TAP topics

Name of Faculty	Title of PhD topic	Project code	Area of the research (One key word)	Nature of the project (Experimental/Modeling/Theoretical/):	Objectives (4-5 lines): You may provide a link to the additional information (Additional description, videos etc.) [Optional]	Background required (e.g. Chemical Engg/Chemistry/Physics, Specific experimental expertise/Knowledge in coding, etc.):
Ranjit Chiplunkar	Physics-Informed Machine Learning for Interpretable Process Monitoring	RC-TAP	Process Systems Engineering	Both: Theoretical (Computational or Modelling) + Experimental	This PhD project will develop machine learning methods that combine physical knowledge with process data for interpretable monitoring of chemical engineering processes. The research will focus on learning compact, physically meaningful representations of process dynamics that reveal hidden patterns and provide insights into process behaviour. The project will focus on a class of machine learning models called probabilistic dynamic latent variable models, which capture process dynamics through a smaller set of underlying variables. Physical knowledge will guide the extraction of meaningful representations, and the Bayesian inference framework will enable learning from data and quantification of uncertainty. Such approach will support understanding of process behaviour, detection of abnormalities, and interpretation of their possible causes. The methods will be evaluated using representative chemical engineering case studies, both via simulations and experiments.	Candidates should have strong foundations in linear algebra, probability, and statistics. An interest in mathematical modelling, machine learning, and coding is essential.
Sujit Jogwar	Foundational Model to Aide Process Design Activity	SuJ-TAP	Process Systems Engineering	Theoretical / Computational / Modelling	Going from a production route concept, such as that embodied in a process flow diagram, to a detailed piping and instrumentation diagram is a challenging and iterative process. Currently it relies heavily on human expert involvement. This project will investigate AI driven approaches to automate significant proportion of this journey enabling the human expert to focus on key decisions. This will involve tools around digitization, multimodal language models, and incorporation of safety analysis methodologies such as Hazop during the design process. This project is in collaboration with a leading industrial partner.	Chemical Engg with interest in control, AI, and coding
Nagappan Ramaswamy	Development of Proton Exchange Membrane Water Electrolyzers	NR-TAP	Clean hydrogen	Experimental	The project will focus on the development and diagnosis of low-temperature water electrolyzer devices for hydrogen production with specific emphasis on decreasing capital expense without impairing performance and durability. The prospective student will apply fundamental chemical and electrochemical engineering principles to improve polarization curve performance, durability under accelerated stress test conditions, optimize hydrogen gas permeability of water electrolyzers.	Chemical engineering

