The Hong Kong University of Science and Technology

UG Course Syllabus

Principles of Experimental Design

CENG4000Q

3 Credits

No pre-requisites

Instructor Name: LINARDI, Darwin

Email: kedarwin@ust.hk

Office Hours: By appointment

Course Description

This course provides undergraduate students with a foundational understanding of experimental design in chemical and biological engineering. Students will learn to formulate research questions, select appropriate methodologies, and develop experimental protocols through workshops that utilize real data. The curriculum covers essential elements such as literature review, instrumentation, data processing, and statistical analysis, allowing students to engage with real-world applications. Emphasizing effective scientific communication, students will practice data visualization and presentation skills through various formats. By the end of the course, students will confidently design and execute experiments, preparing them for future research and professional opportunities in the field.

Intended Learning Outcomes (ILOs)

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

1. Students are expected to learn to develop clear and concise research questions that guide experimental design.
2. Students will conduct comprehensive literature reviews, critically evaluating existing research to inform their experimental design and identify gaps in knowledge.
3. Students are expected to demonstrate the ability to choose and evaluate the qualities of appropriate methodologies and protocols based on the nature of their research.
4. Students will analyze experimental data using statistical methods and software tools to interpret and visualize results to summarize meaningful conclusions to their research questions.
5. Students are expected to communicate their research findings through various formats, including written report, poster presentations, and oral presentations, demonstrating clarity and persuasive skills.
6. Students are expected to work collaboratively on investigative projects, demonstrating teamwork skills and the ability to integrate feedback for continuous improvement in their experimental design processes.

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:

[List specific assessed tasks, exams, quizzes, their weightage, and due dates; perhaps, add a summary table as below, to precede the details for each assessment.]

Assessment Task	Contribution to Overall Course grade (%)	Due date
Course participation	20%	During respective classes
Assignments	20%	During respective classes
Midterm test	20%	Midterm*
Project report	20%	End of semester*
Presentation	20%	Midterm and end of semester*

* 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
Course participation	ILO6	This task assesses students' ability to collaborate effectively with peers on research topics and integrating feedback for continuous improvement in their experimental design processes.
Assignments	ILO3-4	Assignments evaluate students' ability to choose appropriate methodologies and apply statistical methods to analyze data, enhancing their understanding of research processes.
Midterm test	ILO4	The midterm test assesses students' proficiency in analyzing experimental data using statistical methods, reinforcing their ability to interpret and visualize results to support their research questions.
Project report	ILO1-6	The project report encompasses the entirety of the lessons learnt in the course including development of clear research questions, literature reviews, evaluation of methodologies, data analysis, communication of findings, and collaboration throughout the research process.
Presentation	ILO1, ILO6	The presentation assesses students' ability to articulate clear research questions and effectively communicate their findings, demonstrating collaboration and integration of feedback.

Grading Rubrics

Assessment	**Expectations**
Course participation	Actively participate in discussions, group activities, and collaborative projects. Students are expected to provide feedback to peers as well as respond to them.
Assignments	Students to complete provided exercises in Statistics and Financial analysis.
Midterm tests	Students to demonstrate competency in statistics to be able to perform without outside aid.

Project report				
Criteria	Excellent (4 points)	Good (3 points)	Satisfactory (2 points)	Needs Improvement (1 point)
Content and Analysis	Comprehensive coverage of the topic, including a thorough literature review; in-depth analysis where all research questions are clearly addressed.	Good coverage of the topic with a solid literature review; clear analysis addressing most research questions.	Basic coverage of the topic with a limited literature review; some analysis present, but lacks depth; not all questions addressed.	Limited coverage of the topic with minimal or unclear literature review; analysis is insufficient or unclear; many questions not addressed.
Soundness of Data Analysis and Visualization	Data analysis is thorough and well-explained; visualizations are clear, relevant, and effectively support conclusions.	Data analysis is clear and mostly accurate; visualizations are relevant but may have minor issues.	Basic data analysis present, but lacks depth or clarity; visualizations are used but may be unclear or irrelevant.	Data analysis is insufficient or flawed; visualizations are unclear, irrelevant, or missing entirely.
Clarity and Presentation	Exceptionally clear writing with appropriate tone; minimal grammatical errors; formatting is professional.	Clear writing with few grammatical errors; generally appropriate tone; formatting is acceptable.	Some clarity in writing, but several grammatical errors present; formatting may be inconsistent.	Writing is unclear; frequent grammatical errors; poor formatting detracts from readability.

