Department of Computational and Data Sciences (CDS)

Indian Institute of Science, Bengaluru

Research Admissions Interview Procedure

Ph.D. and M.Tech. (Research) Aug 2021 Cycle

Overview

Research activities at the Department of Computational and Data Sciences (CDS) are categorized into two streams: *Computational Science (CDS-CP)* and *Computer and Data systems (CDS-CS)*. The admissions process is common to both the streams.

The admission process for the Aug 2021 cycle comprises two phases. Phase I will be an **online aptitude test** on the HackerEarth platform, which serves as a screening test and Phase II will be an **online oral interview** only for the candidates qualified in the aptitude test conducted in Phase I.

Candidates shortlisted for the **online aptitude test** (Phase I) will receive a call letter email from IISc with the date and the session for your test. This online aptitude test is of 75 minutes duration, which will serve as a screening test. This will have multiple choice and programming questions. You will also receive an email from the CDS department about the online test instructions such as the test link, rules, guidelines, practice test, etc.

The Phase II ***online oral interview*** is for shortlisted students based on the online aptitude screening test conducted in Phase I. Students who qualify in this screening test will be informed about their oral interview date and time by an email, along with a link to the interview. This oral interview will be through video conferencing with a panel of CDS faculty using Microsoft Teams. The interview can last up to 45 minutes. The performance of the candidate in the online interview will contribute to their overall interview marks. The syllabus for the test and the interview is given below.

About a week before the oral interview, the shortlisted candidates will be sent an email from the CDS department to fill an **online student information Google form**. This must be completed and submitted in order to participate in the oral interview. As part of this, they should choose up to three labs for which they will be considered. These labs are described below.

Online Aptitude Screening Test

The Phase I online objective and programming test will be conducted using the HackerEarth online platform. Candidates will need a **desktop/laptop with an internet connection, Chrome, Firefox or Safari browsers, and a webcam**. Candidates will be sent an email with a link to the online test a few days before the test date. The test will be enabled at the start of your session and will last for **75 mins.** It has to be completed in a single sitting. You will need to create a **free HackerEarth account** to take the test. You MUST use the **same email address** as the one used for your IISc Admissions Application. Please do this ahead of time. That email will also have another link to let you take a **practice test**, to test your browser and

webcam, and get familiar with the HackerEarth platform. These practice questions are not from the test syllabus. Candidates may take the practice test as many times as they want. Candidates should get familiar with the programming IDE, compilation and testing interface of HackerEarth to ensure that the programming questions are attempted properly.

The online objective test will have 9 questions. There will be 7 multiple choice questions (each carrying 5 points) and 2 programming questions (with 5 and 10 points). The **topics** for the objective test are:

- Combinatorics, Linear Algebra/Matrices, Probability and Statistics, Differential Equations, Plotting, Data Structures and Algorithms.

The programming languages that you can use are **C, C++** and **Java**. The HackerEarth interface will allow you to type the program, compile it and run test cases, all within the browser. We will provide a basic code template for reading and writing the inputs and outputs for each problem. The candidates should focus on the actual code logic, and brush up on concepts such as if/then/else conditions and for loops.

Students are encouraged to first solve the problems that they are comfortable with and then move on to more difficult problems.

Online oral Interview over Video Conference

Students who qualify in the online screening test will attend an oral interview over a video conference before a CDS faculty committee. We will use **Microsoft Teams**. Details will be provided separately over an email with a link to join and the date and time of the interview session. In the oral interview, you will be questioned on the following basic topics, and on advanced topics that are based on your lab preferences:

Basic Topics: Linear Algebra; Probability & Statistics; Programming, Data Structures, Algorithms; Numerical Methods; Ordinary Differential Equations; Discrete Mathematics. Final year undergraduate level preparation is required.

Advanced Topics: You will be questioned on the topics related to labs selected in the student information Google form. The topics for each lab and the prior training expected are listed below. Candidates choosing a lab must be prepared on *at least one* of the lab-related interview topics.