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Jyoti R Seth	Particle-Stabilized Emulsions and Foams	JS-TAP	Soft Matter	Both: Theoretical (Computational or Modelling) + Experimental	Emulsions and foams underpin critical processes across food manufacturing, pharmaceutical formulation, enhanced oil recovery, and advanced materials synthesis — yet their stability and flow behaviour are governed by interfacial physics that remains poorly understood. When solid particles populate the interface between phases, whether introduced colloids or in situ-crystallizing species such as proteins and monoglycerides, the interface acquires a complex mechanical character that controls coalescence, structural integrity, and ultimately product performance. Despite the industrial stakes, no unified framework exists connecting interfacial microstructural evolution to measurable mechanical response across these stabilizer classes — a gap that limits rational process and formulation design. This PhD project addresses that challenge directly, developing an integrated analytical, computational, and experimental framework through the design of custom instrumentation capable of real-time interfacial imaging under mechanical loading — a capability not yet resolved in the open literature. The candidate will engage across the full research spectrum, from constitutive modelling and high-fidelity simulation to hands-on apparatus development and experimental validation. This project suits candidates with strong foundations in fluid mechanics, transport phenomena, or thermodynamics who are driven to work at the frontier of what is currently measurable and theoretically tractable	Chemical Engineering, Chemistry, Physics, Nanotechnology, Energy Science
Nikhil Subraveti	Continuous manufacturing of liposomal drug products with real-time quality control	NS-TAP	Nanomedicine	Experimental	1. Relate mixing conditions in turbulent impinging-jet mixers to liposome size, polydispersity and internal structure. 2. Derive and test a scale-up rule across an order of magnitude in throughput. 3. Determine how the product withstands downstream processing and mechanical stress. 4. Implement in-line process analytics with process optimization for closed-loop control. 5. Benchmark against a marketed liposomal product.	Chemical Engineering, Chemical Technology or Pharmaceutical Technology. Useful experience: flow setups and pumps, dynamic light scattering, UV-Vis or HPLC, microfluidics, or design of experiments.
Mahesh Tirumkudulu	Fluid Mechanics of Smear-Based Diagnostics	MT-TAP	Fluid mechanics, Diagnostics	Both: Theoretical (Computational or Modelling) + Experimental	Rapid blood tests often need a separate device, strip or cartridge for each analyte, along with careful liquid handling. This PhD project explores a simpler idea. A blade spreads a drop of blood or plasma over a glass slide that carries tiny wells containing dried reagents, and each well fills with a metered volume of sample. The project will study the physics that decides whether a well fills completely and reproducibly. It looks at how capillary and viscous forces compete, and how viscosity, surface tension, well geometry and the dried reagent affect the flow. The aim is a predictive framework and design rules for slides that measure several analytes, such as glucose, creatinine, cholesterol, HbA1c and blood group, from a single drop, without the need for laboratory equipment. The work combines fluid mechanics, thin-film physics, and diagnostics,	A background in Transport phenomena (fluid mechanics, mass transfer, heat transfer) will be essential
Abhijit Chatterjee	Interface Engineering with Multifunctional Electrolytes for High-Voltage, Wide-Temperature Aqueous Zinc-Ion Batteries: A combined experimental and modeling study for addressing degradation challenges	AC-HW-TAP	Sustainability	Both: Theoretical (Computational or Modelling) + Experimental		
Sanjay Mahajani	Circular economy: Reclamation of waste foundry sand by chemical method.	SMM-HW-TAP	Sustainability	Both: Theoretical (Computational or Modelling) + Experimental		
Jyoti R Seth	Field-Driven Beneficiation of Critical Minerals	JS-HW-TAP	Sustainability	Experimental		
Yogendra Shastri	Development of a open-source tool to perform LCA of transport fuels and energy products	YS-HW-TAP	Sustainability	Theoretical / Computational / Modelling		

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Sonali Das	Catalyst and reactor development for sustainable light-assisted CO2 Utilization	SD-FA	Catalysis & Reaction Engineering	Experimental	This project focuses on converting CO_2 into valuable fuels and chemicals. You will work on developing high-performance catalysts and explore photothermal approaches to drive the reaction more efficiently. The work will involve catalyst synthesis, advanced characterization, flow reactor experiments, and reactor design/ optimization.	Chemical Engineering/ Chemistry/ Materials
Sonali Das	Catalyst and process development for plasma-catalytic conversion of greenhouse gases	SD-FA	Catalysis & Reaction Engineering	Experimental	This project explores how greenhouse gases (GHG) such as methane and carbon dioxide can be directly converted into more valuable fuels and chemicals using renewable electricity. You will work with non-thermal plasma and catalysis to enable GHG conversion at low temperatures, addressing key challenges like energy efficiency and product selectivity. The project combines catalyst development, reactor design, and process modeling.	Chemical Engineering/ Chemistry/ Materials
Santosh Noronha	Production of chiral pharma intermediates.	SBN-FA	Bioprocess engineering	Experimental	The objective of this project is to overproduce a key chiral pharma intermediate, currently extracted from plants. The strategies we propose to use include transferring pathways to microbial systems from plants and other microbial systems, manipulation of pathway fluxes in these systems, and engineering relevant enzymes to have improved catalytic activities.	Project-related experience with biochemistry, microbiology and molecular biology techniques would be an advantage.
Nagappan Ramaswamy	Water electrolyzers	NR-FA	Energy consumption of hydrogen production	Experimental	Current water electrolysis methods to produce hydrogen consume very high amounts of electrical energy on the order of 50 to 60 kWh/kg. While energy efficiency is an important metric, the high energy consumption makes the electrolytic hydrogen production routes less favourable since the operational cost (electrical energy price) remains the most dominant factor in water electrolyzer operation. The prospective student will focus on the fundamental electrochemistry to develop new processes that decrease energy consumption.	
Nagappan Ramaswamy	Redox flow batteries	NR-FA	Electrochemical energy storage	Experimental	Long duration energy storage (>= 6 hours) is the need of the hour in the electrochemical energy storage space to support the penetration of renewable electricity into the grid. The prospective student will work on the fundamentals of redox flow batteries with a specific focus on enhancing energy storage duration and round trip efficiency.	
Bharatkumar Suthar	Development and Electrochemical Modeling of Low-Temperature Optimized Sodium-Ion Batteries	BKS-FA	Batteries	Both: Theoretical (Computational or Modelling) + Experimental	This PhD project aims to develop lowtemperature optimized sodium-ion batteries for reliable operation in demanding environments (0 to −20 °C), with relevance to defence and strategic applications. The work combines experimental development (materials, cell fabrication, and diagnostics) with physicsbased electrochemical modeling to understand and overcome key limitations such as transport constraints, interfacial resistance, and performance degradation. The outcome will be robust battery designs and predictive tools for operation in cold and harsh conditions.	Chemical Engg

