University of Debrecen
Faculty of Science and Technology
Institute of Chemistry

CHEMICAL ENGINEERING MSC PROGRAM

2024

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DEAN`S WELCOME

Welcome to the Faculty of Science and Technology!

This is an exciting time for you, and I encourage you to take advantage of all that the Faculty of Science and Technology UD offers you during your bachelor's or master's studies. I hope that your time here will be both academically productive and personally rewarding

Being a regional centre for research, development and innovation, our Faculty has always regarded training highly qualified professionals as a priority. Since the establishment of the Faculty in 1949, we have traditionally been teaching and working in all aspects of Science and have been preparing students for the challenges of teaching. Our internationally renowned research teams guarantee that all students gain a high quality of expertise and knowledge. Students can also take part in research and development work, guided by professors with vast international experience.

While proud of our traditions, we seek continuous improvement, keeping in tune with the challenges of the modern age. To meet our region's demand for professionals, we offer engineering courses with a strong scientific basis, thus expanding our training spectrum in the field of technology. Recently, we successfully re-introduced dual training programmes in our constantly evolving engineering courses.

We are committed to providing our students with valuable knowledge and professional work experience, so that they can enter the job market with competitive degrees. To ensure this, we maintain a close relationship with the most important companies in our extended region. The basis for our network of industrial relationships are in our off-site departments at various different companies, through which market participants - future employers - are also included in the development and training of our students.

Prof. dr. Ferenc Kun
Dean

UNIVERSITY OF DEBRECEN

Date of foundation: 1912 Hungarian Royal University of Sciences, 2000 University of Debrecen

Legal predecessors: Debrecen University of Agricultural Sciences; Debrecen Medical University; Wargha István College of Education, Hajdúböszörmény; Kossuth Lajos University of Arts and Sciences

Legal status of the University of Debrecen: state university

Founder of the University of Debrecen: Hungarian State Parliament

Supervisory body of the University of Debrecen: Ministry of Education

Number of Faculties at the University of Debrecen: 13

Faculty of Agricultural and Food Sciences and Environmental Management

Faculty of Child and Special Needs Education

Faculty of Dentistry

Faculty of Economics and Business

Faculty of Engineering

Faculty of Health

Faculty of Humanities

Faculty of Informatics

Faculty of Law

Faculty of Medicine

Faculty of Music

Faculty of Pharmacy

Faculty of Science and Technology

Number of students at the University of Debrecen: 30,899

Full time teachers of the University of Debrecen: 1,597

210 full university professors and 1,262 lecturers with a PhD.

FACULTY OF SCIENCE AND TECHNOLOGY

The Faculty of Science and Technology is currently one of the largest faculties of the University of Debrecen with about 2,500 students and more than 200 staff members. The Faculty has got 6 institutes: Institute of Biology and Ecology, Institute of Biotechnology, Institute of Chemistry, Institute of Earth Sciences, Institute of Physics and Institute of Mathematics. The Faculty has a very wide scope of education dominated by science and technology (12 Bachelor programs and 14 Master programs), additionally it has a significant variety of teachers' training programs. Our teaching activities are based on a strong academic and industrial background, where highly qualified teachers with a scientific degree involve student in research and development projects as part of their curriculum. We are proud of our scientific excellence and of the application-oriented teaching programs with a strong industrial support. The number of international students of our faculty is continuously growing (currently about 760 students). The attractiveness of our education is indicated by the popularity of the Faculty in terms of incoming Erasmus students, as well.

THE ORGANIZATIONAL STRUCTURE OF THE FACULTY

Dean: Prof. Dr. Ferenc Kun, Full Professor
E-mail: ttkdekan@science.unideb.hu

Vice Dean for Educational Affairs: Prof. Dr. Gábor Kozma, Full Professor
E-mail: kozma.gabor@science.unideb.hu

Vice Dean for Scientific Affairs: Prof. Dr. Sándor Kéki, Full Professor
E-mail: keki.sandor@science.unideb.hu

Consultant on External Relationships: Prof. Dr. Attila Bérczes, Full Professor
E-mail: berczesa@science.unideb.hu

Consultant on Talent Management Programme: Prof. dr. Tibor Magura, Full Professor
E-mail: magura.tibor@science.unideb.hu

Dean's Office
Head of Dean's Office: Mrs. Katalin Kozma-Tóth
E-mail: toth.katalin@science.unideb.hu

English Program Officer: Mrs. Alexandra Csatáry
Address: 4032 Egyetem tér 1., Chemistry Building, A/101, E-mail: acsatary@science.unideb.hu

DEPARTMENTS OF THE INSTITUTE OF CHEMISTRY

Department of Applied Chemistry (home page: http://applchem.science.unideb.hu/)
4032 Debrecen, Egyetem tér 1, Chemistry Building

Name	Position	E-mail	Room
Mr. Prof. Dr. Sándor Kéki, PhD, habil., DSc	University Professor Head of Department	keki.sandor@science.unideb.hu	E505
Mr. Dr. György Deák, PhD, habil.	Retired Associate Professor	deak.gyorgy@science.unideb.hu	E517/A
Mrs. Anita Dékány-Adamoczky	Assistant Lecturer	adamoczky.anita@science.unideb.hu	E516/A
Mrs. Dr. Katalin Margit Illyésné Czifrák, PhD, habil.	Assistant Professor	czifrak.katalin@science.unideb.hu	E503
Mr. Marcell Árpád Kordován	Assistant Lecturer	kordovan.marci@science.unideb.hu	E516/A
Mr. Dr. Ákos Kuki, PhD, habil.	Associate Professor	kuki.akos@science.unideb.hu	E508
Ms. Dr. Csilla Lakatos, PhD	Assistant Professor	lakatoscsilla@science.unideb.hu	E503
Mr. Dr. Lajos Nagy, PhD, habil.	Associate Professor	nagy.lajos@science.unideb.hu	E517/A
Mr. Dr. Tibor Nagy, PhD, habil.	Associate Professor	nagy.tibor@science.unideb.hu	E508
Mr. Dávid Nyul	Assistant Lecturer	nyul.david@science.unideb.hu	E517/A
Mrs. Veronika Csilla Pardi-Tóth	Departmental Engineer	pardi-toth.veronika.csilla@science.unideb.hu	E516/A
Mr. Gergő Róth	Assistant Lecturer	roth.gergo@science.unideb.hu	E516/A
Mr. Prof. Dr. Miklós Zsuga, PhD, habil., DSc	Professor Emeritus	zsuga.miklos@science.unideb.hu	E508

Department of Inorganic and Analytical Chemistry (home page: http://www.inorg.unideb.hu)
4032 Debrecen, Egyetem tér 1, Chemistry Building

Department of Inorganic and Analytical Chemistry (home page: https://kemia.unideb.hu/en)
4032 Debrecen, Egyetem tér 1, Chemistry Building

Name	Position	E-mail	Room
Mr. Prof. Dr. Attila Gáspár, PhD, habil., DSc	University Professor Head of Department	gaspar.attila@science.unideb.hu	D402
Ms. Prof. Dr. Katalin Várnagy, PhD, habil., DSc	University Professor Head of Institute	varnagy.katalin@science.unideb.hu	D406
Mr. Prof. Dr. István Fábián, PhD, habil., DSc	University Professor	ifabian@science.unideb.hu	D508
Mrs. Prof. Dr. Etelka Farkas, PhD, habil., DSc	Professor Emerita	efarkas@science.unideb.hu	D422

Mr. Prof. Dr. Imre Sóvágó, PhD, habil., DSc	Professor Emeritus	sovago@science.unideb.hu	D422
Mr. Dr. Péter Buglyó, PhD, habil.	University Professor	buglyo@science.unideb.hu	D411
Mrs. Dr. Gyöngyi Gyémánt, PhD, habil.	University Professor	gyemant@science.unideb.hu	D518
Mr. Dr. István Lázár, PhD, habil	Associate Professor	lazar@science.unideb.hu	D506
Mrs. Dr. Csilla Kállay, PhD, habil.	Associate Professor	kallay.csilla@science.unideb.hu	D428
Mr. Dr. József Kalmár, PhD, habil.	Associate Professor	kalmar.jozsef@science.unideb.hu	D507
Mrs. Dr. Melinda Andrási Pokoraczkiné, PhD	Assistant Professor	andrasi.melinda@science.unideb.hu	D502
Mrs. Dr. Edina Baranyai, PhD	Assistant Professor	baranyai.edina@science.unideb.hu	D423
Ms. Dr. Annamária Sebestyén, PhD	Master Teacher	sebestyen.annamaria@science.unideb.hu	D308
Mrs. Dr. Ágnes Fejesné Dávid, PhD	Assistant Professor	david.agnes@science.unideb.hu	D426
Mr. Dr. Attila Forgács, PhD	Research Fellow	forgacs.attila@science.unideb.hu	D431
Mr. Dr. Norbert Lihi, PhD	Associate Professor	lihi.norbert@science.unideb.hu	D423
Mrs. Dr. Mária Szabó, PhD	Assistant Professor	szabo.maria@science.unideb.hu	D524
Ms. Dr. Petra Herman, PhD	Assistant Professor	herman.petra@science.unideb.hu	D507
Mrs. Dr. Dóra Szalóki Vargáné, PhD	Junior Research Fellow	szalko.dora@science.unideb.hu	D431
Ms. Dr. Zsófi Sajtos, PhD	Assistant Lecturer	sajtos.zsofi@science.unideb.hu	D423
Ms. Dr. Nóra Cynthia Nagy, PhD	Assistant Lecturer	nagy.cynthiavscience.unideb.hu	D502
Ms. Dr. Fruzsina Simon, PhD	Junior Research Fellow	simon.fruzsina@science.unideb.hu	D431

Department of Organic Chemistry (home page: http://szerves.science.unideb.hu/)
4032 Debrecen, Egyetem tér 1, Chemistry Building

Name	Position	E-mail	Room
Mr. Prof. Dr. Tibor Kurtán, PhD, habil., DSc	University Professor Head of Department	kurtan.tibor@science.unideb.hu	E405
Mr. Prof. Dr. Gyula Batta, PhD, habil., DSc	University Professor	batta@unideb.hu	E18
Mr. Prof. Dr. László Somsák, PhD, habil., DSc	Professor Emeritus	somsak.laszlo@science.unideb.hu	E326
Mrs. Dr. Éva Bokor, PhD	Assistant Professor	bokor.eva@science.unideb.hu	E423; E422

Mr. Dr. László Juhász, PhD, habil.	Associate Professor	juhasz.laszlo@science.unideb.hu	E409; E421
Mrs. Dr. Éva Juhászné Tóth, PhD	Assistant Professor	toth.eva@science.unideb.hu	E423; E408
Mr. Dr. István Timári, PhD	Assistant Professor	timari.istvan@science.unideb.hu	B12
Mr. Dr. Attila Kiss, PhD, habil.	Associate Professor	kiss.attila@science.unideb.hu	E325
Mr. Dr. Máté Kicsák, PhD	Assistant Professor	kicsak.mate@science.unideb.hu	E-423/A
Mrs. Dr. Anita Kónya-Ábrahám, PhD	Assistant Lecturer	dulryc@unideb.hu	E325
Mrs. Dr. Krisztina Kónya, PhD	Assistant Professor	konya.krisztina@science.unideb.hu	E407
Mr. Dr. Sándor Kun, PhD	Assistant Professor	kun.sandor@science.unideb.hu	E423; E422
Mr. Dr. Attila Mándi, PhD	Assistant Professor	mandi.attila@science.unideb.hu	E412; E424
Mr. Prof. Dr. László Szilágyi, PhD, habil., DSc	Professor Emeritus	lszilagyi@unideb.hu	B18
Mrs. Dr. Tünde Zita Illyés, PhD	Assistant Professor	illyes.tunde@science.unideb.hu	E20
Mrs. Dr. Marietta Vágvölgyiné Tóth, PhD, habil.	Associate Professor	toth.marietta@science.unideb.hu	E409, E421
Mr. Dr. János József, PhD	Assistant Professor	jozsef.janos@science.unideb.hu	E421
Mr. Dr. Sándor Balázs Király, PhD	Assistant Professor	kiraly.sandor.balazs@science.unideb.hu	E423/A

Department of Physical Chemistry (home page: https://fizkem.unideb.hu//)
4032 Debrecen, Egyetem tér 1, Chemistry Building

Name	Position	E-mail	Room
Mr. Prof. Dr. Gyula Tircsó, PhD, habil.	University Professor Head of Department	gyula.tircso@science.unideb.hu	D619
Mr. Prof. Dr. István Bányai, PhD, habil., DSc	Professor Emeritus	banyai.istvan@science.unideb.hu	D201
Mr. Prof. Dr. György Bazsa, PhD, habil., DSc	Professor Emeritus	bazsa@unideb.hu	D605
Mr. Dr. Attila Bényei, PhD, habil.	Associate Professor	benyei.attila@science.unideb.hu	D16
Ms. Dr. Réka Borsi-Gombos, PhD	Assistant Professor	gombos.reka@science.unideb.hu	D607
Ms. Dr. Szilvia Bunda, PhD	Assistant Research Fellow	bunda.szilva@science.unideb.hu	D607

Mr. Dr. Tibor Csupasz, PhD	Assistant Lecturer	csupasz.tibor@science.unideb.hu	D520
Ms Dr. Csilla Czégéni, PhD	Assistant Professor	nagy.csilla@science.unideb.hu	D602
Mr. Dr. Zoltán Garda, PhD	Assistant Professor	garda.zoltan@science.unideb.hu	D519
Mr. Prof. Dr. Oldamur Hollóczki, PhD, habil.	University Professor	holloczki.oldamur@science.unideb.hu	D617
Ms. Dr. Henrietta Horváth, PhD	Associate Professor	henrietta.horvath@science.unideb.hu	D602
Mr. Prof. Dr. Ferenc Joó, PhD, habil., DSc	Professor Emeritus	joo.ferenc@science.unideb.hu	D618
Ms. Ágnes Kathó, PhD	Retired Research Lecturer	katho.agnes@science.unideb.hu	D603
Mr. Dr. Ferenc Krisztián Kálmán, PhD, habil.	Associate Professor	kalman.ferenc@science.unideb.hu	D622
Ms. Dr. Mónika Kéri, PhD	Assistant Professor	keri.monika@science.unideb.hu	D202
Ms. Dr. Virág Kiss, PhD	Assistant Lecturer	kiss.virag@science.unideb.hu	D202
Mr. Prof. József Kónya, PhD, DSc	Retired University Professor	konya.jozsef@science.unideb.hu	D108
Ms. Prof. Dr. Noémi Nagy, PhD, habil., DSc	University Professor	nagy.noemi@science.unideb.hu	D108
Mr. Dr. Levente Novák, PhD	Assistant Professor	novak.levente@science.unideb.hu	D201
Mr. Dr. Gábor Csaba Papp, PhD, habil.	Associate Professor	papp.gabor@science.unideb.hu	D603
Ms. Dr. Eszter Mária Papp-Kovács, PhD	Assistant Professor	kovacs.eszter.maria@science.unideb.hu	D206
Mr. Dr. Imre Tóth, PhD, DSc	Professor Emeritus	imre.toth@science.unideb.hu	D520
Ms. Dr. Enikő Tóth-Molnár, PhD	Assistant Research Fellow	molnar.eniko@science.unideb.hu	D507
Mr. Dr. Antal Udvardy, PhD	Assistant Professor	udvardya@science.undeb.hu	D603

ACADEMIC CALENDAR

General structure of the academic semester (2 semesters/year):

Study period	1st week	Registration*	1 week
	2nd – 14th week	Teaching period	13 weeks
Exam period	directly after the study period	Exams	7 weeks

*Usually, registration is scheduled for the first week of September in the fall semester, and for the first week of February in the spring semester.

For further information please check the following link:
https://www.edu.unideb.hu/tartalom/downloads/University_Calendars_2024_25/University_calendar_2024-2025-Faculty_of_Science_and_Technology.pdf

Description of the Chemical Engineering MSc Program

Name and address of the institute: University of Debrecen, H-4032 Debrecen, Egyetem tér 1., Hungary

Responsible faculty: Faculty of Science and Technology

Starting date: 1st September, 2021.

Program supervisor: Prof. Dr. Sándor Kéki, University Professor

Program coordinator: Dr. Réka Borsi -Gombos, Assistant Professor

1. Name of the MSc Program: Chemical Engineering

2. Acquired degree level and specialization:
- **degree level:** MSc (Magister Scientiae, Master of Science)
- **specialization:** - Pharmaceutical specialization
  - Petrochemical and plastic industrial specialization

3. Area of the Program: engineering

4. Duration of studies: 4 semesters

5. Number of required ECTS credits: 120
- **orientation:** balanced (40-60 %)
- **credits gained for the thesis:** 15+15 (in 2 semesters)
- **minimum credits of the optional courses:** 6 credits

6. Classification of the Program by the uniform classification system: 524

7. Objectives and Perspectives, acquired professional competences

Our objective is to train professionals who possess the general knowledge, technical intelligence, and the basics of natural, social and engineering sciences, which are essential for the practice of their chosen profession.

It is likewise important that students acquire the most essential skills in technology and safety, environmental protection, management and social sciences. Specific practical methods as well as the capability of applying acquired skills will help them to get accustomed to the professional requirements and standards of their future workplace. They will be capable of understanding/controlling production processes, preparing quality management and technical services and solving tasks regarding design and development.

Through the learning of basic legal, economic and management skills, students will be trained to carry out projects concerning production and marketing. In addition, senior students will possess the necessary theoretical and practical expertise to solve problems appearing in the processes of the chemical and related industries, and will furthermore be able to operate complex technological systems and carry out research and development tasks.

7.1. Acquired professional competences

a) Knowledge

- The student has a mathematical, scientific (physical and chemical) and technical background to understand processes in chemical and chemistry related industries.
- The student knows the properties of the most important chemicals, their production and application.
- The student knows the basic principles, the design and control options in the technology of chemical processes and industrial tasks.
- The student knows the theories and practices of sustainability, safety and environmental effects related to the chemical industry, as well as health protection and health promotion knowledge.
- The student knows the documentation standards of the profession.
- The student knows the quality management methods in the chemical industry.
- The student knows the chemical technology related economical, management and intellectual property rules and laws.
- The student knows the chemical methods for measurements or analysis, their principles and instrumental background, and their applicability.
- The student knows the information and communication technologies related to chemical engineering.
- The student knows the methods and instruments of computer modelling and simulation related to chemical engineering.
- The student knows the methods for the design and evaluation of experiments.
- The student knows the theories and methods of the connection and integration of technological processes.
- The student knows the most recent results and approach of the technological development.
- The student has knowledge on modern synthetic methods, particularly on green chemistry and catalytical processes.
- The student has comprehensive knowledge on the analysis, modelling and design of the chemical industry and chemical technologies.
- The student has comprehensive knowledge on the process control of the chemical industry and chemical technologies.
- The student knows the most important chemical operations and technologies of the chemical industry in detail.
- The student knows the analytical and spectroscopic methods for the research, development and operation of chemical methods and technologies.

- The student has comprehensive knowledge on materials science and materials technology.
- The student knows and comprehensively applies the theories and methods of quality management used in chemical industry.

b) Ability

- The student is able to use creatively their mathematical and scientific knowledge in order to solve theoretical and practical tasks in the chemical industry.
- The student has the manual skills for professional-research and development.
- The student is able to perform, analyse and test in the field of chemical engineering, chemistry and chemical technology, their evaluation, documentation, and, the development of novel analytical methods if necessary.
- The student is able to process, organize, comprehensively analyze and to draw conclusions from information collected from the operation of industrial chemical processes.
- The student is able to improve their chemical and chemical industrial knowledge base with original ideas and results.
- The student is able to apply their knowledge about the development, control and design of chemical technological processes and systems, and in the related research.
- The student is able to utilize the complex plan and management of the usage of technical, economical, environmental and human resources in the chemical industry.
- The student is able to use and develop methods, models and information technologies to plan, organize and operate chemical industrial systems and processes.
- The student is able to solve problems of quality management, measurement and process control in the chemical industry and chemical technological systems.
- The student is able to cooperate in teamwork in the chemical industry and other professional fields.
- The student is capable of creative problem handling and flexible solution of complex problems, is able to follow the concepts of open-mindedness and value-based life-long learning.
- The student is capable of the safe operation of technological systems without any risk on health, considering the effects on human health, and taking the necessary steps of prevention.

c) Attitude

- The student makes an effort to enforce all known disciplines and requirements of safety, sustainability, environmental protection and energy efficiency.
- The student likes to plan and execute their tasks alone or in a workgroup at a high professional level.
- The student works with a systematic and process-oriented, complex approach.
- The student investigates the possibility to set research, development and innovation goals, and tends to reach them.
- The student is committed to the development of the scientific field with novel/up-to-date knowledge, scientific and technical results.
- The student continuously tends to improve their knowledge and skills.
- The student is open to professional trainings matching their ambitions.

- The student is committed to a higher level, quality work, and tends to mediate this attitude to their colleagues.
- As a leader the student makes their important decisions considering the opinions and arguments of the colleagues.

d) Autonomy and responsibility

- The student is independent and initiative when professional problems need to be solved.
- The student feels responsibility for sustainability and environmental protection.
- The student makes decisions carefully and independently in agreement with the representatives of other professions (not only technical), and takes responsibility for that.
- The student makes decisions considering safety, environmental protection, quality management, consumer protection and product liability.
- The student considers the theory and application of equal chances to access during their work.
- The student applies the principles of work safety, health promotion, the technological, economical and legal regulations, as well as engineering ethics during their professional work and as a leader.
- The student makes an effort to promote the professional improvement of their colleagues.

8. Conditions of the admission to the Program

Minimal number of credits for the admission is 70 from the following fields of science:

- natural sciences (mathematics, physics, materials science, biology, chemistry (min. 10 credits)): 20 credits
- economic and human sciences (economics, management, quality management, safety, social sciences): 10 credits
- basic chemical engineering (unit operations, industrial measurement and analytics, process control, safety, quality management, chemical and environmental technology, chemical industrial technologies): 40 credits.

The minimum requirement for the admission is having 40 credits of the above mentioned fields from their BSc studies. Missing credits can be made up for in the first year according to the Education and Examination Rules and Regulations of the University of Debrecen.
Admission of the students is accepted without preconditions from the following Programs: Chemical Engineering BSc and Biochemical Engineering BSc.

