

# **Indian Institute of Space Science and Technology**

**Thiruvananthapuram – 695547, INDIA**



**Ph.D. Admissions July 2020**

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## **INFORMATION BROCHURE**

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# Vision

*To be a world class educational and research institution contributing significantly to the Space endeavours.*

# Mission

- ☆ *Create a unique learning environment enriched by the challenges of the Space Programme.*
- ☆ *Nurture the spirit of innovation and creativity.*
- ☆ *Establish Centres of Excellence in niche areas.*
- ☆ *Provide ethical and value based education.*
- ☆ *Promote activities to address societal needs.*
- ☆ *Network with national and international institutions of repute.*







**Dr. B. N. Suresh**

Chancellor



**Dr. K. Sivan**

President, IIST Governing Body  
Chairman, IIST Governing Council  
Secretary, DoS /Chairman, ISRO



**Dr. Vinay Kumar Dadhwal**

Director &  
Chairman, Board of Management



**Prof. Y V N Krishna Murthy**

Senior Professor & Registrar



**Prof. A. Chandrasekar**

Dean (Academic & Continuing Education)



**Prof. Raju K. George**

Dean (Research & Development, IPR)



**Prof. Kuruvilla Joseph**

Dean (Student Activities, Student Welfare &  
Outreach Programme)



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# 1. 1. INSTITUTE AND RESEARCH FOCUS

Indian Institute of Space Science and Technology (IIST), situated at Thiruvananthapuram is a Deemed to be University under Section 3 of the UGC Act 1956. IIST functions as an autonomous body under the Department of Space, Government of India. The institute is the first of its kind in the country, to offer high quality education at the undergraduate, graduate, doctoral and post-doctoral levels on areas with special focus to space sciences, space technology and space applications. Equipped with excellent infrastructure and about 100 highly qualified faculty members, IIST has, within a decade of its inception, risen to great heights. It was ranked among the top 30 Engineering institutes of the country according to 2019 NIRF rankings of MHRD with a high score of more than 75% in Teaching, Learning and Resources; a score much better than many premier institutes in the country. The institute currently offers three undergraduate and fifteen postgraduate programmes apart from the Ph.D programme.

Research forms a significant part of the goals envisaged for this premier and unique institute. The main aim is to seamlessly integrate research and development with academics and encourage faculty members to carry on research in their respective areas of interest. Research in IIST is built on the foundations of various academic programmes run by the Departments of Aerospace Engineering, Avionics, Chemistry, Earth and Space Sciences, Humanities, Mathematics and Physics. The major theme of our research portfolio is the application of cutting - edge science to forge new technologies. The institute has set up state-of-the-art facilities in all departments to support its research activities. The Institute is focused on strong interdisciplinary and collaborative work both within the various departments and across the various centres of ISRO, which will help to create the next generation technologies that would address the needs of local, national and global requirements. IIST also appreciates the importance of research collaborations with reputed national/international academic and research organizations.

Ph.D programme in IIST commenced in the year 2010 with an objective to train and groom high quality manpower to support basic and applied research in science and technology to meet the R&D requirement of the country and Indian Space Programme in specific. Admission to Ph.D programme takes place in two sessions every year (January and July) and selection is through national level eligibility test (a valid UGC-CSIR-NET-JRF/Lectureship/fellowship or NBHM/JEST/GATE or screening test conducted by IIST) and an interview. Sixty nine Scholars have been awarded Ph.D degree so far and two hundred and five scholars are currently progressing with their doctoral research.

**Research Council (RC)** which is chaired by Dean (R & D) is a body that promotes and nurtures research activities and oversees research progress and other academic matters of the research

scholars. RC while ensuring that the requirements and research challenges of space science and space technology are duly met also reviews the rules and regulations periodically and recommends amendments, if any, to the Director, IIST.

### 1.1. IIST AT A GLANCE

<b>Strength of Departments</b>		
<b>Department</b>	<b>Faculty members</b>	<b>Scientific/Technical Staff</b>
Aerospace Engineering	25	19
Avionics	23	8
Chemistry	8	4
Earth and Space Sciences	14	3
Humanities	5	0
Mathematics	11	3
Physics	13	8

<b>Ph.D. Enrollment (2010-2020)</b>		
<b>Department</b>	<b>Completed</b>	<b>Ongoing</b>
Aerospace Engineering	12	46
Avionics	12	52
Chemistry	20	20
Earth and Space Sciences	12	29
Humanities	6	10
Mathematics	9	17
Physics	13	31

<b>Postgraduate Enrollment (2010 – 2019)</b>	
<b>Department</b>	<b>Total no. of students enrolled</b>
Aerospace Engineering	158
Avionics	206
Chemistry	59
Earth and Space Sciences	105
Mathematics	57
Physics	66
<b>Total</b>	<b>651</b>

<b>Undergraduate Enrollment (2007 – 2019)</b>	
<b>Course</b>	<b>Total no. of students enrolled</b>
B.Tech. in Aerospace Engineering	743
B.Tech. in Electronics & Communication Engineering (Avionics)	786
B.Tech.* in Engineering Physics (Dual Degree)	347
<b>Total</b>	<b>1876</b>

## **1.2. RESEARCH AT IIST**

Knowledge creation, in all forms do have the ultimate objective of creating Intellectual property, where the research findings turn out to speak of something hitherto unknown. Research, can be envisaged as a conscious movement from the known to the unknown. Where the benefits of research lead to improved quality of life, it culminates into WISDOM. As far as research in Space Sciences and Technology is concerned all of the institute's research efforts are targeted towards careful observations, theoretical hypothesis, computer simulation, validation and planned experimentation.

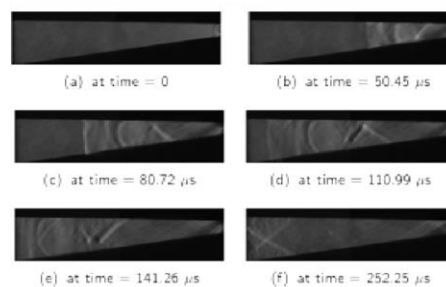
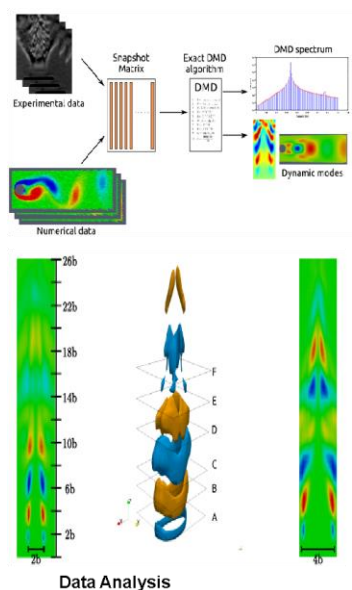
Backed by strong foundation in basic sciences, research in IIST aims to support the nation's pursuit to develop technologies for earth observation, communication, navigation, management of natural resources and space based applications for societal development. Research infra-structure in Space science and Technology and allied areas requires a composite blend of observatory capabilities, data capturing, analytics and state of the art experimental facilities.

IIST has established excellent computational and laboratory facilities to support the research activities in the various specialized areas of Space Sciences and Technology. Research at IIST is a result of fusion of innovative ideas provided by the various departments acting as specialized research centers. An overview of the research activities is presented here.

## Department of Aerospace Engineering

The major research areas in the Department of Aerospace Engineering are briefly highlighted here. There are major research collaborations that are presently ongoing with VSSC, LPSC and other ISRO Centres.

- Aerodynamics and Flight Mechanics:** The research area is mainly focused on unsteady gas dynamics-shock tube experiments, quantitative diagnostics for high temperature flows, hypersonic aerothermodynamics, aeroacoustic flow instability, multi-disciplinary design optimization of aerospace vehicles, lunar/interplanetary mission design and low thrust transfers, transition prediction at high speeds, mixing and self-excited oscillations in supercritical flows and real time and off-line parameter estimation.

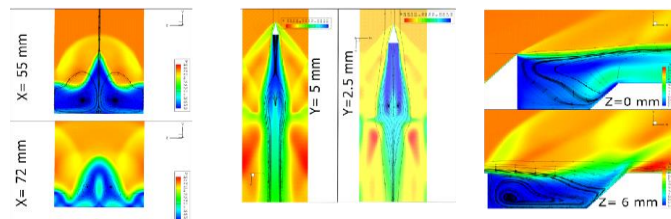


Starting process in a supersonic nozzle

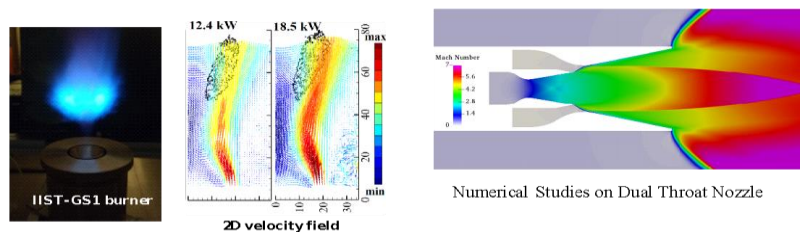




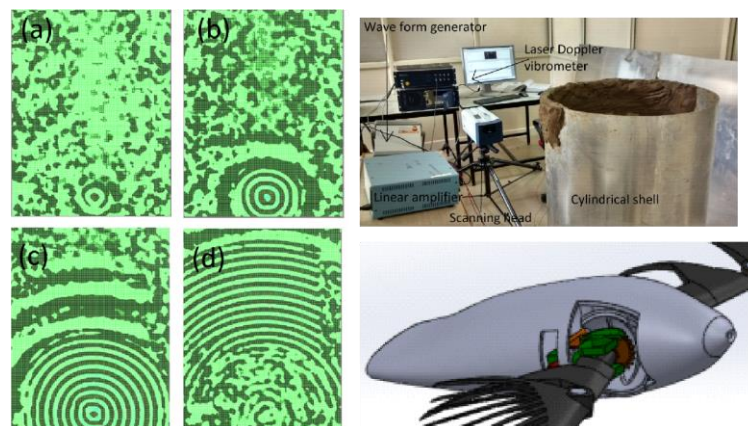
- Thermal and Propulsion:** The research focus is mainly on rocket injector sprays, laminar and premixed combustion, supersonic cavity flows and mixing, laser diagnostics for high speed flows, combustion and rocket sprays, supercritical jet studies at high pressure and temperature, simulation of turbulent reacting flows, reactive heat flow simulations, supersonic combustion modelling, two-phase flow and heat transfer in electronic cooling and film cooling in liquid rocket engines.



