Admission for Post Graduate Diploma in

HPC Domain for Socially Disadvantage Group
(SC and ST communities of India)

Sponsored from Ministry of Electronics and Information Technology (MeitY),
Government of India under National Supercomputing Mission (NSM)

Rulebook for PG-Diploma in HPC Domain

NSM Capacity Building Initiative

Admission rulebook for the candidates who belong to Scheduled Caste (SC) and Scheduled Tribes (ST) communities of India to join C-DAC, ACTS's PG-Diploma in HPC domain.

NSM PG-Diploma in HPC domain September 2023 batch
V1.0

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1. Preamble

This RULE BOOK is a guide for the aspiring candidates belonging to Scheduled Caste (SC) and Scheduled Tribes (ST) communities to join the Post Graduate Diploma courses in High Performance Computing domains. It provides the details of the courses, how to apply, process of admission, selection criteria, entrance examination and its syllabus, documentations, fees, and scholarship.

C-DAC is implementing the National Supercomputing Mission (NSM nsmindia.in), a capacity building initiative of Ministry of Electronics and Information Technology (MeitY), Government of India.

The objective of the project is to develop technology professionals hailing from Scheduled Castes (SC) and Scheduled Tribes (ST) communities, having graduation in Engineering or Post Graduate in Science in selected disciplines, in High Performance Computing (HPC) domains to meet skill and capability building objectives of the NSM.

There are two domains identified to develop the expertise which are the followings:

1. High Performance Computing System Administration
2. High Performance Computing Application Programming

C-DAC has designed and curated the curriculum for the above HPC domains to imbibe the technical skills amongst the aspiring candidates through these two courses to the youth of India to become experts who will work in the HPC domain.

2. About Post Graduate Diploma Course in HPC Domains

The two courses offered are 900 hours duration (NSQF level 8 aligned courses)

1. Post Graduate Diploma courses in HPC System Administration (PG-DHPCSA) and
2. Post Graduate Diploma in HPC Application Programming (PG-DHPCAP).

The details of the courses syllabus and objectives, educational eligibility are provided in the Annexure A & B.

The course requires the candidates to dedicate 6-8 hours per day for six days a week to cover the 900 hours in about 24 weeks in physical classroom and lab sessions. At the end of the course, students meeting 75% attendance and other criteria will be eligible to appear in the C-DAC's Common Admission Test (CCEE). Students successful in the examination will receive a certificate of PG-Diploma.

2.1. Benefits

The selected candidates will benefit with the followings:

1. Candidate will get adequate knowledge and exposure in HPC domain that provides solid foundations for developing, analysing, and implementing HPC Systems.
2. Help candidates from officially designated socially disadvantaged groups (SC & ST) in India.
3. The PG-Diploma courses in HPC domain are free (the usual course fees ranging from INR 90,000/- to 1,15,000/- per student) for the selected candidates. However, a caution deposit of INR 10,000/- will be taken. Please see Refund of Caution Deposit section for details.
4. Candidates' active participation and completion of the PG-Diploma course successfully will provide them with the gateway and an edge in the HPC domain to perform better in the Common Campus Placement Program (CCPP) of the March 2024 batch.

3. Who can apply for the PG Diploma courses in HPC domain?

1. Candidate must belong to Scheduled Caste and Scheduled Tribes communities in India.

2. Candidate must be Graduate in Engineering (10+2+4 or 10+3+3 years) in IT / Computer Science / Electronics / Telecommunications / Electrical / Instrumentation, OR MSc / MS (10+2+3+2 years) in Computer Science, IT, Electronics OR Post Graduate Degree in Mathematics or allied areas, OR MCA from a recognised University. Candidates having Post Graduate Degree in Physics / Computational Sciences are eligible for PG-DHPCAP course.

3. Candidate must have secured 55% or above in the qualifying degree.

4. There is no age restriction for admission to C-DAC's PG Diploma courses. Candidates who have appeared for the final examination of their qualifying degree in 2023 will also be considered for admission to the above courses. By qualifying in C-DAC's admission tests of July 2023, such university result-awaiting candidates can apply for provisional admission in September 2023 batch, subject to the condition that:

   (a) All parts of their qualifying degree examination shall be completed by the date of joining the course, and
   (b) Proof of having passed the qualifying degree with at least the required minimum marks shall be submitted at C-DAC by 31 December 2023.

5. A candidate can avail PG-Diploma course benefits only once.

There is no fees for NSM C-CAT Application for eligible candidates.

Policies / Rules of C-DAC ACTS regarding admission process, course delivery and additional terms and conditions given in Annexure 'E' shall apply.

4. Training Centres and Seat Capacity

The Post Graduation Diploma in HPC domains courses will be conducted at below training centre:

C-DAC's Advanced Computing Training School (ACTS),
C-DAC Innovation Park, Panchawati, Pashan,
Pune-411008 (Maharashtra)

The seating capacity for both courses is 40 seats each.

