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Unit 4 - Week 3

Course outline

How to access the portal ?

Week-1

Week-2

Week 3

- Density Matrix-I
- Density Matrix-II
- Bloch Sphere and Density Matrix
- Measurement Postulates-I
- Measurement Postulates-II
- Quiz : Week 3 - Assignment 3
- Week 3 - Assignment 3 Solutions

Week 4

Week 5

Week 6

Week 7

Week-8

Week 3 - Assignment 3

The due date for submitting this assignment has passed. **Due on 2017-08-16, 23:59 IST.**
As per our records you have not submitted this assignment.

In the following questions, ONLY ONE answer is correct. Choose the most appropriate one. (1X12=12 Marks)

1) A system is in the state $\frac{1}{\sqrt{3}}\,|\,u_1\rangle + i\sqrt{\frac{2}{3}}\,|\,u_2\rangle$, where $|u_1\rangle$ and $|u_2\rangle$ constitute an orthonormal basis. The density matrix ρ of the system is *1 point*

- $\frac{1}{3}|u_1\rangle\langle u_1| + \frac{2}{3}|u_2\rangle\langle u_2|$
- $\frac{1}{3}|u_1\rangle\langle u_1| - \frac{i\sqrt{2}}{3}|u_2\rangle\langle u_1| + \frac{i\sqrt{2}}{3}|u_1\rangle\langle u_2| + \frac{2}{3}|u_2\rangle\langle u_2|$
- $\frac{1}{3}|u_1\rangle\langle u_1| + \frac{i\sqrt{2}}{3}|u_2\rangle\langle u_1| - \frac{i\sqrt{2}}{3}|u_1\rangle\langle u_2| + \frac{2}{3}|u_2\rangle\langle u_2|$
- $\frac{1}{3}|u_1\rangle\langle u_1| - \frac{2}{3}|u_2\rangle\langle u_2|$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\frac{1}{3}|u_1\rangle\langle u_1| + \frac{i\sqrt{2}}{3}|u_2\rangle\langle u_1| - \frac{i\sqrt{2}}{3}|u_1\rangle\langle u_2| + \frac{2}{3}|u_2\rangle\langle u_2|$

2) The trace of ρ^2 for the density matrix given in Q1 is *1 point*

- 1
- 3/4
- 2/3
- 1/3

No, the answer is incorrect.
Score: 0

Accepted Answers:
1

3) A system is in the state $\frac{1}{2}|u_1\rangle + \frac{1}{\sqrt{2}}|u_2\rangle + \frac{1}{2}|u_3\rangle$ The matrix representation of the density matrix is *1 point*

$$\begin{pmatrix} \frac{1}{4} & \frac{1}{2\sqrt{2}} & \frac{1}{2\sqrt{2}} \\ \frac{1}{2\sqrt{2}} & \frac{1}{2} & \frac{1}{4} \\ \frac{1}{2\sqrt{2}} & \frac{1}{4} & \frac{1}{4} \end{pmatrix}$$

$$\begin{pmatrix} \frac{1}{4} & 0 & 0 \\ 0 & \frac{1}{2} & 0 \\ 0 & 0 & \frac{1}{4} \end{pmatrix}$$

$$\begin{pmatrix} \frac{1}{4} & \frac{1}{4} & \frac{1}{2\sqrt{2}} \\ \frac{1}{4} & \frac{1}{2} & \frac{1}{4} \\ \frac{1}{2\sqrt{2}} & \frac{1}{4} & \frac{1}{4} \end{pmatrix}$$

$$\begin{pmatrix} \frac{1}{4} & \frac{1}{2\sqrt{2}} & \frac{1}{4} \\ \frac{1}{2\sqrt{2}} & \frac{1}{2} & \frac{1}{2\sqrt{2}} \\ \frac{1}{4} & \frac{1}{2\sqrt{2}} & \frac{1}{4} \end{pmatrix}$$