Note: Most labs give preference to applicants for the Ph.D. program over the M.Tech. program. Some labs may not even take any students for the M.Tech. program. Students with a B.E./B.Tech. degree are also eligible to apply for the Ph.D. program.

Candidates for the Ph.D. program should prepare well on their fundamentals, come with a focus and knowledge of the research areas they would like to target in their PhD, and have a clarity on the preferred lab(s) and the kind of work done in them. Review the research topics and the papers from the labs you are interested in.

List of labs that are admitting students

1. Computational Mathematics Group (CMG)
Faculty: Sashikumaar Ganesan
Website: *http://cds.iisc.ac.in/faculty/sashi/*
Lab description: The research group focuses on developing and advancing robust numerical (finite element) methods and solvers for data-driven models accelerated with ML/AI with applications to "Digital Twin". Further, the implementation of efficient MPI/OpenMP with GPU parallel algorithms is also a key focus.
In Aug 2021 admissions, CMG is looking for three to four enthusiastic and hard-working Ph.D. candidates interested to work on "Digital Twin" technology.
Interview topics: Numerical Linear Algebra, Numerical Methods, Parallel computing
Prior training: Any degree with prior knowledge on modelling, simulation and strong programming knowledge is expected but no necessary.

2. Computational & Statistical Physics Lab
Faculty: Murugesan Venkatapathi
Website: http://cds.iisc.ac.in/faculty/murugesh/
Lab description: This group is suited for students interested in physics or computational mathematics. Our past results include strong-coupling of emitters with dissipating matter, computational methods for N-body problems in light emission, semi-analytical and numerical methods for eigenvalue problems with some periodicity in matrix entries, Monte Carlo methods for sampling in high dimensions, and error estimators for iterative solvers of linear systems.
Interview topics: Matrix algebra and/or statistics and/or physics.
Prior training: Any degree with bachelor's level expertise on the chosen topic of interest.

3. Biomolecular Computation Laboratory
Faculty: Debnath Pal
Website: pallab.serc.iisc.ernet.in/lab.php
Lab description: The focus of Biomolecular Computation Lab is to understand biological function at multiple scales. Towards this goal we work at molecular level and pathway level and develop methods and algorithms to understand biochemical function better. The scope of work spans the areas of genomics, proteomics and metabolomics. We also work on biomolecules to understand sequence, structure function relationships, their interactions and dynamics. There is opportunity to do research problems in real-life projects in cancer, diabetes, neurodegeneration etc., where intensive bio-computational analysis is required.
Interview topics: Students are expected to have good programming knowledge and a sound understanding in at least one of the basic subjects at the undergraduate level: Math, Physics or Chemistry. Exposure to bioinformatics and computational biology is desirable but not essential.
Prior training: Students from any background with interest in learning biology.

4. Database systems Laboratory
Faculty: Jayant Haritsa
Website: https://dsl.cds.iisc.ac.in/~haritsa
Lab Description: Design, Implementation and Testing of Database Engine Components, including Query Processing, Transaction Processing, and Data Regeneration modules.
Interview topics: Database Models, Languages and Systems
Prior training: UG or PG degree in Computer Science or Information Technology; Strong competence in programming, algorithms and systems.

5. DREAM:Lab (Distributed systems Research on Emerging Applications & Machines)
Faculty: Yogesh Simmhan
Website: http://cds.iisc.ac.in/faculty/simmhan
Lab Description: Focuses on distributed systems, algorithms and software platforms. Research topics on Distributed, Temporal and Dynamic Graphs Algorithms, and Graph Neural Networks; Scalable platforms for distributed and federated deep learning; Storage, query and analysis of Big Data; Middleware for Cloud and Edge computing and Internet of Things (IoT); Distributed software platforms and algorithms for drones/UAVs, video analytics, genomics, AR/VR; Information management and knowledge discovery.
Interview topics: Operating Systems (or) Graph Algorithms (or) Distributed Systems.
Prior training: Students must have a Bachelors' or Masters' degree in Computer Science, Information Technology, Electrical, Electronics and/or Communications. Strong programming, algorithms and systems skills are required. Ph.D. candidates are preferred.

