UNIVERSITÀ DEGLI STUDI DI PALERMO

DEPARTMENT	Ingegneria
ACADEMIC YEAR	2023/2024
MASTER'S DEGREE (MSC)	CHEMICAL ENGINEERING
INTEGRATED COURSE	BIOCHEMICAL PLANT DESIGN - INTEGRATED COURSE
CODE	22870
MODULES	Yes
NUMBER OF MODULES	2
SCIENTIFIC SECTOR(S)	ING-IND/25
HEAD PROFESSOR(S)	GRISAFI FRANCO — Professore Associato — Univ. di PALERMO
OTHER PROFESSOR(S)	GRISAFI FRANCO — Professore Associato — Univ. di PALERMO LIMA SERENA — Ricercatore a tempo determinato — Univ. di PALERMO
CREDITS	9
PROPAEDEUTICAL SUBJECTS	
MUTUALIZATION	
YEAR	1
TERM (SEMESTER)	1° semester
ATTENDANCE	Not mandatory
EVALUATION	Out of 30
TEACHER OFFICE HOURS	**GRISAFI FRANCO** Tuesday 17:00 18:00 Studio personale (Ed. 6 - piano 3) Wednesday 16:00 17:00 Studio personale (Ed. 6 - piano 3) **LIMA SERENA** Tuesday 10:00 12:00 Stanza del docente, Ed. 6, terzo piano

DOCENTE: Prof. FRANCO GRISAFI

PREREQUISITES	For a better understanding of the course topics, it is considered helpful for students to have prior knowledge in the following disciplines: Chemical Thermodynamics Fluid Mechanics Heat and Mass Transfer Phenomena Unit Operations (Heat Exchange, Distillation, Liquid-Liquid Extraction, Absorption).
LEARNING OUTCOMES	Application of Knowledge and Understanding Students will develop a phenomenological understanding of the functioning of the studied equipment. They will also be able to use Excel to model and design equipment for the operation of the considered processes, as well as identify optimal operating conditions. Autonomy of Judgment Students will be able to assess the applicability of the studied unit operations to specific industrial processes, making informed choices when multiple solutions are possible. Communication Skills Students will acquire the ability to effectively discuss issues related to the course topics. They will be able to properly present themes related to different unit operations, using technical terminology and mathematical representation tools. Students will develop these skills through continuous interaction with the instructor and the need to pass an oral examination on the course topics. Learning Skills Students will recognize the need to thoroughly understand the fundamental principles underlying the operations studied and, more generally, the attitude to delve into the subject of their study activities. They will have acquired an additional ideal tool for system modeling (population balance) as well as computational tools to tackle more complex modeling than previously encountered. This knowledge will contribute to the completion of their technical-professional background, even in related fields to chemical engineering.
ASSESSMENT METHODS	The evaluation will be based on a practical test (based on topics from the first 6-credit module) and an oral examination, both aimed at assessing the student's basic skills and problem-solving abilities acquired during the course. The practical test will include examples of equipment sizing for the unit operations described in the course. The evaluation of the practical test will be expressed with a maximum score of 30 and will contribute one-third to the evaluation of the first 6-credit module. There is no minimum passing threshold for the practical test. Regarding the oral examination, the questions will aim to verify: the acquired knowledge, the ability to elaborate, the ability to present information, the capacity to establish autonomous connections between the content independent of the reference texts, the ability to provide independent judgments regarding the disciplinary content, the ability to understand applications related to the discipline, and the ability to contextualize disciplinary content within the professional and technological reference framework. The evaluation of the oral examination will be given on a thirty-point scale according to the criteria listed below: 27-30: Clear understanding of all the topics covered, excellent language proficiency, excellent analytical skills, excellent ability to solve complex problems by applying acquired knowledge. 24-26: Excellent mastery of the topics, good language proficiency, good ability to apply acquired knowledge to solve the proposed problems. 21-23: Basic knowledge of all the topics covered, fair language proficiency, sufficient ability to independently apply knowledge to solve the proposed problems. 19-20: Basic knowledge of the main teaching topics, sufficient language proficiency, limited ability to independently apply acquired knowledge. 18: Minimal basic knowledge of the main teaching topics and technical language, very limited or no ability to independently apply acquired knowledge. First, a score will be calculated for the 6-credit module as a weighted average (1/3 and 2/3) of the evaluation of the written test and the oral examination of the 6-credit module, respectively. The overall evaluation of the course will be determined by the weighted average (based on credits) of the evaluations of both modules (6 and 3 credits). The highest grade ("lode") can only be awarded by the instructor if the oral and written tests receive the maximum evaluation.

TEACHING METHODS	The course takes place in the first semester of the first year of the master's degree program and consists of lectures and numerical exercises in the classroom. It is divided into two modules, one worth 6 CFU (Crediti Formativi Universitari) and the other worth 3 CFU.