9. Characteristics of the Program

9.1. Professional characteristics

9.1.1. Scientific area, specializations:

- Natural sciences (mathematics, chemistry (min. 8 credits), physics, biochemistry)): 20-35 credits
- Economic and human sciences (economics, business, management, quality management): 10-20 credits
- Chemical engineering (general engineering and basic/advanced knowledge of information technology, physical chemistry, analytical chemistry, materials science, measurement, instrumentation, process control, mechanics, unit operations, chemical technology, design of technological units and processes): 15-45 credits.

9.1.2. Specialized knowledge to fulfil the demand of chemical industry (analytical, special chemical industries, process control, design and modelling of technological units and processes, knowledge of the technologies and unit operations of the specialized industrial field, the analytical and spectroscopical methods for the research and development of processes and technologies, materials science and materials technology): 40-60 credits are recommended by the relevant institute.

9.1.3. The 14-week semesters include the following contact hours: 1575 obligatory + 90-120 optional = 1665-1695 hours, which is equivalent to a workload of 30 hours a week.

9.2. Internship

Students have to take part in an at least 4-week long professional internship.

10. Physical education

Students have to take part in physical education lessons for at least 1 semester. The duration of the compulsory sports lesson takes 2 hours weekly. Our University offers a wide range of facilities to complete them. Further information is available from the Sport Centre of the University, its website: http://sportsci.unideb.hu.

11. Requirements of the thesis

Students have to write a thesis in the 3rd and 4th semester. Writing it is the precondition of the entrance to the final exam.
The thesis must involve the solution of a chemical engineering task which the student should solve relying on their previous studies and using secondary literature under the guidance of a tutor in two semesters. The thesis must prove that the author can utilize the acquired theoretical knowledge.

The thesis is preferred to be written in cooperation with an industrial partner of the University, according to the student’s specialization. The student can also choose any topic for a thesis suggested by the faculty or in occasional cases individual topics acknowledged by the head of the department. Only those tasks can be given as thesis that can be accomplished within the allowed time limit relying on the skills acquired during the years of study. The topics of the thesis should be given in a completely formal style and be based on the system of requirements set up by the head of the Institute and the head of the Department responsible for the specialization. Students must be informed of the thesis topics in the first academic week of the first semester the latest. The theses are written with the close collaboration of the candidate and the supervisor.
The formal requirements of the thesis are detailed in the “manual for writing theses” which is handed out to every candidate when they decide upon their topic. The theses must be handed in to the relevant Institute minimum ten days before the beginning of the final exam period. The thesis paper is evaluated by an independent reviewer who gives a grade as well as a short written comment on it. The thesis is given a grade by the final exam committee. In the case the thesis is not accepted the student cannot carry on with the exam.

12. Final Exam

Students of the faculty receive a pre-degree certificate ("absolutorium", stating that all the course-units have been completed) after completing every aspect of their educational and examination requirements. The student can only register for the final exam if the thesis is already submitted, it is accepted and evaluated by the supervisor. The final exam is essential for anyone who wants to get a chemical engineer MSc diploma. The final exam must be taken in front of the final exam committee.

Subjects of the Final Exam:

- Transport processes
- Specialization question: - Pharmaceutical or
  - Petrochemical and plastic industrial

Students without specialization have two questions about Transport processes.

Procedure of the Final Exam

Conditions of taking part in the final exam:

- Acquired pre-degree certificate (absolutorium)
- Submitted thesis
- Submitted evaluation sheet for the thesis, with a minimum grade of pass (2).

Parts of the Final Exam

Picking a question card in both topics, preparation (1-2 minutes)
Brief presentation of the results of the thesis (6 minutes)
Answering the questions about the thesis (4 minutes)
Answering the questions about the 2 subjects (2x10 minutes)

Evaluation of the diploma

Determination options of the grade for the MSc diploma:

- Weighted average of the overall studies at the program
- Grade of the thesis given by the final exam committee regarding the reviewer's evaluation sheet
- Average of the grades received at the final exam for the two subjects

Evaluation of the diploma according to the Education and Examination Rules and Regulations of the University of Debrecen:

excellent	4.81 – 5.00
very good	4.51 – 4.80
good	3.51 – 4.50
satisfactory	2.51 – 3.50
pass	2.00 – 2.50

Completion of the MSc Program

The Credit System

Majors in the Hungarian Education System have generally been instituted and ruled by the Act of Parliament under the Higher Education Act. The higher education system meets the qualifications of the Bologna Process that defines the qualifications in terms of learning outcomes: statements of what students know and can do on completing their degrees. In describing the cycles, the framework uses the European Credit Transfer and Accumulation System (ECTS).
ECTS was developed as an instrument of improving academic recognition throughout the European Universities by means of effective and general mechanisms. ECTS serves as a model of academic recognition, as it provides greater transparency of study programs and student achievement. ECTS in no way regulates the content, structure and/or equivalence of study programs.
Regarding each major the Higher Education Act prescribes which professional fields define a certain training program. It contains the proportion of the subject groups: natural sciences, economics and humanities, subject-related subjects and differentiated field-specific subjects.

During the program students have to complete a total amount of 120 credit points. It means approximately 30 credits per semester. The curriculum contains the list of subjects (with credit points) and the recommended order of completing subjects which takes into account the prerequisite(s) of each subject. You can find the recommended list of subjects/semesters in chapter “Model Curriculum of Chemical Engineering MSc Program”.

Model Curriculum of Chemical Engineering MSc Program

*Knowledge and their subjects; the responsible people	semesters 1.	2.	3.	4.	ECTS credit points	Prerequisite	evaluation (e – oral or witten exam / t - term-grade / p – mid-semester grade / s - signature)
	contact hours, types of teaching (l - lecture / s - seminar / p – laboratory practice) / credit points						
Knowledge of curriculum							
Economy and management subject group – responsible person: András István Kun							
1. Advanced Microeconomics **TTKME4011_EN** *Levente Sándor Nádasi*	2+0+0				2		e
2. Management **TTKME4012_EN** *András István Kun*				2+0+0	2		e
3. Advanced quality management **TTKME4014_EN** *Ágnes Kótsis*		2+0+0			2		t
4. Engineering communication **TTKME4013_EN** *Katalin Tóth*		2+0+0			2		e
5. Intellectual property law **TTKME4015_EN** *György Csécsy*		1+0+0			1		t
6. Engineering Informatics **TTKMG4901_EN** *Sándor Misák*	1+2+0				3		p
Chemical industry knowlege subject group – responsible person: Ákos Kuki							
1. Industrial instrumentation and automatization for Chemical Industry **TTKME4605_EN** **TTKMG4605_EN** *Ákos Kuki*	2+2+0				2+2		e, p
2. Safety and health prevention in chemical industry **TTKME4606_EN** *Tibor Nagy*				2+0+0	2		e
3. Industrial technologies **TTKME4607_EN** *Lajos Nagy*		2+0+0			2		t
4. Pilot Plant II. **TTKML4601_EN** *Lajos Nagy*				0+0+4	4		p
Energetics and transport process subject group – responsible person: Lajos Nagy							
1. Energetics in Chemical Industry **TTKME4604_EN** *Lajos Nagy*	2+0+0				2		e
2. Transport processes I. **TTKME4602_EN** **TTKMG4602_EN** *Ákos Kuki*		2+2+0			2+2		e, p

3. Transport processes II.* **TTKME4603_EN** **TTKMG4603_EN** *Ákos Kuki*			2+2+0		2+2	TTKME4602-EN, TTKMG4602-EN	e, p
Basic knowledge subject group – responsible person: István Szabó							
1. Differential equations **TTMME0803_EN** *Ábris Nagy*	2+2+0				4		e
2. Engineering physics **TTFME2110_EN** *Lajos Daróczi*	2+0+0				3		e
3. Environmental management **TTKME4016_EN** *Csilla Lakatos*				2+0+0	2		e
Organic- and biochemical subject group – responsible person: Marietta Vágvölgyiné Tóth							
1. Bioprocess Engineering I. **TTKME4801_EN** *Levente Karaffa*		2+0+0			2		e
2. Organic synthetic methods I. **TTKME0301_EN** *Marietta Vágvölgyiné Tóth*	2+0+0				3		e
3. Organic chemistry practice **TTKML4301_EN** *Éva Bokor*		0+0+2			1		p
4. Biochemistry IV. **TTKME0303_EN** *Teréz Barna*	2+0+0				2		e
Physical chemistry and separation techniques subject group – responsible person: Attila Kiss							
1. Downstream processing **TTKME4802_EN** *Gyöngyi Gyémánt*				2+0+0	2		e
2. Physical chemistry and practical applications **TTKME4401_EN** **TTKML4401_EN** *Attila Bényei, Ferenc Kálmán*		2+0+2			2+2		e, p
3. Separation techniques III. **TTKME0315_EN** *Attila Kiss*		2+0+0			3		e, p
4. Separation techniques VI. **TTKML4501_EN** *Attila Gáspár*		0+0+2			1	TTKBE0502-EN	e, p
Total credits in curriculum (credit, hourse/week, exams)	15 l 6 s 0 p 23 cr	15 l 2 s 6 p 22 cr	3 l 2 s 0 p 4 cr	8 l 0 s 4 p 12 cr	61 cr		18 e 9 p 3 t

Knowledge and their subjects; the responsible people	semesters				ECTS credit points	Prerequisite	evaluation (e – oral or witten exam / t – term-grade / p – mid-semester grade / s - signature)
	1.	2.	3.	4.			
	contact hours, types of teaching (l - lectue / s - seminar / p – laboratory practice) / credit points						
Knowledge of curriculum: Pharmaceutical specialisation							
Organic and applied synthetic chemistry subject group – responsible person: Tibor Kurtán							
1. Heterocycles **TTKME0327_EN** *Tibor Kurtán*		2+0+0			3		e
2. Pharmaceutical-industry project I. **TTKML4305_EN** *Tibor Kurtán*		0+0+3			3		t
3. Pharmaceutical-industry project II.* **TTKML4306_EN** *Tibor Kurtán*			0+0+3		3	TTKML4305-EN	t
4. High efficiency synthetic methods I. **TTKML0319_EN** *László Juhász*				0+1+3	3		p
Applied pharmaceutical chemistry subject group – responsible person: László Juhász							
1. Instrumental and material analysis **TTKME4502_EN** *Attila Gáspár*		2+0+0			2		e
2. Chemical aspects of drug design **TTKME0314_EN** *László Somsák*	2+0+0				3		e
3. Carbohydrate based drug design **TTKME4303_EN** *László Somsák*			2+0+0		2		e
4. Environment-friendly and catalytic processes **TTKME4402_EN** *Antal Udvardy*			2+0+0		2		e
5. Pharmaceutical and fine chemical technologies **TTKME4304_EN** *László Juhász*			2+1+0		3		e (f)
Total credits in the specialization:	2 l	4 l 0 s 3 p	6 l 1 s 3 p	0 l 1 s 3 p	24 cr		6 e 1 p 2 t
	3 cr	8 cr	10 cr	3 cr			
	15 l 6 s	23 l 3 s 10 p	9 l 3 s 7 p	8 l 1 s 7 p	84 cr		24 e 10 p 5 t
	24 cr	31 cr	14 cr	15 cr			

1. MSc Thesis I. (pharmaceutical) **TTKML4001_EN** *Tibor Kurtán*			0+0+11		15		p
2. MSc Thesis II. (pharmaceutical)** **TTKML4002_EN** *Tibor Kurtán*				0+0+11	15	TTKML4001_EN	p
	15 l 6 s 0 p	23 l 3 s 10 p	9 l 3 s 18 p	8 l 1 s 18 p			
	24 cr	31 cr	29 cr	30 cr			

*Knowledge and their subjects; the responsible people	semesters 1.	2.	3.	4.	ECTS credit points	Prerequisite	evaluation (e – oral or witten exam / t – term-grade / p – mid-semester grade / s - signature)
	contact hours, types of teaching (l - lectue / s - seminar / p – laboratory practice) / credit points						
	Knowledge of curriculum: **Plastic industrial and Petrochemical specialisation**						
	Plastic industrial subject group – responsible person: Lajos Nagy						
1. Plastics processing technologies **TTKME4610_EN** **TTKML4610_EN** *Sándor Kéki*			2+0+4		2+4		e, p
2. Plastic-industry project I. **TTKML4611_EN** *Csilla Lakatos*		0+0+4			3		t
3. Plastic-industry project II.* **TTKML4612_EN** *Csilla Lakatos*			0+0+4		3	TTKML4611_EN	t
	Applied material science subject group – responsible person: Sándor Kéki						
1. Instrumental and material analysis **TTKME4502_EN** **TTKML4502_EN** *Attila Gáspár* *Melinda Andrási*	0+0+4	2+0+0			4+2		p, e
2. Materials science **TTKME4608_EN** *Sándor Kéki*			2+0+0		2		e
3. Modern petrochemistry **TTKME4609_EN** *Sándor Kéki*			2+0+1		3		e
Total credits in the specialization:	0 l 0 s 4 p	2 l 0 s 4 p	6 l 0 s 9 p	-	23 cr		4 e 2 p 2 t
	4 cr	5 kr	14 cr	-			
	13 l 6 s 4 p	21 l 3 s 11 p	9 l 2 s 9 p	8 l 0 s 4 p	84 cr		
	25 cr	28 cr	18 cr	12 cr			

1. MSc Thesis I. (Petrochemical and Plastic-industri project) **TTKML4003_EN** *Sándor Kéki*			0+0+11		15		p
2. MSc Thesis II. (Petrochemical and Plastic-industri project) **TTKML4004_EN** *Sándor Kéki*				0+0+11	15	TTKML4003_EN	p
	13 l 6 s 4 p	21 l 3 s 11 p	9 l 2 s 20 p	8 l 0 s 15 p			
	27 cr	32 cr	18 cr	12 cr			

Optional Courses							
1. Chemical plant **TTKME4612_EN** *Lajos Nagy*		2+0+0			2		e
2. Formulation of bioactive compounds **TTKME4803_EN** *Miklós Vecsernyés*				2+0+0	2		e
3.Nanosystems – Colloids **TTKME4403_EN** *Levente Novák*		2+0+0			2		e
4. Nuclear Analysis I. **TTKME0523_EN** *Noémi Nagy*		2+0+0 (fall)			3		e
5. Environmental risk assessment and bioremediation **TTKME4807_EN** *Magdolna Kaszáné Kiss*	2+0+0				2		e
6. Inorganic Chemistry V. **TTKME0203_EN** *Péter Buglyó*	3+0+0				4		e
7. Computational quantum chemistry [a] **TTKMG0902_EN** *Odamur Hollóczki*		0+2+0 (spring)			3	minimum 12 credits of mathematics	t
8. Complexes of macrocyclic ligands **TTKME0212_EN** *Gyula Tircsó*	2+0+0(fall)				3		e
9. Dangerous and special materials [a] **TTKME0206_EN** *István Lázár*	2+0+0				3		e
10. Biological colloid science [a] **TTKME0411_EN** *Levente Novák*		2+0+0 (spring)			3		e
11. Dosimetry, radiation health effects **TTKME0432_EN** *István Hajdu*			2+0+0		3		e
12. Physical chemistry of living systems **TTKME0417_EN** *Réka-Borsi Gombos*				2+0+0	3		e
13. Metal complex catalyzed organic syntheses **TTKME0420_EN** *Gábor Papp*				2+0+0	3		e
14. Environmental chemistry II. **TTKME0414_EN** *Mónika Kéri*				2+1+1	4		e
15. Structure determination by X-ray diffraction **TTKME0423_EN** *Attila Bényei*	2+0+0				3		e
16. Chemistry of secondary metabolites I. **TTKME0331_EN** *László Juhász*	2+0+0				3		e
17. Chemistry of secondary metabolites II. **TTKML0332_EN** *László Juhász*	0+0+4				3		p

18. Enzyme Biotechnology **TTKME0334_EN** *Teréz Barna*	2+0+0				3		e
19. NMR operator practice I.a **TTKML0004_EN** *Gyula Batta*	0+0+2				2		p
20. Reaction Kinetics/Catalysis **TTKME0437_EN** *Gyula Tírcsó/Csaba Gábor Papp*				2+0+2	4		e
Internship							
10. Internship **TTKMX4601_EN** *Ákos Kuki*		4 weeks (summer)					s
Optional couses total	**6 cr**						**6 cr**
Total credits in the major	**120 cr**						**120 cr**

Course Descriptions of Chemical Engineering MSc Program

(1.) Title of Course: **Advanced microeconomics** **Code**: TTKME4011_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 12 hours - preparation for the exam: 20 hours Total: 60 hours	
Year, semester: 1st year (fall)	
Prerequisite(s): -	
Topics of course	
The Market. Budget Constraint. Preferences. Utility. Choice. Demand. Revealed Preference. Slutsky Equation. Buying and Selling. Intertemporal Choice. Asset Markets. Uncertainty. Risky Assets. Consumer's Surplus. Market Demand. Equilibrium. Auctions. Technology. Profit Maximization. Cost Minimization. Cost Curves. Firm Supply. Industry Supply. Monopoly. Monopoly Behavior. Factor Markets. Oligopoly. Game Theory. Exchange. Production. Welfare. Externalities. Law and Economics. Information Technology. Public Goods. Asymmetric Information.	
Literature	
Compulsory: - Varian, Hal R. (2009): Intermediate Microeconomics: A Modern Approach. W. W. Norton & Company, New York, ISBN: 0393934241. - Bergstrom, Theodore C. – Varian, Hal R. (2010): Workouts in Intermediate Microeconomics. W. W. Norton & Company, New York, ISBN: 0393935159. *Recommended:* - McCloskey, D. N. (1985): An Applied Theory of Price. MacMmillan Publishing Company, New York. ISBN: 0-02-378520-9 Freely available at the author's homepage at http://www.deirdremccloskey.com/docs/price.pdf	
Course objective/intended learning outcomes	
a) Knowledge - He/she knows the tools and methods of managerial economics and the basis of the legal context. **b) Ability** - He/she is able to utilize the complex planning and management of technical, economic, environmental and human resources in the chemical industry.	

- He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning.

c) Attitude

- He/she works with a systematic and process-oriented, complex approach.
- He/she constantly seeks to improve professional competencies.
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.

d) Autonomy and responsibility

- He/she takes individual initiatives in solving professional problems.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Schedule:

1st week

The Market. Budget Constraint.

2nd week

Preferences. Utility.

3rd week

Choice. Demand.

4th week

Revealed Preference. Slutsky Equation.

5th week

Buying and Selling. Intertemporal Choice.

6th week

Asset Markets. Uncertainty. Risky Assets. Consumer's Surplus.

7th week

Market Demand. Equilibrium. Auctions.

8th week

Technology. Profit Maximization.

9th week

Cost Minimization. Cost Curves.

10th week

Firm Supply. Industry Supply.

11th week

Monopoly. Monopoly Behavior.

12th week

Factor Markets. Oligopoly. Game Theory.

13th week

Exchange. Production. Welfare. Externalities.

14th week

Law and Economics. Information Technology. Public Goods. Asymmetric Information

Requirements:

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

During the semester there is a written end-term test in the 14th week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points.

- *for a grade*

The course ends in a **written or oral examination**. Based on the result of the examination questions scored according to pre-set maximum points for each sub-questions. The type of the examination (written or oral) is the choice of the student.

The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or the examination is given according to the following table:

- Score Grade
- 0-59 fail (1)
- 60-69 pass (2)
- 70-79 satisfactory (3)
- 80-89 good (4)
- 90-100 excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

-*an offered grade:*

It may be offered for students on the basis of the result of the end-term test if the grade is at least satisfactory (3).

Person responsible for course: Dr. Judit Kapás, full professor, PhD

Lecturer: Dr. Judit Kapás, full professor, PhD

(2.) Title of Course: Management Code: TTKME4012_EN	ECTS Credit points: 2

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours per week
- practice: 0
- laboratory: 0

Evaluation (exam. / practice. / other): **exam (written examination test)**

Workload (estimated), divided into contact hours:
- lecture: 28
- practice: 0
- laboratory: 0
- home assignment: 0
- preparation for the exam: 0

Total: 28

Year, semester: 2nd year (spring)

Prerequisite(s): -

Topics of course

Organizing and managing systems, human resource management, risk management, quantitative methods of business analysis, marketing, quality management, operations management (production, scheduling, logistics), change management, project management, business communication, strategic management, innovations management, investment decisions, decision making in business. Business organizations and organization behaviour. Business ethics.

Literature

Compulsory:
- Ronald J. Ebert, Ricky W. Griffin (2017): Business Essentials, Global Edition, Person, London.

Recommended:
- Stevenson J. William (2018): *Operations Management. 13th edition*. McGraw-Hill Irvin, London.
- Foster S. Thomas (2013): *Managing Quality: Integrating the Supply Chain, 5th Edition.* Pearson Prentice-Hall, New-Jersey.
- Pinto, Jeffrey K. (2016): *Project Management: Achieving competitive advantage 4th edition*. Pearson, London.

Course objective/intended learning outcomes

a) Knowledge
- He/she knows the tools and methods of managerial economics and the basis of the legal context.
- Students gain knowledge to recognise and solve business problems in enterprises and in non-profit organisations as well.

b) Abilities
- He/she is able to utilize the complex planning and management of technical, economic, environmental and human resources in the chemical industry.
- He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning.

c) Attitude
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.
- He/she constantly seeks to improve professional competencies.
- He/she works with a systematic and process-oriented, complex approach.

d) Autonomy and responsibility
- He/she takes individual initiatives in solving professional problems.

- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Schedule:
1st week: Course introduction.
Basic economic and business concepts.
2nd week: Understanding business environment.
Macro- and microenvironment analysis techniques, markets and organisations. Global and social context of business.
3rd week: Managing and organising business.
The basics of management and leadership. Organisational behaviour. Managing change.
4th week: Human Resource Management.
Employee satisfaction, motivation. Staffing. Performance management. Rewarding.
5th week: Decision making and quantitative business analysis.
The basics of business forecasting and statistical analysis. Models of decision making.
6th week: Marketing essentials.
The 4Ps. Consumer behaviour. Segmentation and targeting. Pricing and promotion.
7th week: Supply chain management.
Value chains, supply chains and the basics of logistics.
8th week: Business information systems.
The basics of accounting and controlling. IT for business.
9th week: Finance.
Basics of finance. The role of banking in business.
10th week: Operations management.
Managing production and service processes. Process mapping. Scheduling. Capacity planning. Inventory management. LEAN management.
11th week: Managing Quality.
Defining quality. Basic tools to measure and manage quality. The voice of the customer.
12th week: Project management.
The strategic role of projects. Basic tools for project planning, monitoring and control. Risk management.
13th week: Business Ethics and Social Responsibility. Innovation management.
14th week: Labour markets.
Demand and supply for labour. Unions. Unemployment and labour shortage. International movement of labour.