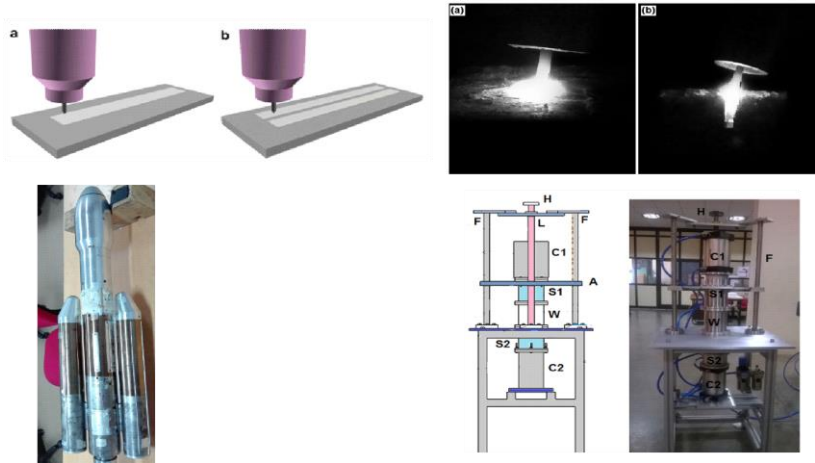
Stream traces and Mach number comparison at different location inside the cavity, without fuel injection - CFD Simulations



- Aerospace Structures and Design:** The research areas involve dynamics of rigid body systems, optimal design, automatic control, robotics, computational structural mechanics, mesh free methods, stochastic mechanics, rover design for lunar mission, finite element analysis of structures, molecular dynamics simulation features of bio composites, damage detection in composite and isotropic materials using time reversed lamb waves and structural dynamics, nonlinear dynamics and vibrations.



- **Materials, Manufacturing and Industrial Engineering:** Major research work involves welding of aerospace materials, micro/nano finishing of engineering surfaces, machining of aerospace materials, metal forming, industrial engineering and optimization techniques in manufacturing.



## Department of Avionics

The Department of Avionics offers Ph.D. programme in various disciplines of Avionics/Electrical/Computer Science Engineering. The department houses excellent faculty members with proven research background in disciplines such as Analog Circuits, Digital System Design, Communication Engineering, Signal Processing, RF and Microwave Engineering, VLSI Design, Navigation, Control and Guidance, Computer Technology and Power Electronics. The department has established various laboratories where research and experiments are undertaken.

The department envisages to undertake futuristic research in areas related to Electronics and Space Science and Technology. The department is endowed with excellent research facilities comparable with the best in the world, which helps researchers achieve excellence in the field of electronics and in particular, in the area of Space Science and Technology.

The department has an ambitious plan of setting up state of the art center of excellence in the areas of Electronics, Communication and Electrical Engineering for which the following research laboratories with world-class facilities and infrastructure is very rapidly coming up: Virtual Reality and 3D Image Processing, Control Systems, Smart Sensors and Networking, Microwave Circuits and Antennas, Power Electronics, Advanced Communication, Digital Signal Processing, Virtual Instrumentation and Smart Systems, VLSI Design, Micro-Nano Electronics, Micro-Electro-Mechanical Systems and Robotics.

The existing research facilities include

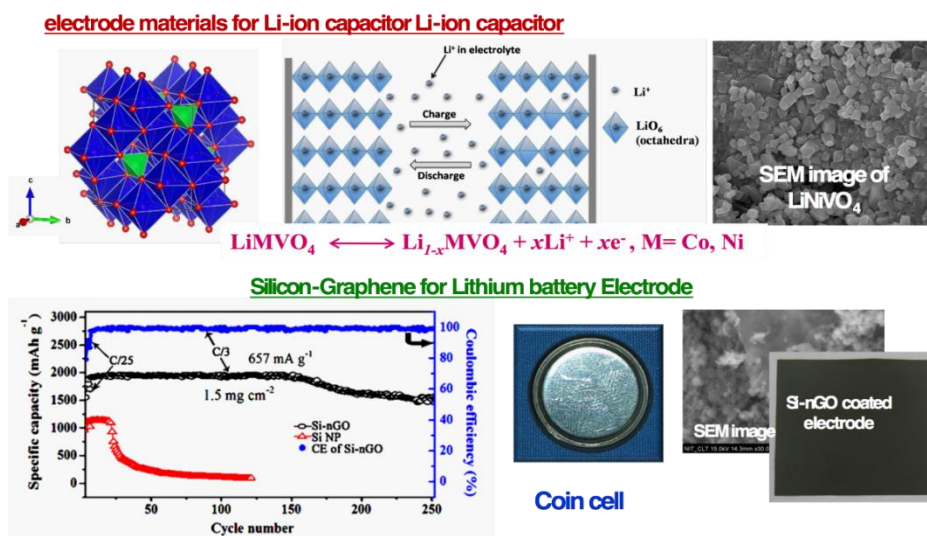
1. Computer vision and Virtual Reality Lab
2. Power Electronics Lab
3. RF and MW lab
4. Advanced communication Lab

The department has active ongoing research collaborations with IISc Bangalore, IIT Bombay, IIT Madras, IIT Kharagpur etc.

## Department of Chemistry

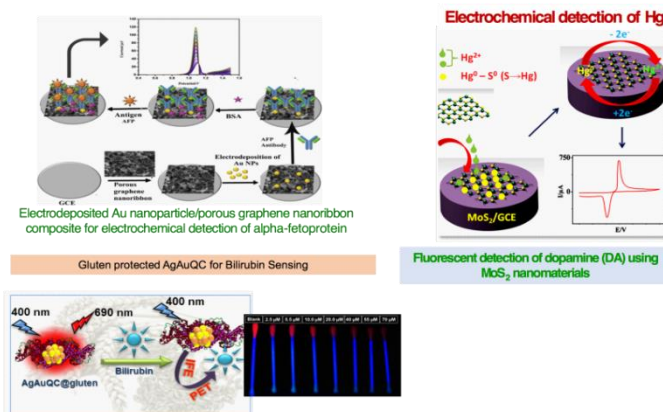
Department of Chemistry is actively involved in knowledge-based advanced research to develop molecules, materials, and prototype systems in the areas of energy, sensors, and space science. The department has successfully completed several research projects and presently has various ongoing research projects funded by ISRO, DST, DBT, DRDO, KSCSTE, etc. The core area of research includes the following themes:

- **Materials for energy applications:** State-of-the-art electrochemical energy storage systems, such as batteries and super-capacitors, are receiving more attention since they can efficiently store energy and synchronously work as power sources. The department is grappling with rational selection and development of materials for efficient and futuristic electrochemical energy storage systems, fabrication of cells, followed by their electrochemical evaluation. Focused research on (nano) materials for various applications, which are futuristic, are currently underway: giving emphasis to green and sustainable development for both materials and the technology involved.





- Chemical sensors:** Chemical sensors for the detection of relevant analytes are attractive in terms of their applicability in environmental and biological studies. Faculty members have developed various nanomaterials and nanostructures with novel functionalities and innovative properties at the nanoscale with high-performance chemical sensing. Nanomaterial-based chemical sensors include a wide variety of candidates, such as fluorescent nanoparticles, plasmonic nanoparticles, nano-electrochemical systems, etc. Some of the examples include Au and Ag quantum dots, carbon dots, 2D layered materials, functionalized carbon nanotubes (CNTs), CdTe quantum dots, carbon-nickel hybrid nanomaterials and gold electrodeposited porous graphene. Also, development of implantable nanoscale biosensors integrating nanotechnology, electronics and biology are underway. The department is keenly looking forward to the fabrication of portable electrochemical electrodes/sensors.



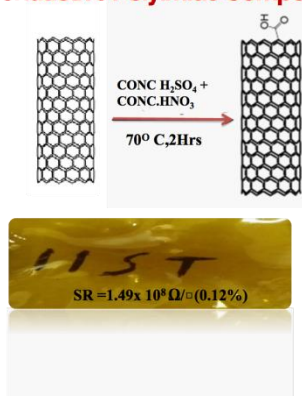
- High temperature materials:** The development of materials that can withstand very high temperatures and the associated engineering that results in dense/porous components is of utmost importance to the aerospace and defence sector. The faculty members of the department of chemistry are actively engaged in the development of novel processing technologies for low density ceramic and carbon foams to achieve very low thermal conductivity with adequate mechanical strength to utilize them in thermal protection systems and EMI shielding. The focus is on using bio-waste and naturally renewable materials of plant origin as a precursor for the development of carbon foams to achieve the goal of sustainable development.



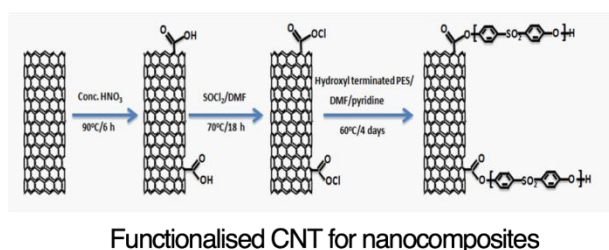
*Carbon foam developed from waste newspaper exposed to oxyacetylene flame*

- Polymer Composites:** The research focus involves various contemporary areas of polymer chemistry and polymer composites. The materials of interest include polymer nanocomposites, toughening of composites for structural applications, surface engineering of nanofillers, polymer blends, bio nanocomposites, latex based nanocomposites, etc. Preparation of efficient EMI shielding materials based on polymer composites is an active research theme.

