Faculty of Engineering and Applied Science

CHEE 330 – HEAT AND MASS TRANSFER

Course Syllabus – Fall 2020

This is your course syllabus. Please download the file and keep it for future reference.

TEACHING TEAM

COURSE INSTRUCTOR

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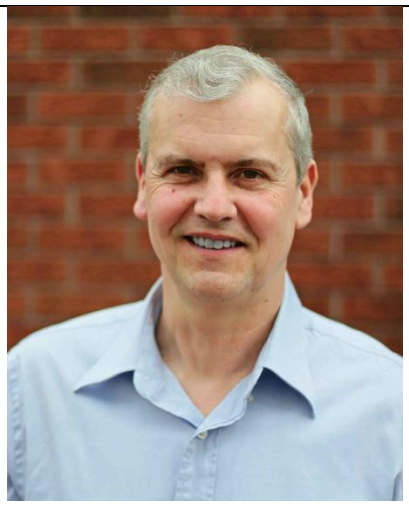

For an up-to-date list of personnel, please check the course website.

COURSE INFORMATION

COURSE DESCRIPTION

This course follows a unified approach to introduce the physical origins and rate equations of heat and mass transfer. The principal topics covered include identification of the driving forces for heat and mass diffusion, development of transport models from first principles, steady state and transient solutions, and convective transfer. The boundary layer analogies are introduced. Closed form analytical solutions and correlations derived from dimensional analysis are used to estimate the heat and mass transfer convection coefficients. (0/0/0/42/0)

PREREQUISITES: CHEE 210 and CHEE 223, or permission of the department.

COURSE LEARNING OUTCOMES (CLO)

Specific course learning outcomes include:

CLO	DESCRIPTION	INDICATORS
CLO 1	Identify mechanisms of heat and mass transfer in order to formulate rate equations.	KB-ES-TrPh (d)
CLO 2	Develop transport models based on the differential equations of heat and mass transfer and their simplified forms; identify suitable boundary conditions.	KB-ES-TrPh (b) PA Formulate
CLO 3	Solve the differential equations for steady-state, one-dimensional problems; and non-steady state problems.	KB TrPh (b) PA-Solve
CLO 4	Estimate heat and mass transfer coefficients based on dimensional analysis, boundary layer analysis and similarity between momentum, heat and mass transfer.	KB TrPh (c) KB TrPh (d)
CLO 5	Solve problems involving convective heat and mass transfer in one phase and two-phase systems	KB TrPh (c)

This course develops the following attributes at the 3rd year level:

Knowledge base, Engineering Science (**KB-ES**): **TrPh (b)** Formulates and applies differential mass, momentum and energy balances to do engineering calculations. **TrPh (c)** Analyzes convective transport of fluids in closed conduits and external flows. **TrPh (d)** Identifies mechanisms of momentum, heat and mass transfers and formulates and applies appropriate constitutive models to describe fluid behaviour.

Problem Analysis (PA): **Formulate** Develop appropriate frameworks for solving complex engineering problems. **Solve** Implement solutions for complex engineering problems.

Relevance to the Program

This engineering science course covers aspects of heat and mass transfer, which together with fluid mechanics comprise one of the corner stones of chemical engineering and engineering chemistry, the so-called "transport courses". The engineering science skills taught in this course are required for 3rd year courses (CHEE 331/332/333 – Design and scale-up of unit operations, CHEE 323 – Industrial catalysis) and 4th year courses (CHEE 412-Transport Phenomena in Chemical Engineering, CHEE 470-Design of Manufacturing processes, CHEE 442 – Introduction to biomedical engineering). This course assumes knowledge of 2nd year fluid mechanics and thermodynamics.

