Module (Course Syllabus) Catalogue

2023-2024

College/ Institute	**Erbil Technical Engineering College**	
Department	**Mechanical and Energy Engineering Techniques**	
Module Name	**Two Phase Flow**	
Module Code	**TPF104**	
Degree	**Technical Diploma** ☐ **Bachler** ☐ **High Diploma** ☐ **Master** ☐ **PhD** ■	
Semester	**Fall**	
Qualification	**Thermal Powers – Heat and Mass Transfer**	
Scientific Title	**Assistance Professor**	
ECTS (Credits)	**05**	
Module type	**Prerequisite** ☐ **Core** ■ **Assist.** ☐	
Weekly hours		
Weekly hours (Theory)	**(03)hr Class**	**(06)Total hrs Workload**
Weekly hours (Practical)	**( )hr Class**	**( )Total hrs Workload**
Number of Weeks	**15**	
Lecturer (Theory)	**Asst. Prof. Dr. Mohammed Jawdat Barzanjy**	
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Lecturer (Practical)		
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Websites		

Course Book

Course Description	Two phase flow with or without phase change is commonly encountered in a variety of engineering processes. The power generation, nuclear reactor technology, food production, chemical process, aerospace and automotive industries are all driving forces in this complex field. Due to its universality in applications, a thorough understanding of two phase flow is of utmost important. Present course is driven by this requirement. Two Phase Flow, is a well established topic in Mechanical and chemical engineering, taught to the post – graduate students as follows: 1. A theoretical weekly program of three hours. 2. A workload weekly program of six hours.
Course objectives	1. Acquire specialized knowledge in modelling the engineering problems and solve by new methods with good accuracy. 2. Use the update advanced numerical methods and compare the results with the engineering analysis methods results 3. Opportunity of deep analysis of advanced engineering and numerical methods.
Student's obligation	For the student to achieve a level of excellence in the subject, the following items should be given utmost consideration: a. Class attendance on regular basis for the purpose of learning. b. Active participation in class discussions. c. Reviewing the lecture notes and topics on weekly basis, noting the ambiguous points, if any, and requesting clarification during instructor office hours.. d. Giving adequate and sufficient priority to preparing for weekly, monthly and final tests.
Required Learning Materials	Due to very equations and rules driving, the essence of teaching program is presented on white board. Sometimes, some explanations of details are prepared on MS power point. There are also assignments and seasonal projects appointed to individual students or groups that help the evaluation process and also support team work effort.

Evaluation

	Task	Weight (Marks)	Due Week	Relevant Learning Outcome
	Paper Review			
Assignments	Homework			
	Class Activity	05		
	Report	05		
	Seminar	10		
	Essay			
	Project			
	Quiz	10		
	Lab.			
	Midterm Exam	20		
	Final Exam	50		
	Total	100		

Specific learning outcome:

Upon completion of the subject, students will be able to:

a. Obtain fundamental knowledge in the area of modes of Two Phase Flow.

b. Apply their knowledge, skills and hand-on experience to the analysis of flow in change phase.

c. Extend their knowledge of mechanical engineering to different situations of engineering context and professional practice in Transforming Phenomenon.

d. Recognize the need for and an ability to engage in life-long learning.

Course References:

1. Ghiaasiaan, S. M., Two-Phase flow, Boiling, and Condensation, Cambridge University Press.
2. Brennen, C.E., Fundamentals of Multiphase Flow, Cambridge University Press.
3. Collier, J. G. and Thome, J. R., Convective Boiling and Condensation, 3rd ed., Oxford University Press.
4. Wallis, G.B., One Dimensional Two Phase Flow, McGraw Hill Higher Education.

