py) ... e=qiskit-0.42.1-py3-none-
any.whl size=12938

```

sha256=727022bb6132caec7f0462c7106119f07cf8d8628e4794f8476eae0d7ada4b20

Stored in directory:

/root/.cache/pip/wheels/40/64/74/29c046bda04fd60f3f6b2e244fa85b70f219e363fc3373f541

Successfully built giskit

Installing collected packages: ply, websockets, websocket-client, symengine, rustworkx, pbr, ntlm-auth, dill, stevedore, requests-ntlm, giskit-terra, giskit-ibmq-provider, giskit-aer, giskit

Successfully installed dill-0.3.6 ntlm-auth-1.5.0 pbr-5.11.1 ply-3.11

giskit-0.42.1 giskit-aer-0.12.0 giskit-ibmq-provider-0.20.2 giskit-

terra-0.23.3 requests-ntlm-1.1.0 rustworkx-0.12.1 stevedore-5.0.0

symengine-0.10.0 websocket-client-1.5.1 websockets-11.0

Looking in indexes: <https://pypi.org/simple>, [https://us-](https://us-python.pkg.dev/colab-wheels/public/simple/)

[python.pkg.dev/colab-wheels/public/simple/](https://us-python.pkg.dev/colab-wheels/public/simple/)

Collecting pylatexenc

Downloading pylatexenc-2.10.tar.gz (162 kB)

162.6/162.6 KB 5.0 MB/s eta

0:00:00

etadata (setup.py) ... e=pylatexenc-2.10-py3-none-any.whl size=136831

sha256=00a6990882fd4dfb2054e571f5bf5d8203f74229e3a0b4068c07f6a2893a8a7c

Stored in directory:

/root/.cache/pip/wheels/a3/68/66/2f15abd0673d83c02f354115feedeb89c3dae2ac319b11090

Successfully built pylatexenc

Installing collected packages: pylatexenc

Successfully installed pylatexenc-2.10

Looking in indexes: <https://pypi.org/simple>, [https://us-](https://us-python.pkg.dev/colab-wheels/public/simple/)

[python.pkg.dev/colab-wheels/public/simple/](https://us-python.pkg.dev/colab-wheels/public/simple/)

Collecting pennylane

Downloading PennyLane-0.29.1-py3-none-any.whl (1.3 MB)

1.3/1.3 MB 17.2 MB/s eta

0:00:00

ent already satisfied: networkx in /usr/local/lib/python3.9/dist-packages (from pennylane) (2.8.8)

Collecting semantic-version>=2.7

Downloading semantic_version-2.10.0-py2.py3-none-any.whl (15 kB)

Requirement already satisfied: appdirs in

/usr/local/lib/python3.9/dist-packages (from pennylane) (1.4.4)

Requirement already satisfied: toml in /usr/local/lib/python3.9/dist-packages (from pennylane) (0.10.2)

Collecting autoray>=0.3.1

Downloading autoray-0.6.3-py3-none-any.whl (48 kB)

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anylinux_2_17_x86_64.manylinux2014_x86_64.whl (16.5 MB)

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ent already satisfied: autograd in /usr/local/lib/python3.9/dist-


```
packages (from pennylane) (1.5)
Requirement already satisfied: cachetools in
/usr/local/lib/python3.9/dist-packages (from pennylane) (5.3.0)
Requirement already satisfied: scipy in /usr/local/lib/python3.9/dist-
packages (from pennylane) (1.10.1)
Requirement already satisfied: numpy<1.24 in
/usr/local/lib/python3.9/dist-packages (from pennylane) (1.22.4)
Requirement already satisfied: requests in
/usr/local/lib/python3.9/dist-packages (from pennylane) (2.27.1)
Requirement already satisfied: future>=0.15.2 in
/usr/local/lib/python3.9/dist-packages (from autograd->pennylane)
(0.18.3)
Requirement already satisfied: charset-normalizer~=2.0.0 in
/usr/local/lib/python3.9/dist-packages (from requests->pennylane)
(2.0.12)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in
/usr/local/lib/python3.9/dist-packages (from requests->pennylane)
(1.26.15)
Requirement already satisfied: idna<4,>=2.5 in
/usr/local/lib/python3.9/dist-packages (from requests->pennylane)
(3.4)
Requirement already satisfied: certifi>=2017.4.17 in
/usr/local/lib/python3.9/dist-packages (from requests->pennylane)
(2022.12.7)
Requirement already satisfied: rustworkx==0.12.1 in
/usr/local/lib/python3.9/dist-packages (from retworkx->pennylane)
(0.12.1)
Installing collected packages: semantic-version, autoray, retworkx,
pennylane-lightning, pennylane
Successfully installed autoray-0.6.3 pennylane-0.29.1 pennylane-
lightning-0.29.0 retworkx-0.12.1 semantic-version-2.10.0
Looking in indexes: https://pypi.org/simple, https://us-
python.pkg.dev/colab-wheels/public/simple/
Collecting tensorflow-addons
  Downloading tensorflow_addons-0.19.0-cp39-cp39-
manylinux_2_17_x86_64.manylinux2014_x86_64.whl (1.1 MB)
  

