QUALIFICATION FILE–Standalone NOS

Fundamentals of Quantum Computing

☐ Horizontal/Generic ☐Vertical/Specialization

☐ Upskilling ☐ Dual/Flexi Qualification ☐ For ToT ☐ For ToA

☐General ☐ Multi-skill (MS) ☐ Cross Sectoral (CS) ☒ Future Skills ☒ OEM

NCrF/NSQF Level: 6

Submitted By:

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Section 1: Basic Details

1.	NOS-Qualification Name	Fundamentals of Quantum Computing	
2.	Sector/s	Electronics	
3.	Type of Qualification ☒ New ☐ Revised	NQR Code & version of the existing /previous qualification: NA	Qualification Name of the existing/previous version: NA
4.	National Qualification Register (NQR) Code & Version	NG-06-EH-02643-2024-V1-NIELIT	5. NCrF/NSQF Level: 6
5	Brief Description of the Standalone NOS	**Nature:** ❖ The Certificate course is targeted for creating qualified professionals in the field of Quantum Computing. Qualification has been developed in consultation with industry experts in the domain, aiming at Empowering the future workforce with necessary skills for employment and entrepreneur development of the qualifier. **Purpose:** ❖ To develop fundamental skills required for Quantum Computing, algorithms, and applications using the Python language	
6.	Eligibility Criteria for Entry for a Student/Trainee/Learner/Employee	a. **Entry Qualification & Relevant Experience:**	

S. No.	Academic/Skill Qualification (with Specialization - if applicable)	Relevant Experience (with Specialization - if applicable)
1	Final Year B.E/B. Tech in IT/Electronics/ CS/Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation /allied branches	NA
2	Final year MCA/M.Sc.in IT/Electronics/ CS/Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation /allied branches	NA
3	NSQF Level 5.5 in IT/Electronics/ CS/Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation /allied branches	1.5 year experience in relevant field

4	NSQF Level 5 in IT/Electronics/ CS/Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation /allied branches	3 year experience in relevant field

b. Age:20 years

7.	Credits Assigned to this NOS-Qualification, Subject to Assessment *(as per National Credit Framework (NCrF))*	2 Credits	8.	Common Cost Norm Category (I/II/III) *(wherever applicable)*: Category II

9.	Any Licensing Requirements for Undertaking Training on This Qualification *(wherever applicable)*	NA

10.	Training Duration by Modes of Training Delivery *(Specify Total Duration as per selected training delivery modes and as per requirement of the qualification)*	☒Offline ☐ Online ☐ Blended

Training Delivery Mode	Theory (Hours)	Practical (Hours)	Total (Hours)
Classroom (offline)	30	30	60

The mode of delivery shall be based on the regional demand and can be offered in any of the above modes mentioned.

11.	Assessment Criteria

Theory (Marks)	Practical (Marks)	Project (Marks)	Viva (Marks)	Total (Marks)	Passing %age
100	60	20	20	200	50

The centralised online assessment is conducted by the Examination Wing, NIELIT Headquarters.

12.	Is the NOS Amenable to Persons with Disability	☒ Yes ☐ No

If "Yes", specify applicable type of Disability:

a. Locomotor Disability: Leprosy Cured Person, Dwarfism, Muscular Dystrophy and Acid Attack Victims
b. Visual Impairment: Low Vision

13.	Progression Path After Attaining the Qualification, wherever applicable	Research Assistant /Quantum Software Developer

14.	How will the participation of women be encouraged?	Participation by women can be ensured through Government Schemes. Occasionally, exclusive batches for women would be run for the proposed courses. Funding is available for women's participation under other schemes launched by the Government from time to time.
15.	Other Indian languages in which the Qualification & Model Curriculum are being submitted	Qualification files available in English & Hindi Language.
16.	Is similar NOS available on NQR-if yes, justification for this qualification	☐ Yes ☒ No
17.	Name and Contact Details Submitting / Awarding Body SPOC *(In the case of CS or MS, provide details of both Lead AB & Supporting ABs)*	Name: Saket Saurabh Email: srv.saket@nielit.gov.in Contact No: 011-25308300 Website: https://nielit.gov.in/
18.	Final Approval Date by NSQC: 30.05.2024	19. Validity Duration: 3 years	20. Next Review Date:30.05.2027