#### Transparent and Electrically Conductive Polyimide Composites

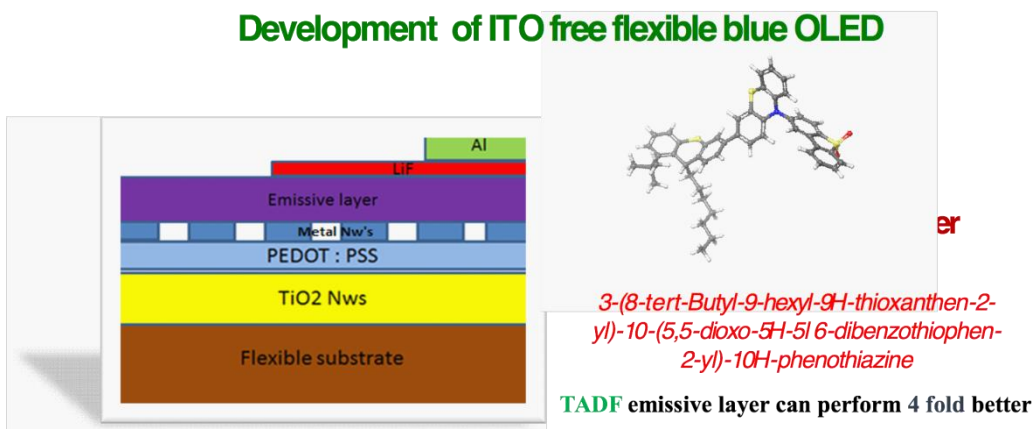


#### Toughened Epoxy- Nanocomposites based on Surface Engineered Nanofillers



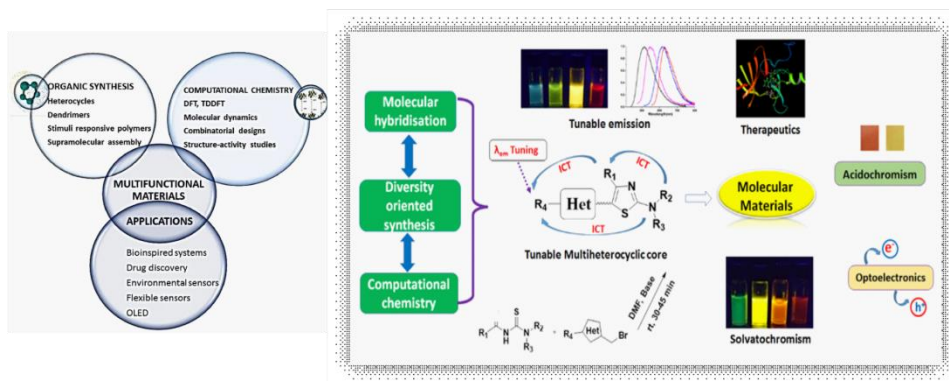
- Organic electronics:** The faculty of the department are also engaged in the area of organic electronics, and have attempted to develop a theoretical model to tune mobility of hole transport materials and emissive materials to enhance the performance of solid state devices. Algorithms for efficient blue thermally activated delayed fluorescence polymer design have also been developed, while the research work on synthesis and fabrication of TADF polymer is in progress.

#### Development of ITO free flexible blue OLED



- Organic Molecules and Functional Materials:** The research in this field of study is about the structural complexities and functional capabilities embraced by organic compounds. The research spans from the atom level picking of units to have molecules designed on computers (de novo approach), developing synthetic strategies, optimizations of synthetic routes and practice of organic synthesis. From drug discovery to development of smart materials for electronic and

optical applications, the concepts of molecular hybridization are applied in the combinatorial design of customized fragments for multifunctional materials and systems.



- **Space biology:** Being located in an academic environment with an emphasis on Space Science and Technology, the department also contributes markedly to the ongoing as well as futuristic space missions. Currently, the group is involved in a space biology payload development for India's first human spaceflight, Gaganyaan with pilot studies for several other spaceflight experiments also being undertaken.

### Major Research facilities

Atomic Force Microscope, ESI Q-ToF Mass Spectrometer, HPLC, Electrospinning machine, Planetary ball mill, Particle size analyser, Glove box, Hot stage polarised microscope, Brabender plasticoder, IR, UV-vis, and Fluorescence spectrometers, TGA, DSC, DMA, GPC, Surface area analyser, Goniometer, Microcompounder, Universal Testing Machine, High Temperature furnaces, Rheometer, Solar simulator, Polarized light microscope, Electrochemical workstation, Battery fabrication and testing facility etc.

## Department of Earth and Space Sciences

The research activities of the Department of Earth and Space Sciences encompass multidisciplinary research areas. The broad research areas are indicated below:

- Astronomy and Astrophysics
- Atmospheric and Ocean Science
- Geology
- Remote Sensing
- **Astronomy and Astrophysics:** Current research activities include multi-wavelength (UV, optical, infrared, millimeter and radio) observations of galactic massive star forming regions, physics of inter-stellar medium, astrophysical masers, multi-wavelength observations of pulsating variable stars, study of accretion physics around compact objects, spectroscopic studies of the intergalactic



medium and galaxy halos, relativistic stellar explosions, and electromagnetic counterparts to gravitational wave events.

- **Atmospheric and Ocean Science:** Current research activities include numerical modeling of the atmosphere as well as measurement and analysis of atmospheric data, mesoscale model, monsoon climate studies, climate modelling, mesoscale modelling, data assimilation, aerosols and climate change, radiation and climate change, atmospheric boundary layer, Air-Sea interaction, Boundary Layer Meteorology, Aerosol-Cloud-Solar radiation-Climate interaction, Radiative forcing, Satellite Remote Sensing, Data assimilation and Mesoscale modelling, Numerical Modeling of Weather systems and Land-atmosphere modeling.
- **Geology:** Current research activities include Planetary Geosciences, Terrestrial Analogues to Mars and the Moon, Crust-Mantle dynamics and interaction processes, behavior of trace and rare-earth elements in igneous and metamorphic systems. Tectonics of East Gondwanaland, Chromite genesis in ultramafic-mafic rocks; Diverse spinels compositions on Earth and Moon, mineral deposits associated with ultramafic rocks, Fluid inclusions; stable and radioactive isotopes in igneous petrogenesis, Geochronology
- **Remote Sensing:** Current research activities include processing and analyzing hyperspectral, multispectral, and LiDAR remote sensing data, big geospatial data analytics, spatial data analysis and modelling, segmentation, classification, clustering, dimensionality reduction, spectral knowledge transfer, parallel processing, multiple classifier systems, spectral matching methods etc. 3D point cloud processing using machine learning techniques, 3D semantic labelling, 3D registration, City GML and spatial DBMS. **Primary Applications:** agriculture, forestry and natural vegetation, coastal zone and mangroves, hydrology and coastal hydrodynamics, urban modelling, industrial applications of hyperspectral imaging, 3D cultural heritage and archaeological structures mapping.

### **Research facilities**

1. Standard meteorological instruments to monitor wind speed and wind direction, air temperature, relative humidity, pressure, rainfall, soil temperature and moisture
2. Planetary Boundary Layer Laboratory with a wide variety of field instrumentation
3. Ponmudi Climate Observatory (PCO) houses state-of-the-art instrumentation for the measurement of greenhouse gases, aerosol optical, physical properties and cloud microphysics along with radiation and meteorological parameters.
4. Regular weather balloon launches (monthly once) from PCO for measurement of vertical profile of ozone along with meteorological parameters up to 35 km.

5. Advanced Petrological Microscopes to study the optical properties of rocks and minerals
6. Trinocular Stereo zoom microscope for observation and imaging of mineral grains, heavy minerals etc.
7. Mineralogical and petrological softwares like IGPET, PETROPLOT, THERMOCAL, TWQ etc
8. A LINKAM heating and freezing stage for optical and fluid inclusion studies of minerals and rocks.
9. Facilities for planetary data processing and analyses including softwares such as ENVI, ArcMap, MATLAB, OriginPro, and Corel Draw
10. DST Sponsored Central Facility for Hyperspectral Remote Sensing for Southern Region: Equipped with Hyperspectral spectro-radiometer (400 - 2500nm), Hyperspectral imaging spectro-radiometer (400 - 1000nm), Plant canopy analyser, Chlorophyll concentration meter, Quantum sensor and Laser distance meter (Leica Disto S-910), LAI meter
11. FARO s350 Terrestrial Laser Scanner
12. Differential GPS
13. Advanced Image Processing, Photogrammetry and GIS software – Envi, ERDAS, LPS, ARCGIS, ecognition
14. Collection of multispectral, hyperspectral images from Indian and international remote sensing satellite and airborne platforms at various resolutions.

### **Research collaborations**

ISRO centers, Tata Institute of Fundamental Research, Mumbai, National Centre for Radio Astrophysics (NCRA), Pune, PRL, IISER-Tirupati, Aryabhata Research Institute of Observational Sciences, IIA, Indian Institute of Science, Bangalore, Physical Research Laboratory (PRL), Ahmedabad, Centre for Earth Sciences (CESS), Indian Institute of Science (IISc), Bangalore, National Centre for Earth Science Studies (NCESS), Thiruvananthapuram, U.R. Rao Satellite Centre (URSC), Bangalore, Aryabhata Research Institute of Observational Sciences, Nainital, Chennai Mathematical Institute, CMI, Chennai, SAG, and IIT Guwahati, University of Agriculture, Bangalore, MSSRF, Mangrove Foundation, University of Southampton, Pennsylvania State University, USA, University of Wisconsin-Madison, USA, UKIRT Observatory-UK, Harvard-Smithsonian Centre for Astrophysics, Massachusetts, USA, Institute for Astronomy, Universidad Nacional Autonoma de Mexico (UNAM), Morella, Mexico, Key Laboratory for Research in Galaxies and Cosmology, Shanghai Astronomical Observatory-China, Korea Astronomy and Space Science Institute-Korea, Instituto Argentino de Radioastronomía CONICET, Buenos Aires,

Argentina, Niigata University, Japan, Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan, Centre de Recherches Pétrographiques et Géochimiques (CRPG) - CNRS/ Université de Lorraine, FRANCE, University of Tokyo, Purdue University, Dept. of Physics and Astronomy, University of Nevada, Las Vegas, USA., Instituto de Astrofísica de Andalucía, Granada, Spain, Max Planck Institute of Radio Astronomy, Bonn.