6. FLAME (FLow Analysis and Multi-physics simulations at Extreme-scale) Lab
Faculty: Konduri Aditya
Website: http://cds.iisc.ac.in/faculty/konduriadi/
Lab description: The research group focuses on the simulation and analysis of multi-scale multi-physics fluid flow problems that leverage high performance computing (HPC) platforms. Specifically, the work would involve development of HPC centric numerical methods and algorithms for solving partial differential equations, application of machine learning methods to analyze and model data generated from simulations, and investigation of turbulent flow problems that arise in combustion systems (gas turbine and scramjet engines), high-speed aerodynamics and environmental flows.
Interview topics: Numerical methods, Linear algebra, Probability, Scientific programming, Differential equations, Fluid mechanics (optional), Programming models (optional)
Prior training: Students should have a Bachelors' or Masters' degree in any one of the following areas: Mechanical Engineering, Aerospace Engineering, Chemical Engineering, Computational Engineering, Computational Physics, Applied Mathematics, Scientific computing or similar areas. Ph.D. candidates are preferred.

7. MATRIX:Lab (Materials-physics & Algorithmic Techniques Research In eXtreme-computing)

Faculty: Phani Motamarri

Website: http://cds.iisc.ac.in/faculty/phanim/

Lab description: The research goal is centered around the development of novel mathematical techniques, HPC driven computational algorithms and application of these algorithms/techniques to address complex materials problems, aimed at pushing the frontiers of current predictive capabilities of computation-based design of materials, with a focus on quantum-mechanical modeling of materials. Research at MATRIX lab is highly interdisciplinary and combines core ideas from condensed matter theory, materials science, mechanics of solids, adaptive finite-element methods, numerical linear algebra, machine learning and a heavy dose of high-performance computing (MPI+GPU Hybrid programming).

Interview topics: Numerical methods, Linear Algebra, Calculus, Scientific programming, Differential equations, Topics based on student's UG/PG background. (for eg: Solid Mechanics, Quantum Physics, Computational Materials, Finite-element methods etc.,)

Prior training: Bachelors' or a Masters' degree in any one of the following areas**:** Mechanical Engineering, Materials Engineering, Chemical Engineering, Computational Engineering, Physics, Applied Mathematic or similar areas. Strong programming skills is a big bonus.

8. Middleware And Runtime Systems (MARS) Lab

Faculty: Sathish Vadhiyar

Website: http://cds.iisc.ac.in/faculty/vss and http://mars.cds.iisc.ac.in

Lab Description: High performance computing (HPC), Parallel computing – middleware, system software, algorithms and applications on large-scale parallel computers and GPUs.

Interview topics: Operating Systems, Graph Algorithms (or) MPI parallel programming interface (Google for "MPI Complete reference" and read Introduction, Point-to-Point and Collective Communications chapters.

Prior training: Students must have a Bachelors' or Masters' degree in Computer Science, Information Technology, Electrical, Electronics and/or Communications. Strong programming, algorithms and systems skills are required.

9. Video Analytics Lab (VAL)

Faculty: R. Venkatesh Babu

Website: http://cds.iisc.ac.in/faculty/venky/ and http://val.cds.iisc.ac.in

Lab Description: Deep Learning for Computer Vision, Representation Learning, Domain Adaptation, Adversarial Learning, Self-supervised and unsupervised learning, Object Detection, 3D reconstruction, Crowd and Traffic Analysis.

Interview topics: Signal Processing, Image Processing, Probability and Machine Learning basics.

Prior training: Students must have a Bachelors' or Masters' degree in Computer Science, Information Technology, Electrical, Electronics and/or Communications or in any other closely related areas.

