



# National Computing Education Accreditation Council NCEAC

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H.001-D**

## COURSE DESCRIPTION FORM

**INSTITUTION:** FAST School of Computing, National University of Computer and Emerging Sciences, Karachi

BS-CS

**Fall 2024**

## PROGRAM(S) TO BE EVALUATED

### Course Description

(Fill out the following table for each course in your computer science curriculum. A filled out form should not be more than 2-3 pages.)

<b>Course Code</b>	CS-4084																	
<b>Course Title</b>	Quantum Computing																	
<b>Credit Hours</b>	3																	
<b>Prerequisites by Course(s) and Topics</b>	MT1004 : Linear Algebra																	
<b>Assessment Instruments with Weights</b> (homework, quizzes, midterms, final, programming assignments, lab work, etc.)	<p>100% Theory</p> <p>Assessment items of Theory Part</p> <table> <tr> <th>Assessment Item</th><th>Number</th><th>Weight (%)</th></tr> <tr> <td>Assignments</td><td>5</td><td>10</td></tr> <tr> <td>Midterm Exams</td><td>2</td><td>30</td></tr> <tr> <td>Project</td><td>1</td><td>10</td></tr> <tr> <td>Final Exam</td><td>1</td><td>50</td></tr> </table>			Assessment Item	Number	Weight (%)	Assignments	5	10	Midterm Exams	2	30	Project	1	10	Final Exam	1	50
Assessment Item	Number	Weight (%)																
Assignments	5	10																
Midterm Exams	2	30																
Project	1	10																
Final Exam	1	50																
<b>Course Instructors</b>	Sumaiyah Zahid																	
<b>Lab Instructors (if any)</b>																		
<b>Course Coordinator</b>	Sumaiyah Zahid																	
<b>URL (if any)</b>																		
<b>Current Catalog Description</b>	This course introduces students to the foundational concepts of quantum computing, blending quantum mechanics principles with computational theory. Topics covered include qubits, superposition, entanglement, quantum gates, and algorithms such as Grover's and Shor's. Students will explore the differences between classical and quantum computers and learn how quantum algorithms																	



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	can solve specific problems more efficiently. The course includes practical exposure to quantum programming languages and cloud-based quantum computers. Prior knowledge of linear algebra and basic programming is recommended.
<b>Textbook (or Laboratory Manual for Laboratory Courses)</b>	Quantum Computing: A Gentle Introduction Textbook by Eleanor Rieffel and Wolfgang H. Polak Quantum Computing for the Quantum Curious Introduction to Classical and Quantum Computing By Thomas G. Wong
<b>Reference Material</b>	Research paper will be provided timely.
<b>Rules and Regulations</b>	<ul style="list-style-type: none"> <li>• All assignments will be considered.</li> <li>• No late submissions will be allowed.</li> <li>• Plagiarism in one item of the assessment instrument will result in cancellation of all items of the corresponding instrument.</li> </ul>
<b>Course Learning Outcomes</b>	<div style="border: 1px solid black; padding: 5px;"> <p><b>A. Course Learning Outcomes (CLOs)</b></p> <p>The course objective is to prepare students with foundational knowledge and practical insights into quantum computing principles, algorithms, and applications.</p> <p>CLO-1 Develop a foundational understanding of quantum mechanics and its relevance to computing.</p> <p>CLO-2 Analyze and interpret quantum algorithms and their applications.</p> <p>CLO-3 Gain practical skills in implementing and simulating quantum algorithms.</p> <p>CLO-4 Synthesize and present findings related to quantum computing concepts.</p> </div> <div style="border: 1px solid black; padding: 5px; margin-top: 5px;"> <p><b>B. Program Learning Outcomes (PLOs)</b></p> <p><b>PLO-1. Computing and Artificial Intelligence Knowledge</b> - Apply knowledge of mathematics, natural sciences, computing fundamentals, and a computing specialization to the solve complex computing problems using artificial intelligence techniques.</p> <p><b>PLO-2. Problem Analysis</b> - Identify, formulate, research literature, and analyze complex computational problems, reaching substantiated conclusions using first principles of mathematics, natural sciences, computing, and artificial intelligence.</p> <p><b>PLO-3. Design/Develop Solutions</b> - Design solutions for complex computing problems and design systems, components, and processes that meet specified needs with appropriate</p> </div>