### **National/ international awards and commendable achievements by Ph.D scholars**

1. The thesis titled 'IRDCs to Star Clusters: In Depth Study of the Structure, Evolution and Kinematics of Few Southern Massive Star Forming Regions' by Dr Veena VS received the K. D. Abhayankar Best Thesis Award for the year 2018 by the Astronomical Society of India (ASI). Dr. Veena was also awarded the Humbolt post-doctoral fellowship in 2018 by the Alexander von Humbolt Foundation to carry out research at the University of Cologne, Germany.
2. Dr Arun Prasad Kumar Green Talents 2015 Young Scientist Award by the Federal Ministry for Education and Research, Government of Germany.

## **Department of Humanities**

Department of Humanities, IIST offers PhD program in four different disciplines - Economics, English, Management and Sociology. The department, in tune with the vision of the institute offers research in diverse areas so as to facilitate a constant dialogue between effectiveness of technology and the needs of society and humanity. Research in Humanities, Social Sciences and Management values scholarly independence, depth and diversity and aspires at refining methodology and practices for the integration of society into space research activities, which will further lead to the production of new knowledge and improved understanding of societal aspects of space science and technology.

The department, offers research in a broad spectrum of interdisciplinary areas such as Technology and Economic development, Space Economics, Indian Economics, Globalization issues, Macro Economics, Travel Writing, Black and Native American Literature, Gender Studies, Cultural Studies, Logistics and Supply Chain Management, Technology management, Impact of technological innovation on Individuals and Societies in past and present, ICT and Society, Study of Marginalized Communities etc.

Currently, the department has a total enrolment of 16 students with 7 full time and 3 part time students pursuing their PhD course, while 6 students have already completed their PhD degree. The department has over the years produced students with outstanding academic training, both in



teaching and research, and are presently well placed in institutes of teaching /research of repute within the country.

### **Commendable achievements by Ph.D scholars**

The thesis titled ‘Social Construction of Empowerment - A Study on the Impact of Government ICT Programmes Amongst Women in Kerala’ by Dr. Rashmi M was adjudged as Best thesis by Kerala Sociological Society in 2017.

The thesis titled ‘Study of Select Issues of Resilient Supply Chains’ by Dr. Rajesh R was recognized as third in top five researchers in India in the area of Supply Chain Management based on the number of publications.

## **Department of Mathematics**

Department of Mathematics actively pursues research in different disciplines of Mathematics. The main research areas include:

- **Differential Geometry and it's aapplications:**

- i. Information geometry
- ii. Classification of Integrable Hamiltonian systems

- **Machine Learning:**

Development of theoretical frame work for Machine Learning algorithms and its application to real world problems

- **Dynamical systems:**

- i. Study of properties of oscillations of oblate and prolate spheroids in an unsteady viscous fluid driven by a periodic force and its effect on the rheological properties
- ii. Study of time series analysis of naturally occurring data

- **Control and stability analysis of deterministic and stochastic partial differential equations:**

The research focus is on the ergodic properties and optimal flow control problems associated with the fluid dynamic models described by various generalizations of Navier-Stokes equations, Burger's equation, and the models with random forces. Research areas also includes the parameter identification problems described by Cahn-Hilliard type systems and other related nonlinear systems.

- **Commutative Algebra and Affine Algebraic Geometry:**

Research is mainly directed in the areas of Affine Algebraic Geometry, specifically Affine fibrations, Epimorphism problems, Cancellation problems, Locally nilpotent derivation, and allied areas and  $A^2$ -fibrations endowed with some specific types of locally nilpotent derivatives.

- **Computational partial differential equations (PDEs):**

In particular, research activity is focused on the development (with emphasis on both theoretical and computational aspects) of numerical techniques such as Finite volume element methods, finite element methods, discontinuous Galerkin methods which are used for obtaining an accurate and robust numerical solution of PDEs occurring in science and engineering with proper initial and boundary conditions. Some of the other recent research work includes discontinuous finite volume approximation of coupled flow-transport problems, immiscible displacement problems, Stokes equations, nonlinear hyperbolic conservation laws, and optimal control problems. A new virtual element formulation for an approximation of semi-linear parabolic and hyperbolic problems is proposed and extended to non-stationary poroelasticity problems.

- **Control Theory:**

Research areas include controllability of fuzzy control systems, Lyapunov Matrix Differential Equations, Impulsive systems etc. Controllability of Delay systems with impulses, Networked systems and Lyapunov systems with delay and impulses, Stability evolution of periodic and quasi-periodic orbits using Poincare surface of section (PSS) in the RTBP and study of planar fly-by trajectories to Moon in the framework of RTBT.

- **Virtual element method :**

The above is a new methodology developed to obtain numerical solutions of partial differential equations over polygonal meshes. Polygonal elements allow flexibility in mesh generation of the domains whereby including hanging nodes and other similar problems that are not allowed in typical finite elements. The challenge in this study is to devise a consistent variational formulation that is VEM computable without losing its convergence properties.

- **Singularly perturbed problems:**

Development (with emphasis on both theoretical and computational aspects) of efficient numerical techniques such as finite difference/finite element methods etc. for solving Partial Differential Equations (PDEs), specifically, singularly perturbed PDEs, is pursued that often arise in several branches of engineering and applied mathematics including fluid dynamics, gas dynamics, heat transfer, semiconductor device modeling, financial modeling, mathematical biology, chemical-reactor theory etc. Some of the current research works include developing and analyzing various

fitted mesh methods for linear and non-linear singularly perturbed PDEs with smooth and non-smooth data, analyzing post-processing technique for system of time-dependent singularly perturbed PDEs on various layer-adapted meshes etc.

- **Modelling and analysis of some communication related queueing problems:**

Faculty have developed models to study the queueing characteristics of nodes in a multihop wireless network that are essential to assess the performance of such systems before they are deployed in real life scenario. Apart from wireless network models, research also focusses on two-way communication models and measures of effectiveness to assess the system performance.

- **Dimension reduction in elasticity:**

Lower dimensional models of elastic/piezoelectric structures are preferred to three dimensional structures when the thickness of the shell is very small and research is underway to obtain the two dimensional approximation for a given three dimensional model.

### **Research Collaborations**

The department has collaborations with Prof. Evsey Morozov and Dr. Alexander Rumyantsev of Karelia research center, Russian Academy of Sciences, Karelia, Russia, with Prof. Ricardo Ruiz-Baier (Currently at Monash University Australia, Prof. Raimund Burger (University of Concepcion, Chile), Ricardo Oyarzua (University of Bio-Bio, Chile), Prof. S.S.Sritharan, Air Force Institute of Technology, Ohio, USA, A.H.Hasanov, Kocaeli University, Turkey, Manil T. Mohan, IIT Roorkee.

## **Department of Physics**

Research conducted in the Department of Physics at IIST covers several important areas of physics. Optics and allied areas and condensed matter physics are two of the most important areas of research undertaken by the faculty. These are supplemented by expertise in other areas in fundamental and applied physics. Some of the research highlights of the physics department faculty are listed in the following.

- **Quantum Dynamics and Quantum Information:**

Dynamics of quantum systems play an important role in quantum information processing and quantum computing. Preliminary research results indicate that there is a strong connection between dynamics of quantum systems and non-classicality of the quantum states. The above research is expanded to include entanglement, squeezing and decoherence to understand more about the relation between dynamics of quantum states and non-classicality and its application to quantum information. There is also research underway that focusses on model quantum systems with time



dependent potential to study the decoherence with an objective of controlling the decay happening due to decoherence.

- **Quantum optics and quantum information:**

Quantum optics and quantum information is one of the fastest growing interdisciplinary subjects due to its potential applications in both basic science and quantum technology. On the one hand, quantum principles allow us to understand the basic phenomena associated with photons, atoms and atom-photon interactions, while on the other hand, state-of-the-art quantum technologies are finding wide range of applications in quantum computation, quantum communication, quantum sensing, quantum metrology, to name a few. The underlying principle of quantum technologies is based on the subtle nonlocal correlation among the parts of a quantum system that has no classical analog, called entanglement. Work is currently underway on the generation of bright quantum entangled light beams with a non-linear four-wave mixing process obtained via interaction of a laser beam with an atomic medium and there is a plan to use the generated bright entangled light for quantum sensing, quantum metrology, quantum imaging and quantum communication.

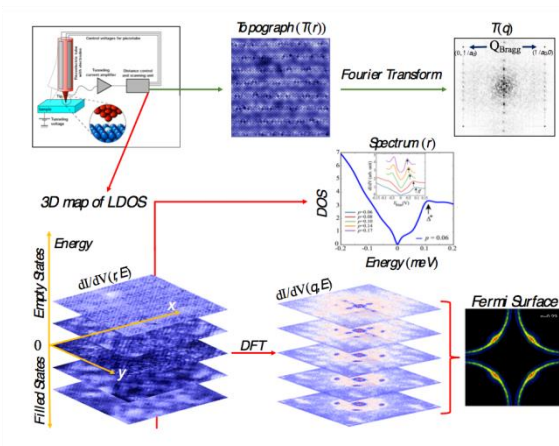
- **Non-equilibrium Statistical Mechanics and Biological Physics.**

Study of steady states and phase transitions in non-equilibrium models. Using statistical mechanics models to understand biological processes. Problems of recent interest: Modeling of ant traffic. Study of effect of long hops and disorder on totally asymmetric exclusion process. Effect of resetting on interacting and non-interacting particle systems.

- **Condensed matter physics:**

Condensed matter physics is the study of emergent behaviour in many particle systems, and one of the main aims is the classification of various phases of matter. Topological phases fall outside the realm of Landau's classification of phases based on symmetry, instead they are distinguished by their topological properties—properties that are impervious to perturbations of the system—such as robust quantum numbers that are protected from decoherence, exotic quasiparticle excitations with nontrivial exchange statistics, and so on. Examples of topological matter include quantum Hall systems, spin liquids and chiral superconductors. The main focus of this research is to theoretically understand properties of the ground state and the emergent excitations in certain topologically ordered systems, such as the Kitaev model and the Su-Schrieffer-Heeger model, using analytical and numerical techniques. Another aspect which is being explored is how topologically ordered systems respond to external driving.

