University of Jordan
School of Engineering
Chemical Engineering Department

1. **Course number and name: (0935441) Mass Transfer Operation**
2. **Prerequisites: Process Heat Transfer (0905343), Chemical Engineering Thermodynamics (2) (0915322)**
3. **Class schedule:** 3 credits
    a. Time and place: Mon., Wed.: 8:00-9:30 at Al-Taher Hall -CHE
    b. Office hours: Mon., Wed., 11:30 – 12:30, Thu., 9:30-10:30
4. **Instructor:** Dr. Zayed Al-Hamamre
5. **Text book: James Welty, Charles E. Wicks Gregory L. Rorrer, Robert E. Wilson, Fundamentals of Momentum, Heat and Mass Transfer, 5th Edition, Wiley, 2014**
6. **References:**
    1. J. D. Seader, Ernest J. Henley, D. Keith Roper, separation process principles, Wiley, 2011
    2. Christie John Geankoplis, Transport processes and separation process principles, 4 edition Prentice Hall; (March 15, 2003)
    3. Coulson, J.M.; and Richardson, J.F.; Chemical Engineering Volume 2, 5th Ed., 1999, Butterworth-Heinemann

7. **Website: http://www2.ju.edu.jo/sites/Academic/z.hamamre/Material/Forms/AllItems.aspx**

8. **Course information:**

Diffusivity and mechanism of mass transfer interphase mass transfer and mass transfer coefficients. Equilibrium stage concept and use of multistages. Equilibrium data and calculations related to binary systems (and introductory to multicomponent) used in design and analysis of following unit operations: Distillation: steady state, flash, batch, multistage column. Gas absorption: multistage continuous contacting, introductory to non-isothermal system, design of packed column. Liquid-liquid extraction and leaching: stage wise calculations, transfer units.

9. **Course objectives and Outcomes:**

Objectives	Outcomes
1. Emphasize the importance of mass transfer as a basic pillar of chemical engineering and its role in several separation processes. [O7]	1.1. Outline the transport phenomenon of mass transfer and its unique role in chemical engineering applications 1.2. Understand the need for separation and purification of mixtures in various kinds of chemical processes involved in treatment of raw materials, intermediate products and final products 1.3. Define the main types of driving forces and agents used separating mixtures
2. Introduce basic fundamentals of mass transfer essential to understand the engineering operations driven by this transport phenomenon. [O1, O2]	2.1. Recognize diffusive and convective mechanisms of mass transfer and their analogy with heat and momentum transport phenomena 2.2. Understand diffusion, diffusion coefficient and driving forces of mass transfer; and use Fick's law to calculate diffusive flux 2.3. Identify convective mass transfer, mass transfer coefficient, interfacial mass transfer, and convective flux equation 2.4. Perform microscopic mass balance on simple geometries. 2.5. Use engineering correlations for estimation of diffusion and mass transfer cofficients under laminar and turbulent flow conditions.
3. Analyze separation requirement and select a suitable unit operation to achieve	3.1. Recognize key operations of mass transfer with emphasis on distillation and absorption/stripping,

the desired output. [O1, O2]	3.2. Understand factors that influence the selection of a feasible separation operation [i,e] 3.3. Identify the role of thermodynamics in separation and use of liquid-vapor, and gas-liquid equilibrium correlations and graphics (relative volatility, K-values, TXY diagram, XY diagrams, Ponchon Savarit chart, distribution cofficients) [a,c] 3.4. Understand the concept of equilibrium stage [a,c] 3.5. Link the use of thermodynamic equilibrium, mass balance and mass transfer rate equations in equipment design [a,c]. 3.6. Distinguish different industrial equipment used in mass transfer–based separations (trayed towers and packed columns) [c].
4. Design and size of continuous binary distillation process equipment. [O1, O2]	4.1. Define distillation as a key unit using a heat-separating agent 4.2. Differentiate between single stage (batch and flash distillation) vs. multistage column distillation 4.3. Understand continuous distillation of ideal binary mixtures and major components of the distillation column 4.4. Perform material balance on distillation columns and basic calculations for feed line, operating lines, optimum reflux ratio, and stage counting of trayed columns using McCabe-Thiele method and liquid vapor equilibrium [a,c] 4.5. Perform energy balance to calculate heat duties of condenser and reboiler 4.6. Size the column using engineering correlations and models 4.7. Understand limiting conditions and complix processes of distillation involving multi-feeds/products, azeotropic distillation, and open steam 4.8. Know column internals, tray efficiency and conditions of optimum operation
5. Design of continuous absorption/stripping process equipment. [O1, O2]	5.1 Define absorption and stripping as key liquid-vapor operations that use a mass separating agent 5.2 Choose a suitable solvent 5.3 Diffrentiate difference between total basis and solute-free basis of calculations 5.4 Perform material balance on stripping/absorption columns 5.5 Design trayed columns absorption/stripping of dilute mixtures using McCabe-Thiele graphical method 5.6 Perform column sizing using Kremser's analytical approach
6. Design and size of continuous extraction process equipment, [O1, O2]	6.1. Explain difference between liquid-liquid, liquid-vapor and liquid-solid operations 6.2. Provide industrial examples of extraction processes and equipment 6.3. Identify the extraction of missible and partially missible systems and related equilibrium data 6.4. Perform mass balance and sizing of extraction cascasdes for dilute missible systems with counter current, co-current and cross flow patterns 6.5. Perform mass balance and sizing of extraction cascades for partially missible systems counter current flow using ternary diagrams
7. Encourage life-long learning enhances students' communication skills. [O1, O2]	7.1. Work in teams to provide a full unit design for a selected problem