Project presentation				
Criteria	Excellent (4 points)	Good (3 points)	Satisfactory (2 points)	Needs Improvement (1 point)
Content and Literature Gaps	Clearly identifies significant gaps in the literature; presents a comprehensive overview of relevant research that supports the project.	Identifies some gaps in the literature; presents a good overview of relevant research, but may miss minor points.	Basic identification of literature gaps; overview of relevant research is present but lacks depth or clarity.	Fails to identify gaps in the literature; overview of relevant research is minimal or unclear.
Data Visualization Effectiveness	Visualizations are clear, relevant, and effectively enhance understanding of the data; well-integrated into the presentation.	Visualizations are relevant and mostly clear; they support the presentation but may have minor issues in clarity or integration.	Some visualizations are present, but they lack clarity or relevance; limited integration into the overall presentation.	Visualizations are unclear, irrelevant, or missing; do not enhance understanding of the data or content.
Clarity and Delivery	Exceptionally clear and engaging delivery; confident presentation style; minimal grammatical errors; uses appropriate language and tone.	Clear delivery with few grammatical errors; generally engaging; appropriate language and tone used throughout.	Some clarity in delivery, but lacks engagement; several grammatical errors present; language may be inconsistent.	Delivery is unclear and unengaging; frequent grammatical errors; inappropriate language or tone detracts from the presentation.

Final Grade Descriptors:

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Demonstrates exceptional understanding of experimental design principles. The work is comprehensive, insightful, and exceeds expectations in quality and depth, showcasing a strong ability to formulate research questions, design robust experiments, and critically analyze results. Students effectively identify gaps in literature and utilize advanced data visualization techniques to communicate findings clearly and persuasively.
B	Good Performance	Shows a solid understanding of the key principles of experimental design, including hypothesis formulation and methodology selection. Work is well-organized and meets requirements, demonstrating competence in data analysis and the ability to identify literature gaps. While the presentation of data is generally clear, there may be minor issues in visualization or integration of findings that prevent it from reaching an excellent standard.
C	Satisfactory Performance	Meets basic requirements and demonstrates a fundamental understanding of experimental design principles. Students can formulate basic research questions and outline methodologies but may struggle with deeper analysis or critical evaluation of results. The identification of literature gaps may be superficial, and data visualizations may lack clarity or relevance, indicating areas for improvement.
D	Marginal Pass	Shows minimal understanding of the principles of experimental design. Work meets some basic requirements but lacks clarity and depth in formulating research questions, selecting methodologies, and analyzing data. Significant gaps exist in the identification of literature and in the effectiveness of data visualization, indicating that substantial improvement is needed to reach satisfactory levels.
F	Fail	Fails to meet basic requirements and demonstrates a lack of understanding of fundamental experimental design principles in chemical and biological engineering. Work is incomplete or unclear, with little to no evidence of critical thinking or analysis. Students do not effectively identify research questions, methodologies, or literature gaps, and data visualizations are either missing or irrelevant, reflecting substantial gaps in knowledge.

Course AI Policy

ChatGPT, Poe, etc. can be used to refine your own writing and presentation or help you learn. They should not be used to complete your assignments for you.

Communication and Feedback

Assessment marks for individual assessed tasks will be communicated via Canvas within two weeks of submission. Feedback on assignments will include [specific details, e.g., strengths, areas for improvement]. Students who have further questions about the feedback, including marks should consult the instructor within five working days or the announced deadline, whichever is earliest, after the feedback is received.

Resubmission Policy

Only the latest work submitted by the deadline will be graded. Submissions after the deadline will be subject to grade penalties without valid reasoning.

Required Texts and Materials

Box, G. E., Hunter, J. S., & Hunter, W. G. (2005). Statistics for experimenters: design, innovation, and discovery.

Maxwell, Scott E., & Harold D. Delaney (2004). Designing experiments and analyzing data: A model comparison perspective.

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.