

Introduction to Granular Matter (JF302 (3:0); January-April 2011)

Dr. Meheboob Alam

Engineering Mechanics Unit

JNCASR, Jakkur P.O., Bangalore 560064, India

Email: meheboob@jncasr.ac.in

Overview of Granular Matter: Granular Matter as Solid, Liquid and Gas. Dense-to-Dilute Regimes and Rapid-to-Slow Flows. Dry-to-Wet Granular Matter. Practical Applications in Industry and Geophysical Phenomena.

Mechanics of Particles and Simulation Techniques: Collision Models for Smooth and Rough Particles. Coefficient of Restitution and Impact Velocity. Coulomb Friction. Electromechanics of Particles. Particle Simulation Techniques: Hard- and Soft-sphere Models.

Kinetic Theory and Constitutive Models: Liouville Equation, Distribution Function and BBGKY-Hierarchy. H-theorem and Irreversibility. Molecular Chaos and Boltzmann Equation. Kinetic Theory of Dense Gases and Enskog Ansatz.

Microscopic Irreversibility and Inelastic Boltzmann Equation. Concept of Granular Temperature and Higher-order Balance Equation. Homogeneous Cooling State and Scaling Solutions of Boltzmann Equation. Transport Coefficients. Effects of Particle Roughness and Coulomb Friction on Inelastic Boltzmann Equation. Binary Mixture and Non-equipartition of Granular Energy.

Rheology and Dynamics: Haff's Law for Homogeneous Cooling State (HCS) and its Experimental Verification. Velocity Distribution Functions and Correlations in HCS and Driven Systems. Steady Couette Shear Flow: Rheology, Normal Stress Differences and Correlations. Driven Binary Mixture: Brazil Nut Segregation and its reverse.

Instabilities and Patterns in Shear Flow. Faraday Waves and Granular Rayleigh Benard Convection in Vertically Vibrated Granular Materials. Shock Waves in Granular Gases.

Jamming and Dense Slow Flows: Dense Granular Matter and Review of Recent Literature. Compactivity and Effective Temperature. Non-equilibrium Fluctuation-dissipation Relations. Plasticity-Theory-Based Models for Slow Flows.

Reference Books

1. Brilliantov, N. and Pöschel, T. (2004) *Kinetic Theory of Granular Gases*, Oxford Univ. Press.
2. Rao, K.K. and Nott, P.R. (2008) *An Introduction to Granular Flow*, Cambridge University Press.
3. Chapman, S. and Cowling, T.G. (1939) *Mathematical Theory of Non-Uniform Gases*, Cambridge University Press.
4. *Annual Review of Fluid Mechanics* (1990, 2000, 2003, 2007)
5. *Review of Modern Physics* (1992, 1996, 1999, 2006)