Department of Computational and Data Sciences (CDS)

Indian Institute of Science, Bangalore

Research Admission Procedure

PhD Jan 2020 Cycle

Research activities at CDS are categorized into two streams: *Computational Science (CD-CP)* and *Computer and Data systems (CD-CS)*. The candidate must apply for CDS and the department committee will shortlist the candidates for a research interview based on their GATE Score and/or B.Tech./M.Tech. scores. The shortlisted candidates must attend an interview, which consists of a *written component* and an *oral interview*. Candidates must carefully review their eligibility and labs they are interested in, and choose one stream, either CD-CP (Computational Science) or CD-CS (Computer and Data System). This is done at the time of interview by filling the *combined preference sheet*. The written and oral topics will be different for these two streams. Please refer to the appropriate brochure carefully before the interview so that you may prepare accordingly and fill the combined preference sheet when you arrive at the interview.

Computational Science (CD-CP)

PhD, Jan 2020 Cycle Admission Brochure

This brochure provides information on the Research Admission process into the Computational Science Stream (CDS-CP) of CDS for 2019. It describes the *research laboratories* in the CDS-CP stream which are accepting students this year, and the *topics* for the written and oral components of the research interview. A *combined Preference Sheet* appended at the end of this brochure must be filled and signed by you when you appear for the interview.

A. Research Streams at CDS

Research activities at CDS are categorized into two streams: *Computational Science (CDS-CP)* and *Computer and Data systems (CDS-CS)*. Research admissions are conducted *separately* for each stream, so please refer the appropriate brochure. **This brochure is only for Computational Science.**

B. Research Admission Process – Computational Science Stream (CD-CP)

The interview process for the Computational Science stream has two stages: Written and Oral (both conducted on the same day).

1. ***Written component*** (Duration: 30 minutes): Total Points 5x2=10

(a) Two mandatory questions: one will be from polynomials, functions, plotting, etc and another will be a programming question

(b) Answer any three out of four questions asked from basic engineering mathematics on following topics: Linear Algebra/Matrices, Probability and Statistics, and Differential Equations.

2. ***Oral Interview***: Candidates who are successful in the written component will attend an oral interview before a CDS-CP faculty committee. In the oral interview, you will be questioned on the basic subjects, and based on your choice of an advanced topic and lab preferences:

Basic Area Subjects: Programming fundamentals; Linear Algebra; Numerical Methods; Ordinary Differential Equations; Probability & Statistics. Final year undergraduate level preparation is required.

Advanced Topics: Matrix Algebra, Numerical and Functional Analysis, Numerical Solution of Differential and Differential-Algebraic Equations, Finite Element Methods, Signal Processing, Computational Biology and Structural Bioinformatics, Graph Algorithms, Structural Biology and Bioinformatics, Computational Fluid Dynamics.

C. List of labs that accept students

1. Medical Imaging Group (MIG)

Faculty: *Phaneendra Yalavarthy*; http://cds.iisc.ac.in/faculty/yalavarthy/MIG/

The research group works on developing computational methods/models in medical imaging. The recent focus has been toward deep learning methods for medical image reconstruction and analysis. Significant portion of the research work in the lab is dedicated toward clinically relevant work with an emphasis on fast imaging methods.

2. Biomolecular Computation Laboratory

Faculty: *Debnath Pal*; pallab.serc.iisc.ernet.in/lab.php

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 bio-molecules 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.

3. Structural Biology & Bio-Computing Lab

Faculty: *K. Sekar*; physics.iisc.ernet.in/~dichome/sekhome/index.html

The research group focuses on solving three-dimensional crystal structures of protein molecules using X-ray crystallography and molecular dynamics simulations. Further, we are also interested in data mining of protein sequences and structures.

4. Computational Mathematics Group

Faculty: *Sashikumaar Ganesan*; http://cds.iisc.ac.in/faculty/sashi/

The research group focuses on the development and advancement of robust numerical (finite element) methods and solver for solving partial differential equations (PDEs) that describe incompressible fluid flows and species concentration and/or energy in complex systems. The group also works on implementing efficient parallel algorithms for high-performance computing.