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Requirement already satisfied: packaging in /usr/local/lib/python3.9/dist-
packages (from tensorflow-addons) (23.0)
Requirement already satisfied: typing-extensions>=4.4.0 in
/usr/local/lib/python3.9/dist-packages (from typeguard>=2.7-
>tensorflow-addons) (4.5.0)
Requirement already satisfied: importlib-metadata>=3.6 in
/usr/local/lib/python3.9/dist-packages (from typeguard>=2.7-
>tensorflow-addons) (6.1.0)
Requirement already satisfied: zipp>=0.5 in
/usr/local/lib/python3.9/dist-packages (from importlib-metadata>=3.6-
>typeguard>=2.7->tensorflow-addons) (3.15.0)
```

Installing collected packages: typeguard, tensorflow-addons
Successfully installed tensorflow-addons-0.19.0 typeguard-3.0.2

##Task I Quantum Computing Part

Part 1

Implement a simple quantum operation with Cirq or PennyLane

1. With 5 qubits
2. Apply Hadamard operation on every qubit
3. Apply CNOT operation on (0, 1), (1,2), (2,3), (3,4)
4. SWAP (0, 4)
5. Rotate X with $\pi/2$ on any qubit
6. Plot the circuit

####CIRQ Implemmentaion

##Solution Using Cirq

```
import cirq
import numpy as np
from random import randint

# Creating a circuit with 5 qubits
circuit = cirq.Circuit()
qubits = [cirq.LineQubit(i) for i in range(5)]

# Applying Hadamard gate on each of qubit
for qubit in qubits:
    circuit.append(cirq.H(qubit))

# Applying CNOT gate on (0,1), (1,2), (2,3), (3,4)
circuit.append(cirq.CNOT(qubits[i], qubits[i+1]) for i in range(4))

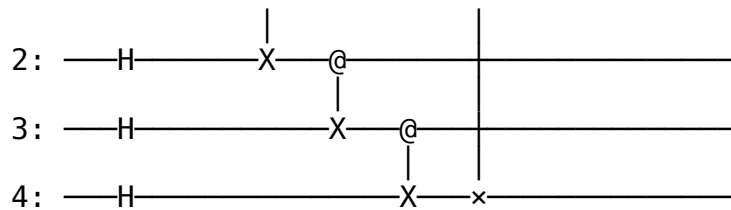
# Applying SWAP gate on (0,4)
circuit.append(cirq.SWAP(qubits[0], qubits[4]))

# Rotatating X with pi/2 on qubit on random circuit
rand_qubit_index = randint(0,4)

circuit.append(cirq.rx(0.5 * np.pi).on(qubits[rand_qubit_index]))

# Display the circuit
print(circuit)
```

```
0: —H—@—————x—Rx(0.5π)—
      |
1: —H—X—@—————|—————
```



PennyLane Implementation

```
import pennylane as qml

dev = qml.device("default.qubit", wires=5)

@qml.qnode(dev)
def circuit():
    # Apply Hadamard operation on every qubit
    for i in range(5):
        qml.Hadamard(wires=i)