5. Admission Process to PG-Diploma Course

5.1. NSM C-CAT Application Process

a. Instruction for New applicants & Students undergoing NSM Pre-CAT course

The online registration and application form for Post Graduate Diploma in High Performance Computing (HPC) domains is available on the C-DAC ACTS website: ***https://www.cdac.in/NSMTrainingSCST*** . Eligible candidates wishing to apply to any of these two courses can register on the website by providing their required details and complete the registration process. There is no fee for NSM C-CAT Application for eligible candidates. A Form No. will be generated after registration, which will serve as login credentials for the candidate. An Admit Card/Hall Ticket will be issued later. Candidate will be ranked for NSM C-CAT only.

b. Instruction for applicants wishing to apply to NSM courses in addition to other PG-Diploma courses (Paid)

Eligible candidates who wish to apply to other PG-Diploma courses of C-DAC ACTS and also apply for the NSM PG-Diploma courses in HPC domain must apply for both separately. Candidate must follow the steps given here under to be consider for the both regular C-CAT and NSM C-CAT.

1. **Candidate must first complete the application process for the regular C-CAT and pay prescribed fees.**
2. Candidate must have selected appropriate degree, discipline, passing marks, and Category II (Section A+B) in the regular C-CAT application form to be eligible for applying for both.
3. Thereafter, at the NSM PG-Diploma courses application form, candidate need to select option to check their eligibility, and if found eligible, can 'one-click apply' for the NSM PG-Diploma courses.

A new application form will be generated having same Form No. as that of regular C-CAT application, and only one combined Admit Card/Hall Ticket will be issued later. Candidate appearing in exam using issued combined Admit Card/Hall Ticket will give the exam only once but he/she will be ranked separately under regular and NSM C-CAT.

Admission to NSM PG-Diploma courses is given based on ranking obtained in NSM C-CAT only. The ranking obtained in regular C-CAT cannot be consider for Admission under NSM PG-Diploma courses or vice-versa.

5.2. NSM C-CAT Admit Cards

Candidates can download their admit cards from C-DAC's website during the dates mentioned under Important Dates in the Annexure D. The venue, date and time of NSM C-CAT will be communicated to the candidates on the admit cards. Instructions for appearing in NSM C-CAT will also be given on the admit card. Candidates must appear for NSM C-CAT on the date and time at the venue specified on the admit card. If the candidate remains absent or coming late for NSM C-CAT, no further chance will be given to candidate.

No candidate will be permitted to appear for NSM C-CAT without a valid admit card. The admit card along with a photo identity proof must be presented to the NSM C-CAT officials/invigilators for verification at the time of the test.

5.3. NSM C-DAC's Common Admission Test (C-CAT)

NSM C-DAC's Common Admission Test (C-CAT) will be conducted in computerised mode physically at C-DAC's test centres on **July 15 & 16, 2023.** Candidates who clear the NSM C-CAT will only be considered for admission to C-DAC's PG Diploma course in HPC in System Administration or PG Diploma in HPC Application Programming of upcoming batches on the basis of their NSM C-CAT ranks.

NSM C-CAT has two sections (Section A and B) of one hour duration each. The medium of C-CAT is English.

Every section in NSM C-CAT will have 50 objective-type questions. Each question will have four choices as possible answers of which only one will be correct. There will be +3 (plus three) marks for each correct answer, -1 (minus one) for each wrong answer, and 0 (zero) marks for each un-attempted question. The maximum mark a candidate can obtain in any one section of NSM C-CAT is 150.

5.4. NSM C-CAT Ranking

Candidates will be provided ranks based on their performances in Section A, Sections A+B, of NSM C-CAT.

Candidates with the lowest 20% performances in section A and section B of NSM C-CAT will not be qualified for ranking in that particular section and its higher sections. Even after the removal of the lowest performers as stated above, if there exist candidates in any section with zero or less than zero marks, then these candidates will also not be qualified for ranking.

Qualified candidates who have selected Category II in the C-CAT application form will be awarded Category I and II ranks based on their performances in Sections A and A+B.

Tie-Breaker Rule: If two or more candidates have acquired the same marks in Section A or Sections A+B, then the candidate having more marks in Section A will be given the higher rank. If these candidates have the same marks in Section A also, then the candidate having higher value in the ratio of 'number of correct answers / number of attempted questions' in the specific section required only for that category of courses will be given the higher rank. Candidates who have the same value of this ratio, and having the same total as well as Section-A marks will be given the same NSM C-CAT rank.

5.5. Counselling & Seat Allocation Process

C-DAC's PG Diploma admission process has two counselling sessions and three rounds of seat allocations. Counselling means online filling of preferences of courses and training centres by the candidates.

There are two rounds of seat allocations based on the **first counselling**. This means that using the course-centre preferences given by the candidates during the first choice filling, two rounds of seat allocations (Round 1 and Round 2) will be done.

Ranking obtained in NSM C-CAT will be used for applying to NSM PG-Diploma HPC courses.

5.6. Caution Deposit

The candidates must confirm the seat allocated during the counselling rounds of the Admission Process to PG Diploma courses in HPC domains by depositing the caution money INR 10,000/- as per timeline mentioned in Important dates (Annexure D). This amount is retained as an interest-free caution deposit which will be refunded to the candidates as per refund section mentioned below.

5.7. Document Verification

The candidates allocated PG-Diploma course through counselling must undergo a document verification process physically conducted at ACTS, C-DAC Pune. The candidate must produce clear photocopies along with original documents of their Government provided Identity proof, caste, and educational certifications during the physical document verification process.

Candidates qualified after Document verification will be registered for PG-Diploma courses.

