# Homework 4

**Due** Nov 11 at 3:59am **Points** 100 **Questions** 10
**Available** until Nov 11 at 3:59am **Time Limit** 60 Minutes
**Allowed Attempts** 3

## Instructions

We use the **conventions in the QBook101**.

The default programming language for coding is Python. You may write pieces of code during this exercise.

Take the Quiz Again

## Attempt History

| | Attempt | Time | Score |
|---|---|---|---|
| LATEST | Attempt 1 | 49 minutes | 70 out of 100 |

**Last Attempt Details:**

| | |
|---|---|
| **Time:** | 49 minutes |
| **Current Score:** | 70 out of 100 |
| **Kept Score:** | 70 out of 100 |

2 More Attempts available

Take the Quiz Again

(Will keep the highest of all your scores)

Correct answers are hidden.

Score for this attempt: **70** out of 100
Submitted Nov 10 at 1:37pm
This attempt took 49 minutes.

Incorrect

### Question 1

0 / 10 pts

The rotation on the unit circle with angle $\theta$ is denoted $R(\theta)$

What is the matrix form of $R(-\theta)$?

*(Hint: Apply each candidate matrix to states $|0\rangle$ and $|1\rangle$ to verify whether the result is the rotated state.)*

- $\begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix}$
- $\begin{pmatrix} \cos\theta & \sin\theta \\ \sin\theta & -\cos\theta \end{pmatrix}$
- $\begin{pmatrix} \sin\theta & -\cos\theta \\ \cos\theta & \sin\theta \end{pmatrix}$
- $\begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix}$
- $\begin{pmatrix} \sin\theta & \cos\theta \\ -\cos\theta & \sin\theta \end{pmatrix}$

### Question 2

10 / 10 pts

If $R(\theta)$ is applied to a qubit initially in state $|1\rangle$ twice,

what is the final state?

- $\begin{pmatrix} -\sin(2\theta) \\ \cos(2\theta) \end{pmatrix}$
- $\begin{pmatrix} \cos(2\theta) \\ -\sin(2\theta) \end{pmatrix}$
- $\begin{pmatrix} \cos(2\theta) \\ \sin(2\theta) \end{pmatrix}$
- $\begin{pmatrix} \sin(2\theta) \\ -\cos(2\theta) \end{pmatrix}$
- $\begin{pmatrix} \sin(2\theta) \\ \cos(2\theta) \end{pmatrix}$

Incorrect

## Question 3

0 / 10 pts

We have a qubit in state $|0\rangle$.

The rotations $R\left(\frac{\pi}{3}\right)$ and $R\left(-\frac{\pi}{6}\right)$ are applied $m$ and $n$ times, respectively.

If the final state is $-|1\rangle$ what can be the values of $(m, n)$?

- (20,7)
- (20,11)
- (20,9)
- (20,5)
- (20,3)

## Question 4

10 / 10 pts

What is $Ref(\theta_1) \cdot \begin{pmatrix} \cos\theta_2 \\ \sin\theta_2 \end{pmatrix}$?

- $\begin{pmatrix} \cos(2\theta_1 - \theta_2) \\ \sin(2\theta_1 - \theta_2) \end{pmatrix}$
- $\begin{pmatrix} \cos(\theta_1 - \theta_2) \\ \sin(\theta_1 - \theta_2) \end{pmatrix}$
- $\begin{pmatrix} \cos(\theta_2 - \theta_1) \\ \sin(\theta_2 - \theta_1) \end{pmatrix}$
- $\begin{pmatrix} \cos(2\theta_2 - \theta_1) \\ \sin(2\theta_2 - \theta_1) \end{pmatrix}$
- $\begin{pmatrix} \cos(\theta_1 + \theta_2) \\ \sin(\theta_1 + \theta_2) \end{pmatrix}$

## Question 5

10 / 10 pts

What is the matrix form of the reflection having the line of reflection $y = -2x$

- $\begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix}$
- $\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$
- $\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}$
- $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$
- ◉ $\begin{pmatrix} 0 & -1 \\ -1 & 0 \end{pmatrix}$

## Question 6

10 / 10 pts

Let $|u\rangle$ be a quantum state on the unit circle with angle $\theta$.