- **Solid state physics:** Atoms coalesce and bind together, their emergent behaviours give rise to new



states of matter. On the quantum scale, the electrons and their strong electromagnetic interactions produce some of the most complex phases containing electron liquids, magnetic lattices, super fluids, electronic glasses, fractional charges, massive particles, topological states etc. These electrons reside on the vicinity of the Fermi surface of those Artificial quantum materials (AQMs). Therefore, probing

interactions of electrons and their elementary excitations, close to the Fermi level, is of fundamental interest to understand electronic properties in strongly correlated electron systems. Using Spectroscopic Imaging Scanning Tunneling Microscopy (SI-STM) and other transport spectroscopic experiments we explore the quantum realm of AQM, identify the underlying interactions leading to their unique phases at the atomic scale and their emergent behavior. SI-STM's unique capability allows it to image directly, the energy resolved electronic local density of states (LDOS, essentially the quantum wave functions of the electrons) in complex quantum matters in both “r-space” and “k-space” with atomic-resolutions (see figure). It reveals directly the impact on atomic-scale electronic structure of processing, dopant profiles, crystalline disorder, and electronic/magnetic phase transitions due to external controlling parameters. Based on the electronic characteristics these new AQM, there are plans to design various electromagnetic sensors for practical applications in space science & technology.

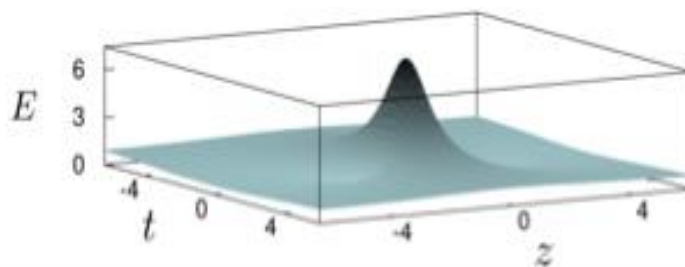
- **Vegetation patterns: What do they tell us?!**

Vegetation over a variety of geographies with adverse environmental conditions are known to display patterns in their growth landscape. Over the years, numerous studies have been put forth to explain the reasons and formation of these observed structures, and their interpretation as symptoms of impending desertification. Research is in progress to understand the phenomenon through a lattice model, and an attempt to explain the resulting criticalities ideas from standpoint of non-linear dynamics and non-equilibrium statistical mechanics.



- **Rogue-breather modes in spin systems:**

A ‘rogue’ wave is marked by a sudden, momentary, yet colossal enhancement in the field amplitude. First witnessed in deep ocean waves, this non-linear phenomenon has gained significance as qualitatively similar behavior is predicted to occur in various other systems, such as optical fibers and BEC. There is investigation currently underway to study the rogue-breather behavior in spin systems, its stability and its quantum interpretation.



## Alumni of IIST

Over the years, the institute has mentored and groomed its’ research scholars who have grown into brilliant academicians, outstanding researchers and successful entrepreneurs. Vertical mobility into high end post doctoral research and entrepreneurial development are the measures of notable growth along with employment. It is indeed a pleasure to note that our research scholars, after completing their Ph.D., are very well placed in institutes/universities/industries of repute within the country and abroad as is evident from their placement data presented below department wise.

Department	PDF		Employed			
	India	abroad	Govt/public sector	Private sector	Faculty position	Self
<b>Aerospace Engineering</b>	1		8		2	1
<b>Avionics</b>	1		6	2	3	
<b>Chemistry</b>	4	1	5	1	8	
<b>Humanities</b>					6	
<b>Earth and Space Sciences</b>	2	3	1		6	
<b>Mathematics</b>	1	2	3	2	1	
<b>Physics</b>	2	4	4	1	2	

## 2. NOTIFICATION- Admission (July 2020)

Applications are invited from highly motivated applicants for admission to the Ph.D. Programme starting in July 2020, in the departments given below:-

- iii. Aerospace Engineering
- iv. Avionics
- v. Chemistry
- vi. Earth and Space Sciences
- vii. Humanities
- viii. Mathematics
- ix. Physics



## **2.1 Ph.D. Programme Categories**

The Ph.D. programme is categorized into two groups:

### **2.1.1 Full time Ph.D. Programme**

In this programme research scholar will pursue research work within the institute or in an identified DoS Centre/Unit on a full-time basis.

Under this Programme, there are three categories based on the funding agency

- a) IIST/DoS Funded
- b) Externally Funded/Sponsored
- c) Project Funded

### **2.1.2 Part Time Ph.D. Programme**

In this programme the research scholar will pursue research work on a part-time basis. Under this programme there are three categories.

#### **a) Internal IIST**

This programme is for employees of IIST, who can be admitted as part time research scholar as per the identified selection procedure.

#### **b) DoS Sponsored**

This programme is for permanent employees of DoS, who can be admitted as part time research scholar as per the identified selection procedure.

#### **c) DoS Sponsored Dual Degree (Masters + Ph.D.)**

This part time Ph.D. programme is for candidates selected for IIST PG Programmes under the DoS sponsored category subject to No Objection from respective ISRO / DoS center/unit for pursuing Ph.D. The sponsored candidates under this category on completion of the minimum requirements of PG Programme shall be permitted to register and undergo Ph.D. course work.

#### **d) Project Funded Programme**

In this category

- i. During the recruitment of the JRF the candidate will be assessed through screening written test cum interview /interview whichever applicable, for the suitability of the Ph.D programme if it is mentioned in the open advertisement for JRF that, the JRF may be considered for registering for Ph.D. at IIST. The

candidate can register immediately or in the beginning of the regular January/July Semester if recommended by the interview panel for Ph.D. admission.

- ii. The JRF under a research project may apply for Ph.D. enrolment if the research project with approved funding is for a minimum period of three years. The applicant will be evaluated by screening test cum interview/interview whichever is applicable, for the suitability of the Ph.D. programme and register immediately or in the beginning of the regular January/July semester if recommended by the selection panel for Ph.D. admission.
- iii. Students joining in the mid of the semester will have to pay the full fee for the applicable semester.

### 3. ELIGIBILITY

- a) **Nationality:** Applicant should be an Indian citizen.
- b) **Age Limit:** Applicant should be below 35 years as on 15.06.2020. Age relaxation is applicable as per Government Rules.

### 4. MINIMUM QUALIFICATIONS:

#### 4.1 Applicants with Master's Degree in Engineering/Technology as their highest qualifying degree

Applicants with Master's Degree in Engineering/Technology must have secured 65% marks or 7.00 CGPA on a scale of 10 or equivalent in the Qualifying Master's degree (60% marks or 6.50 CGPA on a scale of 10 for OBC / EWS, 55% marks or 6.00 CGPA on a scale of 10 for SC/ST/PD). **They must have pursued their Master's degree on the basis of qualified GATE score.** However there is no GATE cut off score for applicants with M.Tech./M.E as the highest qualifying degree, who are applying for Ph.D. in Engineering Discipline. Applicants with Master of Science in Engineering or equivalent from leading foreign Universities with minimum CGPA 8/10 or 3.6 /4 or equivalent can be considered without GATE score.

##### 4.1.1 Selection Procedure

For candidates with M.E/M.Tech. as their highest qualifying degree, selection to the PhD programme will be based on **screening test** followed by an interview. However, candidates with a valid CSIR/NET-JRF or Lectureship/ Assistant Professor post their ME/M.Tech, will be directly called for the interview.

#### **4.2. Applicants with Master's Degree in Science as their highest qualifying degree**

Applicants must have Master's Degree in the relevant area with a minimum of 65% marks or 7.00 CGPA on a scale of 10 or equivalent in the Qualifying Master's degree (60% marks or 6.50 CGPA on a scale of 10 for OBC/ EWS, 55% marks or 6.00 CGPA on a scale of 10 for SC/ST/PD). They must have cleared a National level eligibility test, such as a valid **UGC-CSIR-NET-JRF/fellowship /Lectureship/Assistant Professor or NBHM/JEST/GATE.**

##### **4.2.1 Selection Procedure:**

For candidates applying with their Master's degree in Sciences as their qualifying degree and having a valid score card/certificate in any of the National level eligibility tests listed above, **selection to the programme will be based on an interview.** Applicants applying with their JEST score should have secured a rank within the first 300. Candidates applying with a valid GATE score in a Science discipline, having a minimum score of 500 for General Category (450 for OBC / EWS and 350 for SC/ST/PD categories), are exempted from the screening test conducted by IIST. Applicants having GATE score in Science disciplines less than indicated cut-off above will not be considered for Ph.D. Admission.

#### **4.3. Applicants with Master's Degree in Humanities/Management/Social Sciences as their highest qualifying degree**

Applicants must have Master's Degree in the relevant area of Humanities/Management / Social Sciences with a minimum of 65% marks or 7.00 CGPA on a scale of 10 or equivalent in the Qualifying Master's degree (60% marks or 6.50 CGPA on a scale of 10 for OBC / EWS, 55% marks or 6.00 CGPA on a scale of 10 for SC/ST/PD). They must have cleared a national level eligibility test, such as a valid UGC-NET-JRF fellowship/Lectureship/Assistant Professor /State Government Science and Technology Scheme or similar fellowship schemes of Central/State Governments.

##### **4.3.1 Selection Procedure:**

For candidates applying with their Master's degree in Humanities/Management/Social Sciences as their qualifying degree and having a valid score card/certificate in any of the National level eligibility tests listed above, selection to the programme will be based on an interview.

#### **4.4. Candidates with research fellowship**

Candidates who have been provided research fellowships by State Government Science and Technology Scheme/DST-INSPIRE etc, are eligible to apply, if they have cleared a National level eligibility test, such as **UGC-CSIR-NET (Lectureship /Assistant Professor)/ or JEST/GATE**. A valid GATE score of minimum 500 for General Category (450 for OBC / EWS and 350 for SC/ST/PD categories) in a Science discipline or JEST rank within the first 300 is required.

##### **4.4.1 Selection Procedure:**

Selection to the programme will be based on an interview

#### **4.5. Candidates awaiting results:**

Candidates awaiting their results in the final year/semester are also eligible to apply, provided they satisfy all the other requirements. Such applicants may be screened in for online screening test/interview based on the marks obtained by them until the current year/semester. Based on their screening test/interview performance, these applicants may be provisionally selected, subject to the condition that they have to produce the provisional certificate of obtaining the qualifying degree with required percentage of marks by the date stipulated in their provisional admission letter. If they fail to produce the provisional/ degree certificate, transfer certificate and conduct certificate by this date, their admission offer will be withdrawn and the offer will be given to next eligible applicant in the waiting list.

