

S. No.	Faculty Name	Suggestive title of projects/research area	Key Words of Research Area for Ph.D Advertisement (Max 05 words)	Short description
Department of Computer Science Engineering				
1.	Dr. Gaurav Varshney	Anti Phishing, Anti Spying, Data Protection and Data Tracking over Internet, Security Policies and Protocols, Application Layer Security Mechanisms		PhD positions are available for applied security enthusiast in the area of Network and Application layer security. You are expected to have a basic understanding of protocol stack and the working of the Internet and Web as a whole. Knowledge of Crypto is a plus. Solutions will be developed in the area of Anti Phishing, Spying, data protection, data tracking on the Internet. As data moves across the web can we have mechanism such that we can control the data movement? Can we solve CSRF, XSS as a framework of policies ? How ?
2.	Dr. Sumit Kumar Pandey	Efficient design of symmetric and asymmetric cryptographic primitives and their cryptanalysis, quantum computation, quantum cryptography and quantum cryptanalysis.		NIST is conducting a competition for lightweight cryptography to protect small electronics. These solutions mainly use symmetric cryptography. The security of symmetric key cryptographic primitives significantly depends upon the resistance against the existing attacks and thus a thorough cryptanalysis is required for each

				<p>cipher before its final acceptance.</p> <p>In recent years, there is a considerable advancement in the field of the development of quantum computers. Once the quantum computer becomes reality, factorisation and discrete log problem based public key cryptosystems will become insecure. Therefore, NIST is conducting another competition for the selection of postquantum public key encryption, key-establishment algorithms and digital signature schemes. Thus, the postquantum algorithms may be inevitable for the future. Not only that, there will be a sudden need of those cryptosystems which will be suitable for quantum computers only which leads to a deep research in the area of quantum computation and quantum cryptography.</p>
3.	Dr. Harkeerat Kaur	Biometric Information Privacy, BlockChain Frameworks for Identity management, Location Privacy for Internet of Things		<p>Biometric Information Privacy: Advancement on concepts for revocable and privacy preserving biometrics for remote and web based authentication.</p> <p>BlockChain Frameworks: Designing self sovereign identity management solutions.</p>

				Location Privacy for IoT: Smart data and privacy by design for securing location information over internet of things.
Department of Electrical Engineering				
1.	Ankit Dubey	Edge Caching and Physical layer Security (PLS) for ultra reliable low latency communication (URLLC)		Edge nodes can significantly reduce the average latency of the network by storing the popular files. Physical Layer Security can reduce the burdensome computation and provide more security in IoT environment.
2.	Dr. Sudhakar Modem	Radio frequency based energy harvesting, 5G, IoT, ML for Communication		Performance analysis of RF energy harvesting networks. Prototype design of sensor modules which can operate based on harvested energy. Machine learning for wireless communication.
3.	Dr. Alok Kumar Saxena	Finite-Difference Time-Domain (FDTD) Method and Multi-band Microwave Filter		<ol style="list-style-type: none"> 1. Development of novel FDTD methods with low numerical dispersion error, and their implementation for different practical simulations 2. Development of Multi-band Microwave filters to be used in the 5G technology

4.	Dr. Ravikant Saini	TeraHertz Communication, Cooperative NOMA	Terahertz communication, secure communication, resource allocation, NOMA, cooperative communication	<p>Terahertz band is a band of opportunities with data rates in the range of Tbps. However, the band has serious issues with wave propagation, as waves get absorbed. We wish to develop a channel model and investigate suitable modulation/coding scheme for Terahertz link.</p> <p>NOMA is a promising option being considered for next generation communication network. We wish to investigate cooperative NOMA.</p>
5.	Dr. Kankat Ghosh	Analytical modeling of ISBT (Intersubband Transition) based Al(In)GaN/GaN heterostructure devices for IR (infrared) and THz applications		<p>Intersubband (ISB) transitions are electronic transitions between confined levels in the conduction band. III-nitride semiconductors present a large conduction band offset (≈ 1.8 eV for GaN/AlN). Therefore, it becomes feasible to fabricate ISB devices operating in the near-IR spectral range, particularly in the 1.3–1.55μm wavelength window for fiber-optic communications. Also due to its large LO-phonon energy (91meV), GaN has the potential to operate at higher temperature than GaAs and to cover the whole THz domain.</p> <p>Devices: Quantum Cascade Laser, THz</p>