Section 2: Training Related

1.	Trainer's Qualification and experience in the relevant sector (in years) (as per NCVET guidelines)	B.E./B. Tech in Electronics/ Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation / Instrumentation & Control /Computer Science/Information Technology Minimum 1 year of experience in the field of Quantum Computing
2.	Master Trainer's Qualification and experience in the relevant sector (in years) (as per NCVET guidelines)	B.E./B. Tech in Electronics/ Electronics & Communication/ Electrical/ Electrical and Electronics/Instrumentation/ Electronics & Instrumentation / Instrumentation & Control /Computer Science/Information Technology Minimum 3 year of experience in the field of Quantum Computing
3.	Tools and Equipment Required for the Training	☒ Yes ☐No Available at Annexure-II
4.	In Case of Revised NOS, details of Any Upskilling Required for Trainer	Not Applicable

Section 3: Assessment Related

1.	**Assessor's Qualification and experience in relevant sector (in years)** *(as per NCVET guidelines)*	The assessor carries out theory online assessments through the remote proctoring methodology. Theory examination would be conducted online and the paper comprises MCQ. Conduct of assessment is through trained proctors. Once the test begins, remote proctors have full access to the candidate's video feeds and computer screens. Proctors authenticate the candidate based on registration details, pre-test image captured and I-card in possession of the candidate. Proctors can chat with candidates or give warnings to candidates. Proctors can also take screenshots, terminate a specific user's test session, or re-authenticate candidates based on video feeds.
2.	**Proctor's Qualification and experience in relevant sector (in years)** *(as per NCVET guidelines), (wherever applicable)*	
3.	**Lead Assessor's/Proctor's Qualification and experience in relevant sector (in years)** *(as per NCVET guidelines)*	External Examiners/ Observers (Subject matter experts) are deployed including NIELIT scientific officers who are subject experts for evaluation of Practical examination/ internal assessment / Project/ Presentation/ assignment and Major Project (if applicable). Qualification is generally B.Tech
4.	**Assessment Mode** *(Specify the assessment mode)*	Centralized online examination will be conducted
5.	**Tools and Equipment Required for Assessment**	Same as for training ⊠ Yes ☐ No

Section 4: Evidence of the Need for the Standalone NOS

1.	Government /Industry initiatives/ requirement (Yes/No): Yes.
2.	Number of Industry validations provided: 6
3.	Estimated number of people to be trained: 1000 persons per year shall be trained.
4.	Evidence of Concurrence/Consultation with Line/State Departments (In case of regulated sectors): No. **NIELIT is recognized as AB and AA under Government Category. NIELIT is an HRD arm of MeitY, therefore, the Line Ministry Concurrence is not required.**

Section 5: Annexure & Supporting Documents Check List

Specify Annexure Name / Supporting document file name.

1.	**Annexure:** NCrF/NSQF level justification based on NCrF/NSQF descriptors *(Mandatory)*	*Available at* Annexure-I: Evidence of Level
2.	**Annexure:** List of tools and equipment relevant for NOS *(Mandatory, except in case of online course)*	*Available at* Annexure-II: Tools and Equipment
3.	**Annexure: Industry Validation**	*Available at* Annexure-III: Industry Validation
4.	**Annexure: Training Details**	*Available at* Annexure-IV: Training Details
5.	**Annexure:** Blended Learning *(Mandatory, in case the selected Mode of delivery is Blended Learning)*	*Available at* Annexure-V: Blended Learning
6.	**Annexure/Supporting Document:** Standalone NOS- Performance Criteria Details Annexure/Document with PC-wise detailing as per NOS format (Mandatory- Public view)	*Available at* Annexure-VI: Performance Criteria
7.	**Annexure:** Performance and Assessment Criteria *(Mandatory)*	*Available at* Annexure-VII: Detailed Assessment Criteria
8.	**Annexure:** Assessment Strategy *(Mandatory)*	*Available at* Annexure-VIII: Assessment Strategy
9.	**Annexure:** Acronym and Glossary *(Optional)*	*Available at* Annexure-IX: Acronym and Glossary
10.	**Supporting Document:** Model Curriculum	*Available at* Annexure-C: Model Curriculum