10. Visual Computing Lab (VCL)
Faculty: Anirban Chakraborty
Website: http://visual-computing.in/
Lab Description: At VCL, we are interested in developing novel computer vision and machine learning algorithms to solve visual analytics problems arising from real-world applications. Majority of our ongoing research projects can be categorized into one of the following three areas – 1. Data-efficient deep learning (zero-shot/few shot learning etc.), 2. Learning across modalities/domains (text-based image retrieval, sketch-guided localization, visual question answering, domain adaptation etc.) and 3. Video surveillance (person-reidentification, anomaly detection, human gait and pose analysis etc.)
Interview topics: Image Processing, Linear Algebra, Probability and Machine Learning basics.
Prior training: Students must have a Bachelors' or Masters' degree in Computer Science, Information Technology, Electrical, Electronics and/or Communications or in any other closely related areas.

11. Cloud Systems Lab
Faculty: J. Lakshmi
Website: http://www.serc.iisc.ac.in/faculty/jlakshmi
http://www.serc.iisc.ac.in/faculty/jlakshmi/cloud-system-lab
Lab Description: Cloud System Architectures for end-to-end QoS of hosted applications with regard to performance, security, dependability and fault tolerance; virtualization stack for compute, network and storage clouds; Cloud middleware for elasticity, placement optimization, resilience and other QoS properties.
Interview topics: Operating Systems, Distributed Systems, Computer Organization
Prior training: Students must have a Bachelors' or Masters' degree in Computer Science, Information Technology, Electrical, Electronics and/or Communications.

12. Algorithmic Techniques for Computational Genomics (ATCG)
Faculty: Chirag Jain
Website: http://cds.iisc.ac.in/faculty/chirag
Lab Description: We work at the intersection of computer science and biology to accelerate scientific discovery by designing novel scalable provably good algorithms, data structures and open-source software tools.
Interview topics: Algorithms design and analysis, data structures, graph algorithms
Prior training: Students must have a Bachelors' or Masters' degree in Computer Science, Information Technology, Electrical, Electronics and/or Communications, Biosciences/ Bioengineering. Strong programming, algorithms and interdisciplinary teamwork skills are required.

Preference Sheet – Research Admissions Aug 2021 Cycle

Eligibility for labs taking only CS/EE graduates (please see below for these labs):
B.E./B.Tech. or equivalent degree in Computer Science/Engineering; Information Technology/Science; Electrical, Electronics, Instrumentation, and/or Communication Engineering; or Master's degree in Computer Science; Computer Application or Electronics. Good programming skills are required.

- You need to fill this Preference Sheet through an **online Google Form link** you will receive by email from the CDS department.
- Carefully review the Admissions Brochure, the Research Lab descriptions and their websites before filling the Online Form.
- You may choose up to three labs for which you are eligible and rank order them.
- The labs chosen in the Form are binding and cannot be changed later. Your interview questions will be based on the labs you choose.
- Choose the lab(s) whose research areas most closely match your own interests.

1. Name: _____
2. Application No: _____
3. Program *(Select all that apply)*: [ ] Ph.D. [ ] M. Tech. (Research)
   Note: Students with a BE/BTech degree are also eligible to select the Ph.D. program.
4. External Research Program candidate? *(Tick one)* [ ] No [ ] Yes

Rank up to three research labs you are eligible for, using numbers 1, 2 and 3.

[ ] ATCG Lab [ ] Biomolecular Computation Laboratory [ ] CMG (admits only PhD) [ ] Computational and Statistical Physics Lab [ ] FLAME Lab [ ] MATRIX Lab	**Labs taking only CS/EE graduates** [ ] Cloud Systems Lab [ ] Database Systems Lab [ ] DREAM Lab [ ] MARS Lab [ ] Video Analytics Lab [ ] Visual Computing Lab

I have read and understood the brochure and the instructions before filling in this preference sheet.

Signature: _____ Date: _____ Place: _____