**Indian Institute of Technology Kanpur**
**Proposal for a New Course**

1. Course No: CHE 6XX
2. Course Title: Microhydrodynamics and Suspensions
3. Per Week Lectures: 3 (L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours[0-2]: 0 (A), Credits (3-0-0-0) Duration of Course: Full semester
4. Proposing Department: Department of Chemical Engineering

   Other Departments/IDPs which may be interested in the proposed course: ME, MSE, SEE

   Other faculty members interested in teaching the proposed course: H. H. Katkar, Dipin S. Pillai
5. Proposing Instructor(s): Indranil Saha Dalal
6. Course Description:
   A) Objectives: This course aims to introduce microhydrodynamics leading to macroscopic phenomena in suspension dynamics. The concepts are expected to be useful for dynamics in a variety of systems relevant to chemical engineers, including suspensions, polymer solutions and even biological systems like blood, which is a essentially a suspension of RBCs. The course is aimed primarily towards PG students and would consist of computer-based exercises and term projects as well.

   B) Contents (preferably in the form of 5 to 10 broad titles):
   Lecture-wise break-up (considering the duration of each lecture is 50 minutes)

| S. No. | Broad Title | Topics | No. of Lectures |
|---|---|---|---|
| 1. | Viscous flows | Equations of fluid dynamics, buoyancy and drag, properties of Stokes flow – linearity, reversibility and instantaneity | 4 |
| 2. | Single sphere in Stokes flow | Single sphere flows – rotation, translation, straining, hydrodynamic force, torque, stresslet, Faxén laws | 5 |
| 3. | Solution techniques | Point force solution, point torque and stresslet, integral representation, multipole representation, resistance matrices, slender body theory, boundary integral method | 6 |
| 4. | Pair interactions | Sedimenting pair, pair in shear, pair lubrication interactions, Stokesian dynamics | 5 |
| 5. | Stochastic concepts | Probability distributions, ensemble average, Random walks and diffusion, Brownian motion, Stokes-Einstein relation and Smoluchowski equation, Langevin equation | 5 |
| 6. | Sedimentation | Settling of a suspension of spheres, influence of walls, velocity fluctuations and hydrodynamic diffusion | 4 |
| 7. | Shear flow | Suspension viscosity, non-Newtonian rheology in suspensions, microstructure of sheared suspensions, constitutive modelling of suspension stress, shear-induced diffusion, | 6 |

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|---|---|---|---|
| | | shear-induced migration | |
| 8. | Finite inertia | Oseen solution, settling at finite inertia, migration in pressure-driven flows | 5 |

C) Recommended pre-requisites, if any: PG level transport phenomena course or equivalent

D) Short summary for including in the Courses of Study Booklet:
Stokes flow, Resistance matrices, Pair interactions, Sedimentation, Suspension viscosity, Shear-induced diffusion and migration

7. Recommended text/reference books:
    1. Élisabeth Guazzelli and Jeffrey F. Morris, A physical introduction to Suspension Dynamics, Cambridge University Press (2012).
    2. S. Kim and S. J. Karrila, Microhydrodynamics: Principles and selected applications, Dover publications (2005).

8. Any other remarks: Home assignments and quiz/exams may also consist of computer-based exercises (preferably with Python/Matlab).

Dated:12/2/2025 Proposer: Indranil Saha Dalal

Dated: DPGC Convener:

**The course is approved / not approved**

**Chairman, SPGC**

**Dated:**