    # Apply CNOT operation on (0, 1), (1,2), (2,3), (3,4)
    for i in range(4):
        qml.CNOT(wires=[i, i+1])

    # SWAP (0, 4)
    qml.SWAP(wires=[0, 4])

    # Rotate X with pi/2 on any qubit
    qml.RX(0.5*np.pi, wires= randint(0,4))

    return qml.probs(wires=[0, 1, 2, 3, 4])

drawer = qml.draw(circuit, show_all_wires=True)
print(drawer())
```

Part 2 Implement a second circuit with a framework of your choice:

1. Apply a Hadamard gate to the first qubit
2. rotate the second qubit by $\pi/3$ around X
3. Apply Hadamard gate to the third and fourth qubit 4. Perform a swap test between the states of the first and second qubit $|q_1 q_2\rangle$ and the third and fourth qubit $|q_3 q_4\rangle$

Qiskit Implementation

```
from qiskit import QuantumCircuit

# Creating circuit with 4 qubits
circuit = QuantumCircuit(4)

# Applying Hadamard gate on first qubit
```

```

circuit.h(0)

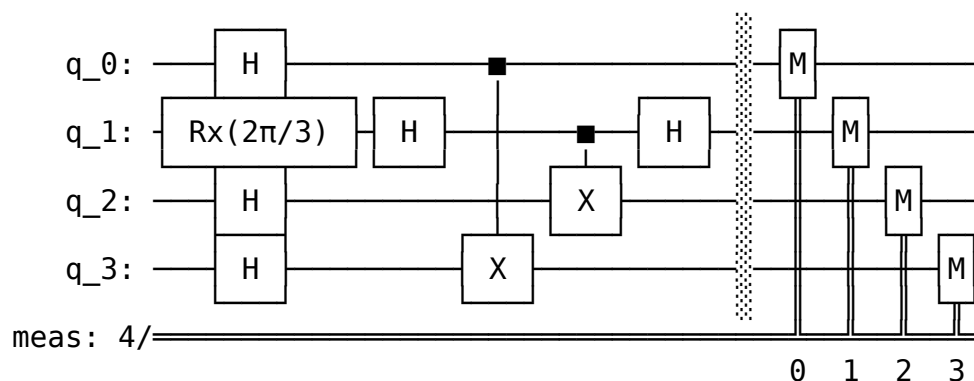
# Rotating the second qubit by pi/3 around X
circuit.rx(2/3 * np.pi, 1)

# Applying Hadamard gate on third and fourth qubit
circuit.h([2, 3])

# Performing swap test between qubit pairs (0,1) and (2,3)
circuit.h(1)
circuit.cx(1, 2)
circuit.cx(0, 3)
circuit.h(1)
circuit.measure_all()

# Display the circuit
print(circuit)

```



```

from qiskit import Aer , execute

# Execute the circuit on a simulator
backend = Aer.get_backend('qasm_simulator')
result = execute(circuit, backend=backend, shots=1024).result()
counts = result.get_counts()

# Print the measurement outcomes and their probabilities
print(counts)

{'0000': 25, '1101': 31, '0111': 92, '0011': 88, '1011': 93, '1010': 85, '1110': 95, '1001': 39, '0101': 39, '1111': 102, '0001': 39, '0010': 109, '1100': 29, '1000': 43, '0110': 88, '0100': 27}

