

## TIME TABLE

| TIME          | Monday                     | Tuesday        | Wednesday      | Thursday       | Friday          |
|---------------|----------------------------|----------------|----------------|----------------|-----------------|
|               | <b>July 19</b>             | <b>July 20</b> | <b>July 21</b> | <b>July 22</b> | <b>July 23</b>  |
| 09.00 - 09.45 | Registration               | Di Renzo       | Wu             | Barreto        | Barreto         |
| 09.45 - 10.30 | Di Renzo                   | Di Renzo       | Di Renzo       | Barreto        | Radl            |
| 11.00 - 11.45 | Wu                         | Wu             | Di Renzo       | Pirker         | Pirker          |
| 11.45 - 12.30 | Di Renzo                   | Wu             | Radl           | Pirker         | Closing remarks |
| 14.00 - 14.45 | Wu                         | Alfano         | Alfano         | Pirker         |                 |
| 14.45 - 15.30 | Flash poster presentations | Alfano         | Alfano         | Pirker         |                 |
| 16.00 - 16.45 | Poster session             | Barreto        | Radl           | Radl           |                 |
| 16.45 - 17.30 | Poster session             | Barreto        | Wu             | Radl           |                 |
| 18.00         | Welcome aperitif           |                |                |                |                 |

## ADMISSION AND ACCOMMODATION

The course is offered in a hybrid format, allowing participants the flexibility to attend either in person or remotely via the Microsoft Teams platform. Admission to on-site attendance is granted on a first-come, first-served basis to comply with the capacity of the lecture room.

### Registration fees:

- **Early Bird On-Site Participation: € 650.00 + VAT\***  
Deadline: May 19, 2027
- **Late On-Site Participation: € 800.00 + VAT\***  
Deadline: July 7, 2027
- **Live Streaming Online Participation: € 250.00 + VAT\***  
Deadline: July 7, 2027

On-site participation includes a complimentary bag, five fixed menu buffet lunches, hot beverages, downloadable lecture notes.

Online participation includes downloadable lecture notes.

Application forms should be submitted online through the website: <http://www.cism.it>. A confirmation message will be sent to participants whose applications are accepted.

Upon request, and subject to availability, a limited number of on-site participants can be accommodated at the CISM Guest House for € 35 per person per night. To request accommodation, please contact: [foresteria@cism.it](mailto:foresteria@cism.it)

\* where applicable; bank charges are not included - Italian VAT is 22%.

## CANCELLATION POLICY

Applicants may cancel their registration and receive a full refund by notifying the CISM Secretariat in writing (via email) no later than:

- May 19, 2027, for early bird on-site participation;
- June 19, 2027, for late on-site participation;
- July 7, 2027, for online participation.

No refunds after the deadlines. Cancellation requests received before these deadlines and incorrect payments will be subject to a € 50.00 handling fee.

## CISM GRANTS

A limited number of participants from universities and research centers who do not receive support from their institutions can request a waiver of the registration fee and/or free lodging.

Requests must be submitted via the CISM website by **May 19, 2027**. Applicants should select the relevant option in the online application form and provide a curriculum vitae and a letter of recommendation from their department head or supervisor confirming that their institution is unable to provide financial support. Preference will be given to applicants from countries that sponsor CISM.

For further information please contact:

CISM (Seat of the course)  
Palazzo del Torso - Piazza Garibaldi 18 - 33100 Udine (Italy)  
tel. +39 0432 248511 (6 lines)  
e-mail: [info@cism.it](mailto:info@cism.it) | [www.cism.it](http://www.cism.it)



# DISCRETE ELEMENT METHOD FOR MODELLING POWDERS, PARTICLES AND MULTIPHASE FLOW

CISM Advanced School  
coordinated by

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University of Surrey, Guildford, UK

**Udine July 19 - 23 2027**

# DISCRETE ELEMENT METHOD FOR MODELLING POWDERS, PARTICLES AND MULTIPHASE FLOW

Powders and granular materials are ubiquitous, constituting over 75% of raw or intermediate processed materials in industry. Accurately predicting their behaviour remains a significant challenge due to distinctive characteristics like cohesion, arching, segregation, and electrostatics, amongst others. The Discrete Element Method (DEM) is a powerful tool to quantitatively investigate particle assembly dynamics across scales. When coupled with Computational Fluid Dynamics (CFD), it enables the study of highly interactive multi-phase systems. The objectives of this course are to provide participants with the necessary knowledge to comprehensively understand the fundamentals of DEM and CFD-DEM for dry solids and fluid-particle systems, respectively, enable full awareness of the

tool's capabilities and limitations, and offer an overview of current research and future directions.

The course offers:

- Fundamentals: Basic DEM concepts, implementation details, and key material/numerical parameters including calibration.
- Advanced particle modelling: Complex shaped, non-spherical, interlocking, flexible, rigid and breakable particles.
- Fluid-particle systems (CFD-DEM): Hydrodynamics, coupling, drag, buoyancy, and added mass.
- Forces & transport: Cohesive forces (van der Waals, liquid bridges, tribocharging), extraction of continuum properties (stresses/strains), and heat/mass transport.
- Computational efficiency: Speeding up DEM via coarse graining, surrogate modelling (recurrence CFD), and AI/Machine Learning.
- Data analysis & applications:

Visualisation of large DEM datasets (HPC) and applications across pharmaceutical, petrochemical, and geotechnical engineering.

The course features dedicated hands-on afternoon sessions utilizing open-source and commercial software to create and run simulations.

The school begins with four shared introductory lectures on the first day to establish a common background. This is followed by thematic lectures from international experts, each focusing on a specific research area. Participants will also engage in:  
- A flash poster presentation (Day 1 afternoon) for a brief introduction to participants' current research projects.

