

The Hong Kong University of Science and Technology

UG Course Syllabus

Rate and Transport Processes in Biological Systems

BIEN 3250

3 credits [3-1-0:3]

Pre-requisite: CENG 2320 AND (PHYS 1112 OR PHYS 1312) Term: Fall 2026-27

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Classes: Lecture Mon & Wed 09:00-10:20, Rm 4504; Recitation Wed 18:00-18:50, Rm 4502

Course Description

BIEN 3250 introduces transport phenomena and reaction kinetics to bioengineering students. It gives a condensed, integrated treatment of fluid mechanics, mass transfer and reaction kinetics in one course, using examples from biological systems throughout. Topics: fluid properties and constitutive equations; hydrostatics and surface tension; dimensional analysis and pipe flow; the Bernoulli equation; conservation principles; membrane transport and filtration; chemical and enzyme (Michaelis-Menten) kinetics; bioreactors; and diffusive and convective mass transfer. The aim is to give students a quantitative perspective on physiology befitting their engineering training, together with the toolkit needed to design biomedical devices such as bioreactors, biosensors and drug-delivery systems. Instruction is by twice-weekly lectures plus a weekly recitation run as a hands-on problem-solving session in which homework is attempted, submitted and discussed within the hour.

Intended Learning Outcomes (ILOs)

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

1. Describe the fundamental principles of transport phenomena and reaction kinetics, and identify the mechanism governing a given biological or biomedical situation.
2. Describe and model rate and transport processes in biological systems, stating and justifying the simplifying assumptions used.
3. Formulate and solve problems involving rate and transport processes, and verify the solution by dimensional and order-of-magnitude checks.
4. Evaluate the connection between rate and transport processes and animal physiology, and how it influences the effective design of biomedical devices.

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:

All assessments are open-notes and are held under supervision (see Course AI Policy).

Assessment Task	Contribution to Overall Course grade (%)	Due date
Homework Q1-Q6, attempted and submitted in recitation (6 x 2.5%)	15%	16/09, 23/09, 30/09, 21/10, 04/11, 25/11/2026 *
Quiz I (covers Weeks 1-5)	25%	05/10/2026, in lecture *
Quiz II (covers Weeks 7-10)	25%	09/11/2026, in lecture *
Final Examination (comprehensive)	35%	07-19/12/2026, scheduled by ARO
Total	100%	

* 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 Q1-Q6	ILO 1, 2, 3	Short supervised problems requiring students to identify the governing mechanism (ILO 1), set up the balance with stated assumptions (ILO 2), and carry the solution to a checked numerical answer (ILO 3). Feedback is given in the same session.
Quiz I	ILO 1, 2, 3	Fluid-mechanics problems assessing recognition of the flow regime (ILO 1), formulation via hydrostatic, Bernoulli and momentum balances and dimensional analysis (ILO 2), and correct quantitative solution (ILO 3).
Quiz II	ILO 1, 2, 3, 4	Conservation and kinetics problems assessing model formulation and solution for reacting biological systems (ILO 1-3), including an item on bioreactor or membrane-device performance (ILO 4).
Final Examination	ILO 1, 2, 3, 4	Comprehensive. Multi-mechanism problems require selection and justification of the governing model (ILO 1, 2) and verified execution (ILO 3); an open-response item requires evaluation of transport limitations in a biomedical device or organ system (ILO 4).

Grading Rubrics

All assessed work in this course is problem-based, and every problem is marked with the single analytic rubric below, published to students on Canvas in Week 1. Partial credit is awarded criterion by criterion: a correct set-up with an arithmetic slip still earns the set-up marks, and a correct number reached by an unjustified route does not.

Criterion (weight)	Excellent	Good	Satisfactory	Marginal / Fail
Problem set-up and physical reasoning (25%)	Correct system/control volume and dominant mechanism identified; all assumptions stated and justified physically.	Correct system and mechanism; assumptions stated, justification partly implicit.	Broad situation right but control volume or mechanism imprecise; assumptions listed without justification.	Wrong governing mechanism or system boundary; assumptions absent or inconsistent.
Model construction (25%)	Correct governing equation, constitutive relation and rate law, with a complete and correct set of	Correct governing equation and rate law; minor omission or error in boundary/initial conditions.	Recognisable governing equation with a structural error (missing term, BC at wrong location).	Governing equation not applicable to the situation, or not attempted.

	boundary/initial conditions.			
Mathematical execution (30%)	Algebra, calculus and arithmetic correct throughout; units carried consistently; answer correct with correct units and precision.	Method correct; at most one minor slip not affecting the structure of the solution; units correct.	Method broadly correct but several execution errors, or units mishandled.	Errors extensive enough that the solution does not follow from the model; units wrong or omitted.
Interpretation and presentation (20%)	Explains the physical meaning, checks against a limiting case or order-of-magnitude estimate, comments on validity; work clearly laid out.	States physical meaning and does a basic sanity check; work legible and mostly organised.	States the answer with little interpretation and no check; work followable but disorganised.	No interpretation or check; work hard or impossible to follow.

Criteria map to the ILOs as: set-up -> ILO 1; model construction -> ILO 2; execution -> ILO 3; interpretation -> ILO 3 and, for design/physiology items, ILO 4.