Requirements: Students are required to continuously study the readings. Attendance is recommended, but not compulsory. The calculation of the final grade determined by the written examination score in 100%, as follows: <51% = 1, 51%–64% = 2, 65%–74% = 3, 75%–85% = 4, 86-100% = 5. The written test contains three short essays and/or problem solving.

Person responsible for course: Dr Levente Sándor Nádasi, PhD; associate professor

Lecturer: Dr Levente Sándor Nádasi, PhD; associate professor

(3.) Title of Course: Advanced Quality Management **Code: TTKME4014_EN**	**ECTS Credit points: 2**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours per week
- practice: 0
- laboratory: 0

Evaluation (exam. / practice. / other):

Workload (estimated), divided into contact hours:
- lecture: 14
- practice: 14
- laboratory:
- home assignment: 16
- preparation for the exam: 16

Total: 60

Year, semester: 1st year (spring)

Prerequisite(s): -

Topics of course

The series of lectures are based on the topics of Quality Managment. This course introduces the participants into the philosophy, the theories and the basic calculations of quality management. Lectures give opportunity to discuss the topics and to get practice in basics techniques of measuring quality, quality improvement, statistical process control, quality management, international standards of quality.

Literature

Compulsory:
- Foster S. Thomas (2017): *Managing Quality: Integrating the Supply Chain.* 6th edition. Pearson Prentice-Hall, New-Jersey, ISBN-13: 978-0133798258

Recommended:

-Joel E. Ross – Susan Perry (2004): Total Quality Management, Text, Cases and Readings. 3rd Edition, Vanity Books International.
-David L. Goetsch - Stanley Davis (2015): Quality Management for Organizational Excellence: Introduction to Total Quality. 8th Edition. Pearson Prentice-Hall, New-Jersey,ISBN-13: 978-0133791853

Course objective/intended learning outcomes

a) Knowledge
- He/She knows the chemistry and chemical technology related economical, management environmental safety, quality assurance (QC/QA), informatics and intellectual property rules and laws.
- He/she has a mathematical, scientific (physical and chemical) and technical background to understand processes in chemical and chemistry related industries.

b) Abilities
-He/She is able to follow and control chemical processes and other technological steps concerning the quality management and quality control.
- He/she is able to utilize the complex planning and management of technical, economic, environmental and human resources in the chemical industry.

c) Attitude
-During his/her work he/she committed to apply the quality concerns including the new assurances

- He/she works with a systematic and process-oriented, complex approach.

d) Autonomy and responsibility

- He/she applies the principles of health and safety at work, the technical, economic and legal regulations, as well as engineering ethics in professional work and as a leader.
- He/She makes decisions according to his/her positions, makes suggestions to qualify his/her colleagues involving their promotions.
- He/she confesses and represents the value system of the engineering profession with responsibility. He/she is open to critical remarks which are professionally well-founded

Schedule:

1st week:

Basic issues of quality: quality of products,KANO-model

2nd week:

Basic issues of quality: quality of services, SERVQUAL model

3rd week:

Product Design – Paired comparison

4th week:

Quality theories- Taguchi method (Design of Experiments)

5th week:

Tools of quality - 7 basic tools of quality (Ishikawa)

6th week:

Statistical Process Control I – Charts for Variables

7th week:

Statistical Process Control II – Charts for Attributes

8th week:

Process Capability

9th week:

Quality management: International Quality standards (ISO, TQM, EFQM model)

10th week:

LEAN Manufacturing and Quality

11th week:

Six Sigma System

12th week:

Product Design – Quality Function Deployment

13th week:

Risk Evalutaion: Failure Mode and Effects Analysis

14th week:

Practicing Case Studies

Requirements:

Attendance at **lectures** is recommended, but not compulsory.

During the semester there is a written end-term test in the 14th week. Beside this students create their own case study.

Grade: 50% case study+50% mide term paper

Score	Grade
0-59	fail (1)
60-69	pass (2)

70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Person responsible for course: Kun, András István, PhD; associate professor

Lecturer: Kótsis Ágnes, PhD; associate professor

(4.) Title of Course: **Engineering communication** **Code**: TTKME4013_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 12 hours - preparation for the exam: 20 hours Total: 60 hours	
Year, semester: 1st year (spring)	
Prerequisite(s): -	
Topics of course	
Analyze Communication Purpose and Audience. How Engineers Learn. Spear The Way to Engineering Success. Presentation Aids. Organize The Talk. Handling Audience Response. Write The Way for Business Impact. Write As If Talking to The Engineering Associates. "Lean" The Expressions. Write Actively—Engineering Is about Actions. Integrating Speaking and Writing Skills. Visuals for Engineering Presentation—Engineers Think in Pictures. Write Winning Grant Proposals. How to Effectively Prepare Engineering Reports. Listening – Interactive Communication about Engineering Risk. - The importance of digital skills for chemical engineering related activities	
Literature	
Compulsory: - John X. Wang: What Every Engineer Should Know About Business Communication. CRC Press, 2008. - Sunita Mishra, Muralikrishna M.: Communication Skills for Engineers, Second Edition, Pearson India, 2011. *Recommended:* - Phillip A. Laplante: Technical Writing: A Practical Guide for Engineers, Scientists, and Nontechnical Professionals, Second Edition, CRC Press, 2018.	
Course objective/intended learning outcomes	
a) Knowledge - He/she knows the information and communication technologies related to chemical engineering. - He/she is familiar with communication concepts, communication channels, Illem, protocol rules - He/she knows the job search channels, until you run the resume creation process - He/she knows a selection of applications and important project management for successful implementation of tenders - He/she knows the rules of communication within the Organization **b) Abilities** - He/she is able to utilize the complex planning and management of technical, economic, environmental and human resources in the chemical industry. - He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning.	

- He/she is suitable for cooperation, participation in group work, after good practice management tasks supply.
- He/she is capable of realistic self-assessment and self-correction
- He/she is able to communicate and behave according to social rules, expectations

c) Attitude

- He/she is open to identify and analyse emerging problems, seek to solve them, synthesize,
- He/she constantly seeks to improve professional competencies.
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.
- As a leader he/she makes important decisions considering the opinions and arguments of colleagues.
- He/she is communicative, positive relationship-creating personality.
- He/she is committed to demanding and qualitative work, further learning skills, and the acquired hydrobiology
- He/she is also suitable for teamwork.
- He/she is open to the reception of new knowledge, learning and culture, continuous training with other professional cooperation. Actively

d) Autonomy and responsibility

- He/she provides for the management of smaller working groups, the autonomy needed to organise their work,
- He/she takes individual initiatives in solving professional problems.
- He/she considers the principle and application of equal access opportunities, as well.
- He/she is characterised by proactive and decision-making and a strong personal responsibility.

Schedule:

1st week

Analyze Communication Purpose and Audience. How Engineers Learn. How Engineers Are Persuaded. Speak or Write: Select the Right Communication Channel. Consider The Communication Purpose and Audience.

2nd week

Spear The Way to Engineering Success. Projecting the Image of the Engineering Profession. Overcome Anxiety. Primary Impact: Nonverbal Body Language. Secondary Impact: Control The Vocal Quality, Volume, and Pace. Optimize The Presentation Environment.

3rd week

Presentation Aids. Engineering: The Real da Vinci Code. Speaking Visually—Guidelines for Using Presentation Aids. Choosing among Options. Creating Visuals with Impact. Delivering with Visuals.

4th week

Organize The Talk. Planning The Talk. Conducting an Audience Analysis: 39 Questions. Organizing The Talk in Seven Easy Stages. Getting Attention and Keeping Interest. "Five Minutes Early"—Time Management for The Presentation. Delivering The Introduction. Presenting The Conclusion.

5th week

Handling Audience Response. Create the Environment. Handle with C.A.R.E. Deal with Hostile Questions. Deal with Other Types of Questions. Control the Q&A Session. Thinking on The Feet.

6th week

Write The Way for Business Impact. Organizing for Emphasis. Make The Bottom Line the Top Line. Purpose Statement and Blueprints. Open Long Reports with a Summary. Use More Topic Sentences. Develop Headings. Structure Vertical Lists.

7th week

Write As If Talking to The Engineering Associates. Use Personal Pronouns. Rely On Everyday Words. Use Short, Spoken Transitions. Keep Sentences Short. Reach Out to The Engineering Readers by Asking Questions. "5 Whys"—A Technique for Engineering Problem Solving.

8th week

“Lean” The Expressions. Introduction. Prune Wordy Expressions. Use Strong Verbs. Cut Doublings and Noun Strings. Eliminate Unnecessary Determiners and Modifiers. Change Phrases into Single Words. Change Unnecessary Clauses into Phrases or Single Words. Avoid Overusing “It is” and “There is”. Eight Steps for Lean Writing.

9th week

Write Actively—Engineering Is about Actions. Active Voice: “Albert Einstein Wrote the Theory of Relativity”. How to Recognize the Passive Voice. How to Write Actively—Use Three Cures. Write Passively for Good Reasons Only. Theory of Completed Staff Work.

10th week

Integrating Speaking and Writing Skills. Everyday Engineering Communications—E-Mails, Phone Calls, and Memos. Effective E-mail Writing: Seven Things to Remember. How to Be Productive on the Phone. “Memos Solve Problems”.

11th week

Visuals for Engineering Presentation—Engineers Think in Pictures. Optimize Slide Layout. Display Engineering Data Effectively. How to Develop Effective Graphics.

12th week

Write Winning Grant Proposals. Know The Audience. Understand Goal and Marketing Strategy. Select the Correct Writing Style. Organize Proposal around the Four Ps. A Brief Checklist before Submitting a Proposal.

13th week

How to Effectively Prepare Engineering Reports. Writing an Effective Progress Report. Develop Informative Design Reports.

14th week

Listening – Interactive Communication about Engineering Risk. Listening – A Forgotten Risk Communication Skill. Listening – Harder Than Speaking and Writing. How to Listen to Voices of Customers about Risk. Listen Attentively: Understanding What Drives Perceived Risk. Thirteen Questions about Risk Communication.

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory.

During the semester there is a written end-term test in the 14th week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points.

- for a grade

The course ends in a **written or oral examination**. Based on the result of the examination questions scored according to pre-set maximum points for each sub-questions. The type of the examination (written or oral) is the choice of the student.

The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

-an offered grade: It may be offered for students on the basis of the result of the end-term test if the grade is at least satisfactory (3).
Person responsible for course: Katalin Kozma-Tóth
Lecturer: Katalin Kozma-Tóth

(5.) Title of Course: **Intellectual property law** **Code**: TTKME4015_EN	**ECTS Credit points: 1**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 1 hour/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 14 hours - practice: - - laboratory: - - home assignment: 6 hours - preparation for the exam: 10 hours Total: 30 hours	
Year, semester: 1st year (spring)	
Prerequisite(s): -	
Topics of course	
The trade mark system and the functions of trade marks. Registrable marks. Relative grounds for refusal of registration. Practice and procedure in the trade marks registry and OHIM. Revocation and invalidity. Assignment and licensing of marks. Infringement of trade marks. Passing off. Remedies and procedure for infringement of trade mark and passing off. Ambush Marketing. The Evolution of Ambush Marketing Laws. Trade Marks and Merchandising. Passing Off, Copyright, and Decisions and Related Rights. Licensing, Broadcasting, and Exhaustion. Advertising and Trade Regulation. Civil and Criminal Proceedings and Border Control. Ambush Marketing: Laws around the World.	
Literature	
Compulsory: - Amanda Michaels and Andrew Norris: A Practical Guide to Trade Mark Law. Oxford University Press, 2014. - Phillip Johnson: Ambush Marketing and Brand Protection. Oxford University Press, 2011. Recommended: - Antony Taubman: A Practical Guide to Working with TRIPS. Oxford University Press, 2011.	
Course objective/intended learning outcomes	
a) Knowledge: - He knows and understands the fundamental laws of the technical and economic legislation. - He/she knows the documentation standards of the profession. b) Ability: - He/she is able to control the services related to the field, the intellectual tasks. - He/she is able to utilize the complex planning and management of technical, economic, environmental and human resources in the chemical industry. c) Attitude: - He/she seeks continuous self-training, self-improvement, further training in the law of intellectual o a higher level of knowledge in the field - He/she constantly seeks to improve professional competencies. - He/she takes an open approach to professional trainings in accordance with his/her ambitions. d) Autonomy and Responsibility:	

- It shall take into account the essential requirements of technical, economic and legal regulations in the workplace.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Schedule:

1st week
The trade mark system and the functions of trade marks
2nd week
Registrable marks
3rd week
Relative grounds for refusal of registration
4th week
Practice and procedure in the trade marks registry and OHIM
5th week
Revocation and invalidity
6th week
Assignment and licensing of marks
7th week
Infringement of trade marks
8th week
Passing off
9th week
Remedies and procedure for infringement of trade mark and passing off
10th week
Ambush Marketing. The Evolution of Ambush Marketing Laws
11th week
Trade Marks and Merchandising. Passing Off, Copyright, and Decisions and Related Rights
12th week
Licensing, Broadcasting, and Exhaustion. Advertising and Trade Regulation
13th week
Civil and Criminal Proceedings and Border Control
14th week
Ambush Marketing: Laws around the World

Requirements: - *for a signature*
Attendance at **lectures** is recommended, but not compulsory.
During the semester there is a written end-term test in the 14th week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points.
- for a grade
The course ends in a **written or oral examination**. Based on the result of the examination questions scored according to pre-set maximum points for each sub-questions. The type of the examination (written or oral) is the choice of the student.
The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)

– 70-79 satisfactory (3) – 80-89 good (4) – 90-100 excellent (5) If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.
Person responsible for course: Prof. Dr. György Csécsy, full professor, PhD
Lecturer: Prof. Dr. György Csécsy, full professor, PhD

(6.) Title of Course: Engeneering informatics Code: TTKMG4901_EN	ECTS Credit points: 3

Classification of the subject: compulsory

Type of teaching, contact hours

- lecture: 1 hour/week
- practice: 2 hours/week
- laboratory: -

Evaluation (exam. / practice. / other): **term mark**

Workload (estimated), divided into contact hours:

- lecture: 14 hours
- practice: 28 hours
- laboratory: -
- home assignment: 42 hours
- preparation for the exam: 6 hours

Total: 90 hours

Year, semester: 3rd year (fall)

Prerequisite(s): -

Topics of course

Basic concepts of control engineering. Control systems. Technological process groups. Development of automation devices and systems. Batch technology control: classification, standards, recipe management, batch process scheduling. Structure, classification, operating model of PLCs. Modular and compact PLC systems. PLC programming, programming languages. Textual and graphic PLC programming languages according to IEC61131-3 standard. Ladder diagram programming language, its set of elements. Program development aspects. Possibilities of programming and program portability. PLC field and sensor buses. Viewpoints of design, methods and steps of design. Tasks of PLC system installation, presentation of a few specific PLC families. High-reliability PLCs and their characteristics: self-test, methods of fault recognition and fault deletion. Human-machine interface (HMI) devices. Supervisory control and data acquisition (SCADA) systems. Concept and structure of distributed control systems.

Literature

Compulsory:

- Rehg J.A., Sartori G.J.: Programmable logic controllers. Pearson, 2nd ed., 2013.
- Bryan L.A., Bryan E.A.: Programmable Controllers. Theory and Implementation. Marletta: Industrial Text Company (2nd ed.), 1997.
- Manufacturers' PLC, HMI manuals, PLC programming manuals.

Recommended:

- Hackworth J.R., Hackworth F.D, Jr.: Programmable logic controllers: Programming methods and applications. Delhi: Pearson Education, 2004.
- Bolton W.: Programmable logic controllers. New Delhi: Newnes (Elsevier), 2008.
- Parr E.A.: Programmable Controllers. An Engineer's Guide. Amsterdam: Newnes (Elsevier, 3rd ed.), 2003.
- Petruzella F.D.: Programmable logic controllers. New York: McGraw-Hill, 4th ed., 2011.

Course objective/intended learning outcomes

a) Knowledge

- He/she knows the basic principles, the planning and controlling options in technology of chemical processes and industrial tasks.

- He/she has a mathematical, scientific (physical and chemical) and technical background to understand processes in chemical and chemistry related industries.
- He/she knows the principles of instruments in chemical industries and technologies, and their operative parts, and their connections.

b) Abilities

- He/she capable to apply the learned methods, models and plannings of chemical technology and chemical processes through calculations.
- He/she is able to improve the chemical and chemical industrial knowledge base with original ideas and results.
- He/she understands and able to describe the elements of industrial and technological units, their operations including the connectivity options.

c) Attitude

- He/she makes effort to improve and apply the practical methods with new results and experiences.
- He/she constantly seeks to improve professional competencies.

d) Autonomy and responsibility

- Following directions he/she can work without supervision considering all quality and safety rules.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Schedule:

1st week

Basic concepts of control engineering. Control systems. Technological process groups. Development of automation devices and systems.

2nd week

Batch technology control: classification, standards, recipe management, batch process scheduling, programming of phases.

3rd week

Structure, classification, operating model of PLCs. Modular and compact PLC systems.

4th week

Program execution modes. Cycle time. Reaction time.

5th week

PLC programming, programming languages. Textual and graphic PLC programming languages according to IEC61131-3 standard.

6th week

Ladder diagram programming language, its set of elements. Program development aspects. Possibilities of programming and program portability.

7th week

Viewpoints of PLC selection, hardware selection, problems of system performance, environmental conditions, operation requirements.

8th week

Industrial control networks. Ethernet network. PLC field bus systems and sensor buses.

9th week

Specifications of Modbus, Profibus, Canopenbus communication.

10th week

High-reliability PLCs and their characteristics: self-test, methods of fault recognition and fault deletion.

11th week

Human-machine interface (HMI) devices.

12th week Supervisory control and data acquisition (SCADA) systems. *13th week* Concept and structure of distributed control systems. *14th week* **End-term test.**
Requirements: *- for a signature* Attendance at **lectures** is recommended, but not compulsory. Attendance at **seminars** is mandatory. Condition for sign obtaining is a submission of homework assignment. *- for a grade* The course ends in a **term mark receipt**. Signature receipt is a precondition for term mark eligibility. End-term test consists of two parts: solution of complex automation problem in computer (PLC) class and a written test based on lecture material. *-an offered grade:* —
Person responsible for course: Dr. Sándor Misák, associate professor, PhD
Lecturer: Gergő Róth, Assistant Lecturer

Knowledge: **Chemical industry knowledge**
Credit range *(max. 12 cr.)*: ***12***
Subjects: **1) Industrial instrumentation and automatization for Chemical Industry**
2) Safety and health prevention in chemical industry
3) Industrial technologies
4) Pilot plant II.

(1.) Title of Course: **Industrial instrumentation and automatization for Chemical Industry** **Code**: TTKME4605_EN; TTKMG4605_EN	**ECTS Credit points: 2+2**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: 2 hours/week
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: 28 hours
- laboratory: -
- home assignment: -
- preparation for the exam: 64 hours

Total: 120 hours

Year, semester: 1st year (fall)

Prerequisite(s):-

Topics of course

Operation of industrial instruments. Selection of instruments for technological processes. Design control and instrumentation of technological processes in the chemical industry. The importance and possibilities of MES (manufacturing execution system) application in the chemical industry.

Literature

Compulsory:
1) Lipták, B.G., Venczel, K.: Instrument and Automation Handbook. Fifth Edition, Volume I., Measurement and Safety. CRC Press, Taylor & Francis Group, 2017

Recommended:
2) Lipták, B.G.: Instrument Engineers' Handbook. Fourth Edition, Process Control and Optimization, Volume II., CRC Press, Taylor & Francis Group, 2006
3) Dunn, W.C.: Fundamentals of Industrial Instrumentation and Process Control. McGraw-Hill Companies, Inc., 2005
4) Smith, C.L.: Basics Process Measurements. John Wiley & Sons, Inc., Hoboken, New Jersey, 2009
5) Baker R.C.: Flow Measurement Handbook. Industrial Designs, Operating Principles, Performance, and Applications. Cambridge University Press, 2000
6) French College of Metrology, Placko, D.: Metrology in Industry. The Key for Quality. ISTE Ltd., 2006

Course objective/intended learning outcomes

a) Knowledge

- He/she knows the design of instrumentation and control of technological processes in the chemical industry. The students learn some properties of instrumentation and their applications.
- He/she knows the methods and instruments of computer modelling and simulation related to chemical engineering.

b) Abilities

- He/she is able to design control of a technological process in the chemical industry.
- He/she is able to choice of instruments for technological processes.
- He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.

c) Attitude

- He/she is open to learn and accept professional, technological improvement and innovation in the topic of control and instruments.
- He/she works with a systematic and process-oriented, complex approach.

Autonomy and responsibility

- He/she is capable to do the operating, developing and design of control and instrumentation of technological processes in the chemical plant.
- In making decisions he/she takes into account the principles of environment protection, quality management, consumer protection, product liability.

Schedule:

1st week

Introduction.

Physical quantities. Definition of physical quantities. Onion model of physical properties. Types of physical quantities. Numerical characterization of physical quantities. The relationship among physical quantities. Definition of group. Axioms of group theory. Abel's and free Abel's group. International System of Unit (SI systems). Definition of dimension.

2nd week

Measurement. Definition of measurement. Conditions of measurability, the Carnap criteria. The purpose of the measurement. Fields of application in chemical industry practice.

Representation of instrumentation and process control. Block diagram, schematic structure/diagram, P&I diagram. Symbols and letters in the P&I diagrams and their meanings. Examples of P&I diagram.

3rd week

The state of the material system and its measurement. Specification and characterization of the state of material systems. Definition of material, material system, and environment. Typical quantities of thermodynamic (TD) processes. Extensive and intensive properties. Deriving of intensive properties. Axioms of thermodynamic. Notions of state, entropy and their relationship. Three basic equations of TD. Specifying the state of a homogeneous phase in TD and chemical engineering practice. The Gibbs Phase Rule, the Intensive Degrees of Freedom (DoF).

