COURSE GUIDE – EXTENDED FORM

Academic year 2026 – 2027

1. Program information

1.1 University	*"Gheorghe Asachi" Technical University of Iasi*
1.2 Faculty	*"Cristofor Simionescu" Faculty of Chemical Engineering and Environmental Protection*
1.3 Department	*Organic, Biochemical and Food Engineering*
1.4 Field	*Chemical Engineering*
1.5 Study level	*Master*
1.6 Specialization	*Chemical and Biochemical Process Technology - CBPT*

2. Course information

2.1.1 Course name				**Scientific research/Engineering project in Biochemical Engineering**			
2.1.2 Course code				505	2.1.3. Course category Fundamental/Specialized/Complementary)		DS
2.2 Course instructor				PhD Lecturer Alexandra Tucaliuc			
2.3 Course instructors for applied activities (S, L, P, Pr)				PhD Lecturer Alexandra Tucaliuc			
2.4 Year of study [2]	1	2.5 Semesterl[3]	1	2.6 Evaluation type[4]	V	2.7 Course type [5]	DOB

3. Amount of time estimated for course activities (hours / term)

3.1 Hours /week	4	3.2 course	1	3.3a sem.	1	3.3b laboratory	2	3.3c project	0	3.3.d. practice	0
3.4 Total hours from curriculum[6]	56	3.5 course	14	3.6a sem.	14	3.6b laboratory	28	3.6c project	0		

Time spent for related activities[7]	Hours
Study of recommended books, course support, scientific papers and course notes	25
Study in library and practical skills development	15
Preparation of seminars / laboratory works / project phases / home works / presentations	10
Evaluation[8]	6
Other activities:	

3.7 Total hours of individual study [9]	56
3.8 Total hours per semestre[10]	108
3.9 Number of credits	4

4. Prerequisites (optional)

4.1 curriculum[11]	-
4.2 learning outcomes	-

5. Requirements

5.1 Conditions for course delivery[12]	Whiteboard, video projector, specific materials will be used. Students must attend the course with their mobile phones turned off.
5.2 Laboratory requirements[13]	Students must enter the laboratory with their mobile phones turned off. During laboratory work, students must wear lab coats and protective equipment appropriate for handling microorganisms. Students must come to the laboratory with written reports on the experiments to be carried out, already studied and understood. Students are not allowed to leave operating equipment unattended. Bringing food into the laboratory is strictly prohibited. Attendance at laboratory sessions is mandatory. Any accident or incident must be reported immediately to the lab supervisor. Unauthorized handling of microorganisms and equipment is strictly forbidden.

6. Overall objective of the course

The course aims to provide students with a foundational understanding of bioreactor design for fermentation control, with a strong emphasis on geometry, real-time monitoring and precise adjustment of key parameters to maintain an optimal growth environment for microorganisms and maximize product yield. Students will gain advanced insights into the design, operation, and optimization of fermentation processes in different types of bioreactor.

7. Learning outcomes

Knowledge	The student / graduate: - describes the basic principles of fermentations processes in specific equipment for sustainable manufacture of industrial products. - explains the basic principles of biocatalytic reactions in different types of bioreactors. - recognizes the specific parameters that can be controlled for bioprocess optimization. - classifies industrial bioreactor types and their operating modes (batch, fed-batch, continuous), including key control parameters and monitoring strategies. - describe the basic concepts of mass balances and process calculations in bioreactors
Skills	The student / graduate: - determine how to choose the right bioreactor design in order to facilitate efficient oxygen transfer, mixing, and heat distribution while also allowing for reliable monitoring and control of parameters like pH and temperature. - evaluate the unit operations applied in biochemical engineering - critically evaluate the feasibility of fermentation, microbial biocatalytic and enzymatic processes in an industrial context and devise a research/development plan - evaluate different bioreactors operating modes (batch, fed-batch, continuous etc.) and their benefits and drawbacks in relation to fermentation process for industrial products manufacturing - create solutions for specific problems in bioreactor manipulation
Responsibility and autonomy	The student / graduate: - respects ethical principles, standards, and values in the correct and timely completion of professional tasks, by adopting a rigorous, efficient, and responsible work strategy in decision-making and problem-solving; - assumes responsibility for contributing to professional knowledge and practices and/or for reviewing the strategic performance of teams; - engages in continuous professional development in their field by appropriately using effective lifelong learning methods and techniques.

8. Teaching methods

The teaching process will involve participatory lectures and debates, supported by PowerPoint presentations made available to students. These presentations include images and diagrams to make the information easier to understand and assimilate. Each lecture will begin with a brief review of the topics covered in the previous session.

The teaching method is also based on discovery learning models, facilitated through both direct and indirect exploration of reality (e.g., experiments, demonstrations, modelling). Additionally, action-based methods will be employed, such as practical exercises, hands-on activities, and problem-solving tasks.