Final Grade Descriptors:

Grades	Short Description	Elaboration on subject grading description
A	Excellent Performance	Comprehensive command of transport and kinetic principles. Identifies the governing mechanism in unfamiliar biological settings, constructs and justifies models independently, executes accurately, and interprets and verifies results. Reasons confidently about physiology and device design, going beyond core requirements.
B	Good Performance	Good knowledge of the main subject matter and competence in problem-solving. Handles familiar and moderately novel problems correctly; set-up is sound with occasional gaps in justification; results generally interpreted, verification inconsistent.
C	Satisfactory Performance	Adequate knowledge of core subject matter. Solves standard problems of a type seen in class, where the governing equation is readily recognised. Some capacity for analysis; interpretation and checking are limited.
D	Marginal Pass	Threshold knowledge of core concepts. Can carry out routine substitutions and single-step calculations, but formulating a model from a physical description is unreliable. Has benefited from the course and has potential to develop in the discipline.
F	Fail	Insufficient understanding of the core transport and kinetics principles, and inability to formulate or solve problems at the required level. Does not meet the threshold requirements for development in the discipline.

Course AI Policy

Students are encouraged to use any AI assistant freely for learning: having concepts explained, generating extra practice problems and worked examples for self-study, checking their own solutions, and exploring problems numerically. AI is meant to facilitate learning, not to replace it - students must still go through the thinking process, conceptualise the approach, and cultivate their own problem-solving skills, because that skill is what the assessments measure. A caution: current AI tools make confident errors on transport and kinetics problems (mis-stated boundary conditions, dropped terms, dimensionally inconsistent answers), so every AI output should be checked against the lecture notes and reference texts.

All assessments - homework, Quiz I, Quiz II and the final examination - are open-notes but AI-free and offline. Students may consult lecture notes, their own notes, homework solutions and other reference material in printed or electronic form, and may bring an iPad, laptop or other personal device for this purpose. Wi-Fi and every other internet connection on that device must be switched off for the whole duration of the assessment. Live internet access, use of an AI assistant, and communication with any other person during an assessment are not permitted and will be treated as academic misconduct under the University Academic

Honor Code. Students are responsible for having their notes downloaded and available offline before an assessment begins. Homework is attempted and submitted within the supervised recitation hour; work submitted outside that hour is not accepted.

Communication and Feedback

Assessment marks for individual assessed tasks will be communicated via Canvas within two weeks of submission. Feedback on homework is immediate: solutions are worked and discussed in the same recitation session. Quiz feedback is given in the recitation of the following week (Quiz I recap 07/10/2026; Quiz II recap 11/11/2026) and covers common errors, model answers and the marking of each rubric criterion. Students who have further questions about the feedback including marks should consult the instructor within five working days after the feedback is received.

Resubmission Policy

There is no resubmission or reassessment of homework, quizzes or the final examination. A student who misses an assessment for a documented medical or other approved reason should notify the instructor as soon as practicable; the weight of the missed component will normally be redistributed to the remaining assessments of the same type.

Required Texts and Materials

No single textbook is required; lecture notes on Canvas are the primary resource. Recommended references: Fournier, Basic Transport Phenomena in Biomedical Engineering, 4th ed., CRC Press, 2018; Truskey, Yuan & Katz, Transport Phenomena in Biological Systems, 2nd ed., Pearson Prentice-Hall, 2009; Saltzman, Biomedical Engineering: Bridging Medicine and Technology, 2nd ed., Cambridge, 2015; Fogler, Elements of Chemical Reaction Engineering, 7th ed., Pearson, 2020; Deen, Introduction to Chemical Engineering Fluid Mechanics, Cambridge, 2016. A non-programmable scientific calculator is required for all recitations and examinations.

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

Canvas (lecture notes, homework and solutions, announcements, grades); AI assistants as described in the Course AI Policy; HKUST Library, which holds all recommended references; instructor office hours and TA consultation hours (announced in Week 1).

Weekly Schedule and Assessment Timeline (Fall 2026)

Week / dates	Topics	Assessment
Wk 1 - 2 Sep	Course administration; overview and definitions of transport processes; recap of engineering mathematics	-
Wk 2 - 7, 9 Sep	Fluid properties, constitutive equations	-
Wk 3 - 14, 16 Sep	Hydrostatics and surface tension	Q1 (2.5%)
Wk 4 - 21, 23 Sep	Dimensional analysis, friction factor, pipe flow	Q2 (2.5%)
Wk 5 - 28, 30 Sep	Pipe flow and Bernoulli equation	Q3 (2.5%)
Wk 6 - 5, 7 Oct	Quiz I week; Quiz I recap 7 Oct	Quiz I (25%)
Wk 7 - 12, 14 Oct	Conservation principles	-
Wk 8 - 21 Oct (19 Oct public holiday)	Conservation principles in biological systems; membrane filtration	Q4 (2.5%)
Wk 9 - 26, 28 Oct	Reaction kinetics: rate laws, temperature dependence; enzyme kinetics (Michaelis-Menten) and inhibition	-
Wk 10 - 2, 4 Nov	Conservation equation and reaction kinetics; bioreactors	Q5 (2.5%)
Wk 11 - 9, 11 Nov	Quiz II week; Quiz II recap 11 Nov	Quiz II (25%)
Wk 12 - 16, 18 Nov	Mass transfer I	-
Wk 13 - 23, 25, 30 Nov (30 Nov last day of classes)	Mass transfer II; course review	Q6 (2.5%)
1-5 Dec	Study break	-
7-19 Dec	Fall Term examinations	Final Exam (35%)