A provisionally selected applicant who is awaiting his/her final certificates may be allowed to join IIST without submitting the provisional/degree certificate on the stipulated date of joining, subject to the conditions that (a) At the time of joining the applicant should have completed all the requirements for the award of the qualifying degree including all examinations, project works and viva voce, (b) The applicant should produce at the time of joining, a Course Completion Certificate issued by the competent authority in the University/Institute specifically confirming that all examinations, project works and viva voce for the qualifying degree are completed, (c) If the above condition is satisfied, the applicant can be given provisional admission with the undertaking that all pending certificates, mark sheets, degree certificates (Original or Provisional) will be submitted to IIST , latest by **31<sup>st</sup>October2020**, failing which the admission shall stand cancelled. For such applicants who are funded by IIST and provisionally admitted to the IIST Ph.D. Programme as per (c) above, no fellowship will be paid during the period before the required certificates are submitted. However, on



regularization of admission following the submission of all required documents before the stipulated date, the applicant will be paid fellowship with retrospective effect from the date of joining.

## 5. RESEARCH AREAS AND SYLLABUS FOR SCREENING TEST

Table 1 (Funded by IIST)

Department of Aerospace Engineering			
Sl. No.	Department code	Research Area	Eligibility
1	PAE01	Computational Fluid Dynamics	M.Tech / ME/MS in Aerospace, Aeronautical, Mechanical Engineering or equivalent.
2	PAE02	Optimisation, Computational, Fluid dynamics, Hypersonics	
<b><u>Syllabus for screening test for PAE01 and PAE02</u></b>  1. Basic Engineering Mathematics 2. Fluid Mechanics (from Gate 2020) (compulsory) 3. Fluid Mechanics - Fluid statics, properties, manometry, buoyancy, stability of floating bodies, forces on submerged bodies, control-volume analysis of mass, fluid acceleration, momentum and energy, differential equations of continuity and momentum, dimensional analysis, Bernoulli's equation, viscous flow of incompressible fluids, elementary turbulent flow, boundary layer, flow through pipes, bends and fittings and head losses in pipes 4. Thermodynamics (GATE 2020)- Properties of pure substances, thermodynamic systems and processes, the behaviour of ideal and real gases, calculation of work and heat in various processes, zeroth and first laws of thermodynamics, the second law of thermodynamics, thermodynamic relations and thermodynamic property charts and tables, availability and irreversibility. 5. Compressible Flows (GATE 2020): Basic concepts of compressibility, Conservation equations; One dimensional compressible flows, Fanno flow, Rayleigh flow; Isentropic flows, normal and oblique shocks, Prandtl-Meyer flow; Flow through nozzles and diffusers.			

	<b>Candidates have to answer two sections – 1. Fluid Mechanics (compulsory) and 2. Either Thermodynamics or Compressible Flows</b>		
3	PAE03	Mechanics of Bio-inspired Composites	Master's Degree in Mechanical / Aerospace / Civil / Applied Mechanics or allied / equivalent areas with Solid Mechanics background.
	<b><u>Syllabus for screening test for PAE03</u></b>  1. Basic Engineering Mathematics 2. Engineering Mechanics - Trusses and frames; Free body diagrams and equilibrium, virtual work; impulse and momentum (linear and angular), kinematics and dynamics of particles & of rigid bodies in plane motion and energy formulations, collisions. 3. Mechanics of Materials - Elastic constants, Stress and strain, Poisson's ratio, thin cylinders, Mohr's circle for plane stress and plane strain, shear force and bending moment diagrams, deflection of beams, bending and shear stresses, torsion of circular shafts, energy methods, Euler's theory of columns, thermal stresses, testing of materials with universal testing machine, strain gauges and rosettes, testing of hardness and impact strength.		
4	PAE04	Machining and Precision Manufacturing	Masters(M.Tech/ME/MS)in Manufacturing Technology / Production Engineering/Mechanical Engineering / Applied Mechanics/Machine Design or Equivalent.

**Syllabus for screening test for PAE04**

1. Basic Engineering Mathematics
2. Engineering materials- Structure, phase diagrams and physical properties of engineering materials- Control of material properties -alloying- heat treatment-mechanical working and recrystallization.
3. Mechanics of Materials- Analysis of Stress, Strain and their relationships-Analysis of Bending, Shear, torsion and combined stresses - Mechanical behavior of materials - Testing methodologies- Residual Stress and effects.
4. Fundamentals of Plasticity-Plastic Deformation and Yield criteria-Mechanics of Metal Forming Processes- Principles, design and methods of bulk deformation processes - Solidification of pure metals and alloys- Principles, design and methods of Metal Casting- Fundamentals of Fusion Welding and solid state welding.
5. Mechanics of Metal Cutting- Single point and multi point cutting- Mechanism of Chip formation - Thermodynamics of chip formation- Types, Geometry and Materials of cutting tools- Tool Wear, Tool life and Machinability of materials- Multi axis CNC machining- Grinding and advanced finishing processes using abrasives- Tribology of machining- Non-traditional and Hybrid Manufacturing Techniques- Fundamentals of Additive Manufacturing.
6. Fundamentals of machine tool mechanisms- machine elements- Machine tool dynamics- Fundamentals of vibration-Theory of chatter in machining Processes.
7. Measurement of geometric features- Limits-Fits and tolerances- Gauge Design- Surface metrology- Non-destructive testing methodologies-Recent trends in metrology and precision manufacturing.

**Department of Avionics**

1	PAV01	Wireless Communication and Signal Processing	B.Tech in ECE and M.Tech in Signal processing, Digital Signal Processing, Communication Systems and its equivalent.
2	PAV02	5G communication	

	<p><b><u>Syllabus for screening test for PAV01 &amp; PAV02</u></b></p> <ol style="list-style-type: none"> <li>1. Signals and Systems: - Continuous-time and discrete-time signals and systems - LTI systems, sampling and reconstruction - Transform domain analysis of LTI system- Fourier, Laplace, and Z-transforms - Discrete Fourier Transform (DFT)- Fast Fourier Transform algorithm -Design of FIR Digital filters, IIR Digital filters. Basics of Multirate processing - Decimation and Interpolation.</li> <li>2. Probability and Random Processes: Probability axioms, conditional probability, discrete and continuous Rvs-CDF, PMF, PDF, conditional PMF/PDF, expected value, variance, functions of a RV, multiple random variables, joint CDF/PMF/PDF-independent/uncorrelated Rvs, sums of Rvs, moment generating function, random sums of Rvs- The sample mean, laws of large numbers, central limit theorem, convergence of sequence Rvs. Introduction to random processes(RP)- Mean and correlation of RP, stationary, wide sense stationary and ergodic processes. RP as inputs to linear time invariant systems: power spectral density, Gaussian processes as inputs to LTI systems, white Gaussian noise.</li> <li>3. Linear Algebra :- Vector Spaces ,Properties of Vector Spaces, Subspaces, Span and Linear Independence, Bases, Dimension Inner-Product Spaces - Inner Products, Norms, Orthonormal Bases, Orthogonal Projections -Null Spaces and Ranges- Eigenvalues and Eigen vectors</li> <li>4. Digital Communication: - Signal space concepts-Gram-Schmidt orthogonalization procedure. Matched filter receiver, ISI, Pulse Shaping, Nyquist criterion for zero ISI, Signaling with duobinary pulses, Eye diagram, Equalizer-Decision Procedure: Maximum a posteriori probability detector- Maximum likelihood detector, Error probability performance of binary signaling. Digital band pass modulation schemes: ASK, FSK, PSK, MSK – Digital M-ary modulation schemes – signal space representation Detection of signals in Gaussian noise</li> </ol>		
3	PAV03	Locomotion control of Humanoid Robots	M.E/M.Tech in Control Systems or Equivalent
	<p><b><u>Syllabus for screening test for PAV03</u></b></p> <ol style="list-style-type: none"> <li>1. Linear Algebra: <ol style="list-style-type: none"> <li>i) Solution of Linear Equations: Vectors and Linear Equations, The Idea of Elimination, Elimination Using Matrices, Rules for Matrix Operations, Inverse Matrices, Factorization, Transposes and Permutations.</li> <li>ii) Vector Spaces and Subspaces: Spaces of Vectors, The Null space of A: Solving <math>Ax = 0</math>, The Rank and the Row Reduced Form, The Complete Solution to <math>Ax = b</math>, Independence, Basis and Dimension, Dimensions of the Subspaces.</li> <li>iii) Orthogonality: Orthogonality of the Subspaces, Projections, Least Squares Approximations, Orthogonal Bases and Gram-Schmidt. Eigen values and Eigenvectors, Diagonalizing a Matrix, Applications to Differential</li> </ol> </li> </ol>		



			<p>Equation Symmetric ,Positive definit Matrices, Singular Matrices, Singular Value Decomposition(SVD).</p> <p>2. Linear Control System Theory:</p> <p>i) Transfer function Approach: Open loop-and closed loop control systems- Transfer function - Control system components-Steady state error- static error coefficient- dynamic error coefficient-Stability Analysis- Root locus- Frequency domain analysis-Bode plot-polar plot-Nyquist stability criterion- Non-minimum phase system - transportation lag, Different types of compensators like PD, PI, PID, Lag, Lead etc.</p> <p>ii) State space Approach: State variable description of LTI systems, Continuous time systems and Discrete time systems, Different canonical forms, Similarity transformation, Solution of state equations, Controllability and Observability, Relation between state variable and input-output descriptions, Stability of State space models, Pole placement through full state feedback, Full order state observers.</p> <p>3. Kinematics, Dynamics and Control of robotic manipulators:Representation of rigid body rotation:</p> <p>i) Rotation matrix, Composition of rotations, Similarity transformation, Parameterization of rotations, Euler Angle, Axis/Angle representation.</p> <p>ii) Representation of rigid body general motion: Homogeneous transformation matrix, Forward and Inverse kinematics, Velocity kinematics, Geometric and Analytic Jacobians, Manipulator redundancy, Singularity issues, Kineto-Static Duality, Closed loop inverse kinematics.</p> <p>iii) Dynamics and Control of serial chain manipulator: Euler-Lagrange formulation and Newton-Euler formulation for joint space dynamics, Task space dynamics based on task Jacobians, Inverse dynamics control for Joint space and task space. Task prioritization for redundant manipulators.</p>
4	PAV04	EM Waves and Antenna Engineering	<p>Masters in Engineering / Technology with Specialization in RF and Microwave Engineering or equivalent areas. The Candidate must have pursued the master's degree on the basis of qualified GATE score in Electronics and Communication</p>