4th week

Degrees of freedom analysis of chemical industrial process unit (CIPU). Concept of DoF of CIPU. Simple and complex CIPU and determination of their DoFs. Conditions of controllability. Relationship between DoF of simple CIPU and DoF of complex CIPU. The role of geometric data of process unit/equipment. Determination of DoF of control in multiple input and multiple output (MIMO) systems with transportation of external thermal energy and mechanical energy.

5th week

Application examples of determination of DoF and design of control of chemical industrial processes, design of P&I diagram. Design of P&I diagram of compressor, pump, flash distillation, continuously pot-still distillation, rectification, and others.

6th week

The simple model of instrument. Functional elements of instruments and their different structure. Interpretation of the functional elements of Bourdon tube thermometer.

Classifications of instruments. Continuous and discrete/sampled measurement. Direct and indirect measurement. Analog and digital instruments. Contact and non-contact instruments. Balancing/nullbalancing and displacement measuring. Wheatstone-bridge. The input and output configuration of instruments. Types of inputs and their presentation on a U-tube manometer and on a foil/film strain gauge. Method of filtering of signals.

7th week

Static properties of instruments. The signalling, measurement and application/operating range. Gain or sensitivity and sensitivity limit. Linearity. Measurement error. Reading errors. Errors from instrument installation position. Calibration, verification, and traceability. Selection of instrument.

8th week

Metrology. Guide to the Expression of Uncertainty in Measurement (GUM).

Dynamic properties of instruments. Measurement noise. Stochastic processes.

9th week

Level and density measurement. Level measurement: Displacer type level detectors. Float level devices. Bubblers. Diaphragm level detectors. Differential pressure level detectors. Non-contacting level sensors. Laser level sensors. Ultrasonic level detectors. Density measurement: pycnometric densitometers, Buoyancy-type densitometers, hydrometer, hydrostatic weighing, balance type densitometers, balance flow vessel, two tube column densitometers, vibrating element densitometers, radioactive densitometers, refractometers, Coriolis densitometers, absorption-type densitometers.

10th week

Flow measurement. Differential pressure flowmeters, Venturi tube flowmeter, orifice plate, nozzle flowmeter, rotameter, turbine and movable vane meters, positive displacement flowmeters, electromagnetic flowmeters, ultrasonic flowmeters, Vortex Shedding flowmeters, thermal mass flow sensors, Coriolis effect mass flowmeters, drag force flowmeters. Others.

11th week

Temperature and heat measurement. Classification of temperature measuring. Filled-bulb and glass-stem thermometers. Bimetallic thermometer. Thermocouples. Resistance temperature detectors, thermistors. Installation. Pirometers. Others.

12th week

Pressure and pressure difference measurement. Absolute and gauge pressure. Total pressure, dynamic pressure and static pressure. Effective pressure. Classification of pressure gauges. U-tube manometers. Barometers. Flexible elements as pressure sensor. Bourdon tube. Barton cell. Diaphragm gauge. Differential pressure instruments. Electronic pressure sensors. Piezoelectric pressure sensor. Vacuum measurement.

13th week

Composition, pH, humidity and moisture measurement. Electrochemical methods, conductometry, voltammetry, coulometry, potentiometry, amperometry. Auto-tritrator. Ion-selective membranes. Direct conductometry measurement. Moisture measurement. Absolute and relative humidity. Gravimetric method. Hygrometers.

14th week

Summation and repetition.

Requirements:

- *for a signature*

Participation in lectures and seminars. The total number of absences for the semester does not exceed three (3).

- *for a grade*

At the end of the course based on the result of written and oral exam (100%).

In the case of failure to perform of first exam, it is possible to take a second exam.

Person responsible for course: Dr. Ákos Kuki, associate professor, PhD

Lecturer: Gergő Róth, Assistant Lecturer

(2.) Title of Course: Safety and health prevention in chemical industry **Code:** TTKME4606_EN	**ECTS Credit points: 2**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: -
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment: 6 hours
- preparation for the exam: 26 hours

Total: 60 hours

Year, semester: 2nd year (spring)

Prerequisite(s):-

Topics of course

Introduction to inustrial safety. Safety Programs. Engineering Ethics. Toxicology. Industrial Hygiene. Source Models. Toxic Release and Dispersion Models. Fires and Explosions. Concepts to Prevent Fires and Explosions. Chemical Reactivity. Relief Concepts. Relief Sizing. Hazards Identification. Risk Assessment. Safety Procedures and Designs. Case Histories.

Literature

Compulsory:
- D. A. Crowl, J.F. Louvar: Chemical Process Safety, Pearson, Boston, USA (2011)
- Roger L. Bauer: Safety and Health for Engineers, Wiley Interscience, New York (2005)
- Richard J. Lewis ed.: Sax's Dangerous properties of Industrial Materials, John Wiley (2005)

Recommended:
- C. D. Classen, Caserett and Doull's Toxicology, McGraw-Hill, New York (2008)

Course objective/intended learning outcomes

a) Knowledge:
- He/she is familiar with basic organic synthesis methods (Nitration, Sulphonation, acylation, halogenation, etc.), the synthesis and technological realization of the most important organic chemical, petrochemical and pharmaceutical ingredients.
- He/she has a comprehensive overview on the theories and methods of quality management used in chemical industry.

b) Ability:
- He/she is able to understand the importance of each technology and the main links to the technologies.
- He/she is able to participate substantially in professional communication in the context of the learned technologies
- He/she is able to expand/improve your knowledge of learned technologies

c) Attitude:
- He/she is open to acquire new scientifically proven knowledge related to the technologies being studied, but to reject unfounded and possibly deceptive claims.

- He/she aims to enforce all known disciplines and requirements of safety, sustainability, environmental protection and energy efficiency.

d) Autonomy and Responsibility:

- He/she is independently able to perform the part tasks marked under professional guidance in relation to the topics in the course, to interpret the results obtained and to evaluate them realistical
- He/she encourages colleagues and subordinates to promote their professional development.

Schedule:

1st week

Introduction to inustrial safety. Safety Programs. Engineering Ethics. Accident and Loss Statistics. Acceptable Risk. Public Perceptions. The Nature of the Accident Process. Inherent Safety.

2nd week

Toxicology. How Toxicants Enter Biological Organisms. How Toxicants Are Eliminated from Biological Organisms. Effects of Toxicants on Biological Organisms. Toxicological Studies. Dose versus Response. Models for Dose and Response Curves. Relative Toxicity. Threshold Limit Values.

3rd week

Industrial Hygiene. Government Regulations. Industrial Hygiene: Anticipation and Identification, Evaluation, Control.

4th week

Source Models. Flow of Liquid through a Hole. Flow of Liquid through a Hole in a Tank. Flow of Liquids through Pipes. Flow of Gases or Vapors through Holes. Flow of Gases or Vapors through Pipes. Flashing Liquids. Liquid Pool Evaporation or Boiling. Realistic and Worst-Case Releases. Conservative Analysis.

5th week

Toxic Release and Dispersion Models. Parameters Affecting Dispersion. Neutrally Buoyant Dispersion Models. Dense Gas Dispersion. Dense Gas Transition to Neutrally Buoyant Gas. Toxic Effect Criteria. Effect of Release Momentum and Buoyancy. Release Mitigation.

6th week

Fires and Explosions. The Fire Triangle. Distinction between Fires and Explosions. Definitions. Flammability Characteristics of Liquids and Vapors. Limiting Oxygen Concentration and Inerting. Flammability Diagram. Ignition Energy. Autoignition. Auto-Oxidation. Adiabatic Compression. Ignition Sources. Sprays and Mists. Explosions.

7th week

Concepts to Prevent Fires and Explosions. Inerting. Static Electricity. Controlling Static Electricity. Explosion-Proof Equipment and Instruments. Ventilation. Sprinkler Systems. Other Concepts for Preventing Fires and Explosions.

8th week

Chemical Reactivity. Background Understanding. Commitment,Awareness, and Identification of Reactive Chemical Hazards. Characterization of Reactive Chemical Hazards Using Calorimeters. Controlling Reactive Hazards.

9th week

Introduction to Reliefs. Relief Concepts. Definitions. Location of Reliefs. Relief Types and Characteristics. Relief Scenarios. Data for Sizing Reliefs. Relief Systems.

10th week

Relief Sizing. Conventional Spring-Operated Reliefs in Liquid Service. Conventional Spring-Operated Reliefs in Vapor or Gas Service. Rupture Disc Reliefs in Liquid Service. Rupture Disc Reliefs in Vapor or Gas Service. Two-Phase Flow during Runaway Reaction Relief. Pilot-Operated and Bucking-Pin Reliefs. Deflagration Venting for Dust and Vapor Explosions. Venting for Fires External to Process Vessels. Reliefs for Thermal Expansion of Process Fluids.

11th week

Hazards Identification. Process Hazards Checklists. Hazards Surveys. Hazards and Operability Studies. Safety Reviews. Other Methods.

12th week

Risk Assessment. Probability Theory. Event Trees. Fault Trees. QRA and LOPA.

13th week

Safety Procedures and Designs. Process Safety Hierarchy. Managing Safety. Best Practices. Procedures–Operating. Procedures–Permits. Procedures–Safety Reviews and Accident Investigations. Designs for Process Safety. Other Designs for Fires and Explosions. Designs for Runaway Reactions. Designs for Handling Dusts.

14th week

Case Histories About Static Electricity, Chemical Reactivity, System Designs, Procedures and Training.

Requirements:

for a signature

Attendance at **lectures** is recommended, but not compulsory.

During the semester there is a written end-term test in the 14th week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points.

- for a grade

The course ends in a **written or oral examination**. Based on the result of the examination questions scored according to pre-set maximum points for each sub-questions. The type of the examination (written or oral) is the choice of the student.

The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or the examination is given according to the following table:

- Score Grade
- 0-59 fail (1)
- 60-69 pass (2)
- 70-79 satisfactory (3)
- 80-89 good (4)
- 90-100 excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

-an offered grade:

It may be offered for students on the basis of the result of the end-term test if the grade is at least satisfactory (3).

Person responsible for course: Dr. Tibor Nagy, assistant professor

Lecturer: Dr. Tibor Nagy, assistant professor

(3.) Title of Course: **Industrial technologies** **Code**: TTKME4607_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory:	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
Year, semester: 1st year (fall)	
Prerequisite(s):	

Topics of course

Nitration reactions in the manufacture of pharmaceutical products, typical nitration technologies.
Sulfonation and sulfation processes and instruments in the industry.
Halogenation, alkylation, acylation, oxidation, reduction processes. Carbon monoxide based reactions.

Literature

Compulsory:
- Klaus Weissermel Hans-Jürgen Arpe, Industrial Organic Chemistry, 2008, ISBN:9783527305780
- Mohammad Farhat Ali, Bassam M. El Ali, James G. Speight, Handbook of Industrial Chemistry: Organic Chemicals, 2005, ISBN: 9780071410373

Recommended:
- Ullmann's Encyclopedia of Industrial Chemistry, Wiley-VCH Verlag GmbH & Co. KGaA., 2002, ISBN: 9783527306732

Course objective/intended learning outcomes

a) Knowledge
- He/She knows the basic principles, the planning and controlling options in technology of chemical processes and industrial tasks.
- He/She knows the chemical methods for measurements or analysis, their principles and instrumental background, and their applicability.
- He/she knows about the development potential of new materials and processes together with its characteristic methods.

b) Abilities
- He/She is able to apply those directives that necessary to operate instruments and control processes in a safe, cost effective way as well as avoid any problems causing health issues.
- He/She is able to follow and control chemical processes and other technological steps concerning the quality management and quality control.
- He/she is able to improve the chemical and chemical industrial knowledge base with original ideas and results.

c) Attitude
- He/She makes effort to improve and apply the practical methods with new results and experiences.

- He/she constantly seeks to improve professional competencies.

d) Autonomy and responsibility

- Following directions he/she can work without supervision considering all quality and safety rules.
- He/She can manage work and worker resources, follow and control the instruments and measuring units.
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week

Nitration reactions, theoretical background, examples from the industry

2nd week

Typical nitration technologies in the industry

3rd week

Sulfonation and sulfation processes and instruments

4th week

Halogenation of aromatic and aliphatic hydrocarbons

5th week

Instruments for halogenation in the industry

6th week

Acylation and alkylation in the industry

7th week

Production of pharmaceutical products using acylation and alkylation

8th week

Carbon monoxide based reactions, theoretical background

9th week

Carbon monoxide based reactions, instruments, examples from the industry

10th week

Oxidation processes, theoretical background, catalysts

11th week

Oxidation processes, instruments in the industry

12th week

Reduction processes, theoretical background, reducing agents

13th week

Reduction processes, instruments in the industry

14th week

Diazotization in the industry, examples

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory.

During the semester there is one test: the end-term test in the 15th week. Students have to sit for the test

- for a grade

The exam grade is calculated by the result of end-term test.

The minimum requirement for end-term test is 50%. Based on the score of the test separately, the grade for the test is given according to the following table:

Score	Grade
0-49	fail (1)

50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

If the score of the test is below 50, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

-*an offered grade:*
It may be offered for students if the grade is at least pass (2).

Person responsible for course: Dr. Lajos Nagy, associate professor, PhD

Lecturer: Dr. Lajos Nagy, associate professor, PhD

(4.) **Title of Course**: **Pilot Plant II.** **Code**: TTKML4601_EN	**ECTS Credit points: 4**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: - practice: 14 hours - laboratory: 56 hours	
Evaluation (exam. / practice. / other): **mid term grade based on lab reports and tests**	
Workload (estimated), divided into contact hours: - lecture: - practice: 14 hours - laboratory: 56 hours- - home assignment: 80 hours - preparation for the exam: Total: 150 hours	
Year, semester: 1st year (spring)	
Prerequisite(s):-	
Topics of course	
Chemical engineer students will be able to work independently in plants/pilot plants, will master skills in operating modern process control softwares, and PLC-controlled devices, as well as solving complex design tasks. The role of automation and digitization in the development of chemical processes.	
Literature	
Compulsory: McCabe, W.L.; Smith, J.C.; Harriot, P. (1993) Unit Operations Of Chemical Engineering (7th Ed) - McGraw-Hill Richard G. Griskey:Transport phenomena and unit operations: a combined approach, (2002), Wiley, ISBN 0-47 1-43819-7 Ullmann's Encyclopedia of Industrial Chemistry, 5th ed., Weinheim, Federal Republic of Germany, VCH, Volumes: B1-B8, 1990-1995. Muhlynov I.: Chemical Technology I-II.	
Course objective/intended learning outcomes	
a) Knowledge - He/She knows the chemical methods for measurements or analysis, their principles and instrumental background, and their applicabilities - He/she knows about the development potential of new materials and processes together with its characteristic methods. **b) Abilities** - He/She understands and able to describe the elements of industrial and technological units, their operations including the connectivity options. - He/She is able to follow and control chemical processes and other technological steps concerning the quality management and quality control. - He/She is able to recognize the possible error symptoms, run diagnostic routines and offer solution based on the results. - He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary.	

c) Attitude

- He/She makes effort to keep his/her chemical engineering knowledge updated related to his/her professional goals.
- He/She makes effort to improve and apply the practical methods with new results and experiences.
- He/she checks for possibilities of setting research, development and innovation goals, and efforts to achieve them; committed to enrich the scientific field by up-to-date knowledge, scientific and technical results.

d) Autonomy and responsibility

- Following directions he/she can work without supervision considering all quality and safety rules.
- He/She can manage work and worker resources, follow and control the instruments and measuring units.
- He/She makes decisions according to his/her positions, makes suggestions to qualify his/her colleagues involving their promotions.
- He/she considers the principle and application of equal access opportunities, as well.

Schedule:

1st week Safety instructions. The basic requirements of laboratory work.

2nd week Preparation of microcrystalline $CaCO_3$ *using a PLC controlled 150 L reactor. The basics of pressure filter operation. Studying the effect of crystallization parameters.*

3rd week Rectification of methanol in a 50 L Lampart type apparatus. Studying the effect of reflux ratio, determination of the number of theoretical plates and the construction of the McCabe-Thiele diagram
.

4th week Membrane filtration on a pilot-plant sized membrane filter unit with different cartridges.

5th week The preparation of casein from cow milk in a 150 L PLC-controlled reactor.

6th week Investigation of fluidization and fluid transport in a pilot-plant sized fluidization apparatus.

7th week Separation of gases (N2-O2) in a gas separation membrane unit.

Requirements: Requirements:

- for a signature

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can’t make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor.

- for a grade

The course is graded based on lab reports created individually. The reports should be prepared after the practices.

Person responsible for course: Dr. Lajos Nagy, associate professor, PhD, habil

Lecturer: Dr. Lajos Nagy, associate professor, PhD, habil

Knowledge: **Energetics and transport process** **Credit range:** *(max. 12 cr.): **10*** Subjects: 1) **Energetics in Chemical Industry** 2) **Transport process I.** 3) **Transport process II.**

(1.) Title of Course: **Energetics in Chemical Industry** **Code**: TTKME4604_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 32 hours Total: 60 hours	
Year, semester: 1st year (fall)	
Prerequisite(s):-	

Topics of course
Energy, work, heat and conversion. Energy and exergy analyses of technological processes. Passive and active heat transfer. Design of heat exchangers. Thermodynamic cycles.
Literature
Compulsory: 1) Wall, G.: Exergetics. Industrial University of Santander, Kolumbia, 2009 2) Nitsche, M.; Gbadamosi, R.O.: Heat Exchanger Design Guide. Elsevier Inc., 2016 3) Wu, Ch.: Thermodynamic Cycles. Marcel Dekker, Inc., 2004 *Recommended:* 4) Ahern, J. E.: The exergy method of energy system analysis. Wiley, New York, 1980. 5) Theodore, L., Ricci, F., Van Vliet, T.: Thermodynamics for the Practicing Engineer. John Wiley & Sons, Hoboken, New Jersey (USA), 2009 6) Levenspiel, O.: Engineering Flow and Heat Exchange. Revised Edition, Springer Science and Business Media, 1998 7) Sandler, S.I.: Chemical, Biochemical, and Engineering Thermodynamics. Fifth Edition, John Wiley & Sons, Inc., 2017
Course objective/intended learning outcomes
a) Knowledge - He/she knows the applications of energy, work and heat conversion and the exergy analyses. - He/she knows the design of heat exchangers.

- He/she knows students learn different thermodynamic cycles
- He/she knows the most recent results and approaches of technological development.

b) Abilities

- He/she is able to comprehend the exergetics in chemical plant.
- He/she is able to comprehend some thermodynamic cycles, e.g. simple power cycle, refrigeration and heat-pump cycle and more complicated cycles, e.g. stem jet refrigeration cycle, absorption refrigeration cycle.
- He/she is able to apply and develop methods, models and information technologies to plan, organize and operate chemical industrial systems and processes.

c) Attitude

- He/she is open to learn and accept professional, technological improvement and innovation in the industrial energetics.
- He/she is able to makes decisions in operation of complex technological processes.
- He/she checks for possibilities of setting research, development and innovation goals, and efforts to achieve them; committed to enrich the scientific field by up-to-date knowledge, scientific and technical results.

d) Autonomy and responsibility

- He/she is capable to do the operating thermal equipments in the chemical plant.
- He/she has responsibility for sustainability, and environmental protection.

Schedule:

1st week

Introduction. Determination of scope of Exergetics of Chemical Industry. Laws of Thermodynamics. Classification of works.

2nd week

Engineering economics. Determination of the energy of material flow. Carnot cycle in T-S diagram. The definition and presentation of exergy and anergy. The Carnot efficiency. Quality of types of energy.

3rd week

Step by step determination of calculation formula of exergy. The h-s diagram of Rant. Determination of extropy.

4th week

Practical example of calculation of energy and exergy balance. Plotting of the results in Sankey diagrams.

5th week

State changes of an ideal gas plotted in p-v and T-s diagrams. *Gay-Lussac's law*. Boyle’s Law. Poisson’s equations, the adiabatic exponent. The polytropic process.

6th week

The choke, choking phenomenon and pressure drop. Gay-Lussac and Joule-Thomson expansions. Isenthalpic expansion. Joule-Thomson coefficient of real gases. The inversion curves. Isentropic expansion. Linde’s process of liquefaction of air.

7th week

Heterogeneous thermal systems. Interpreting and presenting the opportunity of thermal energy and the need of thermal energy and their relationships on the T-S diagram. The thermal nature of the factories. Ways to attach opportunities and needs presented by an example.

8th week

Definition of passive heat transfer. Presentation and calculation of the entropy production of the isothermal heat exchange without heat losses. Thermodynamic quality of heat exchanger. Cocurrent and countercurrent heat exchangers.

9th week

Buckingham π-theorem and its application to determination of Chilton-Colburn equation. Determination of heat transfer coefficient.

10th week

Design of heat exchanger. Reynolds number, Euler number, Prandtl number and Nusselt number. Determination of the equivalent hydraulic diameter. *11th week* Definition of active heat transfer. Active heat transfers between two temperature levels. Thermodynamic Cycles. *12th week* Active heat transfers among three temperature levels. The possible variants, α and β situations. *13th week* Processes among three temperature levels. Stem jet refrigeration cycle. Absorption refrigeration cycle. *14th week* exam
Requirements: **-** *for a signature* Participation in lectures. *The total number of absences for the semester does not exceed three (3).* - *for a grade* At the end of the course based on the result of oral exam (100%). In the case of failure to perform of first exam, it is possible to take a second oral exam.
Person responsible for course: Dr. Lajos Nagy, associate professor, PhD
Lecturer: Dr. Lajos Nagy, associate professor, PhD

(2.) Title of Course: Transport Processes I. Code: TTKME4602_EN; TTKMG4602_EN	ECTS Credit points: 2+2

Classification of the subject: compulsory

Type of teaching, contact hours

- lecture: 2 hours/week
- practice: 2 hours/week
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:

- lecture: 28 hours
- practice: 28 hours
- laboratory: -
- home assignment: -
- preparation for the exam: 64 hours

Total: 120 hours

Year, semester: 1st year (spring)

Prerequisite(s): -

Topics of course

The conservation/rate equations. Fundamentals of fluid mechanics. Fundamentals of heat and component transfer. Separation processes in chemical industry.