Annexure-I: Evidence of Level

NCrF/NSQF Level Descriptors	Key requirements of the job role/ outcome of the qualification	How the job role/ outcomes relate to the NCrF/NSQF level descriptor	NCrF/NSQF Level
Professional Theoretical Knowledge/Process	1. Understanding qubit states, including superposition and entanglement. 2. Exploring the postulates of quantum computing including quantum state, quantum evolution, and quantum measurement. 3. Understanding qubit states using braket notation and dealing with multi-qubit systems.	1. Possesses specialized operational knowledge and understanding of the work. 2. Have complete knowledge of the concept of time required for delivery; and Quality for a range of issues	6
Professional and Technical Skills/ Expertise/ Professional Knowledge	1. Gain the technical skill to implement these algorithms on quantum computers using tools like Qiskit. This involves understanding the logic behind each algorithm and translating it into quantum circuits. 2. Acquire the technical skills needed to design and implement secure communication protocols using quantum principles. This involves understanding concepts like quantum entanglement, quantum teleportation, and leveraging them for efficient communication protocols in quantum networks.	1. Possesses specialized professional and technical skills; displays clarity of professional knowledge and technical skills in a broad range of activities/ tasks. 2. Have knowledge of collecting and interpreting the available information, drawing conclusions & communicating the same.	6
Employment Readiness & Entrepreneurship Skills & Mind-set/Professional Skill	1. Mastery of Quantum Bits, Quantum Gates, Quantum Algorithms like Grover's and Shor's, and Quantum Error Correction equips professionals with advanced problem-solving skills. 2. Learning Python and setting up Qiskit for quantum computing tasks on both simulators and real quantum computers enhances professionals' quantum programming proficiency. 3. Understanding Quantum Teleportation, BB84 Protocol, SuperDense Coding, and Quantum Communication Tools enables professionals to work on quantum communication protocols and quantum cryptography	1. Can explain Entrepreneurial Mindset and describe the importance of it in the context of opportunity curation for future jobs 2. Can comfortably use most of the basic software with proficiency 3. Have the ability to relate to	6

Broad Learning Outcomes/ Core Skill	1. Understanding Quantum Bits, Dirac Notation, Single and Multiple Qubit Gates, No Cloning Theorem, Quantum Interference, and Postulates of Quantum Computing. 2. Proficiency in these areas allows for the development and testing of quantum algorithms and applications.	the 5 pillars of Social Emotional Skills and describe the similarities between SES and Emotional Intelligence 1. Students are able to use, create, and design Multimedia solutions 2. Have knowledge of Multimedia Project Cycle and apply the understanding of Multimedia Project Pitfalls in improving solution	6
Responsibility	Ability to manage the system resources in the most effective manner by appropriate planning, estimation, coordination and control of the activities involved in the design & development of any drone applications /project	1. Takes complete responsibility for delivery and quality of own work and output as also the subordinates. 2. Shares responsibility for the group tasks.	6

Annexure II: Tools and Equipment (lab set-up)

List of Tools and Equipment
   Batch Size: 30

S. No.	Tool / Equipment Name	Specification	Quantity for specified Batch size
1	Classroom	1 (750 Sq. ft to 1000 Sq. ft.)	30
2	Students Chair	30	30
3	Students Table	15 (2 students sharing 1 table)	15
4	Desktop computer with accessories / Laptop	Laptop with minimum specifications: Intel I3 or Celeron processor with at least 8GB RAM, 512GB SSD Hard disk integrated with	15

		graphics card, Display size 15.6-inch, Wi-Fi connectivity and Wired Optical Mouse + Any open source IDE supports to program Qiskit Programming Language.	
5	Internet Connectivity	Seamless internet connectivity with at least 100 Mbps without firewall	

Classroom Aids for offline and blended mode of training:

The aids required to conduct sessions in the classroom are:

1. LCD Projector/Smart Board

Annexure III: Industry Validations/ Government Recognition Summary

S. No	Organization Name	Representative Name	Designation	Contact Address	Contact Phone No	E-mail ID
1	B G Infotech	Amal Das	Centre Head	Kakdihi, Mecheda, Purba Medinipur	9434996748	bginfotech2007@gmail.com
2	Inditech Software Wizard Pvt. Ltd	Sandip Ghosh	Course Coordinator	Mohiary Chanpiritala, P.O. Andul Mouri, PS: Domjur, Dist: Howarh, West Bengal-711302	9230027415	swizardrecruitment@gmail.com
3	Prasanthi Polytechnic	D Prasad	Principal	Duppituru (Vill), Aichutapuram (Md), Visakhapatnam (Dist), Andhra pradesh _ 531011	9849952573	Prasadreddy.1279@gmail.com
4	NICE SHIKSHA VIKAS KENDRA	Motilal Ohdar	Secretory	Moti House, Prince Chowk, (Nice Computer Gali), Simdega, Jharkhand-835223	7992489955	Vtpnice13@gmail.com