Candidates should ensure that they meet the eligibility criteria of the courses for which they are applying. It shall be incumbent upon candidates to prove they meet the prescribed eligibility criteria at the time of taking admission at allocated centre. Issuance of Admit Card and/or NSM C-CAT rank does not automatically entitle a candidate to admission. **In case a candidate is found to be non-eligible during any stage of the admission process or course delivery, his/her admission will be cancelled with immediate effect.**

6. PG Diploma in HPC domains Training:

The candidates will join the C-DAC ACTS Pune to pursue the PG Diploma in HPC training as per the scheduled commencement on **September 08, 2023**.

The students have to attend the PG-Diploma course physically at the training centre and must mark their attendance regularly with a minimum of 75% attendance to take the maximum benefit of the theory and practical sessions conducted by the training centre.

The student must inform the course coordinator for any absence without fail. Students must adhere to general decorum, rules, do's and don'ts, and any prescribed rules and regulation by C-DAC from time to time.

6.1. Stipend

A stipend at the rate of INR 1500/- per month, will be provided to the student for six months. The stipend will be provided in two instalments at the end of each three months periods subject to student maintaining 75% attendance for that period. The stipend will be deposited in the account of the student.

There will be no other amount paid to the students such as accommodation or travel or food during the training period. The students must make their own arrangements of stay and food during their stay at Pune. C-DAC, ACTS Pune does not have any hostel facility for accommodation of the students.

7. C-DAC Course End Examination

The PG-Diploma students on completion of the training and having a minimum of 75% attendance will be allowed to attend the C-DAC Course End Examination (CCEE) as per the schedule. The result and certificates will be issued to the students successful in the examination. Policies/Rules of C-DAC ACTS in this regard shall apply.

8. C-DAC Common Campus Placement (CCPP)

Students who qualify the CCEE and successfully complete the PG-Diploma courses will be allowed to participate in the Common Campus Placement Programme (CCPP). Policies/Rules of C-DAC ACTS in this regard shall apply.

9. Refund of Caution Deposit

An amount of INR 10,000/- retained as interest-free caution deposit will be refunded to the student fulfilling both of following criteria:

- Attendance of minimum 75% of the in PG-Diploma course duration
- Appear in CCEE of the September 2023 batch

Additionally, the caution deposit or a portion thereof may be forfeited on any of the following grounds:

- Penalty against any breakage, misplacement, etc. of property of training centre
- Penalty towards any disciplinary action

The refund of the caution deposit will be done 15 days after the CCEE conduction and submitting the clearance form.

Annexure A: PG-DHPCSA course details

PG-Diploma in HPC System Administration (PG-DHPCSA)

Course Objectives:

PG-DHPCSA will educate the aspirants who want to make an impact in the corporate and academic world in the domain of High Performance Computing system administration as System Administrator, Storage Administrator and IT Infrastructure Specialist. The course is also suitable for those who are already working in HPC administration domain to enhance their theoretical and conceptual knowledge as well as those who would like to start career in HPC administration. The collaboration with the different multi-national companies at the level of mutual research interests and customer related projects will ease the path for campus recruitment. At the end of the course the students will be able to manage HPC infrastructure like network, storage, resource and backup management, efficiently design data center, maintain the HADOOP cluster and map reduce technology, explore on HPC applications and solutions, and understand the fundamentals of various cloud techniques and system security.

Course Focus:

The theoretical and practical mix of the HPC System Administration program has the following learning objectives:

- Fundamental knowledge of High-Performance computing and applications.
- HPC Cluster architecture, Clustering, resource allocation and job scheduling tools, Parallel file systems, Designing Data Centers, Troubleshooting techniques and various other tools for administration and monitoring.
- Hadoop and Map reduce Concepts, designing Hadoop cluster for big data applications.
- Virtualization and Cloud computing technologies, accessing resources and services needed to perform functions with dynamically changing needs.
- Network and Cloud security concepts to create secure development environment, recognizing security loopholes and strengthening the solutions.
- DevOps and automation using container technology and scripting.
- Undertaking industrial research projects for the development of future solutions in the domain of HPC Administration to make an impact in the technological advancement.

Eligibility Criteria:

- Graduate in Engineering (10+2+4 or 10+3+3 years) in IT / Computer Science / Electronics / Telecommunications / Electrical / Instrumentation.

OR

- MSc/MS (10+2+3+2 years) in Computer Science, IT, Electronics.

OR

- Post Graduate Degree in Mathematics or allied areas,

OR

- MCA

Candidate must have secured 55% or above in the qualifying degree.

Pre-requisites:

Candidate should have sound knowledge of Fundamentals of Programming, C programming, and basics of Linux.

Admission Process:

Admission will be through NSM C-CAT (Sec A + B).

Course Modules:

Sr. No.	Name of the Module	No. of Hours
1.	**Computer Architecture**	**30**
2.	**Linux Operating System and Perl**	**80**
3.	**HPC System Administration and Management**	**140**
4.	**Python Programming**	**60**
5.	**Fundamental of Computer Network and Management**	**40**
6.	**Storage and Backup Management**	**50**
7.	**Resource Management and Accounting**	**50**
8.	**Security and Traffic Management**	**70**
9.	**Hadoop Administration**	**80**
10.	**Cloud Services & Security**	**100**
11.	**Aptitude & Effective Communication**	**90**
12.	**Project**	**110**
Total Hours		**900**

Course Content:

1. **Computer Architecture** **(30 Hours)**
   Basic concepts of computer organization, Classes of computer architecture, Processor vs. System architecture, Elements of computer systems, CISC vs. RISC architectures, pipelining, Multi core Processor architecture, Memory Hierarchy, Cache memory, Cache coherency, Standard IO interfaces, GPU elements, Compute GPU Architecture, overview of the latest Intel, AMD, ARM, POWER processors.

