Subject Description Form

Subject Code	CSE583
Subject Title	Analytical and Numerical Methods in Geotechnical Engineering
Credit Value	3
Level	5
Pre-requisite/ Co-requisite/ Exclusion	Students should have knowledge and basic understanding of calculus, soil mechanics, and foundation engineering consistent with undergraduate level study in civil engineering.
Objectives	1. To familiarize students with the basic elastic plastic theory and principle of analytical methods in geotechnical engineering; 2. To understand the fundamental theory and simple implementation of commonly used numerical methods, i.e., finite element method and finite different method; 3. To integrate the knowledge on soil mechanics and different analytical and numerical methods to analyze simple and more complex geotechnical problems.
Intended Learning Outcomes	Upon completion of the subject, students will be able to: a. understand the basic concept of analytical methods and finite element method as modelling techniques in geotechnical engineering; b. apply analytical and numerical methods to analyze and assess simple and more complex soil-structure interaction problems; c. explain the most common constitutive models and their limitations; d. critically assess the results of analysis and to carry out benchmarking against known solutions; e. implement simple numerical code and utilize commercial software (e.g. PLAXIS) to develop finite element model and simulate real geotechnical problems and interpret modelling results.
Subject Synopsis/ Indicative Syllabus	1. Introduction (0.5 week) Design objectives, theoretical considerations, geotechnical structures.

	2. <u>Fundamentals of solid mechanics (1.5 weeks)</u> Stress analysis, strain analysis; elasticity; plasticity; some typical soil models. 3. <u>Analytical methods (3 weeks)</u> Fundamental concept of plasticity theory, limit equilibrium method, limit analysis methods, upper and lower bound principles – applications to bearing capacity, lateral earth pressure problems, and slope stability. 4. <u>Finite element method and practice (5 weeks)</u> The principle of finite element method (FEM), mathematical foundations, nodes, elements and shape functions, principle of virtual displacement, external and internal work; explicit/implicit resolution; multiphysics modelling; practice of programming; implementation of constitutive model; interface of a FEM software (eg. PLAXIS); how to run the software and conduct result analysis; several applications on footing, tunnelling, excavation, dam. 5. <u>Finite difference method and practice (2 weeks)</u> The principle of finite difference method; one-dimensional problems; two-dimensional problems; application of finite difference method in the geotechnical problems; Terzaghi one-dimensional consolidation. 6. <u>Discrete element method and practice (1 week)</u> The principle of discrete element method; mathematical foundations; mechanical foundations; practice of programming; result analysis with related theories.
Teaching/Learning Methodology	1. Lectures to deliver teaching materials; 2. Tutorials to discuss examples and case histories for various topics; 3. Teaching and program practice in computer barn; 4. Assignments; 5. Examination.
Assessment Methods in Alignment with Intended Learning Outcomes	(see table below)

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed				
		a	b	c	d	e
1. Assignment	10%	✓	✓	✓	✓	
2. Mid-term Project	30%	✓	✓	✓	✓	✓

3. Written Examination	60%	✓	✓	✓	✓	
Total	100 %					

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:

Assignment to some more tedious problems will help the students to utilize the more difficult and tedious teaching materials. The test will concentrate on some fundamental principle and challenging concept of the course.

The mid-term project focuses on aspects related to computer programming and numerical computation. It helps students to consolidate their understanding of these topics by solving classical problems.

The examination questions consist of some fundamental concept, conceptual understanding and application of the knowledge to solve different engineering problems.

Students must attain at least grade D in both coursework and final examination (whenever applicable) in order to attain a passing grade in the overall result.

Student Study Effort Expected	Class contact:	
	▪ Lecture	26 Hrs.
	▪ Tutorial	13 Hrs.
	Other student study effort:	
	▪ Self-study and homework	84 Hrs.
	Total student study effort	123 Hrs.

Reading List and References

Books:

1. Bathe, K.J. (1996), Finite Element Procedures in Engineering Analysis. Prentice Hall.
2. Chen, W.F. (1973), Limit Analysis and Soil Plasticity. Elsevier.
3. Cheng Y.M. and Lau C.K. (2008), Soil Slope Stability Analysis and Stabilization – New methods and insights, Francis & Taylors Group.
4. Cook, Malkus and Plesha (1989), Concepts and Applications of Finite Element Analysis. John Wiley.

	5. Jin, Y.F. and Yin, Z.-Y. (2022), Practice of FEM coding step-by-step for computational geotechnics. Springer. 6. Reddy, J.N., An Introduction to the Finite Element Method, McGraw-Hill, 1993 B.M. Das. 7. Smith, I.M., & Griffith, D.C. Programming the Finite Element Method. 2nd Edition (1992), John Wiley & Sons. 8. Wang, X. and Yin, Z.-Y. (2022), Practice of discrete element method in geotechnical engineering. Springer. 9. Yin, JH and Zhu, GF (2020). Consolidation Analyses of Soils. Consolidation Analyses of Soils. CRC Press of Taylor & Francis Group (ISBN 9780367555320). For more information see https://www.routledge.com/Consolidation-Analyses-of-Soils/Yin-Zhu/p/book/9780367555320. 10. Zienkiewicz & Taylor. The Finite Element Method. Vol. 1, 4th Edition, (1989), McGraw Hill. **References:** 1. Brinkgreve, R., Engin, E., Swolfs, W., 2012. Plaxis 2D 2012 user manual. Delft, Netherlands: Plaxis (2012). 2. Foundation design and construction (2006). by Geotechnical Engineering Office (GEO), HKSARG. 3. Geotechnical Manual for Slope, (1984). GEO, HKSARG. 4. Code of Practice for Foundations 2017. Buildings Department, HKSARG. 5. An Explanatory Handbook to the Code of Practice for Foundations 2017 (2019) by HKIE.