

# INDIAN INSTITUTE OF TECHNOLOGY DHARWAD

## Department of Mathematics

Ph.D. Admission: Autumn - 2018

### Minimum Eligibility Criteria:

Category	Educational qualification
General	The eligibility criteria in the qualifying degree is <b>First Class</b> , as specified by the candidate's Institution/University. If the Institution/University does not specify the division/class, then one of the following will be considered as the eligibility criteria:  (1) A minimum of 60% marks (without round off) in aggregate or  (2) a minimum Cumulative Grade Point Average (CGPA) or Cumulative Performance Index (CPI) of 6.0 on the scale of 0-10; with corresponding proportional requirements when the scales are other than on 0-10, (for example, 4.8 on a scale of 0-8).
OBC (NC)	Same as general
SC /ST/PWD	A relaxation of 5% in the qualifying degree is applicable

In addition to above, a candidate must satisfy one of the following:

1. B.Tech students having background in Engineering Physics, Computer Science, Mechanical or Electrical Engineering with *valid* GATE score.
2. M.Sc in Mathematical Science - candidates should possess valid GATE score.
3. M.Phil in Mathematical Science are exempted possessing valid GATE score.
4. M.Tech students with Computer Science, Mechanical or Electrical Engineering background – candidates are exempted from possessing VALID GATE score.
5. Junior Research Fellowship in Mathematical Sciences from CSIR, UGC, DST (INSPIRE fellowship), and other externally funded candidates are encouraged to apply and they are exempted from possessing valid GATE score.

### Research Topics:

- 1) Computational Mathematics – numerical solution of moving boundary problems.

- 2) Computational Biology – this will be a joint work with Bioscience faculty at IIT Dharwad.

**Important dates:**

Last date of application	: 01-06-2018
Announcement of Shortlisted Candidates	: 09-06-2018
Date of Examination	: 12-07-2018
Announcement of Results	: 16-07-2018
Registration	: 25-07-2018

**Selection Process:**

- Schedule for screening test and interview:

Written test and followed by Interview: (Interview may be on the same day of the written test or on the next day)	Proposed Date of Written Test:	<b>12-07-2018</b>
	Duration & Proposed Timings of Written Test:	<b>120 mins (9:00 to 11:00 AM)</b>
	Proposed Dates for Interview:	<b>12-07-2018</b>
	Proposed Timings of Interview:	<b>12:00 PM onwards</b>

- The selection process consists of MCQ type screening test. The duration of the exam would be 120 minutes. The syllabus for the exam is given in the Information Brochure.
- Each question will have 4 options to choose from. Only one option would be correct.
- The exam will have negative marking scheme. For MCQ questions, ¼ th of the points allotted for that question will be deducted for wrong answers.
- Candidates should bring:
  - Printed copy of the online submitted application,
  - Government issued photo id card,
  - Date of Birth certificate,
  - Degree certificate/s along with marks cards/aggregate percentage,
  - Junior Research Fellowship offer letter from UGC/CSIR/INSPIRE fellowship or any other funding agencies.
  - Valid GATE Score,
  - Cast certificate,
  - Income certificate

**Dont's**

1. Mobiles are not allowed in the examination hall or onto the interview room
2. Department's decision is the final regarding any disciplinary matters
3. Institute doesn't take any responsibility of your luggage/items that you leave before entering the examination hall.

## **Application Categories and Financial Support**

The Department of Mathematics admits Ph.D. candidates under the full time research scholarship - Teaching Assistantship (TA) and Fellowship Award (FA).

### **Teaching Assistantship (TA):**

Funded by MHRD, the TAs are expected to assist in the academic/administrative work for smooth functioning of the Institute. Students under this category are entitled to financial support as per MHRD norms.

1. For students with M.Tech./M.E./M.Phil. or equivalent degree as the qualifying degree, the assistantship is payable for a maximum duration of 5 years or up to the thesis submission, whichever is earlier. At present, the monthly rate of assistantship is ₹25,000 for the first 2 years and enhanced rate of ₹28,000/- for the remaining period.
2. For students with B.Tech./B.E. or equivalent degree and students with M.Sc. or equivalent as the qualifying degree and having valid GATE score or having Junior Research fellowship (JRF) of UGC/CSIR or DST INSPIRE fellowship, the assistantship is payable for a maximum duration of 5 years or up to the thesis submission, whichever is earlier. At present, the monthly rate of assistantship is ₹25,000/- for the first two years and enhanced rate of ₹28,000/- for the remaining period.
3. To get Teaching Assistantship, the students concerned must assist in teaching, research and/or administrative work as assigned by the respective Academic Unit to the extent of 8 hours of work per week.
4. The continuation of the assistantship will be subject to satisfactory performance of the duties assigned by the Departments as well as satisfactory academic performance.
5. Employees on the rolls (with or without pay) of any organization are not eligible for admission under this category.

