

# INDIAN INSTITUTE OF TECHNOLOGY DHARWAD

## Department of Physics

### Ph.D. Admissions Brochure

Autumn - 2018

#### Eligibility Criterion:

1. M. Sc. or equivalent degree in Physics.
2. B. Tech./B. E. or equivalent degree in Engineering Physics, Electrical Engineering, Mechanical Engineering, and Computer Science.
3. For General/OBC category candidates and/or for candidates where no concession in academic performance is called for, the eligibility criteria in the qualifying degree is **First Class**, 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:
  - a minimum of 60% marks (without round off) in aggregate. (OR)
  - 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).
4. For SC/ST/PwD category candidates, a relaxation of 5% in the qualifying degree is applicable.
5. The candidates MUST also fulfill ONE of the following additional requirements:
  - Valid GATE Score.
  - Junior Research Fellowship (JRF) of CSIR/UGC/DST INSPIRE or any other funding agencies.
  - M. Phil in Physics or M. Tech./M. E. or equivalent degree in Engineering Physics, Electrical Engineering, Mechanical Engineering, and Computer Science.

#### Research Topics:

- Quantum Information Theory (QIT).
- Interface of QIT with Quantum Optics and Many Body Physics.
- Quantum Communications and Quantum Cryptography.

**Important dates:**

Last date for filing online applications	: 01-06-2018
Announcement of shortlisted candidates	: 04-06-2018
Screening test and interview	: 29-06-2018
Announcement of results	: 05-07-2018
Registration	: 20-07-2018

**Selection Process:**

The following are the important guidelines for the shortlisted candidates for the screening test and interview:

1. Shortlisted candidates should report at the Institute before 8:30 AM on June 29, 2018 for the screening test.
2. No accommodation will be provided/arranged for the candidates participating in the screening test/interview.
3. Candidates should bring their below listed documents, if related to them:
  - Printed copy of the online submitted application form,
  - Proof of payment of application fee,
  - 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/DST INSPIRE fellowship or any other funding agencies.
  - Valid GATE score,
  - Caste certificate,
  - Income certificate, and
  - Scientific calculator.

**Do Not's**

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

### **Screening Test and Interview:**

- Schedule for screening test and interview:

Screening test & Interview	Proposed Date of Screening Test	: <b>29-06-2018</b>
	Duration & Proposed Timings of Screening Test	: 90 min (9:00 to 10:30 AM)
	Total Marks for the Screening Test	: 50
	Proposed Dates for Interview	: <b>29-06-2018</b>
	Proposed Timings of Interview	: 12:00 PM onwards
	Total Marks for the Interview	: 50

- The selection process consists of one and half hour Multiple Choice Questions (MCQ) type screening test. The syllabus for the screening test is given below.
- For MCQ questions, +3 marks for correct answers and -1 mark for wrong answers.
- Only highest scored 10 candidates, per seat, will be called for the interview.
- For final selections, 50% from screening test and 50% from the interview will be considered for cut-off.
- **Document Verification:** Only for candidates short-listed for interview. Certificate required are like
  - Printed copy of the online submitted application form,
  - Proof of payment of application fee,
  - 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/DST INSPIRE fellowship or any other funding agencies.
  - Valid GATE score,
  - Caste certificate,
  - Income certificate, etc.

### **Application Categories and Financial Support**

The Department of Physics 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, DST INSPIRE, etc. and some other organizations. The admission procedure and other requirements are same as applicable to TA.

#### **Syllabus:**

##### *Mathematical Methods of Physics*

Dimensional analysis. Vector algebra and vector calculus. Linear algebra, matrices, Cayley-Hamilton Theorem. Eigenvalues and eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Bessel, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem.

Green's function. Partial differential equations (Laplace, wave and heat equations in two and three dimensions). Elements of computational techniques: root of functions, interpolation, extrapolation, integration by trapezoid and Simpson's rule, Solution of first order differential equation using Runge-Kutta method. Finite difference methods. Tensors. Introductory group theory: SU(2), O(3).