2. **Linux Operating System and Perl** **(80 Hours)**
   Linux: Introduction to Operating System and it's Architecture, Process Management, Signals, Systems Concepts, Processes Scheduling & synchronization, Memory management, File System management, Introduction to Linux, Startup Files, Linux boot process, Installation of Linux, Disk partitioning, Controlling and managing Services, Basic Linux commands, User administration of Linux, Network Configuring, Network

Monitoring and Troubleshooting (netstat/iproute2), System Configuration Files, Perform System Management, Maintenance and troubleshooting, Basic Service Security, Log Management, Network Authentication.

Shell Scripting: Introduction to BASH Command Line Interface (CLI) Error Handling, Debugging & Redirection of scripts Control Structure, Loop, Variable & String, Conditional Statement Regular Expressions, Automate Task Using Bash Script, Security patches, Logging & Monitoring using script.

Perl: Control structure and loops, Useful/necessary functions to memorize, Array Functions, Hash Functions, Array and hash manipulation, Inbuilt special variables Regular Expressions basics, File Handling, Introduction to Modules and Packages, Database Connectivity.

3. **HPC System Administration and Management** **(140 Hours)**

Basics of Data Center Design Management

Data center overview, Real life issues on design, Cabinets, Power, cooling, Cable Management, Safety, efficient design and planning a strategy, Collecting the heat, Heat rejection or reuse, Liquid cooling, Energy use systems, Data Centre Metrics, Best Practices, Fire Protection and Security Systems.

Design of HPC Cluster – Ecosystem

Requirement Analysis, building blocks of HPC, Hardware and software selection process, Design of HPC Cluster, Cluster Planning, Architecture and Cluster software, Cluster building tools, Multicore architecture, Accelerator cards, Configuring & setting environment for accelerator cards, Latest trends and technologies in HPC.

HPC System Management and Monitoring

IPMI, HMC, User management, LDAP, NIS, Node resources, processor usage, memory usage, network usage, statistics, network monitoring, monitoring tools (Ganglia, Collectl, Graphite, nagios and XD mod), System Benchmarking, theoretical peak performance, HPL bench mark, Tuning HPL, OSU Benchmark / IO Benchmark, HPCG Benchmark, Micro benchmarking, macro benching, Application benchmarking and check the scalability of the applications, Ticketing tools for support.

Case study of HPC solutions like Param Shavak

4. **Python Programming** **(60 Hours)**

Introduction to Python, Python basics, Data Types and variables Operators, Looping & Control Structure, List, Modules, Dictionaries, String, Regular Expressions, Functions and Functional Programming, Object Oriented Linux Scripting Environment, Classes, Objects and OOPS concepts, File and Directory Access Permissions, Libraries and Functionality Programming, Writing plugins in Python, Data analysis Automation Process, Debugging basics, Task Automation with Python.

5. **Fundamental of Computer Network and Management** **(40 Hours)**

Introduction to communication system, issues in Computer Networking, OSI Layers, TCP/IP Models, Networking Protocols, IP Addressing and Routing, Network Devices (Hub, Switch, Router), Interconnect networks, Types of Interconnect networks, Gigabit Ethernet,

InfiniBand, Omni Path Architecture(OPA), types of protocol supported, Communication subnet, Interconnect networks subsystem: HCA, FC ports and other supported accessories, Network monitoring.

6. **Storage and Backup Management** **(50 Hours)**

Types of Storage, Protocols, Components of a disk drive, physical disk and factors affecting disk drive performance. RAID level performance and availability considerations, Components and benefits of an intelligent storage system, (DAS) architecture, (SAN) attributes, components, topologies, connectivity options and zoning, FC protocol stack, addressing, flow control, and classes of service, storage replication & HSM, Network Attached Storage (NAS) components, protocols, IP Storage Area Network (IP SAN) iSCSI, FCIP and FCoE architecture, Logical Volume Manager (LVM).

Parallel File Systems

Introduction to Parallel File Systems, types of Parallel File Systems, PVFS2, Lustre, BeeGFS, GPSF, Components, Installation and configuration, benchmarking, comparison of Parallel File Systems, Optimization.

Backup management

Backup, Backup tools, Types of backup, backup policies, Archive, retrieve, backup optimization, restore, Hierarchical Storage Management (HSM), Backup media (LTO), Tape library.

7. **Resource Management and Accounting** **(50 Hours)**

Resource manager, Batch systems, Scheduler, various open source schedulers in HPC PBS Pro, Slurm, SGE, Components of resource manager, installation and configuration of Slurm and PBS Pro, submitting and managing jobs, Writing the batch script , Application level check pointing, Managing nodes, setting server scheduling policies, scheduler integration, Maui, Moab, MPI support, Accounting records, Gold.