				quantum-well photodetector.
6.	Dr. Satyadev Ahlawat	Effective Testing of Integrated Circuits for Automobiles; Security issues in modern day chips.		Automobile/autonomous -vehicles require reliable integrated circuits which can be ensured by proper testing. Security is another issue in integrated circuits which needs to be addressed.
7.	Dr. Karan Nathwani	Pathological Speech Intelligibility Improvement		Pathological speech usually refers to the condition of speech distortion resulting from atypicalities in voice and/or in the articulatory mechanisms owing to disease, illness or other physical or biological insult to the production system. While auto-matic evaluation of speech intelligibility and quality could come in handy in these scenarios to assist in diagnosis and treatment design, the many sources and types of variability often make it a very challenging computational processing problem.
8.	Dr. Ajay Singh	Communication Theory and Systems		<ul style="list-style-type: none"> • Physical Layer Security • D2D Communications • Cognitive Radios • Wireless Powered Communications

				<ul style="list-style-type: none"> • Molecular Communications
9.	Dr. Ankur Bansal	<p>1) WDM based Radio over FSO (RoFSO) System</p> <p>2) Quantum Communication</p>		<p>1) A technique of simultaneous transmission of a wide spectrum of RF signals in both directions over an FSO link is known as RoFSO.</p> <p>2) Quantum communication is related to quantum information processing. It is useful in protecting information channels against eavesdropping by means of quantum cryptography.</p>

Department of Mechanical Engineering

1.	Dr. Sahil Kalra	Control System Design, Robotics and Control, Applications of Finite Elements in Static and Dynamic systems, Mechanical Vibration (Modal Analysis), Pattern Reconfigurable Antennas, Shape Memory Alloys		Control systems have immense applications in Robotics, Automation, and shape reconfiguration of the adaptive structures. Shape Memory Alloys material based systems have hysteresis behavior which is difficult to control using Linear control theory. Broadly, I work on the analysis of such complex problems and find out the engineering solution using experimental and analytical methods.
2.	Dr.Arvind Kumar Rajput	Lubrications of Hydrodynamic/ hydrostatic Journal		Lubrications play a key role in the operation of mechanical components

		and thrust Bearings, Design of Mechanical System, FSI, Coriolis Mass flow measuring Devices, Condition Monitoring,		involving relative motion viz. Bearings, gears, clutch etc. Proper lubrication practices are required for the efficient and durable operation of mechanical components. FSI (Fluid structure interaction is very key area of research and demands lots of research activities as per different applications.
3.	Dr. B. Satya Sekhar	Hydrogen Energy, Renewable Energy Systems		Research and development of hybrid renewable energy storage systems. Numerical and experimental studies on thermally driven hydrogen compressor.
4.	Dr. Saurabh Biswas	Geometrically nonlinear flexible beams undergoing large rotations.		Beams undergoing large rotations but small strains are found in many engineering applications, e.g., robotics, aircraft structures, precision machines. Large rotation of beams introduces geometric nonlinearity in the system. The goal of this study is to develop a computational model of a multibody system of beams undergoing large rotations. Subsequently, reduced order models from the full computational model will be developed.
5.	Dr. R T Durai Prabhakaran	Fibre/matrix interface design and its effect		The interface between the reinforcing agent

		<p>on Fatigue Strength of Polymer Composites</p>	<p>and the matrix plays a pivotal role in determining the mechanical properties of composite materials. A strong interface creates a material that displays exemplary strength and stiffness but is very brittle in nature with easy crack propagation through the matrix and fibre. A weaker interface reduces the efficiency of stress transfer from the matrix to the fibre and consequently the strength and stiffness are not as high, but in contrast, toughness is increased.</p> <p>An experimental study and numerical simulations is planned to evaluate the effect of fibre/matrix interface over the fatigue and impact strength of polymer composites modifying fibre sizings.</p> <p>This work will have collaboration with IIT Delhi</p>
		<p>Design and manufacture of Carbon/Carbon Composites for brakes and discs applications</p>	<p>The need of efficient use of energy & materials is being felt strongly because of diminishing resources in the present times. There has been an important role of materials in the development of civilizations. In the transportation sector when earlier large bulky automobiles are</p>