| 5 | Surekha IT Services | Anjani K | Manager | 8-3-191/84/302, Sharan Residency, Vengalrao Nagar, Hydrabad-500038, Telangana | 8125134134 | info@surekhaitservices.com |
| 6 | AISECTLtd. | Teena Panthi | Assistant Manager | 1-1-387, 3rd Floor, Flat no. 403/404, GNR Heights, Above SBI, Bakaram Road, Musheerabad, Hyderabad - 500020 | 7879982075 | teena.panthi@aisect.org |

Annexure IV: Training Details

Training Projections:

Year	Estimated Training # of Total Candidates	Estimated training# of Women	Estimated training# of People with Disability
2024-25	1000	200	20
2025-26	1000	200	20
2026-27	1000	200	20

Data to be provided year-wise for the next 3 years.

Annexure V: Blended Learning

Blended Learning Estimated Ratio & Recommended Tools:

Refer NCVET "Guidelines for Blended Learning for Vocational Education, Training & Skilling" available on:

S. No.	Select the Components of the NOS	List Recommended Tools – for all Selected Components	Offline: Online Ratio
1	Theory/ Lectures - Imparting theoretical and conceptual knowledge	Online interaction platforms like Zoom, Google Meet	00:100

2	Imparting Soft Skills, Life Skills and Employability Skills /Mentorship to Learners	Online interaction platforms like Zoom, Google Meet	NA
3	Showing Practical Demonstrations to the learners	Online interaction platforms like Zoom, Google Meet	00:100
4	Imparting Practical Hands-on Skills/ Lab Work/ workshop/ shop floor training	PCs/Laptops, Internet ,Any open source IDE supports to program Qiskit Programming Language	00:100
5	Tutorials/ Assignments/ Drill/ Practice	Online interaction platforms like Zoom, Google Meet	00:100
6	Proctored Monitoring/ Assessment/ Evaluation/ Examinations	NIELIT Remote Proctored Software	Theory : 100% Online Practical : 100% Offline
7	On the Job Training (OJT)/ Project Work Internship/ Candidate Training	Any open source IDE supports to program Qiskit Programming Language.	00:100

Annexure VI: Standalone NOS- Performance Criteria details

1. Description

The Standalone NOS equips the students to develop fundamental skills required for Quantum Computing, algorithms, and the applications developed in Quantum Computing using the Python language.

2. Scope

The scope covers the following:

The NOS encompasses a comprehensive study of fundamental concepts like quantum bits (qubits), Dirac notation, quantum gates, and quantum interference. It also covers advanced topics such as postulates of quantum computing, Bell's inequality test, quantum teleportation, BB84 protocol, quantum error correction, and explores the principles of qubit physics including superposition, entanglement, and multi-qubit systems.

3. Elements and Performance Criteria

Quantum Bits and Gates:
- Ability to define and explain quantum bits (qubits) using Dirac notation.
- Proficiency in implementing and analyzing the behavior of single and multiple qubit gates.
- Understanding and application of the No Cloning Theorem in quantum computing experiments.

Quantum Algorithms and Protocols:
- Demonstrated capability to apply quantum algorithms like Grover's Algorithm and Shor's Algorithm to solve specific problems efficiently.
- Competence in implementing quantum protocols such as BB84 Protocol, Quantum Teleportation, and SuperDense Coding for secure communication and information processing.
- Ability to analyze the performance and effectiveness of quantum error correction techniques in mitigating errors in quantum computation.

Qiskit and Quantum Tools:
- Proficiency in setting up Python environments and installing Qiskit on Windows.
- Competence in designing, simulating, and optimizing quantum circuits using Qiskit, including understanding classical and quantum gates and their applications.
- Successful execution of quantum computations on both simulators and real quantum computers, with a focus on obtaining accurate results and analyzing backend information for performance evaluation.

4. Knowledge and Understanding (KU):

The individual on the job needs to know and understand:

Foundations of Quantum Computing:

- Understanding the fundamental concepts of quantum bits (qubits) and their properties, including superposition, entanglement, and quantum interference.

Qiskit and Quantum Programming:

- Proficiency in using Qiskit for quantum programming, including setting up environments, designing quantum circuits using classical and quantum gates, and running simulations.