8. **Security and Traffic management** **(70 Hours)**

Security Fundamentals, Risk Management, Exposure and Countermeasure, DMZ, Firewalls, Types of Firewalls, Limitations of firewall, firewalld, Threat Management Gateway, Web Application Firewall, Packet capturing, Packet Signature and Analysis, Reverse proxy, Virtual Private Networks, Deploy and managing VPN, VPN Performance tuning and error handling, VPN routing, Hybrid VPN, IPSec, CA, SSL/TLS Certificate generation, HMAC, Cryptography, L2TP/PPTP, Intrusion Detection And Prevention, Intrusion risks, Security policy, Monitoring and reporting of traffics, Traffic shaping, Investigating and verifying detected intrusions, Recovering from, reporting and documenting intrusions, Define the Types of intrusion Prevention Systems, Intrusion prevention system basics, Limitations of Intrusion Prevention System, Spoof Prevention, Dos, Ddos, QoS Policy, Nagios and Snort configuration.

9. **Hadoop Administration** **(80 Hours)**

Hadoop Framework: What is Hadoop, Why Hadoop, History of Hadoop, Use Cases of Hadoop, Hadoop eco system, HDFS, Hadoop Distributed File System, HDFS Architecture, Name Nodes, Data Nodes, Secondary Name Node, Command Line Interface, Reading and Writing Date, Hadoop on YARN

Map Reduce: Map Operation, Map Reduce Anatomy, Job Submissions, Job Initialization, Task Assignment, Job Completion, Job Scheduling, Job Failures, Shuffle and sort, Word Count Problem, Word Count Flow and Solution, Word Count Flow and Solution.

Hadoop Environment: Setting up a Hadoop Cluster, Cluster specification, Cluster Setup and Installation, Hadoop Configuration, Security in Hadoop (Security System Concepts used in Hadoop, Hadoop Cluster With LDAP), Administering Hadoop, HDFS – Monitoring & Maintenance (Data transfer Between Clusters, Adding and Removing Nodes, Cluster Rebalancing), Hadoop benchmarks.

10. **Cloud Services & Security** **(100 Hours)**

Cloud Computing: Definition, Characteristics, Components, Cloud provider, SAAS, PAAS, IAAS and other Organizational scenarios of clouds, Administering & Monitoring cloud services, benefits and limitations, Deploy application over cloud. Comparison among SAAS, PAAS, IAAS, Cloud computing platforms: Infrastructure as service: Amazon EC2, Platform as Service: Google App Engine, Microsoft Azure Utility Computing, Elastic Computing, SLA, clusters, cloud analytics, challenges of cloud environment, HPC and Hadoop in the cloud.

Cloud Technologies: Virtualization, Virtual machine provisioning, virtualization applications in enterprises, Pitfalls of virtualization, Multitenant software: Multi-entity support, Multi-schema approach, Multi-tenancy using cloud data stores, Data access control for enterprise applications, OVirt, OpenStack.

Security in Cloud: Cloud security fundamentals, Vulnerability assessment tool for cloud, Privacy and Security in cloud, Cloud computing security architecture: Architectural Considerations- General Issues, Trusted Cloud computing, Secure Execution Environments and Communications, Micro-architectures; Identity Management and Access Control- Identity management, Access control, Autonomic Security. Cloud computing security challenges: Virtualization security management- virtual threats, VM Security Recommendations, VM-Specific Security techniques, Secure Execution Environments and Communications in cloud.

Container based technologies, Automation and administration: Introduction to DevOps, Version controlling, GIT, Branching and Merging, Workflow, Jenkins, Maven, Docker, Containers, Microservices platforms, Kubernetes.

11. **Aptitude & Effective Communication** **(90 Hours)**

12. **Project** **(110 Hours)**

Annexure B: PG-DHPCAP course details

PG Diploma in HPC Application Programming (PG-DHPCAP)

Course Objective:

The theoretical and practical mix of the HPC Software development programs has the following objectives:

- To explore the fundamental concepts of Parallel programming and HPC Solutions and their applications.
- To develop in-depth knowledge and understanding of the High-Performance Computing domain.
- To learn the use of various HPC tools.
- To understand the applications using Map Reduce Concepts, OpenMP, CUDA, MPI, OpenACC.
- Basic introduction to ML, DL and AI

Course Focus:

- To design artificial intelligence enabled products and services for real world problems
- To understand accelerated computing and its capability in reducing ML/DL/AI workloads by evaluating algorithms in Machine Learning and Deep Learning.
- To efficiently use HPC infrastructure in AI workloads.
- To understand and apply various parallel programming libraries like CUDA, MPI, Python for parallel computing to implement HPC Solutions

Eligibility Criteria:

- Graduate in Engineering (10+2+4 or 10+3+3 years) in IT / Computer Science / Electronics / Telecommunications / Electrical / Instrumentation.

OR

- MSc/MS (10+2+3+2 years) in Computer Science, IT, Electronics.

OR

- Post Graduate Degree in Physics/ Computational Sciences/ Mathematics or allied areas,

OR

- MCA

Candidate must have secured 55% or above in the qualifying degree

Pre-requisites: Candidates should have sound knowledge of Fundamentals of Programming, C programming, and basics of Linux.

Admission Process:

Admission will be through NSM C-CAT (Sec A + B).