##### *Classical Mechanics*

Newton's laws. Dynamical systems, Phase space dynamics, stability analysis. Central force

motions. Two body Collisions – scattering in laboratory and Centre of mass frames. Rigid body dynamics- moment of inertia tensor. Non-inertial frames and pseudoforces. Variational principle. Generalized coordinates. Lagrangian and Hamiltonian formalism and equations of motion. Conservation laws and cyclic coordinates. Periodic motion: small oscillations, normal modes. Special theory of relativity- Lorentz transformations, relativistic kinematics and mass–energy equivalence.

Dynamical systems, Phase space dynamics, stability analysis. Poisson brackets and canonical transformations. Symmetry, invariance and Noether's theorem. Hamilton- Jacobi theory.

### *Quantum Mechanics*

Wave-particle duality. Schrodinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box, harmonic oscillator, etc.). Tunneling through a barrier. Wave-function in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Dirac notation for state vectors. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time-independent perturbation theory and applications. Variational method. Time dependent perturbation theory and Fermi's golden rule, selection rules. Identical particles, Pauli exclusion principle, spin-statistics connection.

Spin-orbit coupling, fine structure. WKB approximation. Elementary theory of scattering: phase shifts, partial waves, Born approximation. Relativistic quantum mechanics: Klein-Gordon and Dirac equations. Semi-classical theory of radiation.

### *Electromagnetic Theory*

Electrostatics: Gauss's law and its applications, Laplace and Poisson equations, boundary value problems. Magnetostatics: Biot-Savart law, Ampere's theorem. Electromagnetic induction. Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces. Scalar and vector potentials, gauge invariance. Electromagnetic waves in free space. Dielectrics and conductors. Reflection and refraction, polarization, Fresnel's law, interference, coherence, and diffraction. Dynamics of charged particles in static and uniform electromagnetic fields.

Dispersion relations in plasma. Lorentz invariance of Maxwell's equation. Transmission lines and wave guides. Radiation- from moving charges and dipoles and retarded potentials.

### *Atomic & Molecular Physics*

Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. Relativistic corrections for energy levels of hydrogen atom, hyperfine structure and isotopic shift, width of spectrum lines, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle. Born-Oppenheimer approximation. Electronic, rotational, vibrational and Raman spectra of diatomic molecules, selection rules. Lasers: spontaneous and stimulated emission, Einstein A & B coefficients. Optical pumping, population inversion, rate equation. Modes of resonators and coherence length.

### *Thermodynamic and Statistical Physics*

Laws of thermodynamics and their consequences. Thermodynamic potentials, Maxwell relations, chemical potential, phase equilibria. Phase space, micro- and macro-states. Micro-canonical, canonical and grand- canonical ensembles and partition functions. Free energy and its connection with thermodynamic quantities. Classical and quantum statistics. Ideal Bose and Fermi gases. Principle of detailed balance. Blackbody radiation and Planck's distribution law.

First- and second-order phase transitions. Diamagnetism, paramagnetism, and ferromagnetism. Ising model. Bose-Einstein condensation. Diffusion equation. Random walk and Brownian motion. Introduction to nonequilibrium processes.

### *Electronics and Experimental Methods*

Semiconductor devices (diodes, junctions, transistors, field effect devices, homo- and hetero-junction devices), device structure, device characteristics, frequency dependence and applications. Opto-electronic devices (solar cells, photo-detectors, LEDs). Operational amplifiers and their applications. Digital techniques and applications (registers, counters, comparators and similar circuits). A/D and D/A converters. Microprocessor and microcontroller basics. Data interpretation and analysis. Precision and accuracy. Error analysis, propagation of errors. Least squares fitting,

Linear and nonlinear curve fitting, chi-square test. Transducers (temperature, pressure/vacuum, magnetic fields, vibration, optical, and particle detectors). Measurement and control. Signal conditioning and recovery. Impedance matching, amplification (Op-amp based, instrumentation amp, feedback), filtering and noise reduction, shielding and grounding. Fourier transforms, lock-in detector, box-car integrator, modulation techniques. High frequency devices (including generators and detectors).

### *Condensed Matter Physics*

Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Bonding of solids. Elastic properties, phonons, lattice specific heat. Free electron theory and electronic specific heat. Response and relaxation phenomena. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Josephson junctions. Superfluidity. Defects and dislocations. Ordered phases of matter: translational and orientational order, kinds of liquid crystalline order. Quasi crystals.

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