Optimizer Comparison Report

Number of Qubits Used: 4
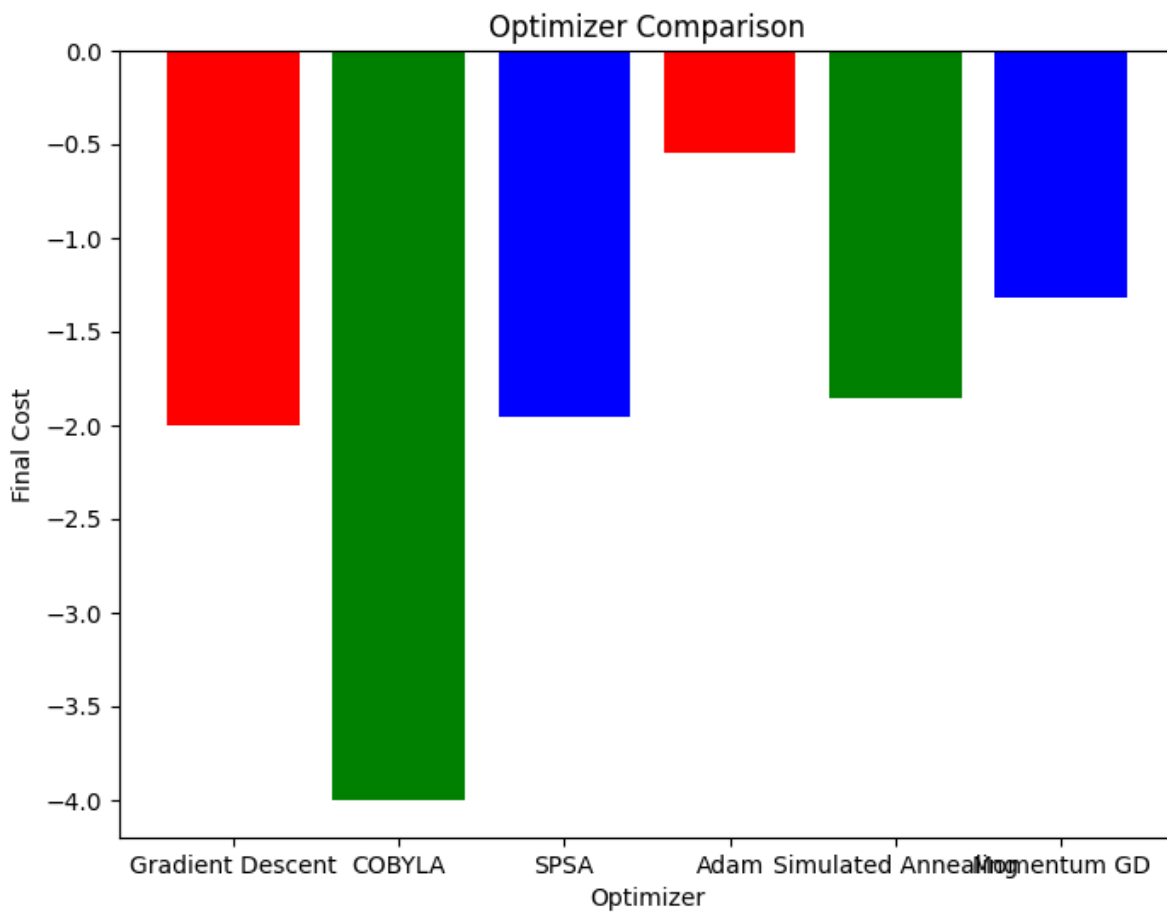
Optimizer Hyperparameters

Gradient Descent: {'learning_rate': 0.01}

COBYLA: {'maxiter': 100}

SPSA: {'maxiter': 100}

Adam: {'learning_rate': 0.001, 'beta1': 0.9, 'beta2': 0.999}

Simulated Annealing: {'initial_temp': 10.0, 'cooling_rate': 0.95}
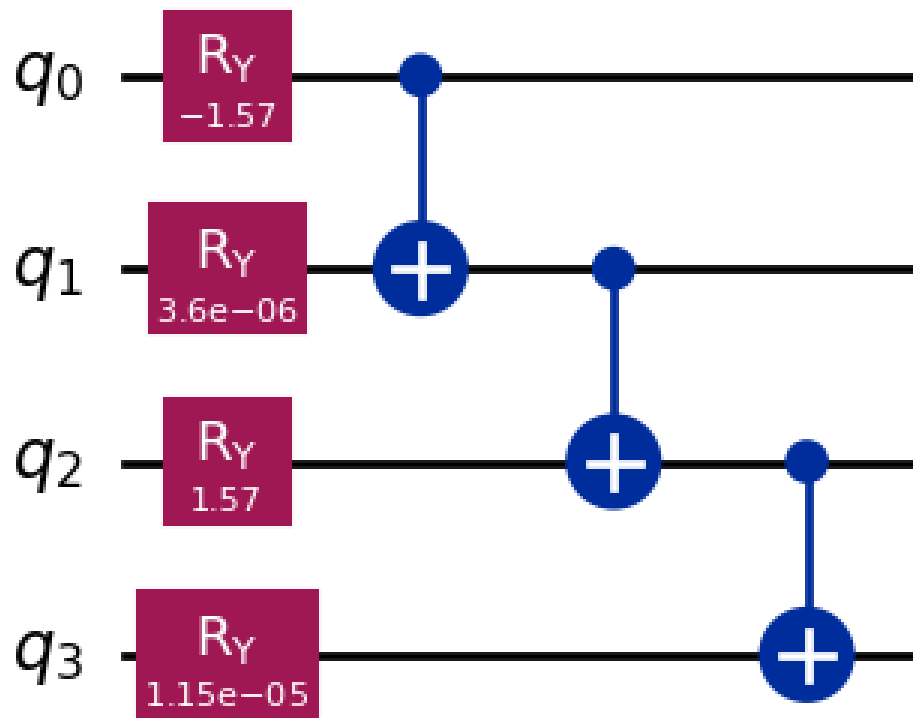
Momentum GD: {'learning_rate': 0.01, 'momentum': 0.9}

Optimizer Comparison Table

Optimizer	Final Cost	Optimized Parameters	Time Taken
Gradient Descent	-2.000000	-1.571, 0.000, 1.571, 0.000	144.66
COBYLA	-4.000000	1.571, -0.000, 4.712, 0.000	87.08
SPSA	-1.956333	-1.165, 0.070, 2.618, -0.037	35.34
Adam	-0.545861	0.425, 0.051, 1.708, 0.330	103.96
Simulated Annealing	-1.854650	-1.065, -0.248, 0.786, 0.230	11.61
Momentum GD	-1.322650	-0.343, 0.050, 1.571, 0.160	104.52

Optimizer Comparison Bar Chart

Quantum Circuit Diagram

Optimization Process Flowchart

```
       Start
         │
         ▼
 Initialize Parameters
         │
         ▼
   Run Optimizer
         │       ▲
         ▼       │  Not Converged
   Compute Cost  │
         │       │
         ▼       │
  Check Convergence
         │
         │ Converged
         ▼
        End
```