Mathematical Foundations and Computational Skills:

- Strong grasp of mathematical foundations relevant to quantum computing, including linear algebra concepts such as matrices, matrix operations, and linear transformations.

5. Generic Skills (GS):

User/individual on the job needs to know how to:

Problem-solving Skills:

- Ability to analyze complex problems in quantum computing and apply appropriate algorithms and techniques to find solutions.

Communication and Collaboration:

- Effective communication skills to convey complex quantum computing concepts, algorithms, and results to both technical and non-technical audiences.

Adaptability and Continuous Learning:

- Adaptability to evolving quantum computing technologies, tools, and platforms, staying updated with the latest advancements and best practices.

Annexure VII: Assessment Criteria

Detailed PC-wise assessment criteria and assessment marks for the NOS are as follows:

NOS/Module Name	Assessment Criteria for Performance Criteria	Theory Marks	Practical Marks	Project Marks	Viva/ Internal Assessment (Marks)
NOS1: **Fundamentals of Quantum Computing** **NOS Code: NIE/ELE/N3101**	*Quantum Bits and Gates:*	30	20	-	-
	PC1: Ability to define and explain quantum bits (qubits) using Dirac notation.	-	-	-	-
	PC2: Proficiency in implementing and analyzing the behavior of single and multiple qubit gates.	-	-	-	-
	PC3: Understanding and application of the No Cloning Theorem in quantum computing experiments.	-	-	-	-
	Quantum Algorithms and Protocols:	30	20	-	-
	PC4: Demonstrated capability to apply quantum algorithms like Grover's Algorithm and Shor's Algorithm to solve specific problems efficiently.	-	-	-	-

PC5: Competence in implementing quantum protocols such as BB84 Protocol, Quantum Teleportation, and SuperDense Coding for secure communication and information processing.			-	-
PC6: Ability to analyze the performance and effectiveness of quantum error correction techniques in mitigating errors in quantum computation.	-	-	-	-
Qiskit and Quantum Tools:	40	20	-	-
PC7: Proficiency in setting up Python environments and installing Qiskit on Windows.			-	-
PC8: Competence in designing, simulating, and optimizing quantum circuits using Qiskit, including understanding classical and quantum gates and their applications.	-	-	-	-
PC9: Successful execution of quantum computations on both simulators and real quantum computers, with a focus on obtaining accurate results and analyzing backend information for performance evaluation.	-	-	-	-
	100	60	20	20
NOS Total	**200**			

Annexure VIII: Assessment Strategy

This section includes the processes involved in identifying, gathering, and interpreting information to evaluate the Candidate on the required competencies of the program.

Assessment of the qualification evaluates candidates to ascertain that they can integrate knowledge, skills and values for carrying out relevant tasks as per the defined learning outcomes and assessment criteria.

The underlying principle of assessment is fairness and transparency. The evidence of the outcomes and assessment criteria. competence acquired by the candidate can be obtained by conducting Theory (Online) examination.

About Examination Pattern:

1. The question papers for the theory exams are set by the Examination wing (assessor) of NIELIT HQS.

2. The assessor assigns roll number.

3. The assessor carries out theory online assessments. Theory examination would be conducted online and the paper comprise of MCQ.

4. The assessor carries out practical assessments.

5. Pass percentage would be 50% marks.

6. The examination will be conducted in English language only.

Quality assurance activities: A pool of questions is created by a subject matter expert and moderated by other SME. Test rules are set beforehand. Random set of questions which are according to syllabus appears which may differ from candidate to candidate. Confidentiality and impartiality are maintained during all the examination and evaluation processes.

Annexure IX: Acronym and Glossary

Acronym

Acronym	Description
AA	Assessment Agency
AB	Awarding Body
NCrF	National Credit Framework
NOS	National Occupational Standard(s)
NQR	National Qualification Register
NSQF	National Skills Qualifications Framework

Glossary

Term	Description
National Occupational Standards (NOS)	NOS define the measurable performance outcomes required from an individual engaged in a particular task. They list down what an individual performing that task should know and also do.
Qualification	A formal outcome of an assessment and validation process which is obtained when a competent body determines that an individual has achieved learning outcomes to given standards
Qualification File	A Qualification File is a template designed to capture necessary information of a Qualification from the perspective of NSQF compliance. The Qualification File will be normally submitted by the awarding body for the qualification.
Sector	A grouping of professional activities on the basis of their main economic function, product, service, or technology.