				<p>compared with today's lightweight, technologically superior vehicles. Carbon-carbon composites are a new class of engineering materials that are ceramic in nature but exhibit brittle to pseudoplastic behaviour.</p> <p>Carbon-carbon is a unique all carbon composite with carbon fibre embedded in carbon matrix and is known as an inverse composite. Due to their excellent thermo-structural properties, carbon-carbon composites are used in specialised application like re-entry nose-tips, leading edges, rocket nozzles, and aircraft brake discs apart from several industrial and biomedical applications.</p> <p>Present works aims to develop experimental set-up at IITJammu campus for processing carbon/carbon composites and expand the work towards design and manufacture of carbon/carbon discs and brakes for automotive/aircraft applications.</p> <p>This work will have collaboration with IIT Delhi and Scottish Research laboratory (LMC/AFRC, Glasgow).</p>
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		<p>Green Buildings and Indoor Air Quality</p>		<p>Sustainable or “green” building design and construction is a method of wisely using resources to create high-quality, healthier and more energy-efficient homes and commercial buildings. A green building is more than the sum of its parts (think resource conservation)—its process and impacts matter, too.</p> <p>This work involves developing innovative applications of building physics research tools and, in a broader context, systemic modelling and assessment of future green buildings and indoor environment.</p> <p>This work will have collaboration with JNTUA and Bangor</p>

				University/Nottingham Trent University, UK.
		Design for X abilities of Wind Turbine Structures (Optimization to improve turbine efficiency using lightweight materials)		<p>Rotor designs suffer from the accumulation of minor losses resulting from: Tip losses, Wake effects, Drivetrain efficiency losses, Blade shape simplification losses. Evaluate current aerodynamic profiles and modify blade design to account bamboo/natural fibre blade designs.</p> <p>Design and Manufacturing of Natural fibre composites based on lightweighting principles. The output of this work is enhance practical efficiency of energy output by minimizing losses and match closely to maximum theoretical efficiency.</p> <p>Wind resource assessments will be carried nearby to campus to evaluate the possibilities for experimental wind turbine installation.</p> <p>This work will have collaborations possibly with National Institute of Wind Energy (CWET), Chennai.</p>
		Design and development of ultralight, strong,		Water pollution is a global problem threatening the entire biosphere

		superinsulating aerogel composites for water purification applications		<p>and affecting the life of many millions of people around the world. Not only is water pollution one of the foremost global risk factors for illness, diseases and death, but it also contributes to the continuous reduction of the available drinkable water worldwide.</p> <p>Present work aims to develop aerogel composite membranes for purifying polluted water.</p> <p>This work will have collaborations possibly with ACG, University of Strathclyde and MG University, Kottayam.</p>
6.	Dr. Goutam Dutta	Nonlinear dynamic analysis of nuclear coupled thermal-hydraulic behaviour of a reactor		<p>In-house numerical model is to be developed and validated with the commercial software results.</p> <p>Need is to predict the stability thresholds and remove such possibilities</p>
Department of Civil Engineering				
1.	Dr. Rimen Jamatia	Constitutive modeling of quasi-brittle materials under hydro-thermal-mechanical loading		Hydro-thermal-mechanical effect on concrete

2.	Prof. Chandan Ghosh	<p>Geotechnical (Infrastructure) engineering</p> <p>Application of Geosynthetics</p> <p>Disaster Mitigation and management</p> <p>Bioengineering for Slope stabilization</p>		<ol style="list-style-type: none"> 1. Seismic microzonation of Indian cities, 2. Landslides hazard mapping, mitigation and failure investigation/rehabilitation measures 3. Integrated Disaster Management Plan for Cities, strategic establishments 4. Rapid (detailed, NDT, DT..) Visual Screening (RVS) of built-up facilities prone to natural and man-made disaster, 5. Evaluation of seismic retrofitting and application base isolators, dampers, 6. Application of Geosynthetics in Civil Engineering (landslides, ground improvements, DAMs, tunneling, erosion controls, Clay-liner for MSW storage, flexible storage reservoir, etc.) 7. Pilot study on Bio-sewerage treatment Plants, Bio-gas, Grey/Rain water harvesting using Vetiver grass, Typha
3.	Dr. Pervaiz Fathima Khatoon	<p>Studies on fatigue crack propagation in reinforced concrete</p>		<p>The research work includes experimental investigations on fatigue crack propagation in reinforced concrete</p>

				specimens and develop analytical models.
4.	Dr. Sameer K S Pachalla	<ul style="list-style-type: none"> • Structural behavior of interlocking brick masonry • Bond behavior of prestressing strands. • Behavior of precast modular buildings 		<p>Full scale structural tests will be performed to evaluate the masonry structures made out interlocking bricks</p> <p>Experiments will be performed to characterize the bond between prestressing strands and concrete</p> <p>Full scale experiments will be performed to evaluate the structural performance of precast modular buildings.</p>

