PFC Training Course
Itasca Consulting Group (Minneapolis, MN)

This four-day course provides guidance in the use of the Itasca codes PFC2D, PFC3D and PFC3D_EV[1] to simulate the mechanical behavior[2] of granular and solid materials. The focus is on simulating the fracture and flow of brittle rock-like materials. The PFC codes provide a general discrete-element engine along with the embedded language FISH, which provides full access to the internal variables of the model and allows one to implement user-defined behaviors. Most PFC modeling requires the use of FISH. After the discrete-element framework that forms the theoretical basis for PFC is understood and FISH is mastered, then the PFC codes can be used to simulate any physical process whose physics can be described by the interactions of discrete bodies.

TOPIC 1: Code Overview and Applications

- Itasca (consulting & software, PFC and other Itasca codes)
- Theoretical bases of discrete-element method and PFC
- Selected applications of PFC
    - Tool-rock interaction during rock cutting, backfill stability, pull-out test of concrete anchor, …
    - "Discrete Element Modeling of Rock Fracture for Nuclear Waste Isolation: Predicting the Effect of Lithophysae on the Properties of Volcanic Tuff"

TOPIC 2: PFC and FISH Tutorials

- Describe PFC, FISH and suggested modeling approach (to manage PFC and its components)
- PFC tutorial (simple data files, no FISH)
- FISH tutorial

[1] Enhanced Visualization for PFC3D (PFC3D_EV) replaces the graphical interface of PFC3D with a state of the art interface that provides accelerated 3D OpenGL graphics and introduces the concept of a *project* as a collection of data files, save states and plot views.

[2] Fluid-particle interaction modeled with the Coupled CFD add-on for PFC3D and the Basic Fluid Analysis option is also presented.

TOPIC 3: Bonded-Particle Model for Rock (BPM)[3]

Emergent behaviors are similar to those of rock and quantitative predictions require a calibration process.

- PFC FishTank support for BPM (includes material-genesis procedure to create a material and material-test procedures to measure its macroproperties)
- Modeling of excavation-induced response: damage around a tunnel

TOPIC 4: Problem Solving with PFC

- Importing Computer-Aided Design data into PFC
  - Create complex wall geometries
  - Generate complex particle shapes (clumps)
- Boundary-value modeling
  - Setup a dedicated modeling environment
  - Examples to be developed interactively based on student interests. Potential examples include: studying the effect of varying the microstructure or microproperties on compression-test response, or creating a shear-box test environment that includes a servo-controlled top wall.

TOPIC 5: Fluid-Particle Interaction

- Introduction to fluid dynamics
- Overview of coupling concepts
  - Coarse-grid method
  - Fine-grid method (Lattice Boltzmann)
- CCFD package (coarse-grid scheme, Coupled CFD add-on for PFC3D)
  - Solid modeling
  - CFD concepts
  - Example applications

TOPIC 6: Focus on Client Applications

- "The Design of PFC 5.0"
- Discuss modeling goals, formulate strategies
- Review previous material or cover it in greater depth, if desired
- Review the final exam from Potyondy's graduate course

[3] Potyondy, D.O., and P.A. Cundall. "A Bonded-Particle Model for Rock," *Int. J. Rock Mech. & Min. Sci.*, ***41***(8), 1329–1364 (2004).