The Hong Kong University of Science and Technology

UG Course Syllabus

Data Science for Neural Engineering

ELEC3810 / BIEN3310

3 Credits

Pre-requisites: (BIEN 2310 OR ELEC 2600 OR ELEC 2600H (prior to 2022-23) OR MATH 2111) AND (BIEN 3300 OR CENG 3300 OR LIFS 3150 OR MATH 2411)

Exclusion: BIEN 4310 (prior to 2022-23), ELEC 4830 (prior to 2022-23)

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Course Description

This is an introductory course for the application of data science in neural engineering. The course will introduce the fundamental principles of data science, the technologies, and implementations of probability and statistical estimation, as well as the modeling of several practical questions in neural engineering. The topics include probability, random variables, statistical detection and estimation, random process, structure and function of the nervous system, encoding and decoding, population coding, neural network, plasticity and learning, neural interfaces, and rehabilitation. Concepts from probability, random processes, and estimation will be introduced so that students can understand and implement real examples of neural engineering, and recognize the impact of the latest technologies.

The course will enhance the vision of the students and encourage them to work in future inter-disciplinary research fields. Students are expected to obtain knowledge of data science and neuroscience, and hands-on experience through a project on brain machine interfaces.

Intended Learning Outcomes (ILOs)

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

1. Explain fundamental concepts in probability, random processes, expectation, and statistical inference.
2. Describe major principles and technologies in neural engineering.
3. Recognize basic neuroanatomy and neural functional mechanisms.
4. Apply coding theory, computational tools, and data science methods to neural systems.
5. Analyze neural data and develop solutions for neural-controlled devices or robotic systems.
6. Demonstrate interdisciplinary problem-solving skills integrating neuroscience, engineering, and programming.

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
Homework	20%	30/10/2026 *
Midterm	30%	15/11/2026 *
Final Project	50%	20/12/2026*

* Assessment marks for individual assessed tasks will be released within two weeks of the due date.

Mapping of Course ILOs to Assessment Tasks

Assessed Task	Mapped ILOs	Explanation
Homework	ILO1.ILO4	This task assesses students' ability to explain fundamental concepts in probability, random processes, expectation, and statistical inference (ILO1), apply coding theory, computational tools, and data science methods to neural systems. (ILO 4).
Midterm	ILO3. ILO4. ILO5	This written exam accesses students' ability to recognize basic neuroanatomy and neural functional mechanisms (ILO 3), apply coding theory, computational tools, and data science methods on the synthetic data (ILO4), and analyze synthetic neural data (ILO5).
Final Project	ILO2. ILO3. ILO4. ILO5. ILO6	The final project and presentation assess students' ability to describe major principles and technologies in neural engineering (ILO2), recognize basic neuroanatomy and neural functional mechanisms (ILO 3), apply coding theory, computational tools, and data science methods on the synthetic data (ILO4), analyze synthetic neural data (ILO5), and demonstrate interdisciplinary problem-solving skills integrating neuroscience, engineering, and programming(ILO6).

Grading Rubrics

1. Accuracy of technical understanding
2. Analytical rigor
3. Application of methods
4. Programming / implementation quality
5. Clarity of presentation
6. Critical thinking and originality

Final Grade Descriptors:

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Demonstrates comprehensive mastery of subject matter, strong analytical ability, and outstanding application skills
B	Good Performance	Shows solid understanding, competent analysis, and effective problem-solving ability.
C	Satisfactory Performance	Meets core learning outcomes with adequate understanding and acceptable performance.
D	Marginal Pass	Demonstrates minimum acceptable achievement of course learning outcomes.
F	Fail	Does not meet the minimum standards required to pass the course.

Course AI Policy

Students may use generative AI tools (e.g., coding assistants, writing support tools, or data analysis assistants) only when explicitly permitted for learning support. Any AI-assisted work submitted for assessment must be clearly acknowledged. Students remain fully responsible for the accuracy, originality, and integrity of submitted work. Unauthorized use of AI in graded assessments may constitute academic misconduct.

Communication and Feedback

Assessment marks for individual tasks will be communicated via Canvas within two weeks of submission. Feedback may include comments on technical strengths, conceptual understanding, coding quality, and areas for improvement. Students with questions regarding marks should consult the instructor within five working days after feedback release.

Resubmission Policy

Unless otherwise specified by the instructor, reassessment or resubmission is not permitted. Exceptional cases will be handled in accordance with university regulations.

Required Texts and Materials

1. Gray, Robert M., and Lee D. Davisson. An introduction to statistical signal processing. Cambridge University Press, 2004.
2. Dayan P, Abbott L F. Theoretical neuroscience: computational and mathematical modelling of neural systems, Cambridge, MA, USA: MIT Press. 01 December 2001.

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.

Additional Resources

Reference：

1. Leon-Garcia Al., Probability, Statistics, and Random Processes for Electrical Engineering, 3rd Edition, Pearson Prentice Hall, 2008.

2. Michael S. Gazzaniga, Richard B. Ivry, George R. Mangun, Cognitive neuroscience: the biology of the mind, 3rd ed, New York: W.W. Norton, 2009

3. Kandel E R, Schwartz J H, Jessell T M. Principles of Neural Science[J]. Ion channels, 2000, 4: 5.

4. Trappenberg T. Fundamentals of computational neuroscience[M]. OUP Oxford, 2009.

5. Akay, Metin, ed. Handbook of neural engineering. Vol. 21. John Wiley & Sons, 2007.

6. Sanchez J C, Principe J C. Brain–machine interface engineering[J]. Synthesis Lectures on Biomedical Engineering, 2007, 2(1): 1-234.

Tentative Syllabus

Week 1: Introduction

Week 2: Probability and Random Variables

Week 3: Statistical detection (MAP, MLE)

Week 4: Statistical estimation (Linear regression)

Week 5: Random Process

Week 6: Structure and Function of the Nervous System (review of basic knowledge of neural signals)

Week 7: Encoding and Decoding (Bayesian estimator)

Week 8: Population Coding (vector space)

Week 9: Neural Networks

Week 10: Supervised Learning

Week 11: Reinforcement Learning

Week 12: Neural Prosthesis and Rehabilitation

Week 13: Review and Neural Interface challenge (Preparation of final projects)