Project Work – Discrete Element Method

This group project aims to deepen your understanding of DEM theory and numerical concepts by extending the educational Python code provided in the exercise sessions. You are expected to implement new features and then carry out suitable verification and validation tests to assess correctness and robustness of your work. The outcomes should be summarized in a poster for presentation at the end of the course, with collaboration encouraged as long as each group member maintains a general understanding of the overall project and results.

Task 1 – Tangential contact force in the HM+D model

Implement the tangential contact contribution for the Hertz-Mindlin spring-dashpot (HM+D) model in the provided DEM code.

- Compute the tangential relative motion at the contact point and the tangential force using the rheological parameters in tangential direction.
- Respect the Coulomb friction condition, if the elastic tangential force exceeds the friction limit.
- Compute the torque due to tangential forces at the contact point for both particles and add it to the rotational equations of motion.

Task 2 – Particle-boundary contact (particle-wall)

Extend the code so that contacts are also detected and resolved between particles and fixed boundaries.

- Introduce a suitable representation of rigid boundaries in 2D (e.g. horizontal floor, vertical wall) and implement particle-wall contact detection including normal overlap.
- Reuse the HM+D contact law to compute normal and tangential forces for particle-wall contacts, treating the wall as rigid (infinite mass) and stationary (zero velocity at the wall).
- Compute the resulting torques on the particles and include all particle-wall forces and torques in the time integration scheme.

Task 3 – Verification and validation of the implementations

Devise and perform meaningful tests to verify and validate your new implementations.

- Develop at least three test scenarios (e.g. particle-particle collisions with friction, particle bouncing on a rigid floor, sliding with friction etc.).
- For each test, define initial conditions and parameters such that the expected behavior can be estimated from theory or simple calculations.
- Compare numerical results with these expectations and assess accuracy, plausibility and parameter sensitivity in your documentation and poster.