Course Module:

Sr. No.	Module Name	No. of hours
1.	Programming Concepts	120
2.	Linux shell scripting, Perl, and PHP	60
3.	Computer Architecture & Interconnects and Co-processor	60
4.	Cloud Computing & Deployment Strategies	60
5.	Analytics & Statistics using Python	80
6.	Parallel programming and Numerical Methods	150
7.	Introduction to High-Performance Computational Programming	60
8.	Introduction to CUDA Programming OpenACC and SYCL	60
9.	Introduction to AI and OpenVino	60
10.	Aptitude & Effective Communication	90
11.	Project	100
Total Hours		900

Course Content:

1. **Programming Concepts** **(120 Hours)**

Software Engineering concepts **(4 Hours)**

C, C++ Programming and Data Structure **(54 Hours)**

Difference between C and C++, pointers and Arrays using Pointers
Classes and Objects, Access Specifiers, Overloading, Inheritance, Polymorphism
Algorithms & Data Structures using C
Stacks, Queues, Linked Lists (Singly, Doubly, Circular), Trees, Graphs, Sorting (Bubble, Quick, Heap, Merge)

Java Programming **(40 Hours)**

Data Types, Operators and Language, Constructs, Inner Classes and Inheritance, Interface and Package, Exceptions, Threads, Java.lang, Java.util, Java. awt, Java.io.

FORTRAN & Go Language **(20 Hours)**

Programs, Arithmetic Operations, Subroutines, Functions, Modules, Interface Formatting, and File Handling, Arrays, Pointers, Derived Data Types, Use of Program Libraries
Go Programming Overview, Environment Setup, Program Structure, Basic Syntax, Data Types, Variables, Constants, Operators, Decision Making Statements, Loops, Functions.

2. **Linux shell scripting, Perl, and PHP** **(60 Hours)**

Linux shell scripting **(30 Hours)**

Linux Commands, Processes scheduling & synchronization, Memory management, File Systems, Shell Scripting, Package Managers (RPM, APM, etc.)

Perl Scripting **(20 Hours)**

Perl Fundamentals, Control structure and loops, Useful/necessary functions to memorize, Array Functions, Hash Functions, Array and hash manipulation, Inbuilt special variables, Regular Expressions basics, File Handling, Introduction to Modules and Packages, Database Connectivity.

PHP **(10 Hours)**

Introduction to PHP, Working with arrays, Functions, Forms, Handling date and Times, Working with Files

3**. Computer Architecture & Interconnects and Co-processor** **(60 Hours)**

Computer Architecture and Interconnects **(40 Hours)**

Basic concepts of computer organization, Classes of computer architecture, Processor vs. System architecture, Elements of computer systems, Goals of computer architecture, Memory Hierarchy, CISC vs. RISC architectures. Multi-Processor architecture, Memories and Caches, Cache coherency, Standard I/O interfaces GPU elements, An overview of the latest Intel processor., Distributed systems, cluster computing, grid computing, connectivity architectures, etc., SMP & NUMA, PCI

Introduction to communication system, issues in Computer Networking, OSI Layers, TCP/IP Models, Discussion of Networking Protocols, IP Addressing and Routing, Hub, Switch, Router, Interconnect Network (types, GB ethernet, OmniPath Architecture, and Infiniband)

Introduction to Processor & Co-processor Architectures **(20 Hours)**

Introduction to processor architecture.

Introduction to different processor Architectures: Intel, AMD, ARM, IBM Power

Introduction to Co-processors: Intel, Nvidia- GPU, FPGA, Cross Compilation techniques.

4**. Cloud Computing & Deployment Strategies** **(60 Hours)**

Cloud Computing & Operations **(33 Hours)**

Introduction to Cloud Computing: Definition, Characteristics, Components, Cloud provider, SAAS, PAAS, IAAS and other Organizational scenarios of clouds, Administering & Monitoring cloud services, benefits and limitations, Deploy application over clouds. Comparison among SAAS, PAAS, IAAS, Cloud computing platforms: Infrastructure as service: Amazon EC2, Platform as Service: Google App Engine, Microsoft Azure Utility Computing, Elastic Computing, SLA, clusters, cloud analytics, challenges of cloud environment, Bare Metal Provisioning, HPC in the cloud, OpenStack and introduction to cloud stack

Introduction to Cloud Technologies: Hypervisors, Architecture of hypervisors, Compare SOAP and REST Web services, AJAX and mashups-Web services: SOAP and REST, SOAP versus REST, AJAX: asynchronous 'rich' interfaces, Mashups: user interface services. Virtualization, Virtual machine provisioning, virtualization applications in enterprises, Pitfalls of virtualization, Multitenant software: Multi-entity support, Multi-schema approach, Multi-

tenancy using cloud data stores, Data access control for enterprise applications

Platforms & Deployment Strategies **(27 Hours)**

Spack

Virtualization: Virtualization Basics, Virtual machine provisioning, virtualization applications in enterprises, Pitfalls of virtualization.

Containers: Container orchestration system, docker, singularity, Kubernetes orchestration system. hands on sessions using any container.