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Bharatkumar Suthar	Zinc-Ion Batteries for Affordable Grid Storage	BKS-FA	Batteries	Both: Theoretical (Computational or Modelling) + Experimental	Zinc-ion batteries (ZIBs) are emerging as a promising option for low-cost, large-scale grid storage, especially in the Indian context where affordability and material availability are critical. Based on abundant and non-critical materials like zinc and water-based electrolytes, ZIBs offer inherent safety and supply-chain resilience compared to lithium-ion systems. This research will focus on developing physicsbased models and simulation tools to understand performance and degradation, and to guide scale-up from lab cells to practical grid systems. The goal is to enable robust, economical energy storage solutions tailored for renewable integration and decentralized power needs in India.	Chemical Engg
Swati Bhattacharya	Decoding the Antiviral Machinery of anti-HIV protein APOBEC3G	SwB-FA	Computational biophysics	Theoretical / Computational / Modelling	Our bodies have a natural protein (called A3G) that can fight off HIV-1 by disrupting the virus's DNA. But HIV has sneaky ways to fight back. We want to understand how this protein moves and interacts at a molecular level so researchers can design better therapies. The student will use computer simulations and data tools to study how A3G works. What they will learn: How to run state-of-the-art molecular dynamics simulations Practical statistical mechanics applied to real biological systems Essential data science tools for analyzing complex molecular data	Students from chemical, chemistry, physics, engineering physics, Biotech/BioEngineering are encouraged to apply. Skills- A keen interest in biomolecular modelling and computational work is required. No prior expertise in structural biology or coding is required.
Nikhil Subraveti	From particle design to cellular delivery: targeted lipid nanoparticles for genetic medicines	NS-FA	Nanomedicine	Experimental	1. Manufacture ligand-bearing lipid nanoparticles continuously in turbulent impinging-jet mixers. 2. Develop quantitative methods to characterise surface properties across a particle population. 3. Relate population characteristics to cellular uptake and transfection efficiency. 4. Extend the approach to multi-component nucleic acid payloads. 5. Maintain product characteristics as manufacturing throughput increases.	Useful experience: cell culture and transfection, flow cytometry, fluorescence microscopy, RT-qPCR, or protein expression and purification.