Department of Chemical Engineering

1.	Dr. P. K. Vijayan	Steady state, transient and stability performance of Thermosiphon Heat Transport Devices (THTD) for solar thermal, nuclear and electronic cooling applications.	Thermal hydraulics, Thermosiphon systems, Passive safety systems, Stability analysis, Computational heat and momentum transfer	Experimental and theoretical studies on THTD models for use in solar, nuclear and electronic device cooling are proposed to be carried out under this. The experiments will be carried out in simulated models at the same dimensionless parameters encountered in the prototype. Analytical models will be developed for the steady state case. Linear and nonlinear techniques will be developed for the stability analysis.
2.	Dr. Gaurav A Bhaduri	Process Intensification, Material Synthesis, Catalysis,	Process Intensification, Chemical Reaction	Development of intensified processes for sustainable chemical and material synthesis or

		Plasmonics, Photochemistry and Photocatalysis, Reaction Engineering, Carbon Capture and Storage, Process design.	Engineering, Environmental Engineering, Bioprocess Engineering, Nanotechnology	separation. Optimization of equipment design parameters as well as process design parameters will be studied. Process intensification techniques like, static mixers, oscillatory baffled reactors, microwave reactors, sonochemical reactors would be studied.

Department of Materials Engineering

1.	Dr. Rakesh K. Tekade	Development of Implantable woven polymeric nanotextile for Long-term photo-chemotherapy; Dendrimer stencil mediated synthesis of gold-nanoseeds for the prevention of post-surgical relapse of resectable Tumours; Green Nanoplates for Laser Directed Chemo-Photothermal Therapy		These projects encompass the development of novel and innovative therapeutic modalities for the clinical interventions of cancer and arthritis. The project activities involves but not limited to the objectives including Formulation development and characterization of nanoparticles, drug delivery device, cell culture techniques, Pharmacokinetics- Pharmacodynamics, Photothermal activity, Evaluation of organ toxicity, hemocompatibility assessment, and other biocompatibility testing studies etc. The projects at one time will also involve quality-by-design (QbD) for product development and optimization.
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2.	Dr. Suman Sarkar	<p>(Non-Equilibrium Materials Processing) Precipitation of microscopic shape memory particles in the crystalline copper matrix- Evolution of novel pseudo elastic effects.</p> <p>Areas: Rapid Solidification, Electron Microscopy, Phase-transformations, Alloy Development.</p>	Electron Microscopy, Alloy, Shape Memory, Microstructure , Stress, Strain, Phase Transformation	<p>The shape memory effect (SME) has attracted more and more attention in recent years. A few shape memory related new phenomena have also been identified. The interesting part of this project is that the first time we will try to introduce some moderate volume fraction of precipitate particles with shape memory alloy composition (Fe-Mn-Si) in the crystalline copper matrix. As we know that the copper does not show the shape memory effects but those shape memory precipitate particles embedded in the copper matrix will introduce pseudo-elasticity or super elasticity effect in the Cu-Fe-Mn-Si alloy system. This project will be the first novel approach of shape memory particle precipitation in crystalline matrix. One can expect of new and exciting property evolution in copper based alloys by the introduction of this mechanism.</p>
Department of Chemistry				
1.	Dr. Pankaj Chauhan	Asymmetric Synthesis, Organocatalysis		Development of novel asymmetric methods for procuring potentially bioactive molecules by