No, the answer is incorrect.
Score: 0

Accepted Answers:

$$\begin{pmatrix} \frac{1}{4} & \frac{1}{2\sqrt{2}} & \frac{1}{4} \\ \frac{1}{2\sqrt{2}} & \frac{1}{2} & \frac{1}{2\sqrt{2}} \\ \frac{1}{4} & \frac{1}{2\sqrt{2}} & \frac{1}{4} \end{pmatrix}$$

4) The density operator ρ evolves with time following the equation *1 point*

$$-i\hbar\frac{d\rho}{dt} = [H, \rho]$$

$$i\hbar\frac{d\rho}{dt} = [H, \rho]$$

$$i\hbar\frac{d\rho}{dt} = H\rho$$

$$-i\hbar\frac{d\rho}{dt} = H\rho$$

No, the answer is incorrect.
Score: 0

Accepted Answers:

$$i\hbar \frac{d\rho}{dt} = [H, \rho]$$

5) The reduced density matrix for the two qubit entangled state $\frac{|00\rangle + |11\rangle}{\sqrt{2}}$, corresponding to either of the qubits is **1 point**

- $\frac{I}{\sqrt{2}}$
- $\frac{I}{2}$
- $\frac{3I}{4}$
- I

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\frac{I}{2}$

6) A two qubit state is given by $\frac{1}{\sqrt{3}}\left[|00\rangle + |01\rangle + |10\rangle\right]$. The reduced density matrix of the first qubit is **1 point**

- $\frac{1}{3}[| 0\rangle\langle 0 | + | 1\rangle\langle 0 | + | 0\rangle\langle 1 | +2 | 1\rangle\langle 1 |]$
- $\frac{1}{2}[| 0\rangle\langle 0 | + | 1\rangle\langle 0 | + | 0\rangle\langle 1 | + | 1\rangle\langle 1 |]$
- $\frac{1}{3}[2 | 0\rangle\langle 0 | + | 1\rangle\langle 0 | + | 0\rangle\langle 1 | + | 1\rangle\langle 1 |]$
- $\frac{1}{3}[2 | 0\rangle\langle 0 | - | 1\rangle\langle 0 | + | 0\rangle\langle 1 | + | 1\rangle\langle 1 |]$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\frac{1}{3}[2 | 0\rangle\langle 0 | + | 1\rangle\langle 0 | + | 0\rangle\langle 1 | + | 1\rangle\langle 1 |]$

7) The centre of the Bloch sphere is **1 point**

- A pure state
- Neither a pure state nor a mixed state
- A mixed state represented by a matrix whose diagonal elements are 1/2 each and the off diagonal elements are 1 each
- A mixed state represented by a diagonal matrix whose elements are 1/2 each

No, the answer is incorrect.
Score: 0

Accepted Answers:
A mixed state represented by a diagonal matrix whose elements are 1/2 each

8) The matrix $\begin{pmatrix} 1/3 & \sqrt{3}i/2 \\ -\sqrt{3}i/2 & 2/3 \end{pmatrix}$ **1 point**

- is a valid density matrix for a system and it represents a pure state
- is a valid density matrix for a system and it represents a mixed state
- is not a valid density matrix since it is not hermitian
- is not a valid density matrix as it is not a positive matrix

No, the answer is incorrect.
Score: 0

Accepted Answers:
is not a valid density matrix as it is not a positive matrix

9) The reduced density matrix corresponding to the first qubit for the state $\frac{\sqrt{3}}{2}|00\rangle + \frac{1}{2}|11\rangle$ is given by *1 point*

- $\frac{1}{4}\begin{pmatrix} 3 & 0 \\ 0 & 1 \end{pmatrix}$
- $\frac{1}{4}\begin{pmatrix} 1 & 0 \\ 0 & 3 \end{pmatrix}$
- $\frac{1}{\sqrt{3}+1}\begin{pmatrix} \sqrt{3} & 0 \\ 0 & 1 \end{pmatrix}$
- $\frac{1}{\sqrt{3}+1}\begin{pmatrix} 1 & 0 \\ 0 & \sqrt{3} \end{pmatrix}$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\frac{1}{4}\begin{pmatrix} 3 & 0 \\ 0 & 1 \end{pmatrix}$