Literature

Compulsory:

1) Bird, R.B., Stewart, W.E., Lightfoot, E.N.: Transport Phenomena. Second Edition, John Wiley & Sons, Inc., USA, 2002
2) Treybal, R.E.: Mass-transfer Operations. International Edition, McCraw-Hill Book Co., 1981

Recommended:

3) Plawsky, J.L.: Transport Phenomena Fundamentals. Third Edition, CRC Press, Taylor & Francis Group, 2014
4) Raju, K.S.N.: Fluid Mechanics, Heat Transfer, and Mass Transfer. Chemical Engineering Practice. John Wiley & Sons, Inc., Hoboken, New Jersey, 2011
5) Polyanin, A.D., Kutepov, A.M., Vyazmin, A.V., Kazenin, D.A.: Hydrodynamics, Mass and Heat Transfer in Chemical Engineering. CRC Press, Taylor & Francis Group, 2002

Course objective/intended learning outcomes

a) Knowledge

- He/she knows fundamentals of transport phenomena.
- He/she knows some separation processes used in chemical industry.
- He/she has comprehensive knowledge on the analysis, modelling and design of the chemical industry and technology.

b) Abilities

- He/she is able to comprehend the operation of some simple separation processes.
- He/she is able to technological design of some simple separation processes.
- He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.

c) Attitude

- He/she is open to learn and accept professional, technological improvement and innovation in the separation processes.

- He/she is able to makes decisions in operation of separation technological processes.
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.

d) Autonomy and responsibility

- He/she is capable to do the operating, developing and design of separation processes in the chemical plant.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Schedule:

1st week

Introduction. Conserved quantities: chemical species, mass, momentum, and energy. General definition of fluid material, uniform, flow, flux, and driving forces. The general balance/conservation/rate equation. Macroscopic and microscopic rate equation. Simplification of the rate equation. Steady-state transport without generation.

2nd week

Similarity and models. Determine dimensionless numbers from rate equation and from dimensional analyses. Buckingham π theorem. Scale-up.

3rd week

Compressible and incompressible fluids. Fluid statics. Kinematics of fluid. Scalar and vector fields. Flow field and description of fluid motion. Continuity equation and source. Convective transport in fluid of different properties. Navier-Stokes equations, Euler's equations, Bernoulli's equation. Newton's viscosity law. Laminar and turbulent flow. Newtonian and non-Newtonian behaviour. Flow in pipe. Friction factor and pressure drop. Moody chart.

4th week

Flow past a single sphere. Gravitational force, Buoyancy force, and Drag force. Friction factor. Flow trough packed beds. Ergun equation. Sedimentation and fluidization. Design of continuous sedimentation. Flow in fluidized bed. Gravity filtration. Rotary filtration.

5th week

Heat exchange. The three mechanisms of heat transfer: conduction, convection, and radiation. Steady-state heat transfer. Combination of heat transfer resistances. Unsteady-state heating and cooling of solid object.

6th week

Type of heat exchangers. Determination of heat transfer coefficient. Loss of entropy in heat transfer. Design of recuperative heat exchanger. Instrumentation and control of heat exchangers.

7th week

Mass transfer. Molecular and convective transport. Interphase steady-state transport and mass transfer coefficient. The two-resistance concept/two boundary layer theory. Equilibrium. Material balance equation. Individual-phase transfer coefficients and overall mass transfer coefficients.

8th week

Gas absorption and desorption. Equilibrium solubility of gases in liquid. Equilibrium curve. Ideal and non-ideal liquid solutions. Henry's law. Choice of solvent for absorption. Cocurrent and countercurrent flow in absorber or stripper. Material balances. Operating lines. Design of countercurrent flow packed bed absorber. Determine the main dimensions and operating parameters of absorber. Minimum liquid-gas ratio for absorbers. Sensitivity analyses. Instrumentation and control of absorption column. Absorption with chemical reaction.

9th week

Batch and continuous distillations. Vapour-liquid equilibrium. Phase diagrams and distribution diagram. Relative volatility. Increased pressure. Ideal Solutions, Rault's law. Azeotropes. Flash distillations. Differential or simple batch distillation. Design of batch distillation. Rayleigh equation. Mass and enthalpy balances.

10th week

Continuous rectification – binary systems. Material and enthalpy balances of fractionators. Design, method of Mcabe and Thile. Multistage (tray) towers. The enriching section, reflux. The stripping section, reboiling ratio. Introduction of Feed, q line. Determine the main dimensions and operating parameters of rectification column. Equimolal overflow and vaporization. Total reflux, infinite reflux ratio, minimum reflux ratio, and total reflux, optimum reflux ratio. Rectification of azeotropic mixtures. Packed towers. The transfer unit.

11th week

Evaporation. Liquid characteristic. Boiling point elevation. Types of evaporators. Single and multiple operation. Enthalpy balances. Crystallization. Solutions and Solubility. Phase equilibria. Nucleation and crystal growth. Industrial techniques and equipment. Crystallizer design and operation.

12th week

Extraction. Liquid equilibria. Isotherm equilateral-triangular coordinates. Systems of three liquids – one pair partially soluble. Systems of three liquids – two pairs partially soluble. System of two partially soluble liquids and one solid. Effect of temperature. Effect of pressure. Single-stage extraction. Multistage crosscurrent extraction. Continuous countercurrent multistage extraction without and with reflux. Material balance equations. Stage efficiency. Industrial equipments.

13th week

Membrane separation and reverse osmosis. Transport models. Membrane materials. Concentration polarization. Driving forces. Effect of operating parameters. Scaling. Fouling. Silt Density Index. System design and operation.

14th week

Summation and repetition.

Requirements:

- for a signature

Participation in lectures and seminars. *The total number of absences for the semester does not exceed three (3).*

- for a grade

At the end of the course based on the result of written and oral exam (100%).

In the case of failure to perform of first exam, it is possible to take a second exam.

Person responsible for course: Dr. Ákos Kuki, associate professor, PhD

Lecturer: Dr. Ákos Kuki, associate professor, PhD

(3.) **Title of Course**: **Transport Processes II.** **Code**: TTKME4603_EN; TTKMG4603_EN	**ECTS Credit points: 2+2**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: 2 hours/week
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: 28 hours
- laboratory: -
- home assignment: -
- preparation for the exam: 64 hours

Total: 120 hours

Year, semester: 2nd year (fall)

Prerequisite(s):TTKME4602-EN, TTKMG4602-EN

Topics of course

The conservation/rate equations with generation term. Fundamentals of fluid mechanics. Fundamentals of heat and component transfer. Separation processes in chemical industry.

Literature

Compulsory:
1) Fogler, H.S.: Essentials of Chemical Reaction Engineering. International edition, Pearson Education, Inc., 2011
2) Levenspiel, O.: The Chemical Reactor Omnibook, Oregon State University, Corvallis, Oregon, 2013

Recommended:

3) Levenspiel, O.: Chemical Reaction Engineering. Third Edition, John Wiley & Sons, Inc., USA, 1999
4) Jr. Hill, Ch.G, Root, T.W.: Introduction to Chemical Engineering Kinetics & Reactor Design. Second Edition, John Wiley & Sons, Inc., Hoboken, New Jersey, 2014
5) Belfiore, L.A.: Transport Phenomena for Chemical Reactor Design. John Wiley & Sons, Inc., 2003

Course objective/intended learning outcomes

a) Knowledge
- He/she knows fundamentals of transport phenomena.
- he/she knows some separation processes used in chemical industry.
- He/she has comprehensive knowledge on the analysis, modelling and design of the chemical industry and technology.

b) Abilities
- He/she is able to comprehend the operation of some simple separation processes.
- He/she is able to technological design of some simple separation processes.
- He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.

c) Attitude
- He/she is open to learn and accept professional, technological improvement and innovation in the separation processes.
- He/she is able to makes decisions in operation of separation technological processes.
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.

d) Autonomy and responsibility

- He/she is capable to do the operating, developing and design of separation processes in the chemical plant.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Schedule:

1st week

Introduction. Classification of chemical reactions. Definition of reaction rate. Kinetic equation of reaction rate. The general mole balance Equation. Classification of chemical reactors. Mole balance of Batch reactor (BR), and its integral form. Mole balance of continuously operating perfectly stirred tank reactor (CSTR), and the design equation. Mole balance of ideal tubular reactor/plug flow reactor (PFR), and the design equation. Mole balance of packed-bed catalytic reactor (PBR), and the design equation.

2nd week

Conversion and reactor sizing. Definition of chemical conversion. Rewrite the design equations with the application of conversion. Determination of size of these reactors when the relationship between the reaction rate and conversion is known. Comparison of CSTR and PFR sizes. Reactors in series. Determination of the best arrangements for reactors in series. Space time, space velocity.

3rd week

Relative reaction rate. Irreversible reactions. Reaction order and rate law. Homogeneous and heterogeneous reactors. Reversible reactions. Thermodynamic equilibrium relationship of reversible reactions. The reaction rate constant. Determination of activation energy.

4th week

Stoichiometry. Relation between the concentration and the conversion. Stoichiometric table for a batch system. Definition of δ, the change in the total number of moles per mole of A reacted. Stoichiometric table for flow systems. Gas phase reactions, variable volumetric flow rate. Definition of ε, change in total number of moles for complete conversion per total moles fed to the reactor. Gas phase volumetric flow rate. Concentrations in a variable-volume gas flow system.

5th week

Isothermal reactor design for single reactions. Design structure for isothermal reactors. Determination batch reaction time to achieve a specific conversion. Batch operation times. CSTR relationship between space time and conversion. The Damköhler I number. CSTR in series. Determination of reactor volume of tubular reactors to produce given mass flow rate of product. Recycle reactors. The Chemical Reaction Engineering (CRE) Algorithm: Mole balance, Rate law, Stoichiometry, Combine, Eveluate.

6th week

Multiple reactions: series, parallel, independent, and complex reactions. Desired and undesired reactions. The minimization of undesired side reactions that occur along with the desired reaction.
Selectivity. Reaction yield. Modified CRE Algorithm for multiple reactions. Examples.

7th week

Basics of non-ideal flow. Mixing. Residence time distribution (RTD). Definition of microfluid and macrofluid. The E curve, the age distribution of fluid. The C step curve and F curve. Relationship between the F and E curves. Tracer technology. Compartments models. Evaluate of different E curves.

8th week

Catalysis and Catalytic reactors. Types of reactors of one and more changing phases: batch reactor, packed bed reactor, fluidized bed reactor, monolith reactor, catalyst tube reactor. slurry reactor, mixed flow reactor, plug flow reactor, recycle reactor. Definition of reaction rate. Performance eqution. Choice of reactor for gas/liquid (G/S) catalytic reaction. The porous catalyst pellet and its properties. Identifying the rate regime. Steps of catalytic reactions. The resistances of component transfer. Concept of a rate-limiting step.

9th week

Pore diffusion. Heat and mass transfer resistances. Influencing effects: shapes of pellets, temperature level, and particle size. Determination of the rate equation from experimental data. Examples for different reactions. Particles having more than one pore size.

10th week

Adiabatic packed bed reactors. Design for a single reactor for exothermic reaction. Energy balance. Thermal stability of reactor. The best operations of exothermic reactions. Design of multistage reactor system. Bubbling fluidized bed reactor. Circulating fluidized bed reactor (CFB)..

11th week

Reaction mechanisms, bioreactions. Enzime and microbial reactions. The pseudo-steady-state-hypothesis (PSSH) and the concept of active intermediates. Developing of rate laws for non elementary reactions. Determination of rate law that is consistent with experimental observation. Applying of the PSSH to biological reactions, with a focus on enzymatic reactions. The Michaelis-Menten (M-M) Kinetics. Briggs-Haldane mechanism. Micro-organism growth kinetics.

12th week

Enzyme fermentation. Batch and plug flow fermentor and their comparison. Mixed flow fermentor. Determination of M-M equation from rate-concentration data. Inhibition by foreign substance. Competitive and non-competitive inhibition. Substrate Inhibition.

13th week

Microbial fermentation. Constant environment fermentation. Batch and mixed flow fermentor. Stoichiometry. Kinetic expression. Monod equation. Batch or plug flow fermentor. Determination of Monod constants from experiment. Optimum operation of fermentors.

14th week

Summation and repetition.

Requirements:

- for a signature

Participation in lectures and seminars. *The total number of absences for the semester does not exceed three (3).*

- for a grade

At the end of the course based on the result of written and oral exam (100%).

In the case of failure to perform of first exam, it is possible to take a second exam.

Person responsible for course: Dr. Ákos Kuki, associate professor, PhD

Lecturer: Dr. Ákos Kuki, associate professor, PhD

Knowledge: Basic knowledge **Credit range: (max. 12 cr.): 9** **Subjects: 1) Differential equations** **2) Engineering physics** **3) Envirolmental management**

(1.) Title of Course: **Differential equations** **Code**: TTMME0803_EN	**ECTS Credit points: 4**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: 2 hours/week - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: 28 hours - laboratory: - - home assignment: - - preparation for the exam: 64 hours Total: 120 hours	
Year, semester: 1st year (fall)	
Prerequisite(s):	
Topics of course	
Introduction to the theory of ordinary differential equations and systems of equations. Separable, exact and homogeneous equations. Linear equations. Homogeneous and inhomogeneous second order linear equations. Nonlinear second order equations. Higher order linear equations. Inintial value and boundary value problems. Numerical methods. Partial differential equations.	
Literature	
Compulsory: - *Recommended:* - J. C. Robinson: An Introduction to Ordinary Differential Equations, 2004, Cambridge University Press, ISBN 9780521533911 - S. Ahmad, A. Ambrosetti: A textbook on Ordinary Differential Equations, 2014, Springer International Publishing, eBook ISBN 978-3-319-02129-4 - Y. Pinchover, J. Rubinstein: An Introduction to Partial Differential Equations, 2005, Cambridge University Press, ISBN 9780521613231 - D. Borthwick: Introduction to Partial Differential Equations, 2016, Springer International Publishing, ISBN 9783319489346	
Course objective/intended learning outcomes	
a) Knowledge: - He/she knows and uses the key concepts and methods of the theory of differential equations and	

equation systems.
- He/she has a mathematical, scientific (physical and chemical) and technical background to understand processes in chemical and chemistry related industries.

b) Ability:
- He/she is capable of applying practical examples of the results and methods of the theory of differential equations and equation systems.
- He/she is able to apply comprehensive theoretical knowledge in practice as well, in the area of mathematics and science related to chemical engineering in order to solve problems.

c) Attitude:
- He/she seeks to apply the knowledge of mathematics to a wide range of practical problems. By applying his acquired knowledge, he seeks to know as much as possible the observable phenomena, to describe its lawfulness and to explain it.
- He/she works with a systematic and process-oriented, complex approach.

d) Autonomy and Responsibility:
- He can use his acquired knowledge to formulate and analyse self-contained problems.
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week First order ordinary differential equations.
2nd week Easy first order explicit differential equations.
3rd week Separable, exact and homogeneous equations.
4th week Systems of first order ordinary differential equation.
5th week Homogeneous and inhomogeneous second order linear equations.
6th week Nonlinear second order equations
7th week Higher order linear equations.
8th week Solutions by infinite series and Bessel functions
9th week Boundary value problems
10th week Numerical methods
11th week Partial differential equations
12th week First order linear equations
13th week Special second order equations
14th week Fourier series

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory. Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Attendance at practice classes will be recorded by the practice leader. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor.

During the semester there are two tests: the mid-term test in the 7th week and the end-term test in the 14th week. For a signature students are required to get 50% of the total number of points during the two test (not separately).

- for a grade

The course ends in a **written or oral examination**. Only students with a signature in practice can be do the examination.

The minimum requirement for the examination is 50%. The grade for the examination is given according to the following table:

Score	Grade
0-49	fail (1)

50-62	pass (2)
63-74	satisfactory (3)
75-87	good (4)
88-100	excellent (5)

Person responsible for course: Ábris Nagy, assistant professor, PhD

Lecturer: Ábris Nagy, assistant professor, PhD

(2.) Title of Course: Engineering physics Code: TTFME2110_EN	ECTS Credit points: 3

Classification of the subject: compulsory

Type of teaching, contact hours

- lecture: 2 hours/week
- practice: -
- laboratory: -

Evaluation (exam. / practice. / other): **terminal exam**

Year, semester: 1st year (fall)

Prerequisite(s):

Subject description: **a brief and informative description** of knowledge to be acquired

Basic physical and material science characteristics, mechanical properties and analytical methods. Thermal properties, temperature. Solutions and mixtures, phase transition, the refrigerator, surface tension, foams. Voltage and pressure sensors. Transport processes, steady-state, time-dependent transport processes, modelling of heat flow, momentum flow. Electrodynamics. Electromagnetic properties, Electrical conductivity, Dielectric and magnetic properties, The electromagnetic field, Interaction of electromagnetic waves with matter, Optical properties, Optical sensors, spectroscopic analytical methods. Microscopy: optical microscopy, transmission electron microscopy, scanning electron microscopy, Atomic force microscopy. Analysis of magnetic properties. Material analysis with ions. X-ray spectroscopy.

Listing of the **2-5** most important compulsory and selected bibliographies with bibliographic data (author, title, publishing data, (maybe pages), ISBN)

1. Erostyák János, Litz József: A fizika alapjai, Nemzeti Tankönyvkiadó Budapest, 2003.
2. Halliday, Resnick, Krane: Physics, Vol. 2, Wiley, 2005.
3. Budó Ágoston, Kísérleti Fizika II, Tankönyvkiadó, Budapest. 1977.

Listing the professional competences (knowledge, ability, etc.), which are gained by means of the subject.

a) knowledge

- He/she knows the principle, methods and devices of the different tests.
- He/she has a mathematical, scientific (physical and chemical) and technical background to understand processes in chemical and chemistry related industries.

b) ability

- He/she is capable of selecting the most suitable method and measuring instrument for the given analytical problem.
- He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning.

c) attitude

- He/she is conscious, creative application of acquired knowledge
- He/she works with a systematic and process-oriented, complex approach.

d) autonomy and responsibility

- He/she selects the analytical methods and evaluating the results
- He/she takes individual initiatives in solving professional problems.

Responsible for the subject (*name, title, academic degree*)**:** Dr Lajos Daróczi, Associate Professor, PhD

Teachers involved in the subject (*name, title, academic degree*)**:**

(3.) Title of Course: **Environmental management**
Code: TTKME4016_EN

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: -
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 26 hours
- practice: -
- laboratory: -
- home assignment: 12 hours
- preparation for the exam: 20 hours

Total: 58 hours

Year, semester: 2nd year (spring)

Prerequisite(s):

Topics of course

Waste management. Environmental management. Environmental economy. Environmental chemistry. Environmental politics. Enironmental pollution. Environment protection.
Quality Management. Basic Environmental definitions. Sustainable development. Environmental problems of production. Concept of environmental management. Development of Environmental management. Environmental regulation tools, methods and techniques, and environmental taxes. Some reparation methods and presentation of the possibility of corporate environmental performance. Environmental impact assessment and environmental indicators. Environmental communication. Additional EMS tools. Life cycle management. Life-cycle assessment. Life Cycle Analysis. Environmental management. International standardisation. History of EN ISO 14000. Standardisation nowadays.EMAS. Integrated systems, economic aspects of sustainable development.

Literature

Compulsory:
- Dr. Csaba Juhász, Nikolett Szőllősi: Environmental management. University of Debrecen, 2008. https://www.tankonyvtar.hu/hu/tartalom/tamop425/0032_kornyezetiranyitas_es_minosegbiztositas/index.html

Recommended:
- I.V Murali Krishna, Valli Manickam, Anil Shah, Naresh Davergave: Environmental Management: Science and Engineering for Industry. Butterworth-Heinemann, 2017.
- Rogene A. Buchholz: Principles of Environmental Management: The Greening of Business. Prentice Hall, 1998.

Course objective/intended learning outcomes

a) Knowledge:
- He knows the basics of environmental economics and environmental protection.
- He/she knows the theories, methods and practices concerning the sustainability, the safety, and the environmental impacts of chemical systems, as well as workplace skills, health protection and health promotion requirements.

b) Ability:

- Ability to understand system level, interpret basic environmental management issues and be able to use the knowledge of the area.
- He/she is able to apply and develop methods, models and information technologies to plan, organize and operate chemical industrial systems and processes.

c) Attitude:

- Open to get new knowledge about this topic.
- He/she constantly seeks to improve professional competencies.

d) Autonomy and Responsibility:

- At a high professional level, it can perform environmental management tasks independently.
- He/she has responsibility for sustainability, and environmental protection.

Schedule:

1st week

General environmental problems. Basic Environmental definitions. Sustainable development. Definition of Sustainable development. The basic principles of sustainable development. Measuring sustainable development. The sustainability indicator's tasks, purpose, role

2nd week

Environmental problems of production. Environmental basis of corporate decisions. Environmental issue management at companies. Environmentally-aware company management.

3rd week

Concept of environmental management. Development of Environmental management. Main characteristics of environmental management. Basics of an EMS. Corporate relations model. Environmental regulation tools, methods and techniques, and environmental taxes. Environmental fees. Emission taxes.

4th week

Main characteristics of environmental management. Basics of an EMS. PLAN: the importance of planning environmental activities and their place in the corporate decision-making process. Understanding the need for good planning, presenting supporting tools.

5th week

Main characteristics of environmental management. Basics of an EMS. Some reparation methods and presentation of the possibility of corporate environmental performance. Environmental impact assessment and environmental indicators.

6th week

CHECK: The role of environmental performance assessment in environmental management, learning about methods, focusing on the indicator method.

7th week

Additional EMS tools: Environmental accounting (at theoretical level). Eco-controlling (at theoretical level). Eco-balance (at theoretical level) Environmental cost calculation – to promote environmental performance evaluation.

8th week

Additional EMS tools: Environmental communication. Global Reporting Initiative. Corporate Social Responsibility. Environmental Reports.

9th week

Life cycle management. Life-cycle assessment. Life Cycle Analysis.

10th week
Additional EMS tools. Eco-mapping. Eco-labelling. Energy labels. Eco-labelling in Hungary. Environmental Risk assessment

11th week
Environmental management. International standardisation. History of EN ISO 14000. Standardisation nowadays.

12th week
EMAS. EMAS registration steps. Environmental policy. Success of the scheme. Implementation costs. Critical EMS Elements. EMAS and EN ISO 14001 integration.