		Photocatalysis and Electro-catalysis		employing, chiral organocatalyst and merging them with Photo- and Electro-catalysis
2.	Dr. Subhas Samanta	Bio-mimetic oxidation catalysis and polymerisation catalysis		The project aims to develop first row transition metal complexes mimicking the reactivity of biologically relevant enzymes and metalloproteins for oxidation reactions. By employing redox non-innocent ligand containing transition metal complexes polymerisation catalysis will also be explored
3.	Dr. Shivnath Mazumder	Computational Design of Photo-Catalytic Water-Splitting Complexes		The project targets to rationally design novel photo-catalytic water-splitting complexes for production of hydrogen gas. The H ₂ can be used as an alternative fuel for transportation.
4.	Dr. Jayaramulu Kolleboyina	Hybrid Porous Materials, 2D Materials,	Porous Materials, Structure-Property, Energy, Environmental	Current research includes the synthesis and study of structure-property relations of various hierarchical porous materials (correlation between textural and transport properties), hydrophobic porous materials and multifunctional hybrid 2D materials/membranes for energy and environmental applications.

5.	Dr. Guru Brahamam R.	Asymmetric Synthesis, Hypervalent Iodine Chemistry and Photoredox Catalysis		Asymmetric synthesis of target orientated molecules in laboratory scale and their up gradation to pharmaceutical industry.
6.	Dr. Amlan K. Pal	Coordination Driven Self-Assembly to Form Molecular Grids and Their Applications	Self-assembly, Grids, Transition Metal ions, Heterocyclic Ligands, Host-Guest Chemistry	This project explores the syntheses of heterocyclic ligands, that involve coupling reactions, respectively. The chelating sites will then be used to coordinate to four different metal ions that are capable of exhibiting distorted tetrahedral geometry, namely Fe(II), Co(II), Cu(I) and Zn(II) to form molecular grids, respectively. Optoelectronic characterization will follow isolation of the desired ligands and grids. The structure-property relationship study of these four grids will be established. Potential applications in selective sensing of anions or encapsulation of different guests will also be sought after.
		Syntheses and Applications of Novel Transition metal complexes as Photoredox Catalysts	Ligands, Metal complexes, Optoelectronic characterizations, Photoredox catalysis	Multidentate heterocyclic ligands will be synthesized, followed by complexations, that will consequently be characterized by set of analytical techniques. Potential applications of these complexes will be sought after as excited-state Photoredox catalysts either to

				photocatalytic production of 'green fuel' hydrogen or for energy demanding organic transformation reactions.
		Syntheses and Applications of Novel Ir(III) Complexes for Efficient OLEDs and LEECs	Ligands, Ir(III) complexes, Optoelectronic characterizations, OLEDs and LEECs	This Project involves synthesis of multidentate ligands and their complexation with Ir(III). The ligands and the complexes will be characterized by a set of analytical and optoelectronic techniques. Potential applications of these luminophores will be used in organic light emitting diodes and light emitting electrochemical cell applications for Solid-state Lighting.
Department of Physics				
1.	Dr. Biswanath Chakraborty	Exploring light-matter interaction in van der Waals heterostructures for photonics and novel device applications		The proposed research will provide an opportunity to work in the cutting edge areas combining the ideas from solid state physics, optics, atomic physics and materials science. The work will primarily focus (but not confined to) on the outstanding properties of two dimensional (2D) van der Waals (VdW) materials like graphene, transition metal dichalcogenides (TMDs), hexagonal boron nitride (hBN) to name a few. An important motivation for exploring 2D VdW materials is their compatibility with silicon

				<p>photonics and CMOS technologies. The projects would consider device fabrication techniques (lithography), film deposition, optical experiments (like confocal set up for single photon detection, Fourier optics, Time resolved photoluminescence, electroluminescence) coupled with simulation of device parameters. The goal is to come up with technologies that will foster the growth in areas of photonics and optoelectronics.</p>
2.	Dr. Ajeet Sharma	Optimization of the use of natural nano-machines		<p>Natural nano-machines carry out a wide range of biological functions. Energetic constraints lead to their limited availability in a cell. Thus, their use in a cell must be optimized. Using the tools of physical sciences, the project aims to understand how nature has optimized the use of natural nano-machines, and then use this knowledge to develop bioengineering principles for various applications.</p>
3.	Dr. Sanat Kumar Tiwari	Visco-elastic properties of dusty plasma medium in DC		

