1. **Course No.**:	CHE 6XX
2. **Course Title**:	**Fluid Dynamics of Microscopic Self-propulsion**
3. Lectures Per Week & Total Classes:	3 [Tutorial:0, Lab:0, Additional Hours:0], 39
4. Proposing Department:	Department of Chemical Engineering
5. Other faculty members interested in teaching:	Indranil Saha Dalal, Rahul Mangal, Dipin S. Pillai
6. Other Departments that may be interested:	ME, Physics
7. Proposing Instructor(s):	Akash Choudhary (`achoudhary@iitk.ac.in`)

Course Description: The ability to predict, control, and design the behaviour of microscopic swimmers such as motile bacteria, synthetic Janus colloids, and medical micro-robots, defines a growing frontier at the intersection of fluid mechanics, biophysics, and engineering. The principles governing locomotion at the micron scale are counterintuitive: fluid inertia is irrelevant, time-reversal symmetry severely constrains what strokes are possible, and a swimmer's fate in confinement is often dictated by the geometry of its far-field *signal*. This course provides students with the theoretical framework to understand these principles, starting from the fundamental properties of viscous flow to quantitative models of biological and artificial microswimmers. By the end of the course, students will be equipped to independently analyse swimmer kinematics and hydrodynamic signatures, apply the reciprocal theorem and image methods to new geometries, and critically read the current research literature on fluid mechanics of active matter and bio-inspired locomotion.

#	Title	Topics	Lec.
1	Motivation & introductory concepts	Artificial and biological microswimmers in nature; Stokes regime and its properties; vector-tensor algebra and index notation; upstream swimming: insights and limitations of a point-like swimmer model.	6
2	Motion of a sphere in Stokes regime	Stokeslet, rotlet, stresslet, drag, torque, Faxén relations, Oseen tensor, mobility and resistance formulation.	8
3	Minimal model of micro-swimming	Scallop theorem; 3-sphere swimmer; Lighthill efficiency; multipole expansion; far-field signature: pusher/puller/neutral swimmer classification.	4
4	General spherical swimmers	Lamb's general solution and Blake's squirmer model, Lorentz reciprocal theorem.	7
5	Catalytic self-propulsion of colloids	Diffusiophoresis and self-diffusiophoresis of Janus colloids: dependence of speed and hydrodynamic signature on catalytic coating modes.	5
6	Swimmer-boundary interactions	Image system for far-field interactions; method of reflections; upstream swimming revisited for bounded flows.	4
7	Anisotropic swimmers	Jeffery orbit for a spheroid; elongated bacteria in shear and Poiseuille flow; introduction to slender body theory, resistive force theory and flagellar propulsion; Taylor's swimming sheet; model of ciliary propulsion.	7

Prerequisites: For UG (3rd and 4th year): Transport Phenomena (CHE311) or equivalent

Fluid Mechanics course. For PG: Transport Phenomena (CHE611) or equivalent Fluid Mechanics course.

Recommended Texts and References

1. É. Guazzelli & J. F. Morris, *A Physical Introduction to Suspension Dynamics*, Cambridge University Press (2016).

2. E. Lauga, *The Fluid Dynamics of Cell Motility*, Cambridge University Press (2020).

Proposer (Date:March 2, 2026)　　　　DPGC Convener (Date:　　　　　　　)

Chairman, SPGC (Date:　　　　　)

The course is approved / not approved