10. Topics covered:

Content	Text book	Ref. 1	Ref. 2	Week
Introduction ***Topics Covered***: Introduction to Mass Transfer and Diffusion,	Ch 24	Ch 3	Ch 6	1

Molecular Diffusion *Topics Covered*: Ficks Law, diffusivity in gas, liquid and solids,	Ch 24	Ch 3	Ch 6	2+3
Differential equation of mass transfer ***Topics Covered:*** steady state and transient analysis	Ch 25-27	Ch 3	Ch 6	4+5
Convection Mass Transfer ***Topics Covered:*** Basic Concept, Mass Transfer coefficient for different geometries: single sphere, cylinder, and flow in pipe, mass transfer between phases	Ch 28-30	Ch 3	Ch 4	6+7
Vapor-Liquid Separation Processes ***Topics Covered:*** Vapor liquid Equilibrium, Simple Distillation Methods: flash distillation, batch distillation.		**Ch 7**	**Ch 11**	**8**
Continuous distillation ***Topics Covered:*** Distillation with reflux, McCabe Thiele Method, ponchon savarit method: Enthalpy concentration diagram		**Ch 7**	Ch 11	9-11
Design of Vapor-Liquid Separation equipment ***Topics Covered:*** Tray column, packed bed column.		**Ch 7**		12
Stage and Continuous Gas-Liquid Separation Processes ***Topics Covered:*** Gas--Liquid Equilibrium, Single-Stage Equilibrium Contact for Gas-Liquid System, Multiple-Contact Stages, Mass Transfer Using Film Mass-Transfer Coefficients and Interface Concentrations, Overall Mass-Transfer Coefficients and Driving Forces	Ch 31	**Ch 6**	Ch 10	13
Absorption in Plate and Packed Towers ***Topics Covered:*** Design of Plate Packed bed Absorption Towers.	Ch 31	**Ch 6**	Ch 10	14+15
Final exams				16

11. **Minimum student materials:** Text book, class handouts, engineering calculator, and an access to Personal Computer with MATLAB and/or Excel.

12. **Instructional methods:**
Lectures, group assignments, class discussion and problem solving Projects and Assignments

13. **Homework Assignments:**
Assignments are due at the beginning of the class period on the specified date; late homework will NOT be accepted (i.e it will be awarded a zero). Please write only on one side of the page. Your name and ID number should be clearly written on first page. Start each problem on a new page. Clearly mark your answers in a box (Never use a red pen in your work). Staple the pages together.

14. **Assessment & Grading:**

Quizzes & Assignments	:	20%
Short exams	:	10%
Midterm Exam	:	30%
Final exam	:	40%
Total	**:**	**100%**

15. **Relationship to Program Outcomes (%)**

O1	O2	O3	O4	O5	O6	O7
√	√					

16. Relationship to Chemical Engineering Program Objectives

PEO1	PEO2	PEO3	PEO 4
√	√	√	√

17. Notes:

a. Discuss the assignments among yourselves. This is helpful to the learning process. However, direct copying of others work will NOT be allowed or tolerated and will result in a reduction of grade.

b. All cases of academic dishonesty will be handled in accordance with university policies and regulations.

c. There will be a number of unannounced quizzes during the semester. Students are expected to be ready to take a quiz any time they have a class. There will be no make-up quizzes.

d. Students are expected to attend EVERY CLASS SESSION and they are responsible for all material, announcements, schedule changes, etc., discussed in class. The university policy regarding the attendance will be strictly adhered

e. Any students with disabilities who need accommodations in this course are encouraged to speak with the instructor as soon as possible to make appropriate arrangements for these accommodations.

f. Exams are scheduled as shown in the syllabus and last 90 minutes. The exams are close textbook and notes. It is your responsibility to bring a calculator, pencils and paper. If you MUST miss one of these exams for an emergency situation, please let me know as soon as possible. If you oversleep or skip an exam you will not have an opportunity to make it up. If you have a valid (according to me) time conflict and you let me know in advance, there is the possibility of taking an exam at an alternate time.

18. ABET Criteria : Outcomes and Assessment: Engineering programs must demonstrate that their graduates have

- O1 Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
- O2 Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
- O3 Communicate effectively with a range of audiences.
- O4 Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
- O5 Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
- O6 Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
- O7 Acquire and apply new knowledge as needed, using appropriate learning strategies.

Date 22-9-2025