13th week
New directions in relation to environmental management: the rise and relevance of the E (environment)-S (social)- G(governance) approach.

Requirements:
- *for a signature*
Attendance at **lectures** is recommended, but not compulsory.
- *for a grade*
The course ends in an **oral examination**. Students should make a short presentation about the chosen topic, which is in close connection with the learnt topics. After the presentation they will get questions about the learnt material. The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or the examination is given according to the following table:

- Score Grade
- 0-59 fail (1)
- 60-69 pass (2)
- 70-79 satisfactory (3)
- 80-89 good (4)
- 90-100 excellent (5)

If the score of the exam is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Person responsible for course: Dr. Csilla Lakatos, assistant professor, PhD

Lecturer: Dr Piroska Harazin, assistant professor, PhD

Knowledge: **Organic- and biochemical**
Credit range *(max. 12 cr.)*: ***8***

Subjects:
1) Bioprocess Engineering I.
2) Organic synthetic methods I.
3) Organic chemistry practice
4) Biochemistry IV.

(1.) Title of Course: **Bioprocess Engineering I.** **Code**: TTKME4801_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 12 hours - preparation for the exam: 20 hours Total: 60 hours	
Year, semester: 1st year (spring)	
Prerequisite(s):	
Topics of course	
Industrial bioprocesses and the biorefinery concept. Omics tools for bioprocess development. Cell factories for industrial bioprocesses. Enzyme systems for industrial bioprocesses. Design and types of bioprocesses. Bioprocess engineering and process optimization. Microbial bioprocesses. Plant cell bioprocesses. Animal cell bioprocesses. Biofilm bioprocesses. Bioreactors for Industrial Bioprocesses. Basics of Bioreactor Design. Stirred-Tank Bioreactors. Nonmechanically Agitated Bioreactors. Packed-bed Bioreactors. Membrane Bioreactors. Photobioreactors. Solid-State Fermentation Bioreactor Fundamentals. Bioreactor Development for the Cultivation of Extremophilic Microorganisms. Application of Microbioreactors for Bioprocesses. Modeling and Control of Bioreactors. Scale-up strategies of Bioreactors. Controls of Industrial Bioprocesses. Principles of bioprocess control. Characterization of industrial bioreactors (mixing, mass and heat transfer). Present status of standard instruments for bioprocess analysis and control. Biosensors. Real-time Knowledge-Based Systems.	
Literature	
Compulsory: - Christian Larroche M. Sanroman Guocheng Du Ashok Pandey: Current Developments in Biotechnology and Bioengineering, Elsevier, 2016. *Recommended:* - Shu Chien, Y. C. Fung, David A. Gough: Introduction To Bioengineering, World Scientific Publishing Co Pte Ltd, 2001. - Pavlovic, Mirjana: Bioengineering, Springer, 2015.	

Course objective/intended learning outcomes

a) Knowledge

- He/She knows the economic importance of biotechnology industries, the main products, production statistics, the laws of microbes (viruses, prokaryotes, unicellular and filamentous fungi), their investigation and use in fermentation processes.
- He/she knows about the development potential of new materials and processes together with its characteristic methods.
- He/She is aware of the basics of microbial stoichiometry, inoculum production, batch and continuous growth of microbial systems.
- He/She knows the structure of bioreactors, the methods of providing the technological parameters (sterility, air supply, stirring, antifoam, temperature, pH).

b) Abilities

- He/She uses fermentation technology (fermenter operation) and bioanalysis (analytical and structural testing tools).
- He/she is able to apply and develop methods, models and information technologies to plan, organize and operate chemical industrial systems and processes.
- He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.
- He/She is capable of interdisciplinary thinking through the acquisition of relevant mathematical, biological, chemical, physical and engineering skills, which makes him/her suitable for the design, implementation and evaluation of scientific experiments.
- He/She is able to identify, raise and solve scientific problems based on his innovative thinking and good problem-solving ability.
- He/She is able to apply theoretical knowledge in practice.
- He/She is able to work independently and in a team as well.

c) Attitude

- He/She shows an inquisitive and studying attitude towards new scientific fields.
- He/She takes care of the further development of his/her theoretical knowledge and practical skills, pursuing continuous self-education.
- He/she aims to enforce all known disciplines and requirements of safety, sustainability, environmental protection and energy efficiency.
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.

d) Autonomy and responsibility

- He/She is collaborative, capable of communicating professional knowledge comprehensibly to his/her team and environment.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.
- In making decisions he/she takes into account the principles of environment protection, quality management, consumer protection, product liability.
- He/She is professionally dedicated.
- He/She keeps the moral values in mind.
- He/She has a broad vision and a responsible mindset.

Schedule:

1st week

Industrial bioprocesses and the biorefinery concept. Omics tools for bioprocess development.

2nd week

Cell factories for industrial bioprocesses. Enzyme systems for industrial bioprocesses.

3rd week

Design and types of bioprocesses. Bioprocess engineering and process optimization.

4th week

Microbial bioprocesses. Plant cell bioprocesses.

5th week

Animal cell bioprocesses. Biofilm bioprocesses. *6th week* Bioreactors for Industrial Bioprocesses. Basics of Bioreactor Design. *7th week* Stirred-Tank Bioreactors. Nonmechanically Agitated Bioreactors. *8th week* Packed-bed Bioreactors. Membrane Bioreactors. *9th week* Photobioreactors. Solid-State Fermentation Bioreactor Fundamentals. *10th week* Bioreactor Development for the Cultivation of Extremophilic Microorganisms. Application of Microbioreactors for Bioprocesses. *11th week* Modeling and Control of Bioreactors. Scale-up strategies of Bioreactors. *12th week* Controls of Industrial Bioprocesses. Principles of bioprocess control. *13th week* Characterization of industrial bioreactors (mixing, mass and heat transfer). Present status of standard instruments for bioprocess analysis and control. *14th week* Biosensors. Real-time Knowledge-Based Systems
Requirements: *- for a signature* Attendance at **lectures** is recommended, but not compulsory. During the semester there is a written end-term test in the 14th week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points. *- for a grade* The course ends in a **written or oral examination**. Based on the result of the examination questions scored according to pre-set maximum points for each sub-questions. The type of the examination (written or oral) is the choice of the student. The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or the examination is given according to the following table: – Score Grade – 0-59 fail (1) – 60-69 pass (2) – 70-79 satisfactory (3) – 80-89 good (4) – 90-100 excellent (5) If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS. *-an offered grade:* It may be offered for students on the basis of the result of the end-term test if the grade is at least satisfactory (3).
Person responsible for course: Dr. Levente Karaffa, associate professor, PhD habil.
Lecturer: Dr. Levente Karaffa, associate professor, PhD habil.

(2.) Title of Course: **Organic synthetics method I.** **Code**: TTKME0301_EN	**ECTS Credit points: 3**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - laboratory: - - home assignment: 14 hours - preparation for the exam: 40 hours Total: 82	
Year, semester: 1st year (fall)	
Prerequisite(s):-	

Topics of course

- General characterization of organic syntheses.
- Methods for introducing key functional groups and their interconversion.
- Most important protecting groups and their application.
- Retrosynthetic analysis and its application.

Literature

Compulsory:

1. Lecture slides

Recommended:

2. F. A. Carey, R. J. Sundberg: Advanced Organic Chemistry, Part B, Plenum: New York-London, 1977.
3. M. B. Smith, J. March: Advanced Organic Chemistry, 5th Ed., Wiley: New York, 2001
4. R. C. Larock: Comprehensive Organic Transformations, Wiley: New York, 1999.
5. J. F. W. McOmie: Protective Groups in Organic Chemistry, Plenum: London-New York, 1973.
6. T. W. Greene, P. G. M. Wuts: Protective Groups in Organic Synthesis, Wiley: New York, 1999.
7. P. J. Kocienski: Protecting Groups, Thieme: Stuttgart-New York, 2004.
8. Stuart Warren, Paul Wyatt: Organic Synthesis: The Disconnection Approach, 2nd Edition, 2009.

Course objective/intended learning outcomes

a) Knowledge

- He/she has general knowledge of organic compounds, including the characteristic properties, preparations and transformability of the various functional groups.
- He/she is able to apply his/her knowledge to solve simple tasks on the field of these derivatives. - He/she knows the practical application of different protective groups.
- He/she is able to plan different synthesis routes for producing an organic compound of a particular structure.
- He/she knows about the development potential of new materials and processes together with its characteristic methods.

b) Abilities

- He/she is able to distinguish between the scientifically proven theories and non-reliable data or information.
- He/she is able to transfer the theoretical knowledge into practical one in research to obtain new results.
- He/she has the manual skills for professional research and development.

c) Attitude

- He/she is open to getting new, scientifically proven knowledge on the subject, but to reject unsubstantiated or possibly misleading claims. –
He/she is committed to quality work at high standards, and efforts to transmit this approach to colleagues.
- He/She is responsible and stands in for the professional ethics.

d) Autonomy and responsibility

- He/she is responsible for his/her own decisions, stand in for these decisions and ideologies.
- He/she is well aware about his/her propositions and its consequences.
- He/she has responsibility for sustainability, and environmental protection.

Schedule:

1st week

Methods for the formation of C=C double bonds.

2nd week

Methods for the formation of C=C double bonds.

3rd week

Methods for the formation of C-Hlg derivatives, metallo-organic compounds and their application for C-C coupling, C-H activation.

4th week

Methods for the formation of C-OH and C-SH bonds.

5th week

Methods for the formation of $C-NH_2$, C-NHR, $C-NRR_1$ bonds.

6th week

Methods for the formation of C=O bond.

7th week

Methods for the formation of COOH/COX groups.

8th week

General aspects of the use of protective groups.

9th week

Cleavage classes (Kocienski's classification). Protection of alcoholic / phenolic hydroxyl groups.

10th week

Protection of 1,2- and 1,3-diols.

11th week

Protection of carboxylic acids (carboxyl group).

12th week

Protection of amines (amino group) and carbonyl group.

13th week

Retrosynthesis: basic concepts, retrosynthetic analysis of aromatic compounds.

14th week

C-X disconnections.

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory. A student may not miss the lecture more than three times during the semester. In case of further absences, a medical certificate needs to be presented. In case a student does not do this, the subject will not be signed and the student must repeat the course.

- for a grade
The course ends in an oral exam in the exam period. The exam grade is the result of the written exam.

The minimum requirement for the examination respectively is 50%. The grade for the written exam is given according to the following table:

Score	Grade
0-49	fail (1)
50-62	pass (2)
63-75	satisfactory (3)
76-87	good (4)
88-100	excellent (5)

If the score of any test below 50, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS

Person responsible for course: Dr. Marietta Vágvölgyiné Tóth, associate professor, PhD

Lecturer: Dr. Marietta Vágvölgyiné Tóth, associate professor, PhD.

(3.) Title of Course: **Organic chemistry practice** **Code**: **TTKML4301_EN**	**ECTS Credit points: 1**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture:
- practice:
- laboratory: 2 hours/week

Evaluation (exam. / practice. / other): **practice**

Workload (estimated), divided into contact hours:
- lecture:
- practice:
- laboratory: 28
- home assignment: 2
- preparation for the exam:

Total: 30

Year, semester: 1st year (spring)

Prerequisite(s): -

Topics of course

The aim of this laboratory practice is to enable students to learn the general synthetic methods of organic chemistry and their practical implementation.
The 2-hour course is compacted that includes 4 x 6 hours laboratory practice and 4 x 1 hours consultation. Students will get an individual list of tasks including four organic compounds to be synthesized and a spectrum analysis task. The execution of the tasks and the order of their implementation are planned by the students.
Chemical syntheses to be carried out are choosen from the following types of reactions:
- nucleophilic substitution reactions
- electrophilic addition reactions
- introduction of functional groups into aromatic rings either by elecrophilic aromatic substitution or by using diazonium salts
- formation of carbon-carbon bonds
- cyclisation reactions.

The organic molecules to be synthesized can be natural compounds (e.g. carbohydrates, amino acids, flavonoids) or related derivatives as well as heterocycles.
The consultations provide opportunities to discuss the theoretical and practical tasks.

Literature

Compulsory:

- J. R. Mohrig, D. G. Alberg, G. E. Hofmeister, P. F. Schatz, C. Noring Hammond: Laboratory Techniques in Organic Chemistry (Supporting Inquiry-Driven Experiments), *4th edition,* W. H. Freeman and Company. ISBN-13: 978-1-4641-3422-7.

Recommended:

- E.K. Meislich, H. Meislich, J. Sharefkin: 3000 Solved problems in Organic Chemistry, McGraw-Hill INC, 1994.
- R:O:C: Norman, J.M. Coxon: Principles of Organic Synthesis, Blackie Academic & Professional, Glasgow, U.K., 1993.

Course objective/intended learning outcomes

a) Knowledge

- He/she knows the laboratory equipment and techniques of organic chemistry, their theoretical background and their practical scope.
- He/she knows the design and evaluation methods of experiments.
- He/she has sufficient practical knowledge to synthesize organic compounds and solve problems.
- Based on his/her organic chemistry knowledge he/she can interpret the results of experiments.

b) Abilities

- He/she is individually able to design experiments and carry out organic reactions.
- He/she is able to make assessment of his/her own results and draw logical conclusions from them.
- He/she is able to recognize and evaluate chemical relationships on the field of organic chemistry.
- Based on known spectra he/she is able to make suggestion on structures of small molecules.
- He/she has the manual skills for professional research and development.

c) Attitude

- He/she is receptive to the knowledge and practical application of organic synthetic methods.
- He/she is open to expand his organic chemistry knowledge and acquire new laboratory techniques.
- During his/her laboratory practice he/she strives for environmentally conscious work and follows the safety rules.
- He/she is committed to quality work at high standards, and efforts to transmit this approach to colleagues.

d) Autonomy and responsibility

- He/she independently organizes his preparative work and takes responsibility for his decisions.
- He/she professionally prepares his experiments and laboratory equipment.
- He/she works carefully, taking into account any potential hazards.
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week

Introduction: (will be held at the first consultation)
Timetable and requirements. Receiving of laboratory equipment and list of tasks. Safety education.

Short written test:
Topics: safety rules, laboratory equipment and main laboratory techniques, determination of molecular formula, calculation of yield, functional groups in organic chemistry.

Preparative work:
Preparation and purification of a selected organic compound from the individual list. Determination of physical properties (melting point or boiling point) and purity (TLC, R_f). Calculation of yield.

2nd week

Short written test:
Topics: substitution and addition reactions (S_N, S_R, Ad_N, Ad_E): their theoretical backgrounds and synthetic applications.

Preparative work: Preparation and purification of the selected organic compound(s) from the individual list. Determination of physical properties (melting point or boiling point) and purity (TLC, R_f). Calculation of yield(s).

3rd week

Short written test:
Topics: theoretical backgrounds and synthetic applications of electrophilic addition and elimination reactions.

Preparative work: Preparation and purification of the selected organic compound(s) from the individual list. Determination of physical properties (melting point or boiling point) and purity (TLC, R_f). Calculation of yield(s).

4th week

Short written test:

Topics: Introduction of functional groups into aromatic rings: electrophilic aromatic substitutions, diazotation, synthetic applications of diazonium salts.

Preparative work: Preparation and purification of the selected organic compound(s) from the individual list. Determination of physical properties (melting point or boiling point) and purity (TLC, R_f). Calculation of yield(s).

Deadline for submitting the spectrum analysis.
Last occasion to present the synthesized products to the instructor.
Assessment.

Requirements:
Attendance at laboratory practice and consultation is mandatory.

In connection with each compound to be synthesized, students must give an oral report on their theoretical organic chemistry and practical knowledge as well as on the safety rules.

Minimum requirements for signing the course:

- Syntheses and characterizations of the selected four organic compounds.
- Sufficient level of the discussion (pass, (2)) for each preparation.
- Minimum level of the written test: at least 50 % of the overall score.
- Submission of the spectroscopic task within the given time.

In case of failure of any subtask, the practice ends with a poor (1) grade.

The final grade will be determined based on the average of the grades of tasks. A weighted average of the grades of subtasks will be calculated in the following manner:

- Activity in laboratory practice, discussion (50 %)
- Short written test (40 %)
- Spectroscopic task (10 %)

Final grade: excellent (5): 90 %; good (4): 75 %; satisfactory (3): 60 %; pass (2): 50 %; fail (1): below 50 %.

Person responsible for course: Dr. Éva Bokor, assistant professor, PhD

Lecturer: Dr. Éva Bokor, assistant professor, PhD

(4.) **Title of Course**: **Biochemistry IV.** **Code**: TTKME0303_EN	**ECTS Credit points: 3**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours/week
- practice:
- laboratory:-

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: 0 hours
- laboratory: -
- home assignment: hours
- preparation for the exam: 60 hours

Total: 60 hours

Year, semester: 2nd year (spring)

Prerequisite(s):-

Topics of course

The lecture series are focusing on the different regulatory mechanisms at the molecular and at the cellular levels. The strategies regulating the protein function will be overviewed. The control by limiting the amount of protein by gene expression in prokaryotic and eukaryotic organisms at transcriptional levels will be mentioned. Hormonal regulation, sensing the environment in multicellular eukaryotic organisms will be discussed.

Literature

Compulsory:
- The lecture notes.

Recommended:

Nelson D.L., Cox M.M.: Lehninger Principles of Biochemistry (W. H. Freeman, Sixth edition, 2012) ISBN-13: 978-14234146.
- Albert B., Bray D. Essential Cell Biology (Fourth edition, Garland Science, 2014) ISBN : 978-0-8153-4454-4.
-Gerhard Krauss: Biochemistry of Signal Transduction and Regulation (Wiley-VCH Verlag GmbH & Co. KGaA, 2014**) ISBN:9783527333660.**

Course objective/intended learning outcomes

a) Knowledge
- He/she knows the different regulatory mechanisms at the molecular and at the cellular level.
- He/she is aware of the fundamentals of the signaling pathways.
- He/she has a mathematical, scientific (physical and chemical) and technical background to understand processes in chemical and chemistry related industries.

b) Abilities
- He/she is able to understand the basis of the integrated metabolic regulation at the cellular and at the organismal level and the basic principles of gene expression.
- He/she is able to understand the molecular mechanism of sensory processes.

- He/she is able to apply comprehensive theoretical knowledge in practice as well, in the area of mathematics and science related to chemical engineering in order to solve problems.

c) Attitude

- He/she is open to the contextual observations of the studied area.
- He/she exhibits interest in the latest research discoveries, reads regularly the advised scientific papers.
- He/she strives to plan and execute tasks alone or in a work team at a high professional level.

d) Autonomy and responsibility

- He/she is capable of considering complex, fundamental questions from his/her professional field on her/his own as well as in a team.
- He/she collaborates with other people in solving problematic tasks.
- He/she has responsibility for sustainability, and environmental protection.

Schedule:

1st week

Bioregulation at the protein level. The storage and the transport of molecular oxygen by heme proteins: myoglobin and hemoglobin. Cooperative binding of molecular oxygen to hemoglobin can be explained by concerted and sequential model. The fetal hemoglobin. Hydrogen ions and carbon dioxide promote the release of oxygen: the Bohr effect. Sickle-cell anemia.

2nd week

Allostery. The characteristics of the allosteric regulation is explained in the case of Aspartate Transcarbamoylase (ATCase). The quaternary structure of ATCase in T and R states. The sigmoidal kinetics of ATCase and its regulatory molecules. Comparison of the Michaelis-Menten kinetics with sigmoidal kinetics.

3rd week

Regulation of glycolysis. The role of the glucose transporters. The irreversible reactions of glycolysis are the regulatory points. The allosteric regulation of phosphofructokinase and pyruvate kinase in liver and in other tissues. The role of phosphofructokinase II and its hormonal regulation. The reciprocally regulated glycolysis and gluconeogenesis.

4th week

Isoenzymes, one of the ways of fine-tuning of metabolism in different cell types or cell compartments. Isoenzymes of hexokinases and lactate dehydrogenases (function, kinetic behaviour, regulation, substrate specificity, location).

5th week

Activation by limited proteolysis – zymogen activation. Pancreatic zymogens: the proteolytic cascade. Structural changes in chymotrypsinogen on its proteolytic cleavage. Substrate specificities and mechanism of serine proteases. Protein protease inhibitors.

6th week

Reversible covalent modification._Post-translational modification by phosphorylation. The driving force of phosphorylation and dephosphorylation. Kinases and phosphatases. The function and regulation of protein kinase A. The phosphorylation of muscle and liver glycogen phosphorylases as well as phosphorylase kinase.

7th week

The overview of signal transduction pathways. Classification of receptors and signal molecules. The receptor-ligand interactions.

8th week

The G protein signal cascade. The structure of the seven transmembrane helix receptors and the heterotrimeric G proteins. The G protein cycle. Turning off the signals. Bacterial toxins target G proteins. Glucagon and ephinephrine.

9th week

The role of G-Protein coupled receptors in sensory perception. Signals which change the resting membrane potential of the nerve cells. Sensory transduction in vision. Light-induced hyperpolarization of rod cells. The termination of the visual signal. Signaling by olphactory receptor neurons.

10th week

Signal cascades based on the membrane lipid phosphatidylinositol. The domain structures of PLC and PKC and their function. Ca^{2+} as a secondary messengers and its sensor protein: Calmodulin.

11th week

Insulin signaling cascade. Processing and secretion of insulin. Insulin receptor and its tyrosine kinase activity. The role of SH2 domain. The activation of protein kinase B and the Glut4 translocation.

12th week

Regulation of blood glucose levels. The coordinated regulation of carbohydrate metabolism. Diabetes Mellitus and hyperglycemia.

13th week

Central dogma of Biology. The structure of DNA and RNA. Regulation of prokaryotic gene expression. Key players and steps of prokaryotic transcription. Promoter recognition. Operon model and its role in gene regulation. Lac operon is under the control of repressor and catabolite activator proteins.

14th week

Regulation of eukaryotic gene expression at different levels. Features of eukaryotic transcription. Cis-regulatory DNA sequence elements and transcription factors. Histone modifications - chromatin remodeling. DNA methylation.

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory.

- for a grade

The course ends in an **examination**.