Internet of Things: IoT definitions, End Devices, Gateways, IoT platforms, Reference architecture, Introduction to IoT devices, Sensors and Actuators, Case studies of IoT solutions

Analytics & Statistics using Python **(80 Hours)**

Data Manipulation, Web Scraping, NumPy & Pandas, Data Pre-processing, Data Manipulation, Data Visualization, Basics of Statistics and Statistical Analytics, Exploratory Data Analysis (EDA), Probability and Distribution functions, Inferential Statistics, Regression-Linear & Logistics, Random Processes

5. **Parallel Programming and Numerical Methods** **(150 Hours)**

Uniprocessor optimization and Pthreads **(15 Hours)**

Compiler level optimizations, Arithmetic optimizations, loop unrolling, loop fusion, loop interchange, Loop invariant code motion, Inlining, Pthreads Overview, What is thread, What are Pthreads, Why Pthreads, Designing Threaded Programs, Pthreads APIs, Creating and Terminating Threads, Passing Arguments to Threads, Joining and Detaching Threads, Stack Management, Miscellaneous Routines, Mutex Variables, and Condition Variables, DPDK /SPDK libraries

Performance Metrics – Speed-up, efficiency, Amdahl's Law, weak/strong scalability, performance/watt, performance/$, Arithmetic Intensity (FLOPS/Bytes)

OpenMP **(50 Hours)**

Why OpenMP, OpenMP Programming Model, OpenMP constructs, Case-Studies (Algorithms and Parallelization Approaches), Matrix –Matrix-multiplication.

Introduction to OpenMP4.0

Message Passing Interface **(55 Hours)**

Basic MPI, MPI Point – to Point, MPI Collective Communication: Data Synchronization, Data Movement, Collective Computation. Advance MPI: Derived Data Types, Derived Types, Special type Constructors, Type Matching, Packing/Unpacking Data, Groups, and Communicators: Virtual Topologies, MPI3 Standard, and MPI Threads, Case Studies (Algorithms and Parallelization Approaches), Micro benchmarking, macro benching. Application benchmarking and check the scalability of the applications

Numerical Methods in Science & Engineering **(30 Hours)**

Approximations and Round-Off errors, Truncation errors, Roots of equations. Roots of Polynomials. Linear Algebraic Equations: Gauss Elimination, Matrix Inversion. Regression and Interpolation. Numerical Integration. Numerical Differentiation. Numerical solution of ordinary and partial differential equations. Case studies include sequential and parallel algorithms. Introduction to Algorithms for scientific domains: Monte Carlo, SIMPLE algorithm for Navier-Stokes equation in CFD, Finite Volume Method, FFTW. **Monte Carlo Methods:** Pseudo-random number generators, parallel random number generation, Monte Carlo methods for numerical integration and simulation, applications (e.g., radiation transport and

network simulation) **Data Management:** Introduction to data management, Parallel file systems and parallel I/O, Scientific data formats and libraries (e.g., NetCDF, and HDF5), Input/Output using MPI, Data intensive computing (distributed file systems and MapReduce), SPARK, Web interface and protocols for data exchange (e.g. OPeNDAP), Workflows for data processing, Benchmarking and profiling data intensive applications
Application Domains – Basics of different domains, algorithms, parallelism, computational characteristics, optimization of computational performance of applications, Case Studies

6. **Introduction to High-Performance Computational Programming (60 Hours)**

Introduction to High-Performance Computing Profiling and debugging tools & Application Optimization (50 Hours)
Profiling and Debugging of codes tools: Roof-line model, gprof, perf, Intel Vtune, gdb, Performance libraries like mkl, lapack, fft, Analysis tools like: ITAC, MPI libraries. Demo of the sample code by using the above tools,
Micro-benchmarks - memory bandwidth, HPL, NAS Parallel Benchmarks (NPB), Interconnect benchmarks (e.g. OSU), Storage benchmarks
Introduction to micro-architecture analysis tools: LIKWID
Resource Management & Monitoring tools, Schedulers & Job Submission (10 Hours)
Introduction to different HPC monitoring tools - ganglia, C-Chakshu, Grafana, Prometheus
Basics of scheduling, Introduction to resource management tools, Introduction to PBS, Torque and SLURM
Job Submission: Writing the batch job script, submission, monitoring. Application level checkpointing

7. **Introduction to CUDA Programming, OpenACC and SYCL (60 Hours)**

CUDA Programming/ OpenCL, (40 Hours)
Introduction to GPGPU, GPU Performance Vs CPU Performance, GPU Computing Application Domain, nVIDIA's GPGPU Hardware Model, GPU Computing with CUDA, Thread Hierarchy, Memory Hierarchy, CUDA constructs, Case-Studies (Algorithms and Parallelization Approaches): Matrix – Multiplication,
Introduction to OpenCL, Host Program, Kernel Program
optimization & debugging using heterogeneous Programming.
OpenACC & One API (SYCL) (20 Hours)
OpenAcc Introduction, Parallelize and optimize loop, Optimize data locality, OpenACC Interoperability and SYCL introduction
Introduction to AI and OpenVino (60 Hours)
Introduction to Machine Learning (using Scikit Learn), Supervised Learning, Model Selection and Boosting, Unsupervised Learning, Neural Networks with Tensor Flow 2.x, intro to Keras, OpenCV, Open Vino.

8. **Aptitude & Effective Communication (90 Hours)**

9. **Project (100 Hours)**

Annexure C: Syllabus of NSM C-CAT

Table 1: Indicative syllabus of the different sections of test papers in NSM C-CAT.

