

# 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	<b>Fermentation based biomanufacturing</b>						
2.1.2 Course code	501	2.1.3. Course category Fundamental/Specialized/Complementary)			DS		
2.2 Course instructor	Professor Alexandra Blaga						
2.3 Course instructors for applied activities (S, L, P, Pr)	Professor Alexandra Blaga						
2.4 Year of study <sup>2</sup>	1	2.5 Semester <sup>3</sup>	1	2.6 Evaluation type <sup>4</sup>	E	2.7 Course type <sup>5</sup>	DOB

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

3.1 Hours /week	4	3.2 course	2	3.3a sem.	0	3.3b laboratory	2	3.3c project	0	3.3.d. practice	0	
3.4 Total hours from curriculum <sup>6</sup>	56	3.5 course	28	3.6a sem.	0	3.6b laboratory	28	3.6c project	0			
Time spent for related activities <sup>7</sup>											Hours	
Study of recommended books, course support, scientific papers and course notes											30	
Study in library and practical skills development											26	
Preparation of seminars / laboratory works / project phases / home works / presentations											20	
Evaluation <sup>8</sup>											3	
Other activities:												
3.7 Total hours of individual study <sup>9</sup>												76
3.8 Total hours per semestre <sup>10</sup>												135
3.9 Number of credits												5

## 4. Prerequisites (optional)

4.1 curriculum <sup>11</sup>	-
4.2 learning outcomes	-

## 5. Requirements

5.1 Conditions for course delivery <sup>12</sup>	Whiteboard, video projector, specific materials will be used. Students must attend the course with their mobile phones turned off.
5.2 Laboratory requirements <sup>13</sup>	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 industrial fermentation and biomanufacturing processes, with a strong emphasis on microbial physiology, metabolic regulation, and reactor engineering. Students will gain

advanced insights into the design, operation, and optimization of fermentation systems used in the sustainable production of industrial products, including cells, enzymes, therapeutics -antibiotics, and bulk chemicals – organic acids, aminoacids.

## 7. Learning outcomes

<b>Knowledge</b>	<p>The student / graduate:</p> <ul style="list-style-type: none"> <li>- describes the role of microbial fermentation, microbial biocatalysis, and enzymatic biocatalysis in the sustainable manufacture of industrial products, including cells, proteins, and chemicals.</li> <li>- explains the physiological and metabolic characteristics of industrial microorganisms used in fermentation-based biomanufacturing.</li> <li>- recognizes the specific stress conditions associated with the production of various bioproducts and how these impact microbial performance.</li> <li>- classifies industrial bioreactor types and their operating modes (batch, fed-batch, continuous), including key control parameters and monitoring strategies.</li> <li>- outlines the biochemical and process-based foundations of biofuel and biogas production from renewable substrates.</li> <li>- summarizes the technological steps and microbial pathways involved in the fermentative production of antibiotics, organic acids, amino acids, enzymes, and vitamins.</li> </ul>
<b>Skills</b>	<p>The student / graduate:</p> <ul style="list-style-type: none"> <li>- determine how different product types (bulk chemicals, fine chemicals, bulk protein, refined proteins, or live cells) affect the choice of the fermentation process and downstream processing, as well as the possible stress factors.</li> <li>- analyse the consistency of experimental data using simple models</li> <li>- critically evaluate the feasibility of fermentation, microbial biocatalytic and enzymatic processes in an industrial context and devise a research/development plan</li> <li>- evaluate different fermentation processes (batch, fed-batch, continuous etc.) and their benefits and drawbacks in relation to delivering a uniform growth environment</li> <li>- create solutions for specific problems in industrial fermentation and defend or modify the solutions</li> </ul>
<b>Responsibility and autonomy</b>	<p>The student / graduate:</p> <ul style="list-style-type: none"> <li>- 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;</li> <li>- assumes responsibility for contributing to professional knowledge and practices and/or for reviewing the strategic performance of teams;</li> <li>- engages in continuous professional development in their field by appropriately using effective lifelong learning methods and techniques.</li> </ul>

## 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 <sup>15</sup>	Teaching methods	Time allocation
9.1.1. Microorganism used in biomanufacturing. Microbial physiology and metabolism in fermentation processes. Product specific stress (e.g. enzymes, protein therapeutics, biofuels, bulk chemicals, and secondary metabolites).	Interactive lecture Guided discussions Clarifying explanations	4 hours
9.1.2. Role of fermentation and biocatalysis in the sustainable manufacture of industrial products (including cells, proteins and chemicals)		2 hours
9.1.3. Reactor designs. Operating modes of fermentation reactors. Basic bioreactor control concepts. On-line process control. Scale-Up and Scale-Down Strategies in Industrial Fermentation		4 hours
9.1.4. Production of biofuels and biogas.		4 hours
9.1.5. Technologies for bio-production of antibiotics		4 hours