	<p><b><u>Syllabus for screening test for PAV04</u></b></p> <ol style="list-style-type: none"> <li>1. Electromagnetic Waves: Wave equation &amp; Uniform Plane waves – Plane waves in lossy and lossless mediums – Normal and oblique incidences of plane waves.</li> <li>2. Transmission Line Theory: LCR model for transmission lines – Analogy with wave equations – characteristics of lossless lines – VSWR, Impedance matching – Smith chart – Case study.</li> <li>3. Waveguides: TEM, TE, TM Waves – wave propagation in Rectangular, Circular &amp; Planar wave guides.</li> <li>4. Microwave Passive Components and Planar Transmission Lines, Scattering parameters, Microwave filter</li> <li>5. Antennas: Basic Radiation Mechanism, Fundamental of Radiation, Antenna parameters, Equivalent Circuit of Antennas, Antenna in receiving mode.</li> <li>6. Wire Antennas: Electrically Short or Small Dipoles, The Half-Wave Dipole, monopole antenna, Loop Antenna, Antenna Arrays – Fundamentals of Antenna Arrays , basic analysis and pattern of two element array, N-element linear array, broadside and end fire array, Pattern Multiplication Theorem, Yagi-Uda Antennas, Log Period Antenna, biconical antenna, Travelling wave antennas, Helical antenna, Folded dipole Antenna, fundamental concept of UWB Antennas, Microstrip Antennas, Fundamentals of Horn and Reflector Antenna Fundamentals of Antenna Measurements</li> </ol>		
5	PAV05	Development of Real Time Gas Sensor Array to Monitor Critical Gases in Crew Module for Human Space Program	<p>ME/M.Tech in Electronics / VLSI /Instrumentation or equivalent areas. The Candidate must have pursued the master's degree on the basis of qualified GATE score in Electronics and Communication or Instrumentation engineering</p> <p><b>Desirable:-</b></p> <p>Candidates should have good knowledge in Semiconductor Devices or Material Synthesis or Electronics Circuit or Gas sensors</p>

**Syllabus for screening test for PAV05**

1. Semiconductor Devices: Energy bands in intrinsic and extrinsic silicon; Carrier transport: diffusion current, drift current, mobility and resistivity; Generation and recombination of carriers; Poisson and continuity equations; P-N junction, Zener diode, BJT, MOS capacitor, MOSFET.
2. Analog electronics: Characteristics and applications of the diode, Zener diode, BJT and MOSFET; small-signal analysis of transistor circuits, feedback amplifiers. Characteristics of operational amplifiers; applications of opamps: difference amplifier, adder, subtractor, integrator, differentiator, instrumentation amplifier, precision rectifier, active filters and other circuits. Oscillators, signal generators, voltage- controlled oscillators and phase-locked loop.
3. Digital Electronics: Combinational logic circuits, minimization of Boolean functions. IC families: TTL and CMOS. Arithmetic circuits, comparators, Schmitt trigger, multi-vibrators, sequential circuits, flip- flops, shift registers, timers and counters; sample-and-hold circuit, multiplexer, analog-to- digital (successive approximation, integrating, flash and sigma-delta) and digital-to- analog converters (weighted R, R-2R ladder and current steering logic). Characteristics of ADC and DAC (resolution, quantization, significant bits, conversion/settling time); basics of number systems, 8-bit microprocessor and microcontroller: applications, memory and input-output interfacing; basics of data acquisition systems.

**Department of Earth and Space Sciences**

3D LiDAR Point Cloud  
Data Processing using  
Machine Learning  
Techniques

M.E/M.Tech/M.S. in        Geoinformatics/Remote Sensing/ GIS/  
Computer Science/Machine Learning/Information Technology or  
equivalent.

**Syllabus for screening test for PES01****Section A: M.E/M.Tech/M. S. in Geoinformatics/Remote  
Sensing/GIS or equivalent**

1. Concepts of Remote Sensing: resolution, sensor, EM Spectra, spectral separability, spectral signatures, multispectral, hyperspectral, microwave, LiDAR remote sensing.
2. Concepts of Photogrammetry: parallax, stereo model, orientation, collinearity and coplanarity, aerotriangulation, orthophoto.
3. Digital Image Processing – Classification techniques, dimensionality reduction, spatial spectral filters, cross validation techniques, accuracy assessment.
4. GIS: Projection and coordinate system, vector/raster analysis, digital elevation model, 3D visualization, WebGIS.
5. Concepts of computer programming

**Section B: Students with M.E/M.Tech/M.S. in Computer Science/Machine Learning/Information Technology or equivalent**

1. Linear Algebra: matrix operations, eigen values and eigenvectors, solution space of system of equations
2. Probability: Fundamentals of probability, random variables, probability distributions
3. Image Processing: image sampling, quantization, color models, image enhancement techniques, image compression, segmentation
4. Machine Learning: Classification techniques, cross validation techniques, performance measures, dimensionality reduction methods, feature selection
5. Database and data structures: Basics of SQL, E-R models, SQL queries, data mining, data normalization, trees, hashing, kD tree, Quad Tree
6. Concepts of computer programming

**Note: Candidates have to answer either Section A or B**

Atmospheric Science (Aerosol-Cloud Interaction)	<p>*M.Sc / M.Tech (Atmospheric Science), M.Sc / M.Tech (Meteorology), M.Sc (Physics), M.Tech (Earth System Science) or any equivalent</p> <p>*Candidates with M.Sc. have to mandatorily clear a National Test indicated in SI No.2. Such candidates can be exempted from the screening test for PES02.</p>
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**Syllabus for screening test for PES02**

1. Spectrum of electromagnetic radiation, Maxwell's equations in free space and linear isotropic media; boundary conditions on the fields at interfaces, radiance and irradiance, solid angle, concepts of scattering, absorption and polarization of radiation, blackbody radiation: the Plank function, Wien's displacement law, the Stefan Boltzmann law; Kirchoff's law, radiative equilibrium, physics of scattering and absorption by particles, Rayleigh scattering, Raman scattering, Lorentz-Mie theory of light scattering, geometric optics, atomic and molecular spectroscopy.
2. Composition of the atmosphere, equation of state, hydrostatic equilibrium, first law of thermodynamics, application of first law, entropy, second law, heat capacity, dry adiabatic processes, transfer processes, moist thermodynamic processes in atmosphere, static stability, global energy and entropy balances.



3. Atmospheric aerosols particle sources and strengths, particle size distribution and chemical compositions, transport, geographical distribution, residence time, cloud characteristics and processes, types of clouds, cloud microphysical processes, growth of cloud droplets, condensation, collision and coalescence, effects of aerosols on clouds: cloud condensation nuclei, cloud droplet spectra, and precipitation, cloud condensation nuclei, development of cloud droplet spectra, effect of aerosol on development of precipitation.

### **Department of Mathematics**

1	PMA01	Machine Learning	M.Tech / M.E. or related degree in Computer Science / Machine Learning & Computing or related areas
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#### **Syllabus for screening test for PMA01**

1. Linear Algebra: Vector spaces, subspaces, linear independence, inner product spaces, orthogonal basis, conditional number, regularization techniques.
2. Matrices: Traces and determinants, eigenvalues and eigenvectors, matrix derivatives.
3. Probability: Fundamental axioms in probability, conditional probability, independence, random variables, expectation, probability distributions.
4. Machine Learning: Classification, regression, clustering, cross validation techniques, performance measures, dimensionality reduction methods, feature selection, association rules, neural networks, kernel methods, deep learning, graphical models, reinforcement learning

### **Department of Physics**

1	PPH01	Experimental Quantum Optics and Quantum Sensing	M.Sc. in Physics or BS-MS in Physics or equivalent.
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**Table 2 : External Fellowship Holders**

Candidates having a valid fellowship from Government agencies such as DST, CSIR, NBHM, UGC and State Government Science and Technology Scheme etc. may also apply for Ph.D. admission in various departments in IIST in the areas given below. Such candidates will be selected based on an Interview.

<b>Sl. No.</b>	<b>Department</b>	<b>Department code</b>	<b>Research Area</b>	<b>Eligibility</b>
1E	Chemistry	ECH01	Nanomaterials for EMI shielding and Energy Storage Applications	M.Sc or BS-MS in Chemistry or equivalent / M.Sc in Polymer Science or Biopolymers /M.Tech in Materials Science or allied branches
		ECH02	Toughened Ceramic Layered Composites	M.Sc or BS-MS in Chemistry or equivalent / M.Tech in Materials Science or allied branches
		ECH03	Energy Storage Materials	M.Sc or BS-MS in Chemistry or equivalent/ M.Sc in Polymer Science / M.Tech in Materials Science or allied branches.
		ECH04	Organic Functional Materials	

2E	Earth and Space Sciences	EES01 EES02	Mangroves Dynamics using Satellite Remote Sensing and GIS	Master degree in Remote Sensing/RS & Geographic Information System / Geoinformatics / Geography/ Applied Geography or equivalent field of study with master degree project carried out in remote sensing and GIS
			Atmospheric Science	M.Sc / M.Tech (Meteorology), M.Sc / M.Tech (Atmospheric Science), M.Sc / M.Tech (Oceanography), M.Sc (Physics) or M.Tech (Earth System Science) or any equivalent subject
3E	Humanities	EHS01	Operations and Supply Chain Management	M.E / M.Tech / M.S (By Research) in Industrial Engineering/ Manufacturing Engineering/ Industrial& Production Engineering/Technology Management/ Industrial Management/ related Areas Or M.B.A. (Specialization in Operations Management with UGC-JRF
4E	Mathematics	EMA01	Numerical Analysis	M.Sc Mathematics / BS-MS in Mathematics or Equivalent
		EMA02	Stochastic Processes; Queuing Theory	M.Sc / BS-MS in Mathematics

5E	Physics	EPH01	Quantum Information and Nonclassicality	MSc in Physics/Master of Science in Solid State Physics / BS-MS in Physics or Equivalent
		EPH02	Experimental Condensed Matter Physics, Strongly Correlated Electron System, High Tc Super Conductors, Magnetic Sensors, Transport Studies and Spectroscopic Imaging	M.Sc. in Physics, BS-MS in Physics / B.Tech in Engineering Physics with M.Sc./M.Tech in related areas of condensed matter physics
		EPH03	Applied/Adaptive Optics	M.Sc (Physics / Applied Physics) / M.Tech (Applied Optics / Optical Engineering / Optoelectronics / Photonics / Laser Technology) / BS-MS in Physics or Equivalent
		EPH04	Classical Optics, Quantum Optics, Quantum Information	MSc in Physics or Equivalent. MTech in Applied Optics / Optical Engineering or any Physics related areas. BS-MS in Physics or Equivalent.