MODULE
ADVANCED UNIT OPERATIONS

Prof. FRANCO GRISAFI

SUGGESTED BIBLIOGRAPHY

• Mc Cabe, Smith, Harriott, “Unit Operations of Chemical Engineering”, 7th Ed., Mc Graw Hill, 2005
• P. Doran, Principles of Biochemical Engineering, 2nd Ed., Academic Press, 2012
• B.K. Dutta, "Massa Transfer and Separation Processes, PHI Learning, 2007
• Perry, Green, “Perry's Chemical Engineers' Handbook”, 9th Ed., Mc Graw Hill, 2019
• Coulson & Richardson, “Chemical Engineering”, Vol. 2, 5th Ed., Butterworth-Heinemann, 2002
• A. Randolph, "Theory of Particulate Processes", Elsevier, 1988

AMBIT	50352-Ingegneria chimica
INDIVIDUAL STUDY (Hrs)	96
COURSE ACTIVITY (Hrs)	54

EDUCATIONAL OBJECTIVES OF THE MODULE

The specific objective of the master's degree program is to train experts in research, development, and design of industrial processes and plants.

Within this module, the aim is to develop skills related to understanding the modeling and design issues of industrial biotechnological plants. The module covers a range of selected unit operations that are commonly employed in the biotechnology industry.

An important aspect of the course is the training in the use of the Microsoft Excel environment for numerical modeling of the performance of industrial units. This training is particularly valuable for cases where simple analytical solutions are not feasible.

By acquiring these skills, students will be equipped to analyze and design industrial biotechnological processes effectively. They will gain proficiency in applying numerical modeling techniques using Excel, enabling them to tackle complex challenges in process optimization and performance evaluation.

SYLLABUS

Hrs	Frontal teaching
8	Mixing and agitation of fluids (in homogeneous phase, solid-liquid suspensions, liquid-gas dispersions, and liquid-liquid dispersions): static and rotating mixers, dimensional analysis of the motion equations in agitated systems, definition of Power Number and Pumping Number, as well as other dimensionless numbers, mixing times (homogenization number). Brief overview of tanks without baffles to prevent vortex formation.
7	Crystallization: Description of particulate solid systems with size distributions using cumulative distributions and population density, description of nucleation and growth kinetics in crystallizing systems, population balance applied to ideal crystallizers, techniques for controlling the product size in the outlet of a crystallizer, description of the equipment used.
8	Absorption with Chemical Reaction: Recap of gas-liquid mass transport in the absence of chemical reaction, partial and total transport coefficients. Higbie's penetration theory. Advantages and disadvantages of chemical absorption compared to physical absorption. Examples of industrial processes. Description of absorption regimes.
4	Psychrometrics: Definition of air-water system parameters, adiabatic saturation temperature, wet-bulb temperature, psychrometric chart and its usage.
2	Drying: General principles, free and bound moisture, equilibrium between moist air and moisture-absorbing materials, drying curves, drying rates, and calculation of drying time.
4	Multicomponent Distillation: Introductory overview, number of columns required for the separation of pure products, criteria for choosing the separation sequence, multicomponent mixtures with ideal behavior, selection of key components, Hengstebeck method, shortcut methods, and rigorous stage-by-stage calculations.

Hrs	Practice
9	Mixing and agitation of fluids
6	Crystallization
3	Psychrometrics and drying
3	Multicomponent Distillation

MODULE
BIOCHEMICAL PLANT AND OPERATIONS

Prof.ssa SERENA LIMA

SUGGESTED BIBLIOGRAPHY	
Pauline Doran, Principles of Biochemical Engineering, Pergamon Press	
AMBIT	20911-Attività formative affini o integrative
INDIVIDUAL STUDY (Hrs)	48
COURSE ACTIVITY (Hrs)	27
EDUCATIONAL OBJECTIVES OF THE MODULE	
Within this module, skills are developed aimed at understanding the modeling and design issues of industrial biotechnological plants. The course covers specific unit operations related to bioprocesses. Additionally, phenomena such as biomass production in various operating modes are modeled, and real case studies are presented.	

SYLLABUS

Hrs	Frontal teaching
5	Adsorption: solid-fluid partitioning equilibria, overview of thermodynamic models for interpreting partitioning equilibria, classification of adsorption isotherms, simplified modeling of concentration fronts advancement, description of main utilized equipment. Ion Exchange, Preparative and Analytical Chromatography.
6	Biomass growth kinetics, Monod equation, case of enzymes and cells supported by porous materials. Modeling of a continuous bioreactor: steady-state behavior, effect of cell recycling. Case of immobilized cells. Fed-batch modelling.
2	Industrial Bioreactors: main construction types, hydrodynamics regimes.
2	Gas-liquid mass transfer in bioreactors
2	Sterilization: cell death kinetics and their temperature dependence; Sterilization strategies for batch, fed-batch, and continuous bioreactors. Pasteurization. Sterilization of air streams required for aerobic fermentations.
1	Anaerobic digestion
1	Cell disruption
4	Case studies: examples of real bioprocesses.

Hrs	Practice
4	Bioreactor modelling