Course Structure and Activities

This course will be delivered in an online format due to the remote teaching and learning requirements of the Fall 2020 semester. Each week students will be provided with the following learning materials:

1. Weekly concept review online session
2. Textbook readings
3. Asynchronous lecture videos
    a. Lecture slides will be available in onQ for notetaking and review
4. Worked problem videos with solutions
    a. Students should attempt practice problems then review the solution videos
5. Synchronous tutorial to answer questions from the weekly content
    a. Led by the TA's or the Instructor
    b. Will be recorded and made available to accommodate time zone differences

Expectations for Lectures/Tutorials

Students should watch the asynchronous videos early in the week to allow time to work on the practice problems. Students should aim to attend the synchronous Zoom Tutorial each week and can raise their hand in the Zoom tool or write a question in the chat feature of Zoom. All course materials will be uploaded to onQ. Students are expected to engage with the course materials on a weekly basis to ensure they do not fall behind and so that they can ask questions when the concepts are being covered.

Course Materials

Mandatory Textbook

- "Heat and Mass Transfer", by Welty, Rorrer and Foster (WRF). This custom textbook is available from the campus bookstore in hard copy and e-book formats. It is compiled from the textbook "Fundamentals of Momentum, Heat, and Mass Transfer" by the same authors, 6th edition, published by Wiley in 2015 (Chapters 15-30). This custom textbook

is listed as mandatory. The original textbook is acceptable. Please note that the 5th edition of the same textbook by Welty, Wicks, Wilson, Rorrer (WWWR) is also acceptable (2008).

Additional Textbooks:

- Bergman, T.L., Lavine, A.S., Incropera, F.P. and DeWitt, D.P., "Fundamentals of heat and mass transfer", 7th Ed. Wiley (Incropera). Brodkey, R.S. and Hershey, H.C., "Transport Phenomena: A Unified Approach", McGraw-Hill (Brodkey). A copy of each of these textbooks has been placed on reserve at Queen's Library.

All course materials (e.g. class notes; tutorials; assignments; problem sets; equation sheets, etc.) are available on the CHEE 330 onQ site, which is the primary LMS used for this course.

COURSE EVALUATION

Deliverable	Week or Date*	Weight
Quiz I	Week 4	15%
Quiz II	Week 8	20%
3 Assignments (in groups of 2 or 3*)	Week 3, Week 6, Week 10	15%
Comprehension Checks**	Throughout Term	10%
Final Exam	Exam Period	40%

* Depending on enrollment ** Best 10 out of 12

All assessments in this course will receive numerical percentage marks. The final grade you receive for the course will be derived by converting your numerical course average to a letter grade according to the established Grade Point Index.

Students are expected to complete their work in a timely fashion. The course instructor will provide notification (on course website) of due dates and any revisions thereof. Submissions after the due date will be penalized at up to 25% per day unless suitable justification is provided.

Unless other arrangements have been approved, departmental policies regarding late and missed assignments, and missed quizzes/exams will be followed. Students must pass the individual examination component (combined mark on midterm or quizzes and final) to pass the course, as stated by departmental policies.

COURSE POLICIES

Please review the following policies concerning copyright, academic integrity, absences and academic accommodations:

COPYRIGHT

Unless otherwise stated, the material on the course website is copyrighted and is for the sole use of students registered in this course. The material on the website may be downloaded for a registered student's personal use but shall not be distributed or disseminated to anyone other than students registered in this course.

ACADEMIC INTEGRITY

Information on policies concerning academic integrity is available in the Queen's University Code of Conduct, in the Senate Academic Integrity Policy Statement, on the Faculty of Engineering and Applied Science website, and from your instructor.

ABSENCES (ACADEMIC CONSIDERATION) AND ACADEMIC ACCOMMODATIONS

For absences and academic accommodations please review the information on the FEAS website.

PERSONAL SUPPORTIVE COUNSELLING

If at any time you find yourself feeling overwhelmed, anxious, sad, lonely, or distressed, consider confidential supportive counselling offered by the Faculty of Engineering and Applied Science.