The grade for the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the exam is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Person responsible for course: Dr. Terez Barna , PhD, assistant professor

Lecturer: Dr. Teréz Barna, PhD, assistant professor

Knowledge: **Physical chemistry and separation techniques** **Credit range:** *(max. 12 cr.)*: ***10*** Subjects: 1**) Down stream processing** **2) Physical chemistry and practical applications** **3) Separation techniques III** **4) Separation techniques VI.**

(1.) Title of Course: **Downstream processing** **Code**: TTKBL0303_EN	**ECTS Credit points: 3**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: - Theoretical lectures, solving independent tasks during the semester	
Evaluation (exam. / practice. / other): **oral exam**	
Workload (estimated), divided into contact hours: - lecture: 14*2 hours (28) - practice: - - laboratory: - - home assignment: 12 hours - preparation for the exam: 40 Total: 80 hours	
Year, semester: 2nd year (spring)	
Prerequisite(s): -	

Topics of course
Concept of downstream processing. Methods and equipment for cell dissruption. Methods of solid liquid separation: centrifugation (ultracentrifugation), filtration (ultrafiltration). Extraction methods. Liquid-liquid and two-phase aqueous extraction., supercritical fluid extraction. Solid-liquid extraction, microwave – accelerated extraction, solid phase extraction (SPE). Fractionation of proteins by selective precipitation. Basic relationships of chromatography, classifications of chromatographic methods. Normal and reverse phase chromatography. Principle of hydrophobic, ion exchange, size exclusion and affinity chromatography methods and their applications in biotechnology.
Literature
Recommended: Krishna Prasad, Nooralabettu (2010). Downstream Processing-A New Horizone in Biotechnology. Prentice Hall of India Pvt. Ltd, New Delhi. ISBN 978-81-203-4040-4. Ram S. Singh. Industrial Biotechnology: An Overview. Chapter in book: Advances in Industrial Biotechnology, 2014
Course objective/intended learning outcomes
a) Knowledge - He/she knows the tools and methods used in biotechnology during the downstream processing - He/she is familiar with the possibilities and limitations of the techniques used in downstream processing (cell dissruption, filtration, centrifugation, chromatographic methods) and the scientific background.

- He/she is familiar with the laboratory and industrial equipment and the basics of their operation.
- He/she owns the approach that treats a technological process as a system and not as a separate element.
- He/she is familiar with the main analytical methods for controlling technological steps.
- He/she has a comprehensive overview on the theories and methods of quality management used in chemical industry.

b) Ability

- He/she is capable of analyzing an industrial product extraction technology, justifying its steps, recognizing problems.
- He/she is able to design a procedure for product extraction, knowing the characteristics of the production technology and the final product.
- He/she is able to select methods for checking the effectiveness of the steps, for evaluating and interpreting the measurement data.
- He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary.

c) Attitude

- He/she is environmentally conscious during his/her laboratory work.
- He/she is open to professional co-operation with professionals working in biotechnology.
- He/she is committed to acquiring new competencies.
- He/she constantly seeks to improve professional competencies.

d) Autonomy and responsibility

- During his work, he/she is able to consider basic professional issues independently, and can produce relevant compilations that can serve as a basis for decisions.
- He/she correctly evaluates the results of his / her own work and compares them with the results of his/her colleagues.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Requirements:

- for a signature

During the semester there are some independent tasks. Students have to submit at least two tasks as a minimum on a sufficient level.

- for a grade

The course is evaluated based on the oral or written examination

Person responsible for course: Dr. Gyöngyi Gyémánt, university professor, PhD, habil

Lecturer: Dr. Gyöngyi Gyémánt, university professor, PhD, habil

(2.) Title of Course: **Physical chemistry and practical applications** **Code**: TTKME4401_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: 0 hours/week - laboratory:	
Evaluation (exam. / practice. / other)**: Written or oral exam, offered grade on the basis of exam test written in the last week of the semester.**	
Workload (estimated), divided into contact hours: - lecture: 28 - practice: - laboratory: - home assignment: 12 - preparation for the exam: 40 Total: 80	
Year, semester: 1st year (spring)	
Prerequisite(s):	
Topics of course	
Thermodynamics in axiomatic approach Basic concepts of irreversible thermodynamics and their applications in engineering Basic concepts of statistical thermodynamics and their applications in engineering Quantum chemistry, computational chemistry theory and applications Advanced reaction kinetics, oscillatory reactions, catalysis Material science, structure determination methods, supramolecular chemistry	
Literature	
Compulsory: - P. W: Atkins, J. de Paula (2006): Atkins' Physical Chemistry 8th Edition, W.H. Freeman and Company, New York, ISBN: 0-7167-8759-8. - Lecture notes and teaching material available via the e-learning system - Frank Jensen: Introduction to Computational Chemistry 2nd Edition, Wiley, 2007, ISBN-13: 978-0-470-01186-7 - Christopher J. Cramer: Essentials of Computational Chemistry: Theories and Models 2nd Edition, Wiley, 2004, ISBN 0-470-09181-9 - Harry Silla: Chemical Process Engineering, Design and Economics, Marcel Dekker, 2003, ISBN: 0-8247-4274-5 *Recommended:* -K. K. Rohatgi-Mukherjee: Fundamentals of Photochemistry (revised edition) - e-book; publisher: New Age International, 1978; 371 pages; ISBN: 0852267843, URL: http://www.ebook3000.com/Fundamentals-OfPhotochemistry_126059.html - Gunnar Jeschke: Advanced Physical Chemistry, Statistical Thermodynamics https://www.ethz.ch/content/dam/ethz/special-interest/chab/physical-chemistry/epr-dam/documents/education/statistical-thermodynamics/stat_TD.pdf	
Course objective/intended learning outcomes	
a) Knowledge	

- He/she gets up-to-date knowledge of mathematics, physics and chemistry to have expertise in the discussed fields of physical chemistry.
- He/she knows information on the most recent results of the coupled disciplines and on directions of development. The students will have basic capability to be informed from scientific publications of the field.
- He/she is familiar with the chemical engineering related measurement theory, metrology, the principles of analysis and material testing.

b) Abilities

- He/she is able to understand and use definitions and concepts used in the course.
- He/she is able to insert the new informations of the course into the earlier learned knowledge base in the fields of thermodynamics, chemical kinetics and structure studies.
- He/she is able to use physical chemistry knowledge in the learning of special requirements of Chemical engineer MSC major.
- He/she is capable to apply the learned knowledge in the everyday practice.
- He/she has the manual skills for professional research and development.

c) Attitude

- The course will help to gain applicable knowledge and general expertise in physical chemistry. As state of the art theories, concepts and methodology will be in their hands students will be capable to understand and evaluate new professional informations and research results and continuously improve their scientific knowledge in later studies and after graduation.
- He/she will have solid theoretical background in the field of physical chemistry to make their work and duties accurately and effectively.
- He/she strives to plan and execute tasks alone or in a work team at a high professional level.

d) Autonomy and responsibility

- The course will help student to be innovative and effective in their work and - also in non-professional environment - build and systematically keep scientifically established opinion in questions and problems in the field of physical chemistry and science.
- In making decisions he/she takes into account the principles of environment protection, quality management, consumer protection, product liability.

Schedule:

1st week Classical approach of thermodynamics. Main concepts and their critical evaluation.
2nd week Axiomatic approach of thermodynamics. Possible solutions of problems in definitions and concepts of classical approach. Thermal and chemical equilibrium, descriptions.
3rd week: Chemical kinetics: basic terminology, catalysis mechanism, applications
4th week: Basics of homogeneous catalysis. Applications in ring opening methatesis, hydrogenations, hydroformylations.
5th week Quantum chemistry. Schrödinger equation and its approximations.
6th week Computational methods in quantum chemistry: applications.
7th week Statistical thermodynamics. Main concepts, internal energy and entropy in statistical approach
8th week Applications of statistical thermodynamics. Statistical definitions of heat capacity, zero point entropy, equilibrium constant
9th week Classical.
10th week Analysis of complex chemical reactions. Enzyme kinetics, inhibition mechanisms, examples, oscillatory reactions..
11th week Basics of heterogeneous catalysis. Applications and case studies.
12th week Photo physics and photochemistry. Examples of photochemical reactions, photo isomerization, photo dissociation, applications
13th Physico-chemical background of modern quality management concepts, regulatory issues in pharmaceutical industry
14th week Structure determination methods. Basics of supramolecular chemistry.

Requirements:

- for a signature
Attendance at **lectures** is recommended, but not compulsory.

During the semester there is a written end-term test in the last week of the semester. Students have to sit for the test.

- for a grade
The course ends in a **written or oral examination**. Based on the result of the examination questions scored according to pre-set maximum points for each sub-questions. The type of the examination (written or oral) is the choice of the student. Questions of the exam with scoring system are provided for the students.

The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Person responsible for course: Dr. Attila Bényei, PhD, Associate Professor

Lecturer: Dr. Attila Bényei, PhD, Associate Professor, Dr. Oldamur Hollóczki, PhD, University Professor

(3.) Title of Course: **Physical chemistry and practical applications**
Code: TTKML4401_EN

ECTS Credit points: 2

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: -
- practice: -
- laboratory: 2 hour/week

Evaluation (exam. / practice. / other): **practice**

Workload (estimated), divided into contact hours:
- lecture: -
- practice: -
- laboratory: 28 hours
- home assignment: 14 hours
- preparation for the exam: -

Total: 42 hours

Year, semester: 1st year (spring)

Prerequisite(s):

Topics of course

This course is intended to stimulate students for independent work. This means that the students are supposed to have well established basic knowledge of laboratory work and capability to design, perform and elucidate physico-chemical experiments and their results as well as to prepare appropriate laboratory notebook. The tasks detailed here contain mainly thermodynamic, equilibrium and kinetic studies.

Topics of measurements:
- Determination of the equilibrium constant by spectrophotometry
- Determination of the stability constant of a metal complex by spectrophotometry
- Determination of ion transport number with the Hittorf's and moving boundary method
- Determination of mean activity coefficient based on solubility measurements
- Investigation of the ionic-strength dependence of the equilibrium constant
- Monitoring the reactions with complicated kinetics by sampling-titrating, spectrophotometric or gasvolumetric method
- A single crystal X-ray measurement by Bruker D8 Venture
- Homogeneous and heterogeneous catalytic hydrogenation reactions in flow reactor

Literature

- Laboratory notes and additional teaching material available via the e-learning system.
- P.W. Atkins, J. de Paula: Atkins' Physical Chemistry 8th Edition, W.H. Freeman and Company, New York, ISBN: 0-7167-8759-8, 2006
- Á. Kathó, V. Kiss, A. Udvardy, A. Bényei, Physical Chemistry laboratory measurements for MSc students, Egyetemi Kiadó
- K. Ősz, A. Bényei: Physical Chemistry Laboratory Measurements (for students of Pharmacy, Chemistry and Chemical Engineering). Debreceni Egyetemi Kiadó, ISBN: 978-963-318-143-0, 2011

Course objective/intended learning outcomes

a) Knowledge
- He/she has global knowledge on science other than chemistry, and capable to organize this information.
- He/she knows various methods from chemical labs or industries, able to show it to other people and apply them including the equipments and their safe usage.
- He/she is familiar with the chemical engineering related measurement theory, metrology, the principles of analysis and material testing.

b) Abilities
- He/she is able to recognize and evaluate the global relationships on the field of chemistry.
- He/she is able to carefully apply the newest chemical theories in practice and design lab experiments or industrial processes based on these results.
- He/she is able to evaluate graphically the experimental data, analyze them and make consequences. Based on these results he/she can present new trends in research or development without supervision.
- He/she is able to use his/her knowledge to solve advanced level chemistry problems including proving the solutions.
- He/she has the manual skills for professional research and development.

c) Attitude
- He/she is committed to protect the environment in both chemical labs and industries. This attitude is shown to other co-workers as well.
- He/she makes effort to apply those technologies that makes lower environmental changes/loads.
- He/she strives to plan and execute tasks alone or in a work team at a high professional level.

d) Autonomy and responsibility
- He/she is responsible in collaboration with other professionals (especially from the field of environmental economy and safety) without supervision.
- In making decisions he/she takes into account the principles of environment protection, quality management, consumer protection, product liability.

Schedule: One of the measurements listed above (**Topics of course**) per week except the 1st practice (introduction, general information and safety training).

Requirements:

Participation on the laboratory practice is compulsory. The measurements and knowledge of the associated theory are marked and an overall mark will be given. Safety training (1st week) is mandatory before the first lab practice (2nd week). Everybody should work individually according to the pre-set schedule (which will be provided on the 1st week). Lab practices are 4 hours long every week (from the 2nd until the 4th week). Being late or failed mark on the written test from the appropriate measurement is equivalent with an absence. In accordance with the regulations of University of Debrecen, attendance is compulsory with the exception of health or family problems (the reason of absence should be certified). In this case, the students should agree with the teacher on replacement dates for the missed experiments.

Requirements for the grade:

The measurements (regularly) and written tests (occasionally) according to the knowledge of the associated theory are marked and the overall mark will be given based on these.

- All of the notebooks of the measurements have to be marked as “pass (2)” or better for the successful completion.
- The minimum requirement for the written tests is 60%. Based on the score of the tests separately, the grade for the tests is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the average of written tests is below 60% the best grade for the course can be only “pass (2)” in any other cases the final mark is given with weighted average by means of the mark of the written tests and notebooks in 1 to 2 ratio.

Person responsible for course: Dr. Ferenc Krisztián Kálmán, associate professor, PhD

Lecturer: Dr. Tibor Csupász, PhD, assistant lecturer

(4.) Title of Course: **Separation techniques III.** **Code**: TTKME0315_EN	**ECTS Credit points: 3**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - laboratory: - home assignment: 20 hours - preparation for the exam: 14 hours Total: 90 hours	
Year, semester: 2nd year (fall)	
Prerequisite(s):	
Topics of course	
Basic principles of different modern analytical methods in the field of HPLC, GC, SFC. Examples and applications for chromatographic studies of organic compounds.	
Literature 1. Effective Organic Compound Purification, Teledyne ISCO, Lincoln, USA (2010) 2. D.A. Skoog, J.J. Leary: Principles of Instrumental Analysis, New York (1992) 3. L.R. Snyder, J.J. Kirkland: Introduction To Modern Liquid Chromatography, Wiley, 1979 4. P. Schreider, A. Bernreuter, M. Huffer: Analysis of Chiral Organic Molecules, Walter de Gruyer, 1995	
Course objective/intended learning outcomes	
a) Knowledge - Have systematic knowledge on the various subject of chemistry, their main principals including basics of analytical methods studied during BSc courses. - He/she has an insight into the main industrial processes and technologies within the scope of his/ her expertise. **b) Abilities** - Using the knowledge and experiences acquired during the course he/she is able to analyse HPLC, GC SFC provided results and accomplish structure, purity verification and/or determination of main analytical parameters from relevant chromatograms. - He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary. **c) Attitude** - He/she is receptive to establish and apply new chemical technologies. - He/she is open to collaborate with professionals on the field of chemistry, environmental chemistry, treating the new chemical trends critically but carefully. - He/she is committed to quality work at high standards, and efforts to transmit this approach to colleagues. **d) Autonomy and responsibility** - He/she is responsible for his/her own decisions, stand in for these decisions and ideologies.	

- He/she recognizes the unsafe environment both in laboratory on industry, and makes decisions according to this.
-He/she is well aware about his/her propositions and its consequences.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Schedule:

1st week

Introduction, overview of major chromatographic concepts. Categorization of chromatographic techniques by stationary and mobile phase. Chromatographic stationary phases. Retention Volume, Retention Time, Peak Height, peak area, Half Width, Bandwidth, Theoretical Plate Number, Theoretical Plate Height, Resolution, Signal, Noise, Drift, Signal / Noise, LOD, LOQ, tailing factor, peak asymmetry. Definition and use of the Kováts index in analytical chemistry.

2nd week

Size Exclusion Chromatography. Principles and mechanism of separation. Stationary phases in chromatography, physical and chemical structures, the newest developments. Instrumentation and operation of the separation processes.

3rd week

Calibration of GPC-SEC. Eluents and detectors.

4th week

Most common errors (GPC-HPLC comparison) and elimination of them.

5th week

Instruments of modern column chromatography and their use. How can a TLC data be used as a pre-experiment? Transfer of TLC data to column chromatography.

6th week

Chiral chromatographic methods. Introduction. Use of chiral GC, HPLC.

Basics of Stereochemistry from chromatographic point of view. The concept of chirality. Different chiral and achiral chromatographic systems.

7th week

Chiral interactions and their application in separation techniques. Enumeration of chiral stationary phases 1. Adapting methods from achiral systems to chiral stationary phases.

8th week

Chiral interactions and their application in separation techniques. Enumeration of chiral stationary phases 2. Adapting methods from achiral systems to chiral stationary phases.

9th week

Hyphenated Techniques. GCMS, HPLCMS SFCMS, and chiral chromatography. Method of development in chiral chromatography 1.

10th week

Hyphenated Techniques. GCMS, HPLCMS SFCMS, and chiral chromatography. Method of development in chiral chromatography 2.

11th week

Stationary Phases, Mobile Phases in Reverse Phase Liquid Chromatography. The role of pH in the separation of proton-active compounds. Preparation of liquid chromatographic buffer solutions, their properties and their application possibilities.

12th week

The usage of gradient chromatography. The possibilities of eliminating the difficulties and pitfalls of it.

13th week

Instrumentation of liquid chromatography.

14th week
Closing test.

Requirements:
- *for a signature*
Attendance at **lectures** is highly recommended, but not compulsory.
- *for a grade*
The course ends in a **written exam** during the examination period following the course.

The minimum requirement for the end-term test is 60%. Based on the score of the test, the grade for the exam is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the written exam is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS

Person responsible for course: Dr. Attila Kiss, PhD, associate professor

Lecturer: Dr. Attila Kiss, PhD, associate professor

(5.) Title of Course: Separation techniques VI. Code: TTKML4501_EN	ECTS Credit points: 1
Classification of the subject: compulsory	
Type of teaching, contact hours - laboratory: 2 hours/week, organized in six blocks in the semester	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: - - practice: - - laboratory: 28 hours/semester - home assignment: 14 hours/semester - preparation for the exam: - Total: 42 hours/semester	
Year, semester: 1st year (spring)	
Prerequisite(s):TTKBE0502-EN	

Topics of course

Basic concepts, theoretical and practical aspects, carry-out and use of fundamental laboratory analytical separation and identification processes. Basic operation principles of modern analytical instruments using separation methods in their working methods. Use of analytical instruments and techniques to separate and identify components of complex samples.

Literature

Compulsory:
1) Specific handouts, each provided for the given laboratory practice.
2) Separation process principles: chemical and biochemical operations / J. D. Seader, Ernest J. Henley, D. Keith Roper.—3rd ed. 2011, ISBN 978-0-470-48183-7, John Wiley & Sons, Inc.
3) Modern analytical chemistry / David Harvey. — 1st ed., 2000, ISBN 0–07–237547–7, The McGraw-Hill Companies, Inc.
Recommended:
4) Modern HPLC for practicing scientists / by Michael W. Dong., 2006, John Wiley & Sons, Inc., Hoboken, New Jersey, ISBN-13: 978-0-471-72789-7
5) Modern size-exclusion liquid chromatography / André M. Striegel et al., 2nd ed., 2009 by John Wiley & Sons, Inc., ISBN 978-0-471-20172-4
6) Modern practice of gas chromatography., 4th ed. / edited by Robert L. Grob, Eugene F. Barry. 2004 by John Wiley & Sons, Inc., ISBN 0-471-22983-0
7) Affinity Chromatography Methods and Protocols, 2nd Ed., Ed. by Michael Zachariou, 2008, Humana Press, a part of Springer Science+Business Media, LLC, ISBN: 978-1-58829-659-7
8) Gel Electrophoresis of Proteins A Practical Approach, 3rd Edition, B. D. Hames, Oxford University Press, 1998, ISBN 0-19-963641-9
9) Thin-Layer Chromatography, 4th Edition, by Joseph Sherma, Bernard Fried, 1999, Marcel Dekker Inc., New York, Basel, ISBN: 0-8247-0222-0

Course objective/intended learning outcomes

a) Knowledge
- He/she fundamentally knows principles, procedures, properties, reactions and chemical processes required to perform analytical laboratory separation processes, and control and properly use classic and modern instrumental analytical techniques.

- He/she has an insight into the main industrial processes and technologies within the scope of his/ her expertise.

b) Abilities

- He/she is able to apply the most important terminology, theories, procedures of the given separation-related analytical field when completing the relevant tasks.
- He/she is able to create fundamental models of separation processes and perform instrumental analytical investigations.
- He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary.

c) Attitude

- He/she is open to learn and accept professional, technological improvement and innovation in his/her profession and convey it genuinely.
- He/she makes a decision in complex and unexpected cases by completely taking into account legal and ethical norms.
- He/she is committed to quality work at high standards, and efforts to transmit this approach to colleagues.

d) Autonomy and responsibility

- Even in unexpected decision-making situations he/she is capable of considering complex, fundamental questions from his/her professional field and elaborating them on the basis of the given sources.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.
- He/she confesses and represents the value system of the qualified chemists' or chemical engineers' profession with responsibility. He/she is open to critical remarks which are professionally well-founded.

Schedule:

1st block

Gas chromatography.

2nd block

High pressure liquid chromatography.

3rd block

Thin layer chromatography.

4th block

Gel permeation chromatography.

5th block

Low pressure liquid chromatography.

6th block

Radioisotopes separation.

Requirements:

- for a signature

Attendance at all of the laboratory practice blocks and fulfilment of the required experiments/tasks, preparing and presenting a valid lab report.

- for a grade

The course ends in a **term mark**.