TEST PAPER	TOPICS	DURATION
Section A	English, Quantitative Aptitude, Reasoning, Computer Fundamentals & Concepts of Programming	1 hour
Section B	C Programming, Data Structures, Object Oriented Programming Concepts using C++, Operating Systems & Networking, Basics of Big Data & Artificial Intelligence	1 hour

Table 2: Reference books for the various topics in NSM C-CAT

SECTION	TOPIC	REFERENCE BOOK
A	English	Any High School Grammar Book (e.g. Wren & Martin)
	Quantitative Aptitude & Reasoning	Quantitative Aptitude Fully Solved (R. S. Aggrawal) Quantitative Aptitude (M Tyara) Barron's New GRE
	Computer Fundamentals & Concepts of Programming	Foundations of Computing (Pradeep Sinha & Priti Sinha)
B	C Programming	C Programming Language (Kernighan & Ritchie) Let Us C (Yashavant Kanetkar)
	Data Structures	Data Structures Through C in Depth (S. K. Srivastava)
	Operating Systems & Networking	Operating System Principles (Silberschatz, Galvin, Gagne) Data Communication & Networking (Forouzan)
	OOP Concepts	Test Your C ++ Skills (Yashavant Kanetkar)
	Basics of Big Data & AI	Fundamentals of Data Engineering (Joe Reis, Matt Housley) Artificial Intelligence for Dummies (John Paul Mueller, Luca Massaron)

Annexure D: Important Dates

No.	Event	Date	
a	Beginning of Online Registration and Application for NSM C-CAT	6 June 2023	
b	**Closing of Online NSM C-CAT Registration & Application**	**5 July 2023**	
c	Downloading of NSM C-CAT Admit Cards	11 - 15 July, 2023	
d	**NSM C-DAC's Common Admission Test (C-CAT) at the Test Centres**	**15 July 2023**	**16 July 2023**
e	Announcement of NSM C-CAT Ranks	28 July 2023	
f	**Online Selection of Courses (1st Counselling)**	28 July – 4 August 2023	
g	Declaration of First Round of Seat Allocation	7 August 2023	
h	**Last Date of Caution deposit (Rs 10,000) for candidates allocated seats through the first round**	14 August 2023 (till 5pm)	
i	Declaration of Second Round of Seat Allocation	18 August 2023	
j	**Last Date of the Caution deposit (Rs 10,000) for candidates allocated seats through the second round**	**22 August 2023 (till 5pm)**	
k	**Payment of Caution deposit (Rs 10,000) and Online Selection of Courses (2nd Counselling)**	**24 - 30 August, 2023 (till 5 pm)**	
l	Declaration of Third Round of Seat Allocation (based on 2nd Counselling)	31 August 2023	
m	Last Date of Registration of Students	6 September 2023	
n	**Start of PG Diploma Courses**	**8 September 2023**	
o	**End of PG Diploma Courses**	**22 February 2024**	

Annexure E: Additional Terms & Conditions

(a) Candidate/student agrees that the information provided by them during application/ admission/ course through forms, emails, or other means are correct. Candidate/ student allows C-DAC to use the information provided by them for its own purposes, to the extent allowed by applicable laws, and contact them for communication through notification on its websites, emails, or SMS.

(b) The cities, dates, etc. for C-CAT are indicative/tentative and may change as per evolving pandemic related orders of the government and local authorities. Candidate agrees that while their city preferences for C-CAT will be taken into consideration for allotting test centres, C-DAC may allot any city or centre for operational and practical reasons at its own discretion.

(c) Candidate/student agrees to provide reasonable additional information including, but not limited to, identification, fingerprint, audio / video surveillance, etc. for conduction or proctoring of physical or online examination for admission or course progression.

(d) C-DAC reserves the right to modify or cancel any parts of the Admission Rule-book, processes and results including, but not limited to, exams, mode of exams, question papers, announced dates, courses, syllabus, cities, centres, intake capacities, ranks, seat allocation, candidatures, admissions, etc. as it deems fit, partly or wholly, at any stage without assigning any reasons thereof.

(e) Application to the courses by candidates and/or admission in any of the courses by students shall indicate their acceptance of all Terms & Conditions, Conduct Rules, Dos & Don'ts, etc. as may be prescribed by C-DAC from time to time. C-DAC shall have the right to impose appropriate disciplinary and other penalties for violation of prescribed terms and rules, including cancellation of candidature, admission, placements, and/or award of certificate.

(f) In case a candidate is found to be non-eligible during any stage of the admission process or course delivery, his/her admission will stand cancelled with immediate effect and he/she will be subjected to the forfeiture of the caution deposit.

(g) Use of any unfair means, coercion, inducement, violent, indecent, disorderly, threatening, or offensive behaviour or language by way of gesture, voice, writing, symbols, etc. shall constitute ground for suspension/expulsion from C-CAT and/or course, or debarment from joining/attending C-DAC examination(s) and/or course(s) in future. Decision of C-DAC in this regard shall be final and binding. Such students may be subjected to the forfeiture of the caution deposit.

(h) All communication from candidates must be made only to the email addresses and phone numbers given in relevant sections of this Admission Rule-book. **Sending emails or phone calling or messaging directly to officials of C-DAC or ATCs is prohibited.**

(i) **Depending upon the prevailing city/state-wise pandemic and any other guidelines, the training centres may plan the course delivery-mode and communicate the same to the students upon confirmation of admission and thereafter.** Decision and directions of C-DAC in this regard shall be final and binding on all students.

(j) All decisions of C-DAC with regards to the admission provisions, processes and results shall be final and binding on all candidates/students.

Annexure F: Flowchart for PG-Diploma Course