



# UNIVERSITÀ DEGLI STUDI DI PALERMO

<b>DEPARTMENT</b>	Ingegneria
<b>ACADEMIC YEAR</b>	2022/2023
<b>BACHELOR'S DEGREE (BSC)</b>	CHEMICAL AND BIOCHEMICAL ENGINEERING
<b>SUBJECT</b>	PRINCIPLES OF CHEMICAL AND BIOCHEMICAL ENGINEERING
<b>TYPE OF EDUCATIONAL ACTIVITY</b>	B
<b>AMBIT</b>	50297-Ingegneria chimica
<b>CODE</b>	19577
<b>SCIENTIFIC SECTOR(S)</b>	ING-IND/24
<b>HEAD PROFESSOR(S)</b>	TAMBURINI                      Professore Associato                      Univ. di PALERMO ALESSANDRO
<b>OTHER PROFESSOR(S)</b>	
<b>CREDITS</b>	12
<b>INDIVIDUAL STUDY (Hrs)</b>	192
<b>COURSE ACTIVITY (Hrs)</b>	108
<b>PROPAEDEUTICAL SUBJECTS</b>	
<b>MUTUALIZATION</b>	
<b>YEAR</b>	2
<b>TERM (SEMESTER)</b>	2° semester
<b>ATTENDANCE</b>	Not mandatory
<b>EVALUATION</b>	Out of 30
<b>TEACHER OFFICE HOURS</b>	<b>TAMBURINI ALESSANDRO</b> Monday    15:00    17:00    Edificio 6 - ex Dipartimento di Ingegneria Chimica - 3° Piano - Corridoio di Teoria dello Sviluppo di Impianti Chimici - ultima stanza a sinistra  Thursday   15:00    17:00    Edificio 6 - ex Dipartimento di Ingegneria Chimica - 3° Piano - Corridoio di Teoria dello Sviluppo di Impianti Chimici - ultima stanza a sinistra

<b>PREREQUISITES</b>	Consolidated knowledge on: algebra, functions of one or more variable, infinitesimal calculus, mechanics, chemistry, phase equilibrium and state diagrams.																														
<b>LEARNING OUTCOMES</b>	<p>knowledge and understanding</p> <ul style="list-style-type: none"> <li>- After the course the student will become able to face problems related to transport phenomena and will become familiar with mass, energy and momentum balance equations as well as related transport constitutive models. Furthermore, he will be able in calculating and/or evaluating friction factors and heat and mass transfer coefficients. Basic knowledge of radiant heat transfer will be provided.</li> <li>- The student will be able to select and use the needed and appropriate relationships for chemical as well as biochemical engineering processes.</li> </ul> <p>making judgements</p> <ul style="list-style-type: none"> <li>- The student will be able to autonomously evaluate transport phenomena relationships applicability, results reliability and confidence, boundary conditions to apply to transport phenomena problems.</li> </ul> <p>Skills in application knowledge and understanding</p> <ul style="list-style-type: none"> <li>- learning of new and more complex approach to problems involving the course topics will be easier as fundamentals and logic approach scheme to face problems are current contents of the course.</li> </ul> <p>communication skills</p> <ul style="list-style-type: none"> <li>- The student will acquire the skill of state and transfer problems related to course topics by the use of the appropriate scheme mathematics and terminology.</li> </ul> <p>Learning skills</p> <ul style="list-style-type: none"> <li>- By the acquired knowledge on transport phenomena the student will own the fundamental approach of balance equations, both macroscopic and microscopic, to complex problems;</li> <li>- Moreover, he will know the difference between qualitative and quantitative approach to chemical engineering design of units and reactors.</li> </ul>																														
<b>ASSESSMENT METHODS</b>	<p>The assessment will be based on class written test + oral exam. The written class test is used only to assess whether the student is ready to perform the oral exam. The following criteria and score table will be applied to oral and the final evaluation, obtained by summing the individual criteria score will result in a pass if ranging from 18 to 30.</p> <p>Indicator - Knowledge and competence of contents Descriptor and score range:</p> <table> <tr><td>Excellent</td><td>10</td></tr> <tr><td>Autonomous and effective</td><td>8-9</td></tr> <tr><td>Acceptable</td><td>6-7</td></tr> <tr><td>Fragmentary or partly superficial</td><td>4-5</td></tr> <tr><td>Inadequate</td><td>0-3</td></tr> </table> <p>Indicator - Applicative skill, precision, logical-thematic coherence Descriptor and score range:</p> <table> <tr><td>Excellent</td><td>10</td></tr> <tr><td>Adequate</td><td>8-9</td></tr> <tr><td>Acceptable also if partly driven</td><td>6-7</td></tr> <tr><td>Limited</td><td>4-5</td></tr> <tr><td>Inadequate</td><td>0-3</td></tr> </table> <p>Indicator - Expression and terminology, reprocessing skills and multi-disciplinary connections Descriptor and score range:</p> <table> <tr><td>Excellent</td><td>10</td></tr> <tr><td>Effective and well-structured</td><td>8-9</td></tr> <tr><td>Generally satisfactory</td><td>6-7</td></tr> <tr><td>Hesitant and rough</td><td>4-5</td></tr> <tr><td>Inadequate</td><td>0-3</td></tr> </table>	Excellent	10	Autonomous and effective	8-9	Acceptable	6-7	Fragmentary or partly superficial	4-5	Inadequate	0-3	Excellent	10	Adequate	8-9	Acceptable also if partly driven	6-7	Limited	4-5	Inadequate	0-3	Excellent	10	Effective and well-structured	8-9	Generally satisfactory	6-7	Hesitant and rough	4-5	Inadequate	0-3
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<b>EDUCATIONAL OBJECTIVES</b>	The course aims to train the students on fundamentals and application of transport phenomena knowledge for professional work as well as applied																														