9. Course content

9. 1. Courses[15]	**Teaching methods**	**Time allocation**
9.1.1. Fundamentals of bioreactor design: ideal vs. non-ideal bioreactors, stirred tank reactor (STR) geometry, impellers, spargers, design equations and scale-up considerations	Interactive lecture Guided discussions Clarifying explanations	2 hours
9.1.2. Types of bioreactors and operating modes: batch, fed-batch, continuous (chemostat), mechanical stirred vs. airlift bioreactors, advantages, limitations, industrial applications		2 hours
9.1.3. Microbial growth kinetics in bioreactors: Monod and substrate-inhibition models; determination of growth parameters (μmax, Ks, Yx/s), effect of pH, DO, temperature, shear stress.		2 hours
9.1.4. Immobilized cell systems: carrier types and immobilization techniques, mass transfer limitations in immobilized systems, applications in industry and biocatalysis		2 hours
9.1.5. Instrumentation and control in bioreactors: pH, DO, temperature, agitation, airflow sensors, basic control strategies (PID, cascade)		2 hours
9.1.6. Mass Balances and process calculations: cell mass, substrate, and product balances, elemental and redox balances, gas balances (O_2 uptake, CO_2 evolution)		2 hours

9.1.7. Bioprocess design and optimization: use of models in process optimization, case studies of scale-up and tech transfer, economic and sustainability aspects		2 hours

Course bibliography:
1. S Katoh (2015). Biochemical Engineering 2e – A Textbook for Engineers, Chemists and Biologists, Ed. Wiley Vch. Germany ISBN: 9783527338047.
2. Avijit Ghosh, Sudipta Dey Bandyopadhyay, Subhabrata Sengupta (2021) – Advances in Bioprocess Engineering and Technology, Ed. Springer Verlag, Singapore
3. J. Smith – Biotechnology, Fifth edition, Cambridge University Press, The Edinburgh Building, Cambridge CB2 8RU, UK, 2009
4. Najafpour-Darzi, G. Biochemical Engineering and Biotechnology (3rd ed.). Elsevier Science, 2025, https://doi.org/10.1016/C2024-0-00583-8
5. Zhong, J.-J. Bioreactor Engineering. In *Comprehensive Biotechnology*; Elsevier: Amsterdam, The Netherlands, 2011; pp. 257–269.

9.2b Laboratory	Working methods [17]	Observations, Time allocation
9.2.b.1. Bioreactor Setup and Sterilization: Components of a bench-scale stirred tank bioreactor; Inoculation and sterilization procedures; Aseptic techniques	Practical demonstrations, exercises, experiments	4 hours
9.2.b.2. Microbial growth in stirred tank bioreactor (free cells): batch fermentation *s. cerevisiae*, monitoring OD, pH, DO, agitation, calculation of growth rate and yield		4 hours
9.2.b.3. Microbial growth in airlift bioreactor: setup of a lab-scale airlift reactor, comparison of growth parameters with STR, Gas-liquid mass transfer estimation		4 hours
9.2.b.4. Immobilized cell fermentation: immobilization using alginate beads, fermentation with immobilized *Saccharomyces*, analysis of productivity and stability		4 hours
9.2.b.5. Determination of k_{La} (oxygen transfer rate): dynamic gassing-out method, effect of agitation and aeration on oxygen transfer, correlation with microbial growth		4 hours
9.2.b.6. Mass balances in bioreactor experiments: calculation of cell yield, substrate consumption, product formation; data processing from experimental runs; biomass and CO_2 balances		3 hours
9.2.b.7. Comparative operation – batch vs. fed-batch: setup of a simple fed-batch strategy; monitoring substrate concentration and productivity; advantages in preventing substrate inhibition		4 hours
9.2.b.8. Final evaluation		1 hours

9.3 Seminar		
9.3.1 Theoretical bioreactor design: students solve design problems for STR and airlift reactors; design calculations (volume, power input, aeration)		4 hours
9.3.2 Growth curve analysis and parameter estimation: analysis of real or simulated data sets; estimation of µmax, Yx/s, qs, qp, maintenance coefficient		4 hours
9.3.3 Bioprocess case study – from Lab to Pilot: analysis of a published fermentation process; discussion of scale-up challenges; process flow diagrams and economic evaluation		4 hours
9.3.4 Final evaluation		2 hours