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Jyoti R Seth	Technologies for Clearing Blockages in Pipelines Using Electric Fields	JS-FA	Field driven flows	Both: Theoretical (Computational or Modelling) + Experimental	The project aims at developing innovative, energy-efficient methodologies—currently lacking in optimized pipeline management—for the electrohydrodynamic remediation and prevention of wax blockages in crude oil transport. Building on fundamental research demonstrating that electric fields can break down wax networks into low-viscosity fluids to restore flowability, the candidate will investigate the precise mechanisms governing electric field interactions with paraffinic microstructures. On the application and engineering spectrum, the work will extend to the multi-objective design of field-generating devices, characterization of field-wax interaction kinetics, and evaluation of localized, rechargeable power architectures to enhance operational sustainability. The project will combine theoretical analysis, computational modeling, and prototype device design aimed at minimizing energy costs and operational disruptions in crude oil logistics. Though primary focus will be on device design and numerical/analytical modelling, the candidate will have an opportunity to study the phenomena from a fundamental perspective and apply the learnings to other applications in healthcare and smart materials.	CHemical/Mechanical Engg, Physics, Chemistry, Materials
Jyoti R Seth	Field-Driven Active Particle Propulsion and Collective Dynamics	JS-FA	Active Flows	Both: Theoretical (Computational or Modelling) + Experimental	How do individually propelled particles — driven by external electric or magnetic fields — collectively organise, exchange momentum, and give rise to emergent flow structures that cannot be predicted from single-particle behaviour alone? This question sits unresolved at the intersection of electrokinetics, non-equilibrium statistical mechanics, and multiphase flow, yet its answer has direct consequences for the rational design of active colloidal systems in applications ranging from microscale transport to responsive materials. This PhD project will pursue that answer rigorously, through a tightly coupled experimental and computational programme spanning bulk suspensions and fluid interfaces.Candidates with strong grounding in fluid mechanics, transport phenomena, or applied physics, and the appetite to pursue open problems with both analytical and experimental rigour, are strongly encouraged to apply.	CHemical/ Mechanical Engg, Physics, Chemistry, Materials
Sarika Mehra	A high-productivity CHO platform for difficult-to-express biologics	SM-FA	biotechnology	Experimental	Bispecific antibodies, Fc-fusions and other complex biologics are often limited not by transcription but by the capacity of the endoplasmic reticulum to fold and secrete them, which keeps titres low and manufacturing costs high. We have generated TuniCHO-K1, a tunicamycin-adapted CHO-K1 host with expanded ER folding capacity, which shows a 12-fold increase in cell-specific productivity and is phenotypic stable over 40 generations. This project will test whether that advantage extends to difficult-to-express proteins, taking the host into suspension culture, generating cell lines for a bispecific target, and comparing productivity and product quality in controlled fed-batch bioreactors. The project spans mammalian cell engineering, bioprocessing and therapeutic protein production.	experimental expertise preferred

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Rajdip Bandyopadhyaya	Chemical sensor device development for detection of water pollutants and technology for their removal	RB-FA	Water	Experimental	We have already developed in our lab. an autonomous device for real-time, water quality monitoring by both physical and chemical sensors (some of the sensors being developed by us), with years of earllier work in our lab. by a multidisciplinary team of Chemical, Mechanical and Electrical Engg. students. We have also worked extensively on separation and removal of pollutants (arsenic, heavy metal, microplastics etc.) from water, by our nanoparticles and composites. In this new PhD project now, we will combine above steps of sensing and removal of pollutants from water. For this, first we will combine both physical and chemical sensors in a single device. Next, reactive adsorption of these pollutants by nanoparticle coated polymereic fibre will be carried out, to provide clean drinking water. Thus one has to have either some background or interest in chemical, environmental, materials engg. for basic research or have liking of designing and fabricating of electromechanical devices, to fit into our current multidisciplinary team and carry out PhD research. These research areas and projects were earlier funded by DST, India and Toray, Japan. Presently it is funded by GESH, IIT Bombay. Students of either Engineering or science background can learn and do research in this PhD project.	Engg.: Chemical, Environmental, Mechanical, Electrical

