

Particle Technology

JMBC/T-MAPPP course

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The logo for Multi Scale Mechanics (MSM) is displayed in a stylized, lowercase, italicized font. It is positioned at the bottom left of the slide, below a solid blue horizontal bar that spans the width of the slide.

Granular Materials

Real:

- sand, soil, rock,
- powder, pills, granulate,
- grain, rice, lentils,
- ... and many others ...

Model Granular Materials

- steel/aluminum spheres
- **hard spheres** with **dissipation** (& friction)



Overview

Particle Technology?

Production, handling, modification
and use of particles.



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Production, handling, modification and use of particles.

Wet or dry



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Size range from
nm to cm



Overview

Particle Technology?

Production, handling, modification and use of particles.

Wet or dry

Size range from nano- to centi-meters

Applications:

Chemical, Mechanical, Geotechnical Engineering,
Agriculture, Petro-chemical, Food, and Pharma Industry
Mineral Processing, Advanced Materials, Energy, Environment



Goals

Broad overview of Particle Technology + Exercises

Day #1

Particles, size-shape classification, measurement + interaction with fluids

Day #2

Particle Flow, Comminution, Synthesis + Applications

Day #3

Particle rheology, interaction and two-phase flow, energy/heat processes

Day #4

Mixing/Segregation, Nanoparticle technology, sedimentation/fluidization

Day #5

Capillarity, wetting, granulation and attrition, population balance;



Literature – on contacts and DEM method for dry particles

more: (<http://www2.msm.ctw.utwente.nl/sluding/publications.html>)

[1] S. Luding *Collisions & Contacts between two particles*,

in: *Physics of dry granular Media*, eds. H. J. Herrmann, J.-P. Hovi, and S. Luding, Kluwer Academic Publishers, Dordrecht, 1998 [<http://www2.msm.ctw.utwente.nl/sluding/PAPERS/coll2p.pdf>]

[2] S. Luding, *Introduction to Discrete Element Methods: Basics of Contact Force Models and how to perform the Micro-Macro Transition to Continuum Theory*, *European Journal of Environmental and Civil Engineering - EJECE* 12 - No. 7-8 (Special Issue: Alert Course, Aussois), 785-826 (2008),

[http://www2.msm.ctw.utwente.nl/sluding/PAPERS/luding_alert2008.pdf]

[3] S. Luding, *Cohesive frictional powders: Contact models for tension*

Granular Matter 10(4), 235-246, 2008, [<http://www2.msm.ctw.utwente.nl/sluding/PAPERS/LudingC5.pdf>]

[4] M. Lätzel, S. Luding, and H. J. Herrmann, *Macroscopic material properties from quasi-static, microscopic simulations of a two-dimensional shear-cell*, *Granular Matter* 2 (3), 123-135, 2000, [<http://www2.msm.ctw.utwente.nl/sluding/PAPERS/micmac.pdf>]

[5] Regina Fuchs, Thomas Weinhart, Jan Meyer, Hao Zhuang, Thorsten Staedler, Xin Jiang, Stefan Luding, *Rolling, sliding & torsion of micron-sized silica particles - Experimental, numerical and theoretical analysis*, *Granular Matter* 16/3, 281-297, 2014

Literature – Books on DEM and modeling

Computer Simulation of Liquids, M. Allen and D. Tildesley, Clarendon Oxford, 1987

The Art of Molecular Dynamics Simulation

D. C. Rapaport, Cambridge University Press, 2004

Computational Granular Dynamics - Models and Algorithms

Pöschel, Thorsten, Schwager, T., Springer, 2005

Understanding the DEM: Simulation of Non-Spherical Particles for Granular and Multi-body Systems, Hans-Georg Matuttis, Jian Chen, 2014

Adhesive Particle Flow – A Discrete-Element Approach,

Jeffery S. Marshall, Shuiqing Li, Cambridge, 2014

and:

http://en.wikipedia.org/wiki/Discrete_element_method