Course Type	Course Code	Name of Course	L	T	P	Credit
DE	NCHD510	Introduction to Granular Mechanics	3	0	0	3

Course Objective

- To provide a comprehensive knowledge of the mechanics of granular material because despite being the second-most handled material in industries and our activities, the mechanics of granular materials remains poorly understood by engineers

Learning Outcomes

Students will develop:

- A comprehensive understanding of the mechanics of granular materials
- Ability to solve industrial problems related to the storage, discharge, transportation, flow, and mixing of granular materials

Unit No.	Description of Lectures	Contact Hours	Learning Outcomes
1.	**Introduction**: Introduction to granular materials, their complex behaviour and wide applications	3	Recognition of granular materials as a complex fluid. Familiarity with their wide occurrence in industries and nature, recognizing their importance for study.
2.	**Basics**: Characterization of granular materials: Physical and mechanical characterization, Interactions in granular materials: Inter-particle and fluid-particle interactions	5	Familiarity with different characterization techniques for physical and mechanical properties of the particles of granular materials. Basic knowledge of different particle-particle and fluid-particle contact forces.
3.	**Granular statics**: Packing of granular materials, Force chains, Stress distributions in static granular piles and silos filled with granular materials	4	Insights into the statics of granular materials, recognizing similarities and dissimilarities in behavior compared to classical fluids and solids.
4.	**Granular dynamics: Quasi-static flows**: Plasticity of granular materials, Mohr-Coulomb theory, Critical state theory, Discharge of granular materials through hoppers, Issues of hopper jamming and its suppression	7	Knowledge of plastic behavior of granular materials and different classical theories devoted to plasticity. Understanding of discharge of granular materials through hoppers and problems of jamming.

5.	**Granular dynamics: Dense flows**: Jop-Forterre-Pouliquen (JFP) visco-plastic rheological model, Applications of JFP model to flows in different geometries like inclined planes, channels, rotating drums, and hoppers. Limitations of JFP model, **Saint-Venant** equations and their applications	**8**	Understanding of flows of granular materials at moderate shear rates in different geometries, which are important to industries. Familiarity with modeling of these flows using some classical models.
6.	**Granular dynamics: Rapid flows**: Granular kinetic theory and its applications and limitations	**4**	Basic knowledge of Granular Kinetic Theory. Familiarity with the application of this theory for flows at high shear rates.
7.	**Complex Granular flows:** Granular flows of mixtures of particles of different sizes, densities, and shapes, Issues of segregation and its analysis, Granular flows of cohesive particles	**6**	Familiarity with realistic granular flows, recognizing their complexities. Knowledge of modeling of these flows.
8.	**Numerical simulations of granular flows**: Introduction to Discrete Element Method (DEM) Simulations, Hands-on tutorial for LIGGGHTS, an open source DEM software, Problem solving using LIGGGHT	**5**	Familiarity with DEM simulations. Experience of solving flow problems using LIGGGHTS.
	Total	**42**	

Textbooks:

1. B. Andreotti, Y. Forterre, and O. Pouliquen. *Granular media between fluid and solid*. Cambridge University Press, 2013.

Reference Books:

1. J. Duran. *Sands, powders, and grains: An introduction to the physics of granular materials*. Springer, 2000.

2. K. K. Rao and P. R. Nott. *An introduction to granular flow*. Cambridge University Press, 2008.