The Hong Kong University of Science and Technology

UG Course Syllabus

Numerical Solutions to Geotechnical Problems

CIVL 4750

3 Credits

Prerequisites

MATH 230 (Introduction to Numerical Methods)

CIVL 3730 (Fundamental of Geotechnics/Soil Mechanics)

CIVL 3720 (Geotechnical Analysis and Design)

Name: Shiwei Zhao, Deyun Liu

Email: ceswzhao@ust.hk, deyunliu@ust.hk

Office Hours: By email appointments

Course Description

This course aims to provide students with necessary knowledge and numerical skills to solve practical geotechnical problems. The students will be taught to use knowledge of soil mechanics and geotechnical engineering and general-purpose computer software packages to solve practical geotechnical problems associated with seepage, slope stability, consolidation and piles. Commonly available computer programs based on the limit equilibrium method, finite difference method and finite element method will be the focus of the course.

Intended Learning Outcomes (ILOs)

By the end of this course, students should be able to:

ILO1: Explain the fundamental concepts of numerical modeling in geotechnical problems.

ILQ2: Explain the applicability of the limit equilibrium method, finite difference method and finite element method.

ILQ3: Develop analytical skills and establish technical judgements and understanding on selection of model parameter, setup of models and verification of numerical solutions.

ILO4: Use popular geotechnical software packages including Geo-Slope, PLAXIS and FLAC in practical design and analysis.

ILO5: Execute a complete project in team from problem formulation, time management, design/implementation, up to verification and documentation.

Assessment and Grading

This course will be assessed using criterion-referencing and grades will not be assigned using a curve. Detailed rubrics for each assignment are provided below, outlining the criteria used for evaluation.

Assessments

Assessment Task	Contribution to Overall Course grade (%)	Due date
In-class activities	5% (bonus points)	Week 1 to 13
Homework assignments	5 x 10%	TBD
Group term project	40%	TBD
Group project presentation	10%	TBD

Mapping of Course ILOs to Assessment Tasks

Assessed Task	Mapped ILOs	Explanation
In-class activities	ILO1, ILO2, ILO3. ILO4	This task assesses students' ability to catch up with the lecture materials that cover the basics of numerical solutions (ILO1, ILO2) and the tutorials on the popular geotechnical software packages (ILO3, ILO4).
Homework assignments	ILO1, ILO4	Homework evaluates students' ability to explain the use of the software packages (ILO4) and to comprehend and recall the theoretical knowledge discussed in the lecture (ILO1).
Group term project Group project presentation	ILO3, ILO5	These tasks allow students to put into practice what they have learned in both theoretical knowledge and software skills through their tailor-made project. Additionally, it focuses on project planning, effective teamwork, and leadership skills.

Grading Rubrics

Below are **table-style rubrics** for **A1–A7** (aligned to your 7 syllabus modules). **Scale:** 4 = Excellent · 3 = Good · 2 = Satisfactory · 1 = Marginal · 0 = Deficient. (**Each criterion = 20%**, total 100%). These rubrics are applicable to both homework and group term project.

A1 — Use of Computers in Geomechanics

Criterion (20% each)	4	3	2	1	0
Problem abstraction & type	Correct, complete; units/BC/IC precise	Minor omissions	Adequate but generic	Incomplete/ambiguous	Not demonstrated
Analytical/benchmark reproduction	Correct and verified	Minor numeric drift	Roughly consistent	Weak/partial	None/incorrect

Method/software choice	Well-justified FD/FEM/LEM; limits clear	Mostly justified	Basic rationale	Weak rationale	Inappropriate
Numerical error awareness	Clear truncation/round-off trends	Partial trends	Mentioned only	Vague	Absent
Communication & reproducibility	Clean figures; runnable files + README	Minor gaps	Reads with effort	Disorganized	Not reproducible

A2 — Introduction to FD & FEM (1D pile, Terzaghi FD; FEM weak form)

Criterion (20% each)	4	3	2	1	0
Problem & BC/IC correctness	Geometry/load/symmetry precise	Small issues	Adequate	Significant gaps	Incorrect
FD implementation & stability	Stable, consistent; no spurious oscillations	Minor artifacts	Works but fragile	Unstable at times	Fails
FEM weak form & element essentials	Proper shape funcs/Gauss/constraints	Minor slips	Basic but valid	Misapplied	Not shown
Verification & comparison	Matches analytical/hand/FD; explains diffs	Small deviations	Partial checks	Minimal checks	None
Communication & reproducibility	Settings/screens + models/scripts clear	Minor gaps	Usable with effort	Messy	Not runnable

A3 — 2D FEM Seepage with SEEP/W (steady + transient)

Criterion (20% each)	4	3	2	1	0
SWCC & k(θ) selection	Sources/fit clear; assumptions stated	Minor gaps	Representative	Weak basis	Unjustified
BC/IC suitability	Realistic heads/flux/rain; suction profile sound	Small issues	Adequate	Doubtful	Incorrect
Model build & controls	Mesh/time-step well chosen; convergence noted	Minor tuning needed	Acceptable	Unstable/opaque	Inadequate
Results & mass balance	Heads/flux plots; mass-balance quantified	Minor imbalance	Reported qualitatively	Vague	Missing
Sensitivity/scenarios	ks/rainfall effects evidenced	Limited scope	Minimal	Token	None