FA topics

Rajdip Bandyopadhyaya	Gravity-driven device for removal of microorganisms, metals and microplastics from water	RB-FA	Water	Experimental	We have already developed a working prototype for killing and removal of E. coli from water. It is based on our synthesized nanocomposite, made of Ag-Cu nanoparticle impregnated on granular activated carbon and packed into a filter column, which is driven by gravity-head of the water column. Consequently, it can continuously disinfect water in absence of electricity, by the action of nanoparticles on the bacteria. In the current project, the aim is to further study the removal of heavy metals and microplastics, by the same or related class of nanocomposites, as these are all critical contaminants present in water. To this end, we have already demonstrated, adsorbents and nanoparticles which remove arsenic, lead, cadmium and microplastics to make the water potable, fir for drinking. The final outcome would be a modular water treatment device, usable for household drinking water needs, by combining concepts of adsorption, reaction engineering, fluid flow and functional design principles to make a zero-energy, self-sufficient device. The work is mostly experimental with reasonable scope of modeling, if the student is interested. They get to work and learn in a multidisciplinary team of bio-sciences, chemical and mechanical engineering students, contributing to the overall goal of the project. The project was earlier funded by SERB (ANRF, India.	Engg.: Chemical, Environmental, Bioengg.

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Rajdip Bandyopadhyaya	Engineering nanoparticle size and shape: Multiscale modeling, simulation and applications	RB-FA	Nanoparticle	Both: Theoretical (Computational or Modelling) + Experimental	Nanoparticles show new and interesting properties different from bulk materials due to their extremely small size (diameter), large specific surface area and spatial anisotropy. It is thus critical to understand the variables that control its synthesis, leading to a desired application. Control of mean nanoparticle size, particle size distribution and specially, anisotropic particle shapes is the first step in many of these applications, involving enhanced adsorption and reaction rates. To gain further insight into the mechanism of formation of nanoparticles, we have already developed models on how individual nanoparticles form by processes like multiphase mass transfer, reaction, nucleation, Brownian collision, surface growth, coagulation and Ostwald ripening, followed by interparticle forces and differential growth rates along different crystal facets, leading to anisotropic particles. With the above mechanism in place, in this PhD project, one has to build on our existing mesoscale mathematical models (population balance equations) and computer simulation (kinetic Monte Carlo) codes to apply for nanoparticle formation and growth in microemulsions, macroemulsions and bulk solvents. In conjunction, one can also carry out experiments, if required, involving other complex nanostructures, like core-shell or oval and flower-shaped nanoparticles, besides cylindrical nanorods. Copper/silver/gold as metallic and iron oxide/zinc oxide/silica as metal oxide nanoparticles will be considered as typical model systems, since we are already using them, for different applications, like, chemical sensing, water purification devices, catalysis and drug delivery. Thus, the student can only perform multiscale computational research (using population balance equation or kinetic Monte Carlo simulation) or do a combination of experiments and modeling. Depending on the student's interest, there would be further scope to use the model and simulation predictions with available or new experimental data, for improving these exciting applications of nanotechnology. Finally, exploring whether anisotropic particles can display enhanced reactivity, is of paramount importance, as it will open up a new paradigm in reaction engineering. This will lead to enhancement in rates of existing or new chemical reactions, utilizing such particles as catalysts. It can be a potential new paradigm in reaction engineering.	Engg.: Chemical, Mechanical, Nanoscience and Engg.
Hemant Nanavati	Accurate Molecular Models for Real Polymers	HN-FA	Polymer Chemical Physics	Theoretical / Computational / Modelling	We develop compact, closed form, but accurate molecular models as well as elasticity relationships for real polymers, incorporating structural aspects. The applications include synthetic (e.g., those used as matrix for solid propellant) as well as high performance Bio-sourced polymers.	(Chemical Engg/Chemistry/Physics/Materials Science/Polymers) + Knowledge of coding

FA topics

Hemant Nanavati	Molecular Modeling of Elasticity of Spider Silk and Related Biopolymers	HN-FA	Biopolymer Physics	Both: Theoretical (Computational or Modelling) + Experimental	In this project, the aim is to understand quantitatively the molecular elasticity of biopolymers with potential engineering applications. The first example is Spider Dragline Silk, which may be several times stronger than steel (after normalizing the density). The work involves experimental, computational and theoretical analyses of the molecular structure of the biopolymer system.	(Chemical Engg/Chemistry/Physics/Materials Science/Polymers) + Knowledge in coding