The Hong Kong University of Science and Technology
Department of Civil and Environmental Engineering

Course code Course title Instructors	CIVL 4220 Scientific Machine Learning for Infrastructure Systems Jize ZHANG
Prerequisites Credit	MATH2111 or MATH 2121 or MATH 2131 or MATH 2350 AND COMP1021 or COMP 1022P or COMP 1029P 3
Textbook(s) and/or other materials	Kevin P. Murphy. 2022. *Probabilistic Machine Learning: An Introduction*, MIT Press, Ian Goodfellow, Yoshua Bengio, and Aaron Courville. 2016. *Deep Learning*, MIT Press, Christopher Bishop. 2006. *Pattern Recognition and Machine Learning*, Springer.
Course Objectives	1. Represent uncertainty in parameters in civil engineering system models using probability and statistical techniques; 2. Solve basic supervised learning tasks, such as: regression, classification, and filtering; basic unsupervised learning tasks, such as: clustering, dimensionality reduction, and density estimation; 3. Create civil engineering domain-specific machine learning models that encode existing physical information and other causal assumptions 4. Apply basic Python software (e.g., numpy, scipy, scikit-learn) and advanced Python software (e.g., pytorch, Julia, Jax) for modelling and analyzing civil engineering systems.
Topics	• Fundamentals of probability models • Uncertainty Propagation and Bayesian Inference • Supervised and Unsupervised Learning • Gaussian Process • Deep Neural Networks • Advanced Topics
Computer usage	Computational software toolboxes allowed
Lab Projects	No lab work required
Class/lab schedule	Two 80-minute lectures per week
Contribution to the professional component	40% understanding fundamentals of probabilistic and statistics topics 40% modelling and solving probability-related problems in civil engineering 20% mastering / utilizing numerical methods and tools to solve problems
Relationship to program objectives	***1. Provide probability and statistical skills in civil engineering design, construction and management*** This course conveys statistics and probability knowledge which can be used to address uncertainties in engineering design, construction and management. ***2. Stimulate self-learning through open-ended problems*** The course provides some basic knowledge in computer simulation and the use of computing software toolboxes, which are utilized to treat traditionally tedious problems efficiently and creatively on computers.
Relationship to program outcomes	***1. Obtain fundamental knowledge in mathematics and science*** Students learn the fundamental theories of probability and statistics, and apply them in practical scenarios involving uncertainties in civil engineering systems. ***2. Acquire an ability to apply modern engineering and IT tools*** Students are taught to use state-of-the-art computing software toolboxes such as Python

	3. Develop an ability to identify and formulate civil engineering problems and propose feasible solutions Students are frequently exposed to examples/scenarios with open-ended design questions, which require them to apply theories learnt to define, formulate and eventually analyze the uncertainty of civil engineering systems of concern. ***4. Develop an appreciation of the breath of civil engineering and acquire basic knowledge in several disciplines*** Students are exposed to non-deterministic problems from multiple disciplines of civil engineering, and hence made aware that uncertainty exists in all types of science and engineering scenarios.
Assessment of Outcomes	1. Assignments are given to students to facilitate learning in the subject (for outcomes 1, 2, 3, 4) 2. Final projects and literature review reports will be required to assess student understanding during the learning process (for outcomes 1, 2, 3)
Prepared by	Jize ZHANG
Date	23 Jan 2024