As per MHRD directives, the employees of any organizations with or without pay are not eligible for admission under TA category. Candidates selected in this category have to resign from the current job and submit a relieving letter from their employer before joining the programme. Students getting assistantships from the Institute may join projects sponsored by external agencies and obtain corresponding fellowships in lieu of TA ship.

### **Fellowship Award (FA):**

These students are financially supported under various Govt. / Semi Govt. schemes like CSIR, UGC, DAE, DST or DST INSPIRE etc. and some other organizations. The admission procedure and other requirements are same as applicable to TA.

## **Syllabus for candidates who want to do research in Computational Mathematics:**

### **Analysis**

Elementary set theory, finite, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, supremum, infimum. Sequences and series, convergence, limsup, liminf. Bolzano Weierstrass theorem, Heine Borel theorem.

Continuity, uniform continuity, differentiability, mean value theorem. Sequences and series of functions, uniform convergence. Riemann sums and Riemann integral, Improper Integrals. Monotonic functions, types of discontinuity, functions of bounded variation, Functions of several variables, directional derivative, partial derivative, derivative as a linear transformation, inverse and implicit function theorems. Metric spaces, compactness, connectedness. Normed linear Spaces. Spaces of continuous functions as examples.

### **Linear Algebra**

Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations. Algebra of matrices, rank and determinant of matrices, linear equations. Eigenvalues and eigenvectors, Cayley Hamilton theorem. Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms. Inner product spaces, orthonormal basis. Quadratic forms, reduction and classification of quadratic forms.

### **Complex Analysis**

Algebra of complex numbers, the complex plane, polynomials, power series, transcendental functions such as exponential, trigonometric and hyperbolic functions. Analytic functions, Cauchy-Riemann equations. Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Maximum modulus principle, Schwarz lemma, Open mapping theorem. Taylor series, Laurent series, calculus of residues. Conformal mappings, Mobius transformation.

### **Ordinary Differential Equations (ODEs)**

Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs. General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.

### **Partial Differential Equations (PDEs)**

Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs. Classification of second order PDEs, General solution of higher order PDEs with constant coefficients, Method of separation of variables for Laplace, Heat and Wave equations.

### **Numerical Analysis**

Numerical solutions of algebraic equations, Method of iteration and Newton-Raphson method, Rate of convergence, Solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration, Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods. Numerical Linear Algebra: Fundamentals of matrix theory; least squares problems; computer arithmetic, conditioning and stability; direct and iterative methods for linear systems; eigenvalue problems.

### **Syllabus for candidates who want to do research in Computational Biology:**

## **Calculus**

Limits, continuity, differentiability. Mean value theorem, Taylor's Theorem, Maxima and Minima. Riemann integrals, Fundamental theorem of Calculus, Improper integrals, applications to area, volume. Convergence of sequences and series, power series. Partial Derivatives, gradient and directional derivatives, chain rule, maxima and minima, Lagrange multipliers. Double and Triple integration, Jacobians and change of variables formula. Parametrization of curves and surfaces, vector Fields, line and surface integrals. Divergence and curl, Theorems of Green, Gauss, and Stokes.

## **Linear Algebra**

Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations. Algebra of matrices, rank and determinant of matrices, linear equations. Eigenvalues and eigenvectors, Cayley Hamilton theorem. Matrix representation of linear transformations, change of basis. Inner product spaces, orthonormal basis, quadratic forms.

## **Ordinary Differential Equations (ODEs)**

Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs. General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem.

## **Numerical Analysis**

Numerical solutions of algebraic equations, Method of iteration and Newton-Raphson method, Rate of convergence, Solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration, Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods. Numerical Linear Algebra: Fundamentals of matrix theory; least squares problems; computer arithmetic, conditioning and stability; direct and iterative methods for linear systems; eigenvalue problems.

## **Probability and Statistics**

Basics of probability including conditional probabilities, Bayes Rule; basic idea of random variables (univariate and multivariate); expectation, variance, conditional expectations, covariances and correlations; various discrete distributions such as binomial, geometric, negative binomial, Poisson, hypergeometric; various continuous distributions such as the Normal, Beta, Gamma; estimation theory; hypothesis tests; confidence intervals; goodness-of-fit tests; correlation and linear regression; analysis of variance.