COURSE OVERVIEW

CHEE 330 || Module overview

Course learning outcomes (CLO): Students will be able to:

1. **Identification of mechanisms of heat and mass transfer. Formulation of rate equations.**
2. **Development of transport models based on the differential equations of heat and mass transfer and their simplified forms; identification of suitable boundary conditions.**
3. **Solutions of the differential equations for steady-state, one-dimensional problems; solutions for non-steady state problems.**
4. **Estimation of heat and mass transfer coefficients based on dimensional analysis, boundary layer analysis and similarity between momentum, heat and mass transfer.**
5. **Solution of problems involving convective heat and mass transfer in one phase and two phase systems**

Students are expected to augment lecture material through reading of associated sections of the textbook, and to practice execution of course principles by completing posted problem sets.

Module	**Lecture approach* and content** *Asynchronous lecture videos & lecture slides available on onQ* *Synchronous weekly review/Q&A session on zoom*	**Tutorials**** *Tutorial and practice problems are available on onQ*	**Assessment (CLO, and % of course grade)**
Module 1 (Wks 1-3)	**Topic I: Introduction to Heat and Mass Transfer** **Topic II: Fundamentals of Heat Transfer (CLO1, CLO2)** • Modes of heat transfer • Conduction • Thermal properties • Convection • Radiation • Combined mechanisms of steady state heat transfer	Tutorials 1-3 (CLO1, CLO2)	Material is included on Quiz I (CLO1, CLO2) Group assignment #1 (5%, CLO1, CLO2) Weekly comprehension checks (1%, CLO1, CLO2)

Quiz I	**Covers Module 1**		***Quiz I:*** *Questions (which may include multiple choice) and problems which will target CLO1 and 3, worth 15% of course grade*
Module 2 (Wks 4-5)	**Topic III: Fundamentals of Mass Transfer (CLO1, CLO2)** • Molecular mass transfer, Fick's rate equation • The diffusion coefficient • Introduction to convective mass transfer • Steady-state molecular diffusion	Tutorials 4,5 (CLO1, CLO2)	Material is included on Quiz II (CLO1, CLO2) Weekly comprehension check (1%, CLO1, CLO2)
Module 3 (Wks 6-7)	**Topic IV: Differential Equations of heat transfer – Solutions for one dimensional steady-state and transient problems (CLO2, CLO3)** • Conservation of energy • Derivation of differential energy equations • Special forms • Boundary conditions • Solutions for 1D, steady-state conduction without heat generation • Solutions for 1D, steady-state conduction with heat generation • Unsteady-state heat transfer	Tutorials 6,7 (CLO2, CLO3)	Material is included on Quiz II (CLO2, CLO3) Group assignment #2 (5%, CLO2, CLO3) Weekly comprehension checks (1%, CLO2, CLO3)
Module 4 (Wks 8)	**Topic V: Differential Equations mass transfer – Solutions for one dimensional steady-state and transient problems (CLO2, CLO3)**	Tutorial 8 (CLO2, CLO3)	Material is included on final (CLO2, CLO3)

	• Derivation of mass transfer equations • Special forms • Boundary conditions • Solutions for 1D, steady-state mass transfer • Solutions for 1D systems with chemical reaction		Weekly comprehension checks (1%, CLO2, CLO3)
Quiz II	**Covers Module 1 – 3**		***Quiz II:*** *Questions (may include multiple choice) and problems which will target CLO2 and 3, worth 20% of course grade*
Module 5 (Wk 9-11)	• Dimensional analysis • Boundary layer analysis • Momentum, heat and mass transfer analogies • Convective heat and mass transfer calculations	Tutorial 10, 11 (CLO4, CLO5)	Material is included on final (CLO4, CLO5) Group assignment #3 (5%, CLO4, CLO5)
Module 6 (Wk 12)	**Topic VII: Convective Mass Transfer between Two Phases (CLO5, CLO6)** • Two-resistances theory • Individual and overall mass transfer coefficients	Tutorial 12 (CLO5)	Material is included on final (CLO5)
EXAM	**Covers Module 1 – 5**		***Final exam:*** *Questions (which may include multiple choice) and Problems which target all CLO, worth 40% of course grade*