Course topics (Theory)	Week	Learning Outcome
What is Two Phase Flow .. ?	1	
Flow regimes and notation	2	
Flow patterns and flow regime maps	3	
Momentum equation for two-phase flow	4	
Flow in bubble columns	5	
Mid – Semester Examination	6	
Pressure drop Bubble rise velocity	7	
Slug flow in vertical tubes	8	
Seminar	9	
The homogeneous model for two-phase flow Momentum equation for the homogeneous flow model	10	
Friction factors for the homogeneous model	11	
Two-phase multiplier	12	
Separated flow models - I	13	
Separated flow models – II	14	
Final Semester Examinations	15	

Questions Example Design

Note: Attempt all the questions.

Q1. *Choose the correct answer for each of the following:*			***20 Marks***
	1. Mass transfer takes place …	(a) in a multi phase (b) in a double phase (c) only in a single phase	
	2. The fluid moves under the influence of an external force is …..	(a) Forced convection (b) Natural convection (c) Free convection	
	3. If there is any variation in density within the fluid phase, the ….. currents develop	(a) Forced convection (b) Natural convection (c) Diffusion	
	4. Momentum transfer as given by	(a) $J_A = -D_{AB}\frac{dC_A}{dz}$ (b) $q = -k\frac{dT}{dz}$ (c) $\tau = -\mu\frac{dv}{dz}$	
	5. Reynolds postulated that the mechanisms for transfer of (Momentum, Energy and Mass) are identical. Accordingly,	(a) f / 2 (b) f / 3 (c) f / 4	
	6. Based on data collected in both (Laminar and Turbulent) flow regimes, they found that:	(a) $j_D = j_H = \frac{f}{4}$ (b) $j_D = j_H = \frac{f}{3}$ (c) $j_D = j_H = \frac{f}{2}$	
	7. $Sh = 0.664\, Re_L^{1/2} Sc^{1/3}$	(a) $(\text{Laminar})\ Re_L < 2-5*10^5$ (b) $(\text{Laminar})\ Re_L < 2-4*10^5$ (c) $(\text{Laminar})\ Re_L < 2-3*10^5$	

8. For very low (Re), the (Sh)	(a) $Sh = 2 + C\,\mathrm{Re}^{m}\,Sc^{1/2}$ (b) $Sh = 2 + C\,\mathrm{Re}^{m}\,Sc^{1/3}$ (c) $Sh = 3 + C\,\mathrm{Re}^{m}\,Sc^{1/3}$
9. Mass transfer from the inner wall of a tube to a moving fluid is	(a) $Sh = 0.023\ \ \mathrm{Re}^{0.83}\ \ Sc^{0.44}$ (b) $Sh = 0.023\ \ \mathrm{Re}^{0.83}\ \ Sc^{0.55}$ (c) $Sh = 0.033\ \ \mathrm{Re}^{0.83}\ \ Sc^{0.44}$
10. Henry's law is	(a) $P_{Ai} = C_{Ai} / H$ (b) $P_{Ai} = H / C_{Ai}$ (c) $P_{Ai} = H\,C_{Ai}$
11. In the study of convective heat transfer, the heat flux is connected to heat transfer coefficient as:	(a) $Q/A = q = h(t_s - t_m)$ (b) $Q/A = q = h(t_m - t_s)$ (c) $Q/A = q = h.l\,(t_s - t_m)$
12. The analogous situation in mass transfer is handled by an equation of the form:	(a) $N_A = k_c (C_A - C_{As})$ (b) $N_A = k_c (C_{As} - C_A)$ (c) $N_A = k_c.l\,(C_{As} - C_A)$
13. Prandtl Number = Pr = …..	(a) thermal diffusivity / mass diffusivity (b) momentum diffusivity / mass diffusivity (c) momentum diffusivity / thermal diffusivity
14. Schmidt Number = Sc = …..	(a) thermal diffusivity / mass diffusivity (b) momentum diffusivity / mass diffusivity (c) momentum diffusivity / thermal diffusivity
15. Lewis Number = Le = …..	(a) thermal diffusivity / mass diffusivity (b) momentum diffusivity / mass diffusivity (c) momentum diffusivity / thermal