10) Consider a two qubit state $\frac{1}{\sqrt{7}}\left(|00\rangle + \sqrt{2}|01\rangle + \sqrt{3}|10\rangle + |11\rangle\right)$ If we measure the first qubit and obtain $|0\rangle$, then the second qubit collapses to *1 point*

- $\frac{1}{\sqrt{3}}\left(|0\rangle + \sqrt{2}|1\rangle\right)$
- $\frac{1}{\sqrt{3}}\left(\sqrt{2}|0\rangle + |1\rangle\right)$
- $\frac{1}{\sqrt{7}}\left(|0\rangle + \sqrt{2}|1\rangle\right)$
- $\frac{1}{\sqrt{7}}\left(2|0\rangle + \sqrt{3}|1\rangle\right)$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$\frac{1}{\sqrt{3}}\left(|0\rangle + \sqrt{2}|1\rangle\right)$

11) In Q 10, the probability that a projective measurement of the first qubit gives is $|0\rangle$ *1 point*

- 5/7
- 4/7

- 3/7
- 2/7

No, the answer is incorrect.
Score: 0

Accepted Answers:
3/7

12) Consider a two qubit state $\frac{1}{\sqrt{11}}\left(|00\rangle + \sqrt{5}|01\rangle + \sqrt{2}|10\rangle + \sqrt{3}|11\rangle\right)$. The probability of measuring $|0\rangle$ for the first qubit is

1 point

- $\frac{1+\sqrt{5}}{\sqrt{11}}$
- $6/11$
- $\frac{(1+\sqrt{5})^2}{11}$
- $5/11$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$6/11$

In the following questions, ONE or MORE answer(s) is(are correct. Choose all the appropriate ones. (2X4=8 Marks)

13) Which of the following properties must be satisfied for the density matrix corresponding to a mixed state?

2 points

- Its eigenvalues must be non-negative
- The distance of the state from the origin of the Bloch sphere should be less than 1
- Trace $(\rho^2) \leq$ Trace (ρ)
- It satisfies Liouville equation

No, the answer is incorrect.
Score: 0

Accepted Answers:
Its eigenvalues must be non-negative
The distance of the state from the origin of the Bloch sphere should be less than 1

14) Consider a two qubit state $\frac{1}{\sqrt{2}}\left[|00\rangle + |01\rangle\right]$. Which of the following matrices are members of the set corresponding to the measurement operators for the second qubit?

2 points

i) $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$

ii) $\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

iii) $\begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{pmatrix}$

iv) $\begin{pmatrix} 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$

- [ ] (i) and (ii)
- [ ] (i) and (iii)
- [ ] (ii) and (iii)
- [ ] (iii) and (iv)

No, the answer is incorrect.
Score: 0

Accepted Answers:
(iii) and (iv)

15) Let ρ be a density matrix given by $\rho = p|0\rangle\langle 0| + q|1\rangle\langle 1|$. It follows that ***2 points***

- [ ] $p + q = 1$
- [ ] $p^2 + q^2 = 1$
- [ ] $p^2 + q^2 < 1$
- [ ] Trace$(\rho^2) = p^2 + q^2$

No, the answer is incorrect.
Score: 0

Accepted Answers:
$p^2 + q^2 < 1$

16) A system is a statistical mixture of states in which 25% are in state $|0\rangle$ and the remaining in state $|1\rangle$. If the measurement is made in $\{|+\rangle, |-\rangle\}$ basis, then the probability of finding the system in state $|+\rangle$ is ***2 points***

- [ ] 1
- [ ] 3/4
- [ ] 1/2
- [ ] 1/4

No, the answer is incorrect.
Score: 0

Accepted Answers:
1/2

Previous Page End