9.1.6. Technologies for bio-production of organic acids and amino-acids		4 hours
9.1.7. Technologies for bio-production of enzymes and vitamins		4 hours
9.1.8. Technologies for vaccine production		2 hours
<b>Course bibliography:</b>		
<p>1. Shah, M.P. &amp; Vyas, B.R.M. (eds.) (2023). Emerging Technologies in Applied and Environmental Microbiology, 1st ed. Academic Press. ISBN: 9780323998956 (print), 9780323911436 (eBook).</p> <p>2. Shijie Liu – Bioprocess Engineering, Kinetics, Sustainability, and Reactor Design, second edition, Elsevier, Radarweg 29, PO Box 211, 1000 AE Amsterdam, Netherlands, 2017</p> <p>3. J. Smith – Biotechnology, Fifth edition, Cambridge University Press, The Edinburgh Building, Cambridge CB2 8RU, UK, 2009</p> <p>4. Najafpour-Darzi, G. Biochemical Engineering and Biotechnology (3rd ed.). Elsevier Science, 2025, <a href="https://doi.org/10.1016/C2024-0-00583-8">https://doi.org/10.1016/C2024-0-00583-8</a></p> <p>5. Verma, P. (Ed.). Industrial Microbiology and Biotechnology: Emerging Concepts in Microbial Technology. Springer, Singapore. ISBN: 978-981-99-2815-6., 2023, DOI: <a href="https://doi.org/10.1007/978-981-99-2816-3">https://doi.org/10.1007/978-981-99-2816-3</a></p> <p>6. Verma, P. (Ed.). Industrial Microbiology and Biotechnology. Springer, Singapore. ISBN: 978-981-16-5213-4, 2022, DOI: <a href="https://doi.org/10.1007/978-981-16-5214-1">https://doi.org/10.1007/978-981-16-5214-1</a></p> <p>7. Agrawal, R. Textbook of Industrial Microbiology. Springer, Singapore. ISBN: 978-981-97-9581-9., 2024, DOI: <a href="https://doi.org/10.1007/978-981-97-9582-68">https://doi.org/10.1007/978-981-97-9582-68</a>.</p>		
<b>9.2b Laboratory</b>	Working methods <sup>17</sup>	Observations, Time allocation
9.2.b.1. Occupational safety and fire protection training. Laboratory introduction (autoclave, bioreactor, laminar flow hood, centrifuge, etc.)	Practical demonstrations, exercises, experiments	2 hours
9.2.b.2. Batch fermentation for itaconic acid production Using <i>Aspergillus terreus</i>		6 hours
9.2.b.3. Enzyme production – $\beta$ -Galactosidase fermentation Using <i>E. coli</i> .		6 hours
9.2.b.4. Bioethanol production via fed-batch fermentation using <i>Saccharomyces cerevisiae</i>		6 hours
9.2.b.5. Final evaluation		2 hours
<b>Bibliography for applied activities</b> (seminar / laboratory / project):		
<p>1. Rigel, N., &amp; Izquierdo, J. Laboratory Exercises in Microbiology (12th ed.). McGraw-Hill Education. (2022).</p> <p>2. Badal C Saha, Emerging biotechnologies for production of itaconic acid and its applications as a platform chemical, <i>Journal of Industrial Microbiology and Biotechnology</i>, Volume 44, Issue 2, 1 February 2017, Pages 303–315, <a href="https://doi.org/10.1007/s10295-016-1878-8">https://doi.org/10.1007/s10295-016-1878-8</a></p> <p>3. Zhang, R.; Liu, H.; Ning, Y.; Yu, Y.; Deng, L.; Wang, F. Recent Advances on the Production of Itaconic Acid via the Fermentation and Metabolic Engineering. <i>Fermentation</i> <b>2023</b>, <i>9</i>, 71. <a href="https://doi.org/10.3390/fermentation9010071">https://doi.org/10.3390/fermentation9010071</a></p> <p>4. Ciobanu CP, Blaga AC, Froidevaux R, Krier F, Galaction AI, Cascaval D. Enhanced growth and <math>\beta</math>-galactosidase production on <i>Escherichia coli</i> using oxygen vectors. <i>3 Biotech</i>. 2020 Jul;10(7):298. doi: 10.1007/s13205-020-02284-4</p> <p>5. Gennari, A., Simon, R., de Andrade, B. C., Kuhn, D., Renard, G., Chies, J. M., Volpato, G., &amp; Volken de Souza, C. F. (2023). Recombinant production in <i>Escherichia coli</i> of a <math>\beta</math>-galactosidase fused to a cellulose-binding domain using low-cost inducers in fed-batch cultivation. <i>Process Biochemistry</i>, 124, 290–298. <a href="https://doi.org/10.1016/j.procbio.2022.11.024">https://doi.org/10.1016/j.procbio.2022.11.024</a></p> <p>6. Chang, Y.-H.; Chang, K.-S.; Chen, C.-Y.; Hsu, C.-L.; Chang, T.-C.; Jang, H.-D. Enhancement of the Efficiency of Bioethanol Production by <i>Saccharomyces cerevisiae</i> via Gradually Batch-Wise and Fed-Batch Increasing the Glucose Concentration. <i>Fermentation</i> <b>2018</b>, <i>4</i>, 45. <a href="https://doi.org/10.3390/fermentation4020045">https://doi.org/10.3390/fermentation4020045</a></p> <p>7. Hung, Y. H. R., Chae, M., Sauvageau, D., &amp; Bressler, D. C. (2023). Adapted feeding strategies in fed-batch fermentation improve sugar delivery and ethanol productivity. <i>Bioengineered</i>, 14(1). <a href="https://doi.org/10.1080/21655979.2023.2250950">https://doi.org/10.1080/21655979.2023.2250950</a></p> <p>8. Karapatsia, A., Penloglou, G., Chatzidoukas, C., &amp; Kiparissides, C. (2016). Fed-batch <i>Saccharomyces cerevisiae</i> fermentation of hydrolysate sugars: A dynamic model-based approach for high yield ethanol production. <i>Biomass and Bioenergy</i>, 90, 32–41. <a href="https://doi.org/10.1016/j.biombioe.2016.03.021">https://doi.org/10.1016/j.biombioe.2016.03.021</a></p>		