		diffusivity	
	16. the equation for energy transport by Convection and molecular Diffusion becomes …..	(a) $q=h\Delta T+\sum_i N_i \overline{H}_i$ (b) $q=h\Delta T+\sum_i N_i / \overline{H}_i$ (c) $q=h/\Delta T+\sum_i N_i \overline{H}_i$	
	17. The molar flux (NA) is calculated by diffusion through stagnant gas model as …..	(a) $N_A=\frac{-C}{1-y_A}\frac{d y_A}{d Z}$ (b) $N_A=\frac{-C D_{AB}}{1-y_A}\frac{d y_A}{d Z}$ (c) $N_A=\frac{-D_{AB}}{1-y_A}\frac{d y_A}{d Z}$	
	18. To find humidity, we can write equation for the mass and energy fluxes as …..	(a) $N_A=k_c\left(C_{Ai}-C_A\right)=k_y\left(y_{Ai}+y_A\right)$ (b) $N_A=k_c\left(C_{Ai}+C_A\right)=k_y\left(y_{Ai}-y_A\right)$ (c) $N_A=k_c\left(C_{Ai}-C_A\right)=k_y\left(y_{Ai}-y_A\right)$	
	19. In the air - film surroundings, the wet - bulb, the mass and energy fluxes are coupled as …..	(a) $N_A \lambda = q$ (b) $N_A / \lambda = -q$ (c) $N_A \lambda = -q$	
	20. in the wet – bulb Thermometer …..	(a) $T_i = T - \frac{\lambda}{C_p}\left(y_{Ai}-y_A\right)$ (b) $T_i = T \frac{\lambda}{C_p}\left(y_{Ai}-y_A\right)$ (c) $T_i = T - \frac{2\lambda}{C_p}\left(y_{Ai}-y_A\right)$	
Q2.	A solid disc of benzoic acid (3 cm) in diameter is spin at (20 rpm) and (25°C). Calculate the rate of dissolution in a large volume of water. Diffusivity of benzoic acid in water is ($1.0 * 10^{-5}$ cm^2 / s), and solubility is (0.003 g / cm^3). The following mass transfer correlation is applicable: $Sh = 0.62\ Re^{½}\ Sc^{1/3}$		***35 Marks***

Where: $Re = \frac{D^2 \omega \rho}{\mu}$, ω - An angular speed in (rad / s).

Q3.

A very thin polymeric coating of thickness (0.1 mm) uniformly coats a rectangular surface. The rectangular surface has a length of (20 cm) and a width of (10 cm). The coating contains a solvent that must be evaporated away from the coating in order to cure the coating. Initially, there is (0.001 mole) of solvent per (cm^3) of coating loaded in the coating. A heated plate just beneath the surface maintains the coating at a uniform temperature of (40 °C), and the vapor pressure exerted by the solvent is (0.05 atm) at (40 °C). Air gently flows parallel to the surface at a velocity of (5.0 cm/s). The surrounding air at (1.0 atm) total system pressure and (20 °C) represents an ''infinite sink'' for mass transfer. You may neglect any molecular diffusion of the solvent through the very thin polymeric film and focus only on the convection aspects of the problem.

45 Marks

(a) What is the average mass transfer coefficient (k_c) ?

(b) How long will it take for the solvent to completely evaporate from the coating ?

Given

The physical properties at 303 K are:

Kinematic viscosity $\upsilon = 0.158\ cm^2 / s$

Density $\rho = 1.17\times10^{-3}\ g / cm^3$

The diffusion coefficient of species in air at (30 °C) , $D_{AB} = 1.025\ cm^2 / s$

Correlation	Conditions
$Sh_L = 0.664\ Re_L^{0.5}\ Sc^{0.33}$	(Laminar) $Re_L < 2 \times 10^5$
$Sh_L = 0.0365\ Re_L^{0.8}\ Sc^{0.33}$	(Turbulent) $Re_L > 2 \times 10^5$

Extra notes:

Due to a number of unforeseen reasons that may lead to shifting of the academic semester program, it may be subjected to modifications. Also extra curriculum hours may be needed to cover all the topics. The students shall be notified of the changes if and when they may occur.

External Evaluator