5. Computational & Statistical Physics Lab

Faculty: *Murugesan Venkatapathi*; http://cds.iisc.ac.in/faculty/murugesh/

This group is suited for students interested in physics, or mathematical analysis, or scientific algorithms. Examples of our recent results include a theory of strong-coupling of emitters with dissipating matter, computational method for quantum N-body problems in emission, analysis of polynomial recurrence relations and fast computing methods for eigenvalue problems, methods of estimation to substitute Markov-Chain-Monte-Carlo (MCMC) sampling, and error estimators for linear solvers.

6. QUEST (Quantifying Uncertainty in Engineering, Science and Technology) Lab

Faculty: *Deepak Subramani;* http://cds.iisc.ac.in/faculty/deepakns/

The goal of our research is to build holistic science-based data-driven computational solutions to complex engineering and environmental problems. Example applications include climate change, cyclone predictions, coastal hazard management, and optimal vehicle routing. Pursuant to our goal, we develop and apply fundamental theories, numerical schemes and software systems. We invite students who are interested in any of the following topics: numerical solution of stochastic partial differential equations, uncertainty quantification, Bayesian and deep learning of dynamical systems, fluid dynamics of the atmosphere and oceans, and path planning of autonomous vehicles in dynamic environments.

7. Computational Flow Physics Lab

Faculty: *Konduri Aditya*; http://cds.iisc.ac.in/faculty/konduriadi/

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.

8. Computational Nano-physics Group (CNPG)

Faculty: *Phani Motamarri*; https://sites.google.com/view/cnpg/home

The group's broad research interests are centered around advancing the current predictive capabilities of computation-based design of materials using first principles-based quantum mechanical methods, with applications geared towards design of stronger light-weight materials, clean-energy, and next generation bio-molecular electronic devices. In particular, the focus will be on developing mathematical techniques and scalable computational algorithms that can leverage the latest heterogeneous parallel computing architectures and future exa-scale machines for ab-initio material modeling. Research combines ideas from condensed matter theory, materials science, solid mechanics, adaptive finite element methods, numerical linear algebra and a heavy dose of high-performance computing.

Preference Sheet – Research Admissions Jan 2020 Cycle

Written and Oral Interview for Computational Science (CD-CP) and Computer and Data Systems (CD-CS) are SEPARATE.

Candidates may attend ONLY ONE of CD-CP or CD-CS interview.

Eligibility for CD-CP: *BE / B Tech or equivalent degree in any discipline or M Sc or equivalent degree in Mathematical Sciences; Physical Sciences; Electronics; Instrumentation; Computer Science or Master's in Computer Application. In all cases: a background in Mathematics and Programming is required*

Eligibility for CD-CS: *BE / B Tech or equivalent degree in Computer Science/ Engineering; Information Technology/Science; Electrical and Communication Engineering; Electrical Engineering or Master's degree in Computer Science; Computer Application or Electronics. In all cases: a background in Programming is required*

- Carefully review the Brochures, and Research Lab descriptions and websites before filling in this Preference Sheet.
- You may choose **only one stream (CD-CP or CD-CS)**, and up to three labs in that stream.
- **The stream chosen here is binding and cannot be changed after the written interview.**
- Choose the lab(s) whose research areas most closely match your own interests.
- You may change your lab preference during oral interview.

1. **Research Stream *(Tick Only One)*: [ ] CD-CP [ ] CD-CS**
2. Name:

   _____
3. Application No:

   _____
4. Program *(Select all that apply)*: [ ] Ph.D.
5. External Research Program candidate? *(Tick one)* [ ] No [ ] Yes
6. Rank up to three research labs in your selected stream using numbers 1, 2 and 3.

If you selected **CD-CP stream** above:	If you selected **CD-CS stream** above:
[ ] Medical Imaging Group [ ] Biomolecular Computation Laboratory [ ] Structural Biology & Bio-Computing Lab [ ] Computational Mathematics Group [ ] Computational & Statistical Physics Lab [ ] QUEST Lab [ ] Computational Flow Physics Lab [ ] Computational Nano-Physics Group	[ ] MARS Lab [ ] Video Analytics Lab [ ] DREAM Lab

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

Signature: _____ Date: _____ Place: _____