	(Physics)	discharge based experiments.		
		Thermodynamic and transport properties of plasmas through machine learning techniques		
4.	Dr. Venkata Sathish Akella	Self-propulsion by Marangoni forces at the air-water interface (Experimental)	Soft Matter Physics	Forces that arise due gradients in interfacial tension between two fluids are known as Marangoni forces. My current interest lies in understanding the dynamics of particles driven by Marangoni forces at air-water interface. These systems (both single- and multi-agent systems) are simple to set up, yet powerful in helping us understand random walks, collective dynamics etc.
5.	Dr. Rahul R. Salunkhe	Development of 2D heterostructures for energy storage applications		
Department of Mathematics				

1.	Dr. Tanmay Sarkar	Analytical and numerical study of certain partial differential equations.		<ol style="list-style-type: none"> 1. Devise efficient numerical schemes of the fractional KdV equations along with error analysis. 2. Study the optimal control problems arising in production systems and subsequently, perform the sensitivity analysis.
2.	Dr. Sartaj Ul Hasan https://sites.google.com/site/sartajulhasan/	Finite Fields and Applications		<ol style="list-style-type: none"> 1. Study of permutation polynomials over finite fields. 2. Study of recursive sequences over finite fields and their applications in cryptography.
3.	Dr. Ajay Kumar	Combinatorial Commutative Algebra		<p>The symbiosis of combinatorics and commutative algebra have proved beneficial for many branches of mathematics. Many problems in combinatorics can be proved using tools of commutative algebra. Graphs and simplicial complexes play an important role in combinatorial commutative algebra. In order to see the relationship between commutative algebra and combinatorics, one can</p>

				associate monomial ideals to certain combinatorial objects such as graphs, simplicial complexes. Thus it is always interesting to find the relationship between combinatorial invariants of a combinatorial object and algebraic invariants of the associated monomial ideal.
Department of Humanities and Social Sciences				
1.	Dr. Varsha Singh	Images and Culture, Popular epics, Adaptation, retelling and translation		Visual narratives (theory and performance), Literary thought and philosophy, political Literature, Image Studies, Graphic novels and Comics in India, Representations of Food, Disease and Illness in Literature, Popular mythology and epics, Genre and Canon, Violence Studies, Gender and Culture, Translation Studies
2.	Dr. Quleen Kaur Bijral	Postcolonial and Subaltern Studies; Film and Media Studies; Ecocriticism and Environmental Humanities; Literature and Philosophy; Existentialism and Theatre of Absurd; Mythology and Literature; Comparative Literature; Emerging Fields as in Apocalyptic Fiction		Literary Theory and Criticism from the vantage of postcolonial, ecocritical, film studies, psychoanalytic, Subaltern and other prominent as well as time-tested parameters of the theoretical framework. The selection of works can be from various genres of world literature and so forth. Emerging Fields such as

		and Cinema and so forth.		Apocalyptic Fiction and Cinema, Cyber Crime, Migratory/Travel Literature and so on in order to cater to growing fields of interest, assessing momentous changes in literature as well as incorporating the essential model of comparison- reworking of mythology, and so on.
3.	Dr. Joby Varghese	Values in science and technology; Testimonial knowledge in pharmaceutical research and clinical trials; Ethics; Bioethics; Western Philosophy; Epistemology		The role of non-epistemic values such as ethical, social, political values in scientific research; The problems and feasibility of testimonial scientific knowledge claims; Addressing the problem of epistemic risk which encroaches through funding effect, lack of freedom and preference bias during a scientific research so that to a certain extent the scientific knowledge claims which are gained through testimony can be made more plausible; Normative and applied ethics
4.	Dr. Sukanya Mondal	South Asian Subaltern Studies, Voices from the margin, Masculinity Studies		Literature that represents the underprivileged sections of society, Literature that defines various aspects of normative masculinity or problematizes those norms, colonial war literature and masculinity

5.	Dr. Sayantan Mandal	Sociology of Education, Social Diversity Discrimination and Inclusion, Social development, Higher Education, Education Policy, ICT and Education, Teaching Learning, Sustainable Tourism		Social diversity, discrimination based on caste, social or economic class in educational institutions; Higher education - issues related to policy, international and transnational policy analysis; Teacher Professional Development - focusing on school and higher education, Government Schemes and programmes; Innovative Teaching-Learning approaches, ICT and its uses in Education - integrating ICT and Teaching Learning in Indian Higher Educational Institutions. Sustainable Tourism -in the Himalayan region focusing on the problems related to overtourism, social changes due to tourism.