We apply $Ref(\theta_1)$ and then $Ref(\theta_2)$

What is the angle of the final state?

- ◉ $-2\theta_1 + 2\theta_2 + \theta$
- $2\theta_1 + 2\theta_2 - \theta$
- $\theta_1 + \theta_2 - \theta$
- $2\theta_1 + 2\theta_2 + \theta$
- $-2\theta_1 - 2\theta_2 + \theta$

Incorrect

## Question 7

0 / 10 pts

Which one of the following pairs of quantum states cannot be distinguishable?

- $|+\rangle$ and $|-\rangle$
- ◉ $-|+\rangle$ and $|-\rangle$
- $|1\rangle$ and $-|1\rangle$
- $|0\rangle$ and $-|1\rangle$
- $|0\rangle$ and $|1\rangle$

## Question 8

10 / 10 pts

Which one of the following pairs of quantum states is perfectly distinguishable?

- (●) $\left(\sqrt{\frac{5}{7}}|0\rangle - \sqrt{\frac{2}{7}}|1\rangle, -\sqrt{\frac{2}{7}}|0\rangle - \sqrt{\frac{5}{7}}|1\rangle\right)$
- ( ) $\left(\sqrt{\frac{5}{7}}|0\rangle + \sqrt{\frac{2}{7}}|1\rangle, -\sqrt{\frac{2}{7}}|0\rangle - \sqrt{\frac{5}{7}}|1\rangle\right)$
- ( ) $\left(\sqrt{\frac{5}{7}}|0\rangle + \sqrt{\frac{2}{7}}|1\rangle, -\sqrt{\frac{5}{7}}|0\rangle - \sqrt{\frac{2}{7}}|1\rangle\right)$
- ( ) $\left(\sqrt{\frac{5}{7}}|0\rangle - \sqrt{\frac{2}{7}}|1\rangle, -\sqrt{\frac{5}{7}}|0\rangle - \sqrt{\frac{2}{7}}|1\rangle\right)$
- ( ) $\left(\sqrt{\frac{5}{7}}|0\rangle + \sqrt{\frac{2}{7}}|1\rangle, \sqrt{\frac{5}{7}}|0\rangle - \sqrt{\frac{2}{7}}|1\rangle\right)$

## Question 9

10 / 10 pts

Let $|u_1\rangle = \begin{pmatrix} \cos\theta_1 \\ \sin\theta_1 \end{pmatrix}$ and $|u_2\rangle = \begin{pmatrix} \cos\theta_2 \\ \sin\theta_2 \end{pmatrix}$ be two different quantum states, where $\theta_1, \theta_2 \in (0, \pi)$

If the probabilities of being in states $|0\rangle$ for $|u_1\rangle$ and $|u_2\rangle$ are the same,

which one of the followings is correct for $\theta_1$ and $\theta_2$?

- ( ) $\theta_1 + \theta_2 = \frac{3\pi}{2}$
- ( ) $|\theta_1 - \theta_2| = \frac{\pi}{4}$
- ( ) $\theta_1 + \theta_2 = \frac{\pi}{2}$
- ( ) $|\theta_1 - \theta_2| = \frac{\pi}{2}$
- (●) $\theta_1 + \theta_2 = \pi$

## Question 10

10 / 10 pts

We have 1000 copies of the identical qubit in state $\begin{pmatrix} \cos\theta \\ \sin\theta \end{pmatrix}$, where $\theta \in \left(-\frac{\pi}{2}, \frac{\pi}{2}\right)$

After measuring 1000 copies, we observe $|0\rangle$ 201 times and state $|1\rangle$ 799 times.

Which one of the followings can be more likely a value of $\theta$ in degree?

- ( ) -80
- ( ) 15

-63

-45

30

Quiz Score: **70** out of 100

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