## 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:	Completeness and correctness of knowledge.	Systematic observation of students (individual/team assignments – assignments	20 %	60%

Final Exam / Assessment	<p><i>Logical coherence, fluency, strength of argumentation.</i></p> <p><i>Capacity for analysis, personal interpretation, originality, creativity.</i></p> <p><i>Degree of mastery of specialized terminology and communication skills.</i></p> <p><i>Ability to apply acquired skills.</i></p> <p><i>Ability to process data and solve given problems.</i></p>	<p><i>must be completed during the week between lectures, preparation of a report – case study).</i></p>		
		<p><i>Formative assessment test (ongoing evaluations throughout the semester).</i></p>	40 %	
		<p><i>Summative assessment test (final evaluation).</i></p>	40 %	
10.5b Laboratory	<p><i>Laboratory activity – Ability to work in a team, ability to apply learned knowledge in practice, in different contexts.</i></p> <p><i>Capacity for analysis, personal interpretation, originality, and creativity.</i></p>	<p><i>Completion of laboratory sheets (all lab works must be completed, allowing the makeup of only one missed lab work);</i></p> <p><i>Assessment test (laboratory colloquium).</i></p>		40%
10.6 Conditions for passing				
<p>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.</p>				

Date: 3.09.2025

Course instructor: Associate professor Alexandra Blaga

Course instructors for applied activities: Associate professor Alexandra Blaga

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

<sup>1</sup> Bachelor's / Master's degree.

<sup>2</sup> For Bachelor's: 1-4; for Master's: 1-2.

<sup>3</sup> For Bachelor's: 1-8; for Master's: 1-4.

<sup>4</sup> Exam (E), assessment (A) – according to the curriculum.

<sup>5</sup> DOB – mandatory course, DOP – optional course, DFA – elective course;

<sup>6</sup> Duration equals 14 weeks multiplied by the number of hours listed at point 3.1 (similarly for points 3.5 and 3.6abc).

<sup>7</sup> The lines below refer to individual study; total is completed at point 3.7.

<sup>8</sup> Between 2 and 6 teaching hours, not included in individual study.

<sup>9</sup> Total number of individual study hours (sum of values from previous lines).

<sup>10</sup> 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.

<sup>11</sup> Prerequisite courses that must be passed previously or their equivalents are indicated.

<sup>12</sup> Teaching resources: blackboard, video projector, flipchart, specific teaching materials, etc.

<sup>13</sup> Technical equipment: computers, software packages, experimental stands, etc

<sup>14</sup> 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>).

<sup>15</sup> Titles of chapters and paragraphs.

<sup>16</sup> Teaching methods: discussions, debates, presentations and/or paper analyses, exercises and problem solving.

<sup>17</sup> Practical demonstrations, exercises, experiments.

<sup>18</sup> Case studies, demonstrations, exercises, error analysis, etc.