**Applicants who hold External Fellowships, meeting Table 2 requirements, can also apply for research areas listed in Table 1 provided they meet the eligibility.**

## **6. RESEARCH FELLOWSHIP**

- a)** All scholars selected to the programme in specializations listed in Table 1 shall receive a fellowship of Rs.31000/- per month. Research Scholars selected with UGC/CSIR/NET-JRF/NBHM and State Government Science and Technology Scheme etc., shall draw fellowship from the concerned organizations. For all research scholars with external fellowship, the concerned rules and regulations apply.
- b)** If a scholar selected to the programme in specializations listed in Table 1 (IIST/Dos funded category) has been awarded fellowship from UGC/CSIR/NET-JRF/NBHM and State Government Science and Technology Scheme etc, the scholar would draw fellowship from the agency concerned.
- c)** The fellowship will be enhanced to Rs.35,000/- per month based on a performance review after two years of Research.
- d)** Research Fellowships awarded by IIST shall be for a period of 4 years. Under exceptional circumstances with the recommendation of DC and evaluation of RC extension up to maximum of twelve months could be granted. Fellowship is tenable till submission of thesis or maximum period whichever is earlier.
- e)** Research Fellowship will not be extended beyond the period mentioned above. The scholars would have to support themselves on expiry/beyond the period of fellowship.
- f)** The scholars will be required to assist the Departments in tutorials, practical training in labs or similar academic activities normally limited to 6 hours per week.
- g)** The scholars will have to pay applicable fees as well as charges for the services provided by the Institute like boarding/lodging/medical facilities etc., as per IIST rules.
- h)** For those who receive fellowship from agencies such as DST, CSIR, NBHM, UGC and candidates who have been provided research fellowship by State Government Science and Technology Scheme through competitive written test etc., the Institute will not bear the fellowship of the student if the same is stopped due to any reasons by the concerned agency

## 7. FEE STRUCTURE

(To be paid at the beginning of every semester)

Sl No	Description	Full Time
1	Tuition Fee/Statutory Semester Fee	1,500/-*
2	Student Amenities Fee***	1,350/-
3	Hostel Charges***	4,500/-**
4	Establishment Charges***	4,000/-
5	Medical Charges***	800/-
6	Registration Fee (One-Time)	1,000/-
7	Thesis Submission Fee (One-Time)	1,000/-
8	Re-Registration Fee (If any)	1,500/-
	<b>Total</b>	<b>12,150/-</b>

**Note:**

\*For SC/ST/PD Tuition Fee/Statutory Semester Fee is exempted.

\*\*Students of Ph.D programmes can purchase food coupons for Canteen Services separately.

\*\*\* Based on decisions of Board of Management, fees could be revised during the study period.

## 8. GENERAL SELECTION PROCEDURE:

- Applications will be received through on-line only.
- Candidates having fellowship from funding agencies such as DST, CSIR, NBHM, UGC, State Government Science and Technology Scheme etc, applying to research areas in Table 2 may also apply for other research areas in Table 1, if eligible.
- Candidates are advised to visit the individual department profiles for more details on the respective areas of research.



- d) Candidates with valid fellowship from Government funding agencies shall upload a scanned copy of the fellowship award letter.
- e) A short-list of applicants for screening test and interview will be displayed in IIST website.
- f) **Selection Criteria based on screening test & Interview:**
  - i. The students who have participated in the screening test will be shortlisted for interview, if they secure a minimum of 30 % in each of Section A and Section B and a combined mark of 50 % and above for Section A and Section B together.
  - ii. There will be a relaxation of 5 % for SC/ST/PD and OBC / EWS students, i.e., SC/ST/PD and OBC / EWS students require a combined mark of 45 % and above for Section A and Section B together, while the minimum is 30% in each of the Section A and B respectively.
  - iii. There will be a 70 % weightage for the screening test and 30 % weightage for the interview.
  - iv. A student securing less than 10 marks out of 30 marks in the interview will not be selected irrespective of category and irrespective of the performance in the screening test.
  - v. The combined mark for the screening test and interview for a UR student should be 60 % and above to be selected
  - vi. For the SC/ST/PD and OBC / EWS students, the combined mark for the screening test and interview should be 55 % and above.
- h) The list of provisionally selected candidates, after the interview, will be displayed in the IIST website.
- i) The date of the screening test will not be changed under any circumstances. The date of interview span over a period of several days. In case the date and time of the interview clashes with the applicant's End semester examination in his/her qualifying examination, the Institute will consider shifting the date and time of interview within the overall window available.
- j) During interview, candidates will be tested in their main research area and not restricted to the syllabus of the screening test.

## 9. HOW TO APPLY:

Applications shall be submitted **online** at the IIST website: <http://admission.iist.ac.in>. Applications received online only will be considered.

- a) The applicants will not be allowed to make any changes in their registration profile once submitted. Hence utmost care should be taken by the applicants while filling their profile.
- b) Application fee for General/EWS/OBC candidates who are male is Rs. 700/- per Department (for SC/ST/PD and Women applicants - Rs.350/- per Department). If the applicant is eligible and wishes to apply for more than one Research Area in the same Department, he/she need not pay any additional application fee. The application fee is non-refundable. Applicants, who wish to apply to multiple departments, will have to pay the appropriate application fee (sum of the application fee for each department).
- c) The application fee shall be paid through online after the course registration only.
- d) **Applicants who are employed in Government/Semi Government/PSUs/ Autonomous Bodies need to produce a “No Objection Certificate (NOC)” from the current employer at the time of Interview.**
- e) SC/ST/OBC / EWS/Persons with Disabilities (PD) applicants shall upload the relevant certificate in the website before the prescribed date.

## 10. ADMISSION AND REGISTRATION

- a) Applicants whose selection is approved by the Director, IIST will be admitted to the Ph.D. programme by duly undergoing the process of admission and registration in the respective academic departments on the dates specified in the communication to the selected candidates.
- b) All the Ph.D. students (Full time and part time) are required to register every semester along with the progress report in the prescribed format.
- c) The registration lapses if the candidates do not complete the Ph.D. requirement in the maximum stipulated period. Re-registration will be required for such candidates subject to specific approvals and payment of the re-registration fee.

## 11. ACCOMMODATION

### 11.1 Full-time Programme

- a) IIST Funded The institute is residential to all Research scholars under this category. Only married students who opt to stay outside will be provided HRA. The research scholars are expected to be on-campus for the entire duration of the Ph.D. programme. Students under the above category will have the highest priority for hostel accommodation.
- b) DoS Funded Students under this category are eligible for hostel accommodation during their course work, visits and Research work as applicable

c) Externally Funded / Sponsored and Project Funded scholars availing HRA from the funding agencies may opt to stay outside. Students under the above category will have the second priority for hostel accommodation.

### **11.2 Part-time Programme**

Students under this category are eligible for hostel accommodation during their course work, visits and Research work as applicable subject to availability.

## **12. DURATION OF THE PROGRAMME**

Category	Normal Duration		Extension (with approval)
	Minimum	Maximum	
Full Time	Three years	Four years	Up to Six years
Part Time	Three years	Five years	Up to seven years

Beyond the normal duration, in exceptional and genuine cases, the Research scholars can apply for an extension up to one year at a time, for the submission of the thesis. Based on the recommendation of the Doctoral Committee (DC) on the progress of the research work, and the endorsement of the Research, Director, IIST may approve extension for submission of thesis.

Beyond the duration of six years for full-time scholars, and beyond the duration of seven years for part-time scholars, no further extension for the submission of the thesis can be granted, and the candidacy will be terminated. Re-registration is granted for exceptional cases upon strong recommendation from the DC on the basis of adequate reasons for delay. Re-registration fee amounting to Rs. 1500/- will be charged at the time of Re-registration.

## **13. DISCIPLINE**

- a) Every scholar is expected to maintain highest standards of academic integrity.
- b) Every scholar is required to observe disciplined and decorous behaviour both inside and outside the campus and should not indulge in any activity, which will tend to bring down the reputation of the Institute.
- c) Any act of indiscipline by the scholar reported to any authority of the Institute will be referred to the Disciplinary Committee of the Institute.

- d) The Committee will investigate the charge and recommend suitable punishments, if it finds the charges substantiated. Director, IIST will take necessary action based on the recommendation of the Disciplinary Committee.

## **14. ATTENDANCE AND LEAVE OF ABSENCE**

- a) All full time research scholars are eligible for thirty days leave of absence in a year subject to a maximum of fifteen days in a semester (01st July - 31st Dec & 01st Jan – 30th June) including absence on medical grounds. The scholars can avail leave after recommendation from the supervisor/co-supervisor and 13 approval from the concerned HOD. Maternity leave as per Government of India instructions issued from time to time would be available. The scholars shall sign in the attendance register on all working days.
- b) Part Time Ph.D. scholars from ISRO/DoS Centres shall sign in the attendance register on all working days during the period of their residential requirement at IIST Campus and shall be eligible for leave regulations as per Full Time Research scholars.

**Note: For further details, refer Ph.D Rules and Regulations of IIST. (<https://www.iist.ac.in/academics/rules-regulations>).**