	research on chemical and biochemical engineering unit and process design.
<b>TEACHING METHODS</b>	Lectures + practical tutorials.
<b>SUGGESTED BIBLIOGRAPHY</b>	<p>Bird, R. Byron, Stewart, Warren E., Lightfoot, Edwin N., Transport Phenomena - revised 2nd Edition, Wiley (2007), ISBN: 978-0470115398</p> <p>R. Mauri – Fenomeni di trasporto. – Pisa University Press; 3 edizione (9 luglio 2014), ISBN: 978-8867413522</p> <p>M.C. Annesini, Fenomeni di Trasporto: Fondamenti e Applicazioni. Edizioni Efesto, 2015, ISBN 10: 8899104417 ISBN 13: 9788899104412</p> <p>M. Ciofalo - Lezioni di Termoidraulica - Scoietà Editrice Esculapio. ISBN: 978-88-9385-295-1</p>

## SYLLABUS

Hrs	Frontal teaching
25	<p>Stress, stress tensor definition, newtonian fluids definition, viscosity dependence on temperature and pressure. Balance principle, conservative quantities balance, total mass balance. Applications to the case of ideal chemical reactors.</p> <p>Momentum balance and boundary conditions. Steady state differential mass balance on systems with velocity depending on one coordinate (inclined plane laminar flow, pipe laminar flow, slit flow). Stokes law.</p> <p>Laminar vs turbulent flow, Reynolds number, turbulent flow properties. Dimensional analysis and Buckingham theorem, friction factor definition, relationship between friction factor and Reynolds number, pipe pressure loss, drag force and falling submerged objects terminal velocity calculation.</p> <p>Momentum macroscopic balance, energy dissipation and mechanical energy balance (Bernoulli equation), concentrated and distributed mechanical energy loss; macroscopic balance examples.</p> <p>Microscopic momentum balance.</p>
23	<p>Heat flow, Fourier law, thermal conductivity dependence on temperature and pressure, Prandtl number.</p> <p>Heat balance and boundary conditions, steady heat flow trough flat slab and composite flat slabs, heat exchange coefficient, series composition of thermal resistances in flat geometry; steady heat flow trough a cylindrical walls and composite cylindrical walls, heat exchange coefficient, series composition of thermal resistances in cylindrical walls.</p> <p>Heat conduction with generation (electrical Joule effect, viscous dissipation, chemical reaction); heat transfer in laminar pipe flow; cooling fin, natural convection.</p> <p>Transient heat conduction: energy differential balance, solutions with fixed wall temperature and wall heat exchange coefficient, dimensional analysis of the problem, different regimes and Biot number. Dimensional analysis of heat transport by Buckingham theorem, dimensional correlations for heat transfer coefficient, Coburn analogy.</p> <p>Macroscopic energy balance equation and applications. Microscopic energy Balance.</p> <p>Radiant heat transfer: opaque body, absorbance coefficient and emissivity, grey bodies, Stefan Boltzmann law, Lambert law, view factors.</p>
22	<p>Mass flow, Fick's law, dependence of diffusivity on temperature and pressure, Schmidt number; Mass balance and boundary conditions. Equimolar diffusion and stagnant component diffusion, mass transfer coefficients; diffusion with surface chemical reaction.</p> <p>Transient solid diffusion, analogy with transient solid heat transfer. Penetration theory, instantaneous and averaged mass transfer coefficient, limitation for the solution applicability.</p> <p>Mass transfer coefficient dimensional analysis by Buckingham theorem, adimensional heat and mass transfer numbers analogy.</p> <p>Interface mass transfer conditions, phase equilibrium, series combination of mass transfer resistances.</p> <p>Macroscopic mass balance.</p> <p>Microscopic mass balance. Applicazioni biologiche.</p>
Hrs	Practice
15	<p>Hydrostatic forces on flat submerged surfaces, curved surfaces and buoyancy calculations.</p> <p>Pressure loss and flow rate in laminar pipe flow and for free surface inclined plane flow calculations.</p> <p>Tangenziale stress in pipes and submerged objects calculations.</p> <p>Bernoulli equation for hydraulic circuit calculations and for physiological fluid systems.</p> <p>Terminal velocity determination of falling objects calculations.</p>
12	<p>Steady heat conduction calculations, with and without generation, in solids with different geometries.</p> <p>Heat exchange coefficients calculations.</p> <p>Steady macroscopic energy balance application to open and closed systems.</p> <p>Lumped and distributed parameters heat transient calculations.</p>
11	<p>Steady diffusion in different geometries calculations.</p> <p>Mass transfer coefficient calculations.</p> <p>Open and closed systems macroscopic mass balance applications.</p> <p>Lumped and distributed parameters transient mass transfer calculations.</p>