- A poster session following the initial presentations, promoting informal discussion and collaboration.

- Hands-on practical sessions across two afternoons showcasing the creation, execution, and data visualization of simulations using both open-source and commercial DEM codes.

- Daily interactions and collaborative learning sessions to foster networking.

The course is primarily addressed to doctoral students, early career researchers, practicing engineers, and technologists. While no prior DEM knowledge is required, participants should possess a solid foundation in graduate-level solid mechanics and fluid mechanics, alongside computational modelling experience. It is ideal for PhD candidates and R&D scientists (from food, pharma, energy, or structural sectors) aiming to develop solutions for processing complex particulate materials or establish new modelling groups.

## PRELIMINARY SUGGESTED READINGS

Norouzi, H. R., Zarghami, R., Sotudeh-Gharebagh, R., & Mostoufi, N. (2016). Coupled CFD-DEM Modeling: Formulation, Implementation and Application to Multiphase Flows. John Wiley and Sons Inc. <https://doi.org/10.1002/9781119005315>  
O'Sullivan, C. (2011). Particulate Discrete Element Modelling. A Geomechanics Perspective. 1st Edition. CRC Press. <https://doi.org/10.1201/9781482266498>  
Chapter 9 - Discrete Element Methods in "Particle Technology and Engineering", J.P.K. Seville and C. Wu (2016), Elsevier. <https://doi.org/10.1016/B978-0-08-098337-0.00009-6>

Wu, C. (2027, to appear) DISCRETE ELEMENT METHODS: Principles, Coupling and Applications. Elsevier.  
Guo, Y., & Curtis, J. S. (2015). Discrete Element Method Simulations for Complex Granular Flows. Annual Review of Fluid Mechanics, 47(1), 21–46. <https://doi.org/10.1146/annurev-fluid-010814-014644>  
Ge, W., Wang, L., Xu, J., Chen, F., Zhou, G., Lu, L., Chang, Q., & Li, J. (2017). Discrete simulation of granular and particle-fluid flows: from fundamental study to engineering

application. Reviews in Chemical Engineering, 33(6). <https://doi.org/10.1515/revce-2015-0079>  
Kieckhefen, P., Pietsch, S., Dosta, M., & Heinrich, S. (2020). Possibilities and Limits of Computational Fluid Dynamics–Discrete Element Method Simulations in Process Engineering: A Review of Recent Advancements and Future Trends. Annual Review of Chemical and Biomolecular Engineering, 11(1), 397–422. <https://doi.org/10.1146/annurev-chembioeng-110519-075414>  
Dosta, M., Andre, D., Angelidakis, et al. (2024). Comparing open-source

DEM frameworks for simulations of common bulk processes. Computer Physics Communications, 296, 109066. <https://doi.org/10.1016/J.CPC.2023.109066>  
Pirker, S. & Lichtenegger, T. (2018) Efficient time-extrapolation of single- and multiphase simulations by transport based recurrence CFD (rCFD), Chemical Engineering Science, 188, 65. <https://doi.org/10.1016/j.ces.2018.04.059>  
Alkin, B. et al. (2025) NeuralDEM for real time simulations of industrial particular flows, Communications Physics, 8, 440. <https://doi.org/10.1038/s42005-025-02342-4>

## INVITED LECTURERS

**Francesca Orsola Alfano** - Università della Calabria, Rende, Italy  
*4 lectures on:* Utilization of open-source and commercial DEM codes (Hands-on session). DEM applications in industrial dry particle systems (Hands-on session). Handling and visualization of DEM big data (Hands-on session). DEM applications in industrial fluid-particle systems (Hands-on session).

**Alberto Di Renzo** - Università della Calabria, Rende, Italy  
*2 Intro + 4 lectures on:* Introduction to: foundations of solids and fluid mechanics for particulate systems. Introduction to: contact mechanics, general implementation details of the DEM. Calibration of material and numerical parameters. Cohesive forces in dry systems I: electrostatics. Fluid-particle interactions: momentum coupling principles. Fluid-particle interactions: mixing and segregation phenomena.

**Daniel Barreto Gonzalez** - Edinburgh Napier University, UK  
*5 lectures on:* Modelling of non-spherical and rigid particles. Micro-macro transition: extraction of continuum properties. Analysis of stresses and strains in granular assemblies. DEM in geotechnical engineering I: Quasi-statics, particle breakage and soil element tests. DEM in geotechnical engineering II: Large strain/deformation problems.

**Stefan Pirker** - Johannes Kepler Universität Linz, Austria  
*5 lectures on:* Speeding up (CFD-)DEM simulations II: field based methods. Recurrence CFD surrogates for particulate processes. Hands-on session: rCFD simulations of fluidized bed processes I. Hands-on session: rCFD simulations of fluidized bed processes II. Speeding up (CFD-)DEM simulations III: AI-based NeuralDEM.

**Stefan Radl** - Technical University of Graz, Austria  
*5 lectures on:* Heat transfer modeling in multiphase granular systems. Speeding up (CFD-)DEM simulations I: coarse graining. Modelling interlocking and flexible non-spherical particles. Chaos and uncertainty inherent to DEM Simulations. Tribocharging in particulate systems.

**Chuan-Yu (Charley) Wu** - University of Surrey, Guildford, UK  
*2 Intro + 4 lectures on:* Introduction to DEM: basic concepts, importance, and industrial applications. Introduction to continuum modelling and transition from dry systems to fluid-particle coupling. Cohesive forces II: van der Waals interactions. Cohesive forces III: liquid bridges in wet systems. Fluid-particle interactions: drag, pressure gradients, and advanced models. DEM applications in the pharmaceutical and food industries.

## LECTURES

All lectures will be given in English. Lecture notes can be downloaded from the CISM web site. Instructions will be sent to accepted participants.