

# Quantum Learning & Research Notes

Mattqsim

February 9, 2026

# Contents

<b>1</b>	<b>Linear Algebra</b>	<b>1</b>
1.1	Vectors and Vector Spaces . . . . .	1
1.2	Inner Products and Norms . . . . .	1
1.3	Linear Operators . . . . .	1
1.4	Eigenvalues and Eigenvectors . . . . .	1
1.5	Hermitian and Unitary Operators . . . . .	1
1.6	Tensor Products . . . . .	1
1.7	Change of Basis . . . . .	1
1.8	Spectral Decomposition . . . . .	1
1.9	Commutators . . . . .	1
<b>2</b>	<b>Probability</b>	<b>2</b>
2.1	Probability Spaces . . . . .	2
2.2	Random Variables . . . . .	2
2.3	Expectation and Variance . . . . .	2
2.4	Joint and Conditional . . . . .	2
2.5	Markov Processes . . . . .	2
2.6	Stochastic Matrices . . . . .	2
2.7	Measurement as Random Process . . . . .	2
2.8	Information Measures . . . . .	2
<b>3</b>	<b>Quantum Mechanics</b>	<b>3</b>
3.1	Postulates of Quantum Mechanics . . . . .	3
3.2	State Vectors and Density Matrices . . . . .	3
3.3	Unitary Time Evolution . . . . .	3
3.4	Measurement Theory . . . . .	3
3.5	Composite Systems and Entanglement . . . . .	3
3.6	Quantum Gates . . . . .	3
3.7	Quantum Channels . . . . .	3
3.8	Open Quantum Systems . . . . .	3

3.9	Quantum Circuits . . . . .	3
<b>4</b>	<b>Quantum Simulator, qsim</b>	<b>4</b>
4.1	Statevector Simulation . . . . .	4
4.2	Operator Simulation . . . . .	4
4.3	Shot Based Execution . . . . .	4
4.4	Numerical Errors . . . . .	4
4.5	Performance Tradeoffs . . . . .	4
<b>5</b>	<b>Quantum Error Correction, qec</b>	<b>5</b>
5.1	Repetition Code . . . . .	5
5.2	Stabilizer Formalism . . . . .	5
5.3	Syndrome Extraction . . . . .	5
5.4	Logical Operators . . . . .	5
5.5	Failure Modes . . . . .	5
<b>6</b>	<b>Quantum Security, qsec</b>	<b>6</b>
6.1	Threat Models . . . . .	6
6.2	Post Quantum Assumptions . . . . .	6
6.3	Quantum Safe Primitives . . . . .	6
6.4	Toolkit Design . . . . .	6
	<b>Appendices</b>	<b>7</b>
<b>A</b>	<b>Equations</b>	<b>7</b>
<b>B</b>	<b>Notes</b>	<b>8</b>
<b>C</b>	<b>Future</b>	<b>9</b>

# Chapter 1

## Linear Algebra

1.1 Vectors and Vector Spaces

1.2 Inner Products and Norms

1.3 Linear Operators

1.4 Eigenvalues and Eigenvectors

1.5 Hermitian and Unitary Operators

1.6 Tensor Products

1.7 Change of Basis

1.8 Spectral Decomposition

1.9 Commutators

# Chapter 2

## Probability

2.1 Probability Spaces

2.2 Random Variables

2.3 Expectation and Variance

2.4 Joint and Conditional

2.5 Markov Processes

2.6 Stochastic Matrices

2.7 Measurement as Random Process

2.8 Information Measures

# Chapter 3

## Quantum Mechanics

3.1 Postulates of Quantum Mechanics

3.2 State Vectors and Density Matrices

3.3 Unitary Time Evolution

3.4 Measurement Theory

3.5 Composite Systems and Entanglement

3.6 Quantum Gates

3.7 Quantum Channels

3.8 Open Quantum Systems

3.9 Quantum Circuits

# Chapter 4

## Quantum Simulator, qsim

### 4.1 Statevector Simulation

### 4.2 Operator Simulation

### 4.3 Shot Based Execution

### 4.4 Numerical Errors

### 4.5 Performance Tradeoffs

# Chapter 5

## Quantum Error Correction, qec

### 5.1 Repetition Code

### 5.2 Stabilizer Formalism

### 5.3 Syndrome Extraction

### 5.4 Logical Operators

### 5.5 Failure Modes



# Chapter 6

## Quantum Security, qsec

### 6.1 Threat Models

### 6.2 Post Quantum Assumptions

### 6.3 Quantum Safe Primitives

### 6.4 Toolkit Design

# Appendix A

## Equations

# Appendix B

## Notes

# Appendix C

## Future