from qiskit.visualization import plot_histogram

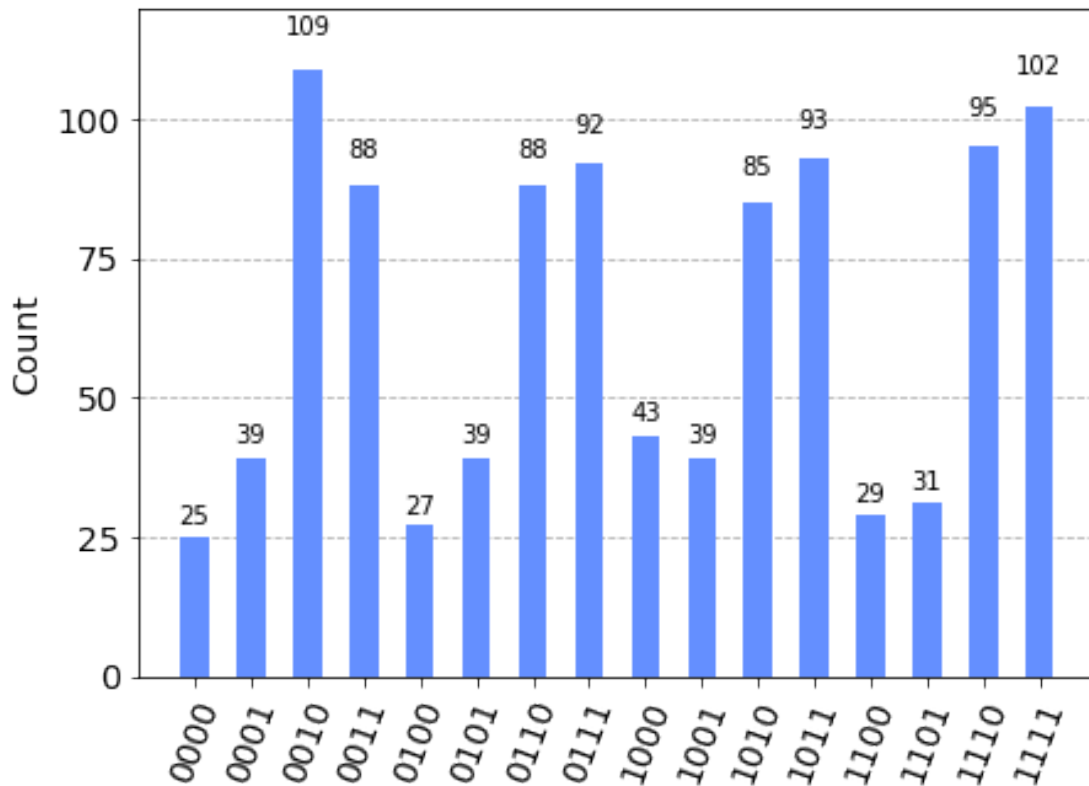
# Print the measurement outcomes and their probabilities
print(counts)

```

```
# Visualize the measurement outcomes
```

```
plot_histogram(counts)
```

```
{'0000': 25, '1101': 31, '0111': 92, '0011': 88, '1011': 93, '1010':  
85, '1110': 95, '1001': 39, '0101': 39, '1111': 102, '0001': 39,  
'0010': 109, '1100': 29, '1000': 43, '0110': 88, '0100': 27}
```



```
from qiskit.visualization import circuit_drawer, plot_state_city
```

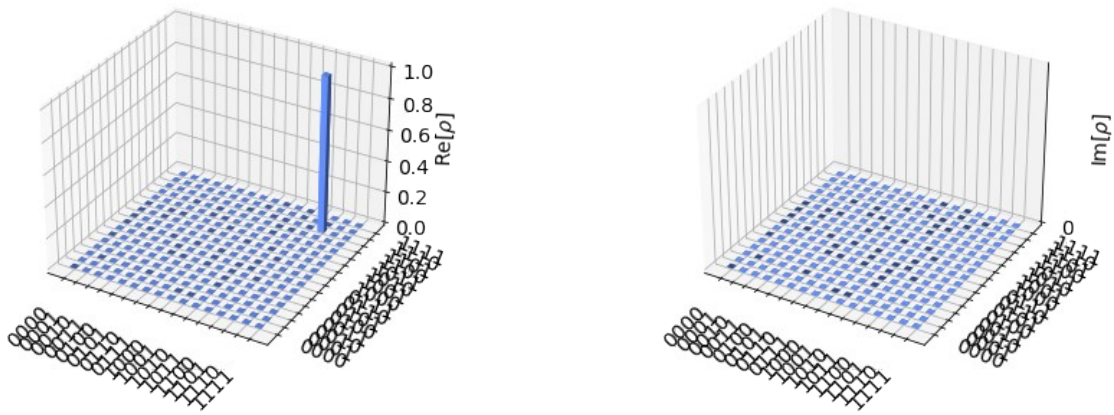
```
# Visualize the final state of the circuit
```

```
statevector = execute(circuit,
```

```
backend=Aer.get_backend('statevector_simulator'),shots=1024).result().
```

```
get_statevector()
```

```
plot_state_city(statevector)
```



```
import matplotlib.pyplot as plt
circuit.draw(output='mpl')
```