Bibliography for applied activities (seminar / laboratory / project):
1. Sobotka M, et al. Review of Methods for the Measurement of Oxygen Transfer in Microbial Systems. Ann. Rep. Ferm. Proc. 5, 1982: 127–210; http://dx.doi.org/10.1016/B978-0-12-040305-9.50009-1.
2. Tribe LA, Briens CL, Margaritis A. Determination of the Volumetric Mass Transfer Coefficient (kLa) Using the Dynamic "Gas out–Gas in" Method: Analysis of Errors Caused by Dissolved Oxygen Probes. Biotechnol. Bioeng. 46(4) 1995: 388–392; https://doi.org/10.1002/bit.260460412.
3. Suresh S, Srivastava VC, Mishra IM. Techniques for Oxygen Transfer Measurement in Bioreactors: A Review. *J. Chem. Technol. Biotechnol.* 84(8) 2009: 1091–1103; https://doi.org/10.1002/jctb.2154.
4. Ying Zhu, hapter 14 - Immobilized Cell Fermentation for Production of Chemicals and Fuels in Bioprocessing for Value-Added Products from Renewable Resources. New Technologies and Applications, 2007, Pages 373-396, https://doi.org/10.1016/B978-044452114-9/50015-3
5. Federico Cerrone & Kevin E. O'Connor, Cultivation of filamentous fungi in airlift bioreactors: advantages and disadvantages, Applied Microbiology and Biotechnology, 109(41), 2025
6. MJ Rossi , FX Nascimento, AJ Giachini, VL Oliveira, A Furigo Jr., Airlift bioreactor fluid-dynamic characterization for the cultivation of shear stress sensitive microorganisms, Journal of Advances in Biotechnology, 2016, 5(2), ISSN 2 3 4 8 - 6 2 0 1

10. Evaluation

Activity type	10.1 Evaluation criteria	10.2 Evaluation method		**10.3 Percentage of the final grade** *(recommended to be proportional to the number of hours allocated to each type of activity)*
10.4 Type of evaluation: Final Exam / Assessment	*Completeness and correctness of knowledge.* *Logical coherence, fluency, strength of argumentation.* *Capacity for analysis, personal interpretation, originality, creativity.* *Degree of mastery of specialized terminology and communication skills.* *Ability to apply acquired skills.* *Ability to process data and solve given problems.*	*Systematic observation of students (individual/team assignments – assignments must be completed during the week between lectures, preparation of a report – case study).*	*20 %*	50%
		Formative assessment test (ongoing evaluations throughout the semester).	*40 %*	
		Summative assessment test (final evaluation).	*40 %*	
10.5b Laboratory/Seminar	*Laboratory activity – Ability to work in a team, ability to apply learned knowledge in practice, in different contexts.* *Capacity for analysis, personal interpretation, originality, and creativity.* *Capacity for engineering problems solving* *Capacity for design and specific parameter calculations in biochemical processes*	*Completion of laboratory sheets (all lab works must be completed, allowing the makeup of only one missed lab work);* *Assessment test (laboratory colloquium /seminar test).*		50%
10.6 Conditions for passing				
The final evaluation result for a course is determined by considering the scores and weights assigned to each activity within the course. Whole-number grades from 10 to 1 will be awarded, with a grade of 5 certifying the achievement of the minimal learning outcomes required for the course and the awarding of the corresponding study credits.				

Date: 3.09.2025

Course instructor: PhD Lecturer Alexandra Tucaliuc

Course instructors for applied activities: PhD Lecturer Alexandra Tucaliuc

Date of approval by the department: 5.09.2025

Head of Department
Associate professor Corina Cernatescu

Date of approval by the Faculty Council: 8.09.2025

Dean,

Professor Teodor Malutan

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[1] *Bachelor's / Master's degree.*
[2] *For Bachelor's: 1-4; for Master's: 1-2.*
[3] *For Bachelor's: 1-8; for Master's: 1-4..*
[4] *Exam (E), assessment (A) – according to the curriculum.*
[5] *DOB – mandatory course, DOP– optional course, DFA– elective course;*
[6] *Duration equals 14 weeks multiplied by the number of hours listed at point 3.1 (similarly for points 3.5 and 3.6abc).*
[7] *The lines below refer to individual study; total is completed at point 3.7.*
[8] *Between 2 and 6 teaching hours, not included in individual study..*
[9] *Total number of individual study hours (sum of values from previous lines).*

[10] *Total of direct teaching hours (3.4) plus individual study hours (3.7); must equal the number of credits (3.9) multiplied by 27 hours per credit.*
[11] *Prerequisite courses that must be passed previously or their equivalents are indicated.*
[12] *Teaching resources: blackboard, video projector, flipchart, specific teaching materials, etc.*
[13] *Technical equipment: computers, software packages, experimental stands, etc*
[14] *Learning outcomes presented as knowledge, skills, responsibility, and autonomy specific to the course, aligned with level 7 of the National Qualifications Framework (NQF) and adapted to the type of university program. For research master's programs, these include competences necessary for conducting independent scientific research (https://www.aracis.ro/wp-content/uploads/2025/07/Standarde-specifice-masterat.pdf).*
[15] *Titles of chapters and paragraphs.*
[16] *Teaching methods: discussions, debates, presentations and/or paper analyses, exercises and problem solving.*
[17] *Practical demonstrations, exercises, experiments.*
[18] *Case studies, demonstrations, exercises, error analysis, etc.*