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	<p>consideration for public health and safety, cultural, societal, and environmental considerations.</p> <p><b>PLO-4. Investigation &amp; Experimentation</b></p> <ul style="list-style-type: none"> <li>- Conduct investigation of complex computing problems using research based knowledge and research based methods</li> </ul> <p><b>PLO-5. Modern Tool Usage</b></p> <ul style="list-style-type: none"> <li>- Create, select, and apply appropriate techniques, resources and modern computing and artificial intelligence tools, including prediction and modelling for complex computing problems.</li> </ul> <p><b>PLO-6. Society Responsibility</b></p> <ul style="list-style-type: none"> <li>- Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal, and cultural issues relevant to context of complex computing problems.</li> </ul> <p><b>PLO-7. Environment and Sustainability</b></p> <ul style="list-style-type: none"> <li>- Understand and evaluate sustainability and impact of professional computing and artificial intelligence work in solving complex computing problems</li> </ul> <p><b>PLO-8. Ethics</b></p> <ul style="list-style-type: none"> <li>- Apply ethical principles and commit to professional ethics and responsibilities and norms of computing and artificial intelligence practice.</li> </ul> <p><b>PLO-9. Individual and Team Work</b></p> <ul style="list-style-type: none"> <li>- Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.</li> </ul> <p><b>PLO-10. Communication</b></p> <ul style="list-style-type: none"> <li>- Communicate effectively on complex computing and AI activities with the computing and artificial intelligence community and with society at large.</li> </ul> <p><b>PLO-11. Project Management and Finance</b></p> <ul style="list-style-type: none"> <li>- Demonstrate knowledge and understanding of management principles and economic decision making and apply these to one's own work as a member or a team.</li> </ul> <p><b>PLO-12. Life Long Learning</b></p> <ul style="list-style-type: none"> <li>- Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological changes.</li> </ul>				
<p><b>C. Mapping of CLOs on PLOs</b> (CLO: Course Learning Outcome, PLOs: Program Learning Outcomes)</p> <table> <tr> <th></th><th>PLOs</th></tr> <tr> <td></td><td></td></tr> </table>			PLOs		
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	<table border="1" style="width:100%; border-collapse: collapse; text-align: center;"> <tr> <th colspan="2"></th> <th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th> </tr> <tr> <th rowspan="4" style="writing-mode: vertical-rl; transform: rotate(180deg);">C L O S</th> <th>1</th> <td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <th>2</th> <td></td><td>✓</td><td></td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <th>3</th> <td></td><td>✓</td><td>✓</td><td>✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <th>4</th> <td></td><td></td><td></td><td></td><td>✓</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> <tr> <th></th> <th></th> <td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td> </tr> </table>																1	2	3	4	5	6	7	8	9	10	11	12	C L O S	1	✓	✓	✓										2		✓			✓								3		✓	✓	✓									4					✓																					
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<b>Topics Covered in the Course, with Number of Lectures on Each Topic</b> (assume 15-week instruction and one-hour lectures)	<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <th colspan="4" style="background-color: #e0e0e0;">Topics to be covered:</th> </tr> <tr> <th style="width: 50%;">List of Topics</th> <th style="width: 10%;">No. of Weeks</th> <th style="width: 10%;">Contact Hours</th> <th style="width: 30%;">CLO(s)</th> </tr> <tr> <td>Quantum Computation: History &amp; Overview</td> <td align="center">1</td> <td align="center">3</td> <td align="center">1,2</td> </tr> <tr> <td>Quantum Mechanics for quantum computing</td> <td align="center">1</td> <td align="center">3</td> <td align="center">1,2</td> </tr> <tr> <td>Quantum Instruction Sets &amp; Quantum Circuits</td> <td align="center">2</td> <td align="center">3</td> <td align="center">1, 2,4</td> </tr> <tr> <td>Intro to The Variational Quantum Eigensolver</td> <td align="center">1</td> <td align="center">3</td> <td align="center">2</td> </tr> <tr> <td align="center" colspan="4"><b>Mid Term 1</b></td> </tr> <tr> <td>Quantum Encodings</td> <td align="center">1</td> <td align="center">3</td> <td align="center">1,2,3</td> </tr> <tr> <td>Quantum Algorithms – Grover's and Shor's</td> <td align="center">1</td> <td align="center">3</td> <td align="center">1,2</td> </tr> <tr> <td>Quantum Machine Learning</td> <td align="center">2</td> <td align="center">3</td> <td align="center">1,2,3</td> </tr> <tr> <td>Quantum Approximate Optimization</td> <td align="center">1</td> <td align="center">3</td> <td align="center">1,2,3</td> </tr> <tr> <td align="center" colspan="4"><b>Mid Term 2</b></td> </tr> </table>														Topics to be covered:				List of Topics	No. of Weeks	Contact Hours	CLO(s)	Quantum Computation: History & Overview	1	3	1,2	Quantum Mechanics for quantum computing	1	3	1,2	Quantum Instruction Sets & Quantum Circuits	2	3	1, 2,4	Intro to The Variational Quantum Eigensolver	1	3	2	<b>Mid Term 1</b>				Quantum Encodings	1	3	1,2,3	Quantum Algorithms – Grover's and Shor's	1	3	1,2	Quantum Machine Learning	2	3	1,2,3	Quantum Approximate Optimization	1	3	1,2,3	<b>Mid Term 2</b>																																				
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	Quantum Neural Networks: Variational Methods	1	3	2,3
	Quantum Convolution Neural Networks	1	3	2,3
	Quantum Hardware	1	3	2,3
	Project Presentations	1	3	3,4
	Total	16	48	
<b>Programming Assignments Done in the Course</b>	Using Qiskit and PennyLane in Python.			
<b>Class Time Spent (in hours)</b>	<b>Theory</b>	<b>Problem Analysis</b>	<b>Solution Design</b>	<b>Social and Ethical Issues</b>
	28	10	5	2
<b>Oral and Written Communications</b>	Every student is required to submit at least __1__ written reports of typically __10__ pages and to make __1__ oral presentations of typically __15__ minute's duration. Include only material that is graded for grammar, spelling, style, and so forth, as well as for technical content, completeness, and accuracy.			