A4 — Slope Stability (SLOPE/W) with rainfall coupling

Criterion (20% each)	4	3	2	1	0
Geometry & stratigraphy	Layers/γ/c′/ϕ′/phreatic line correct	Minor edits	Basic	Partial/misaligned	Wrong
Method selection & assumptions	Suitable LEM; limits explicit	Mostly suitable	Adequate	Weak	Inappropriate

Pore-pressure coupling	Seepage import or justified proxy; FOS impact	Minor gaps	Basic use	Weak linkage	None
Search/computation	Slip search + strength reduction sound	Minor tune	Acceptable	Inefficient/ unclear	Unsound
Sensitivity & interpretation	Key controls identified; implications clear	Mostly clear	Limited	Vague	Absent

A5 — Introduction to Soil Constitutive Models

Criterion (20% each)	4	3	2	1	0
Theory grasp	Elastic/plastic/CSSM concepts accurate	Minor slips	Basic	Gaps	Misconceptions
Model choice & scope	Well-matched to problem; limits clear	Mostly apt	Adequate	Weak fit	Poor/none
Parameter determination	From tests/typical data; units/source clear	Minor gaps	Rough estimates	Weak basis	Not justified
Benchmark comparison	Curves/results align with refs/tests	Small drift	Partial	Minimal	None
Communication & reproducibility	Parameter tables; loadable files	Minor gaps	Basic	Disorganized	Missing

A6 — 2D/3D FE Stress–Strain (PLAXIS 2D/3D)

Criterion (20% each)	4	3	2	1	0
Model & staging	K_0, boundaries, loads, sequences realistic	Minor fixes	Adequate	Weak	Flawed
Constitutive model & parameters	MC/HS etc. justified; drained/undrained clear	Minor gaps	Basic	Doubtful	Inapt
Numerical controls & convergence	Mesh/solver choices robust; non-convergence handled	Minor tuning	Acceptable	Frequent issues	Uncontrolled
Results & comparisons	Settlements/deflections/stresses vs benchmarks	Small diffs	Some checks	Minimal	None
Robustness & reproduction	Mesh independence/param sensitivity; files complete	Partial	Basic	Weak	Absent

A7 — 2D FD & FLAC (incl. strength reduction)

Criterion (20% each)	4	3	2	1	0
Model & BC/IC	Domain/boundaries/initial stresses correct	Minor edits	Adequate	Weak	Incorrect
Loading & sequencing	Steps clear; controls appropriate	Minor issues	Basic	Confusing	Incoherent
Strength reduction implementation	Procedure and FOS extraction sound	Minor gaps	Works	Fragile	Fails
Numerical stability & controls	Iteration/damping/step well managed	Some tuning	Basic	Unstable	Not managed
Documentation & reproducibility	Input/logs/screens complete; labeled plots	Minor gaps	Adequate	Messy	Missing

Final Grade Descriptors:

[As appropriate to the course and aligned with university standards]

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Demonstrates comprehensive mastery of numerical geomechanics; correct and efficient implementation of methods; rigorous verification/validation and sensitivity studies; critical interpretation that informs engineering decisions; professional documentation and full reproducibility.
B	Good Performance	Strong grasp of methods with minor shortcomings; appropriate model setups and parameter choices; reasonable checks; clear, mostly reproducible reporting; conclusions supported by results.
C	Satisfactory Performance	Adequate understanding of core topics; completes required analyses with basic checks; limited depth in interpretation; documentation sufficient to follow main steps.
D	Marginal Pass	Threshold understanding; analyses contain notable gaps or weak justification; minimal checking; conclusions only partially supported; documentation barely sufficient.
F	Fail	Insufficient understanding or incorrect application of numerical methods; missing or flawed analyses; absent verification/validation; conclusions unsupported; inadequate documentation.

Course AI Policy

Generative AI may support communication and workflow but must not replace students' technical work or learning outcomes (problem formulation, numerical implementation, parameter selection, verification/validation, and engineering judgement). Students are fully responsible for the accuracy, legality, and integrity of submitted work.

Communication and Feedback

Marks posted on Canvas within two weeks of submission. Feedback will briefly state strengths and areas for improvement, aligned to the rubric. Queries/Regrade: contact the instructor within five working days of feedback release. A recheck may increase, decrease, or leave unchanged the mark.

Resubmission Policy

To ensure fairness for students who submit assignments on time, a penalty for late submission is listed as follows:

- Late submission within 1 day, 25% penalty will be applied.
- Late submission between 2 to 3 days, 50% penalty will be applied.
- Late submission for more than 3 days will not be accepted.

Required Texts and Materials

1. Zhao, J.D., 2021. CIVL 4750 Lecture Notes for Numerical Solutions to Geotechnical Problems, HKUST.
2. GEO-SLOPE International Ltd. 2007. SEEP/W and SLOPE/W 2007 Manuals. www.geo-slope.com
3. Itasca Consulting Group, Inc. 2000. FLAC Fast Lagrangian Analysis of Continua, V4.0, www.itascacg.com
4. PLAXIS 2D/3D 2010 Manual. www.plaxis.nl

Academic Integrity

Students are expected to adhere to the university's academic integrity policy. Students are expected to uphold HKUST's Academic Honor Code and to maintain the highest standards of academic integrity. The University has zero tolerance of academic misconduct. Please refer to Academic Integrity | HKUST – Academic Registry for the University's definition of plagiarism and ways to avoid cheating and plagiarism.