Each block of practice ends in a mark. A mean value of all marks received in the course are calculated. The minimum requirement for the examination is a mean value of 2.00. Based on the mean value, the grade for the term mark is given according to the following table:

Mean value	Grade
0-1.99	fail (1)
2.00-2.74	pass (2)
2.75-3.49	satisfactory (3)

3.50-4.24	good (4)
4.25-5.00	excellent (5)

If the mean value is below 2.00, students retake the laboratory practice in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS

Person responsible for course: Dr. Ádám Kecskeméti, Ph.D. Associate Research Professor

Lecturer: Selected lecturers from the Institute of Chemistry, UD

<u>PHARMACEUTICAL SPECIALISATION</u>

Knowledge: **Organic and applied synthetic chemistry**

Credit range *(max. 12 cr.)*: ***12***

Subjects:
1) Heterocycles
2) Pharmaceutical-industry project I
3) Pharmaceutical-industry project II.*
4) High efficiency synthetic methods I

(1.) Title of Course: Heterocycles **Code: TTKME0327_EN**	**ECTS Credit points: 3**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week for day-time course, 8 hours/semester for reading course - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 10 hours - preparation for the exam: 40 hours Total: 78 hours	
Year, semester: 1st year (spring)	
Prerequisite(s): -	

Topics of course

- Classification and nomenclature of heterocyclic compounds.
- Preparation and reactions of oxiranes, thiiranes and aziridines.
- Characterization, preparation and reactions of four-membered heterocycles with one heteroatom.
Preparation of azetidine-2-one derivatives and introduction of β-lactam antibiotics.
- Description of five-membered heterocycles with one or more than one
- Characterization of benzene-condensed five-membered heterocycles.
- Characterization, preparation and reactivity of 2H-pyran derivatives.
- Characterization, preparation and reactivity of piridine derivatives.
- Characterization of six-membered heterocycles with more than one heteroatom.
- Six-membered derivatives with one or two heteroatoms.
- Representatives of flavonoids, their preparation and reactions.

Literature

Compulsory:
Supporting material with lecture slides available at the homepage of the Department of Organic Chemistry

Recommended:

Theophil Eicher, Siegfried Hauptmann: The chemistry of heterocycles; structure, reactions, syntheses, and applications, 2nd edition, WILEY-VCH GmbH & Co. KGaA, 2003.
John A. Joule, Keith Mills: Heterocyclic chemistry, 5th edition, A John Wiley & Sons, Ltd., 2010.

Course objective/intended learning outcomes

a) Knowledge

- He/she knows the nomenclature, preparations, reactions and occurrence of the major heterocycles containing O, N and S heteroatoms and is able to explain the diffferent characteristics of heterocyclic compounds.
- He/she has systematic knowledge on the various subject of chemistry, their main principals including the theoretical and practical application built on these principals.
- He/she is well informed about modern synthetic methods, particularly about green catalytic processes.
- He/she knows about the development potential of new materials and processes together with its characteristic methods.
- He/She has knowledge to solve problems on the field of natural processes, using natural sources, and understanding the chemical background of living and non-living systems.

b) Abilities

- He/she is able to retrieve literature data on the synthesis and reaction of heterocyclic compounds, to process those data and to use the literature data to interpret the results. He/She is able to explain the reactivity of heterocycles.
- Using the knowledge and experiences acquired during the MSc course, he/she is able to execute laboratory experiments or measurements to demonstrate proper chemical phenomena, or syntheses and characterization of new compounds, and using analytical methods for developing new reactions.
- He/she is able to apply comprehensive theoretical knowledge in practice as well, in the area of mathematics and science related to chemical engineering in order to solve problems.

c) Attitude

- He/she is receptive to establish and apply new chemical and environmental technologies.
- He/she is responsible and stands in for the professional ethics.
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.

d) Autonomy and responsibility

- He/she can make own decisions even in complex professional questions and discussions.
- He/she recognizes the unsafe conditions both in academic and industrial laboratories and environment and makes decisions according to this.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Schedule:

1st week

Definition and importance of heterocycles. Classification and nomenclature of heterocycles.

The student acquires the conventional and systematic nomenclatures of simple and condensed heterocycles and learn the different subgroups and classification of heterocycles.

2nd week

Preparation, occurrence and reactions of oxiranes. Enantioselective epoxidation.

The student gets acquainted with the three-membered, oxygen-containing heterocycles, their synthesis and reactivity.

3rd week

Characterization of thiiranes and aziridines, their preparation and reactions.

The student gets acquainted with the three-membered, sulfur- or nitrogen-containing heterocycles, their preparation and reactivity.

4th week

Description of four-membered heterocycles with one heteroatom, their preparation and reactions. Preparation of azetidine-2-one derivatives and introduction of β-lactam antibiotics.

The student is able to explain the reactivity of four-membered heterocycles with one heteroatom and knows their preparation. He or She recognizes the importance of azetidine-2-one subunit in β-lactam antibiotics.

5th week
Characterization, preparation and reactions of furan and thiophene derivatives.

The student is able to interpret the preparation and reactivity of furan and thiophene derivatives.

6th week
Synthesis and reactions of pyrrole derivatives.

The student knows the preparation and reactions of pyrrole derivatives and is able to compare them with those benzene and other five-membered heterocycles with one heteroatom.

7th week
Characterization of five-membered heterocycles with more than one heteroatom I.

The student can interpret the reactivity of 1,2- and 1,3-azoles compared to those of other π-excessive heterocycles.

8th week
Characterization of five-membered heterocycles with more than one heteroatom II.

The student learns the main representatives and occurrence of 1,2- and 1,3-azoles.

9th week
Characterization of benzene-condensed five-membered heterocycles.

The student is able to compare the reactivity of benzene-condensed five-membered heterocycles with those of other five-membered heterocycles and explain the differences.

10th week
Characterization, synthesis and reactions of 2*H*-pyrane derivatives.

The student knows the occurrence, synthesis and reactions of 2*H*-pyrane derivatives.

11th week
Representatives, synthesis and reactions of flavonoids.

The student learns the definition, basic skeletons, natural occurrence and reactions of flavonoids.

12th week
Characterization, synthesis and reactions of pyridine derivatives.

The student is able to interpret the reactivity of π-electron deficient heterocycles, knows their occurrence and main transformations.

13th week
Six-memberd heterocycles with more than one heteroatom.
The student can interpret the reactivity of six-membered heterocycles with more than one heteroatom and knows the possible pathways for their preparations.

14th week
Six-membered heterocycles with one or more than one heteroatom.

The student knows the structures, preparation and reactivity of seven-membered heterocycles with one or more than one heteroatom.

Requirements:

- for a signature
Attendance at **lectures** is highly recommended, but not compulsory.

- for a grade
The course ends with a written **exam**. The list of short questions used for the written exam is available at the homepage of the Department of Organic Chemistry. The minimum requirement for achieving the course is 50%.

Score	Grade
0-49	fail (1)

50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

Person responsible for course: Dr. Tibor Kurtán, professor, DSc.

Lecturer: Habil. Dr. Tibor Kurtán, professor,DSc

(2.) Title of Course: **Pharmaceutical-industry project I.** **Code**: TTKML4305_EN	**ECTS Credit points: 3**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: -
- practice: -
- laboratory: 3 hours/week

Evaluation (exam. / practice. / other): **term grade**

Workload (estimated), divided into contact hours:
- lecture: -
- practice: -
- laboratory: 45 hours
- home assignment: 45 hours
- preparation for the exam: -

Total: 90 hours

Year, semester: 1st year (spring)

Prerequisite(s):

Topics of course

The student need to solve problems related to the pharmaceutical industry. It can be a literature search, a measurement or an analytical/synthetical research project. Topics are given by researchers or industries operating on pharmaceutical field, therefore topics are different for each student in each semester. Most important partners of the University of Debrecen are TEVA Pharmaceutical and Richter Gedeon, they provide most of the topics and supervisors.

Literature

Literature is given by the supervisor of the topic for each student. It can be a technological or operational guide, a textbook or a scientific paper. In many cases students need to find literature for their own project on the internet or in the library.

Course objective/intended learning outcomes

a) Knowledge:
- He/she knows the conditions of safe work in the laboratory and in the field of working plant.
- He/she knows the principle of individual synthesis and the possibilities of practical implementation both in the laboratory and in the plant.
- He/she understands the technical solutions that can be used to produce the product.

- He/she has an insight into the main industrial processes and technologies within the scope of his/ her expertise.
- He/she is well informed about modern synthetic methods, particularly about green catalytic processes.

b) Ability:
- He/she is able system level see through, interpreted basic synthetic procedures and can use knowledge of this area. It can also solve industrial problems.
- He/she is able to engage in professional communication from the above area and their practical application.
- He/she is able to expand/improve the knowledge of the production and properties of each type of medicinal product at basic level for new tasks.
- He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.

c) Attitude:
- Open to get new knowledge about this topic. He asks his colleagues to work accurately and to comply with the rules of accident protection and safety technology, as well as an example of his own work.
- As a leader he/she makes important decisions considering the opinions and arguments of colleagues.

d) Autonomy and Responsibility:
- In addition to professional management, it can perform chemical and technical tasks independently. It is capable of performing and evaluating basic synthetic works. It also understands the principle of practical implementation
- He/she considers the principle and application of equal access opportunities, as well.

Schedule: Students need to discuss it with their supervisors individually

Requirements: The supervisor considers the grade based on the value of the student's work, the attitude and diligence during the literature search, a measurement or working on an analytical/synthetical research project.

Person responsible for course: Prof. Dr. Tibor Kurtán, University Professor
Head of Department , PhD, DSc

Lecturer: supervisors are staff members of the Institute of Chemistry at University of Debrecen or specialists at the cooperating industrial partners (e.g. TEVA Pharmaceutical, Richter Gedeon), however in this case a co-supervisor from the Institute of Chemistry continously verifies the work.

(3.) Title of Course: **Pharmaceutical-industry project II.** **Code**: TTKML4306_EN	**ECTS Credit points: 3**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: -
- practice: -
- laboratory: 3 hours/week

Evaluation (exam. / practice. / other): **term grade**

Workload (estimated), divided into contact hours:
- lecture: -
- practice: -
- laboratory: 45 hours
- home assignment: 45 hours
- preparation for the exam: -

Total: 90 hours

Year, semester: 2st year (fall)

Prerequisite(s):TTKML4305-EN

Topics of course

The student need to solve problems related to the pharmaceutical industry. It can be a literature search, a measurement or an analytical/synthetical research project. Topics are given by researchers or industries operating on pharmaceutical field, therefore topics are different for each student in each semester. Most important partners of the University of Debrecen are TEVA Pharmaceutical and Richter Gedeon, they provide most of the topics and supervisors.

Literature

Literature is given by the supervisor of the topic for each student. It can be a technological or operational guide, a textbook or a scientific paper. In many cases students need to find literature for their own project on the internet or in the library.

Course objective/intended learning outcomes

a) Knowledge:
- He/she knows the conditions of safe work in the laboratory and in the field of working plant.
- He/she knows the principle of individual synthesis and the possibilities of practical implementation both in the laboratory and in the plant.
- He/she has an insight into the main industrial processes and technologies within the scope of his/ her expertise.
- He/she is well informed about modern synthetic methods, particularly about green catalytic processes.

b) Ability:
- He/she is able system level see through, interpreted basic synthetic procedures and can use knowledge of this area. It can also solve industrial problems.
- He/she is able to engage in professional communication from the above area and their practical application.
- He/she is able to expand/improve the knowledge of the production and properties of each type of medicinal product at basic level for new tasks.
- He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.

c) Attitude:

- He/she is open to get new knowledge about this topic. He asks his colleagues to work accurately and to comply with the rules of accident protection and safety technology, as well as an example of his own work.
- As a leader he/she makes important decisions considering the opinions and arguments of colleagues.

d) Autonomy and Responsibility:

- In addition to professional management, he/she can perform chemical and technical tasks independently.
- He/she is capable of performing and evaluating basic synthetic works. It also understands the principle of practical implementation
- He/she considers the principle and application of equal access opportunities, as well.

Schedule: Students need to discuss it with their supervisors individually.

Requirements: The supervisor considers the grade based on the value of the student's work, the attitude and diligence during the literature search, a measurement or working on an analytical/synthetical research project

Person responsible for course: Prof. Dr. Tibor Kurtán, University Professor
Head of Department, PhD, DSc

Lecturer: supervisors are staff members of the Institute of Chemistry at University of Debrecen or specialists at the cooperating industrial partners (e.g. TEVA Pharmaceutical, Richter Gedeon), however in this case a co-supervisor from the Institute of Chemistry continously verifies the work.

(4.) Title of Course: High efficiency synthetic methods I. Code: TTKML0319_EN	ECTS Credit points: 3
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: - - practice: 1 hour/week - laboratory: 3 hours/week	
Evaluation (exam. / practice. / other): **term grade**	
Workload (estimated), divided into contact hours: - lecture: - - practice: 14 hours - laboratory: -42 hours - home assignment: 28 hours - preparation for the exam: - Total: 84 hours	
Year, semester: 2st year (spring)	
Prerequisite(s):	

Topics of course

- Understanding the theory of the most important high-performance techniques, practice of methods capable for the synthesis of various organic compounds.
- Use of microwave technology, various flow condition methods and cleaning techniques.

Literature

Compulsory:

1. Slides and experimental descriptions provided by the lecturer.

Recommended:

2. O. Kappe: Microwaves in Organic and Medicinal Chemistry, Vol. 25, 2005.
3. O. Kappe: Microwaves in Organic and Medicinal Chemistry, Vol. 52, 2012.
4. Santiago V Luis: Chemical Reactions and Processes under Flow Conditions, 2009.
5. Stefan Bräse: Combinatorial Chemistry on Solid Supports, 2007.

Course objective/intended learning outcomes

a) Knowledge

- He/she knows the theory, practical applicability, opportunities and limitations of techniques that can be used in high efficiency synthesis and He/She is gaining practice in several methods.
- He/she knows the methods of designing synthesis of organic compounds using high efficiency techniques.
- He/she is well informed about modern synthetic methods, particularly about green catalytic processes.

b) Abilities

- He/she is able to use the new approaches on the field of chemical research and innovation to apply the main theories, practical information, application and technology as well as understanding and analyzing scientific data.
- He/she has the manual skills for professional research and development.
- He/she is able to recognize and evaluate the global relationships on the field of chemistry.
- He/she is able to distinguish between the scientifically proven theories and non-reliable data or information
- He/she is able to carefully apply the newest chemical theories in practice and design lab experiments or industrial processes based on these results.
- He/she is able to gain knowledge on the professional chemical language to present his/her knowledge and communicate.

c) Attitude
- He/she is receptive to establish and apply new chemical technologies.
- He/she is being active to start and participate in professional discussions.
- He/she is open to collaborate with professionals on the field of chemistry, environmental chemistry, treating the new chemical trends critically but carefully.
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.

d) Autonomy and responsibility
- He/she is responsible for his/her own decisions, stand in for these decisions and ideologies.
- He/she recognizes the unsafe environment both in laboratory and industry, and makes decisions according to this.
- He/she can operate chemical or industrial instruments or equipment with responsibility, and manage persons working with these.
- He/she takes individual initiatives in solving professional problems.
- He/she is well aware about his/her propositions and its consequences.

Schedule:

1st week

Theoretical background of the applied techniques 1.

2nd week

Theoretical background of the applied techniques 2.

3rd week

Use of a CEM microwave reactor 1.

4th week

Use of a CEM microwave reactor 2.

5th week

Use of a TECAN robot 1.

6th week

Use of a TECAN robot 2.

7th week

Use of a BIOTAGE SP4 fluid chromatograph 1.

8th week

Use of a BIOTAGE SP4 fluid chromatograph 2.

9th week

Use of a H-cube reactor 1.

10th week

Use of a H-cube reactor 2.

11th week

Use of ASIA flow reactor 1.

12th week

Use of ASIA flow reactor 2.

13th week

Study the optical active organic compounds using polarimeter.

14th week

Exam including the theoretical background and the practice

Requirements:

- for a signature

Participation at **laboratory** is compulsory. A student must attend the practice classes and may not miss none of them during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Attendance at lab courses will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed lab courses should not to be made up for at a later date! Students are required to bring the drawing tasks and drawing instruments of the course to each lab courses. Active participation is evaluated by the teacher in every class. If a student's behavior or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

- *for a grade*

The course ends in a term mark which is calculated as an average of:

- Theoretical knowledge (70%)
- Practical grade (30%)

Grade:

excellent (5) 90 %, good (4) 75 %, satisfactory (3) 60 %, pass (2) 50 %, fail (1) below 50 %

Person responsible for course: Dr. László Juhász PhD, habil, associate professor

Lecturer: Dr. László Juhász PhD, habil, associate professor

Knowledge: **Applied pharmaceutical chemistry**

Credit range: *(max. 12 cr.)*: ***12***

Subjects:
1) Instrumental and material analysis
2) Chemical aspects of drug design
3) Carbohydrate based drug design
4) Environment-friendly and catalytic processes
5) Pharmaceutical and fine chemical technologies

(1.) Title of Course: **Instrumental and material analysis** **Code**: TTKME4502_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory:	
Evaluation (exam. / practice. / other): **examination**	
Workload (estimated), divided into contact hours: - lecture: 48 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 42 Total: 90 hours	
Year, semester: 1st year (spring)	
Prerequisite(s):	

Topics of course

The course surveys the history, methods, theories, fundamentals and some practical aspects of analysis of several instrumental analytical methods and techniques. Important additional topics are the sampling, electrophoresis, atomic spectrometry, sensors, immunoanalysis, labelling methods, thermal analysis, polarography. The course is connected to some topics of the Instrumental Analysis laboratory practices and complete the knowledge acquired in BSc level.

Literature

Daniel C. Harris: Quantitative Chemical Analysis, 7th Ed., 2007, Freeman and CoH.H.
Willard, L.L. Merritt, J.A. Dean, F.A. Settle: Instrumental methods of Analysis, Wadsworth Publ. Co., Belmont, 1988.
Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch: Fundamentals of Analytical Chemistry, 8th. ed., 2004, Brooks/Cole

Course objective/intended learning outcomes

a) Knowledge
- He/she fundamentally knows principles and means of instrumental analysis, sample pretreatment, data evaluation and validation of the measurements.
- He/she expansively knows the operating principles of the instrumental analysis, auxiliary devices.

- He/she knows the most recent results and approaches of technological development.

b) Abilities

- He/she is able to apply the most important terminology, theories, procedures of the given instrumental analysis field when completing the relevant tasks.
- He/she is able to find solutions for the analytical problems.
- He/she is able to solve problems of quality management, metrology and process control in the chemical industry and chemical technological systems.
- He/she is prepared for the administration of technological activities, as well as for cooperation in teamwork in the chemical industry and other professional fields.

c) Attitude

- He/she is open to learn and accept professional, analytical improvement and innovation in his/her profession and convey it genuinely.
- He/she checks for possibilities of setting research, development and innovation goals, and efforts to achieve them; committed to enrich the scientific field by up-to-date knowledge, scientific and technical results.
- He/she makes a decision in complex and unexpected decision cases by completely taking into account legal and ethical norms.

d) Autonomy and responsibility

- Under supervision he/she is responsible in collaboration with other professionals (especially from the field of analytical and environmental economy and safety).
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.
- He/she confesses and represents the value system of the instrumental analytical profession with responsibility. He/she is open to critical remarks which are professionally well-founded.

Schedule:

1st week: Quality ensurance, validation parameters, evaluation methods (2h)

2nd week: Sampling, storing samples (2h)

3rd week: Sample pretreatment methods (2h)

4th week: Atomic emission methods. ICP-AES. Laser ablation sample introduction. ICP-MS. Graphite furnace atomic absorption methods. Background correction methods (2h)

5th week: Labelling analytical methods. Immunoanalysis. ELISA (2h)

6th week: Ion exchange chromatography. Ion chromatography. Supercrtitical fluid chromatography. (2h)

7th week: Gel electrophoresis. Capillary electrophoresis. Electroosmosis. Detection on gels. (2h)

8h week: Microfluidic application in analytical chemistry. Lab-on-a-chip. Bioanalyzer 2100 (2h)

9th week: Characterization and classification of sensors. Electrochemical and semiconductive sensors (2h)

10th week: Attenuated total reflexion spectrometry. Surface plasmon resonance spectroscopy. Molecularly imprinted polymers and their analytical applications. (2h)

11th week: Fundamentals and instrumentation of polarography. Methods of polarography. Cyclic voltammetry. Inverse voltammetry. Bipotentiometry. (2h)

12th week: Continuous analysis. Kinetic analytical methods. (2h)

13th week: Methods of the thermal analysis (TG, DTG, DTA, DSC) (2h)

14th week: Consultations. Survey and classification of the analytical methods. (2h)

Requirements:

Attendance at lectures is recommended, but not compulsory.
The course ends in an examination (written test).
The minimum requirement for the examination is 50%. Based on the score of the test, the grade is given according to the following table:

Score	Grade
0-50	fail (1)

50-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

Person responsible for course: Dr. István Fábián, University Professor DSc, habil

Lecturer: Dr. István Fábián, University Professor DSc, habil

(2.) Title of Course: **Chemical aspects of drug design**
Code: TTKME0314_EN

ECTS Credit points: 3

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: -
- laboratory: -

Evaluation (exam. / practice. / other): **oral exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment: -
- preparation for the exam: 62 hours

Total: 90 hours

Year, semester: 1st year (fall)

Prerequisite(s):

Topics of course

The students will get acquainted with the complex process of finding and/or discovery, design and development of drugs. The following main topics will be handled: drugs as chemical, legal and commercial entities; Intermolecular interactions responsible for the development of drug action; characterization of interactions between a small molecule and a biological target; drug targets, pharmacodynamics and pharmacokinetics; structure-activity relationships. These topics will be illustrated by several case studies.

Literature

1. G. L. Patrick: An introduction to medicinal chemistry, 4th edition, Oxford University Press, New York, 2009. (978-0-19-923447-9)
2. R. B. Silverman, M. W. Holladay: The organic chemistry of drug design and drug action, 3rd ed., Academic Press, 2012. (978-0-12-382030-3)
3. H. J. Smith, C. Simons (Eds.): Enzymes and their inhibition – Drug development. CRC Press, Boca Raton, 2005.

Course objective/intended learning outcomes

a) Knowledge

- He/She understands the progress and future trends in chemistry and chemical industries.
- He/She has knowledge to solve problems in the field of biomolecular interactions.
- He/she knows about the development potential of new materials and processes together with its characteristic methods.

b) Abilities

- He/She is able to recognize and evaluate the global relationships on the field of chemistry.
- He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary.

c) Attitude

- He/She is receptive to establish and apply new chemical and environmental technologies.
- He/She is responsible and stands in for the professional ethics.
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.

d) Autonomy and responsibility

- He/She can make own decisions even in complex professional questions, discussions.
- He/She is well aware about his/her propositions and its consequences.
- He/She is responsible for his/her own decisions, stand in for these decisions and ideologies.
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week

Definition of drugs, their types, and modes of action. Intermolecular interactions, hydrophobic/solvophobic effects. Participation of proteinogenic amino acid side chains in secondary chemical bondings.

2nd week

Characterization of interactions between small molecules-biological macromulcules: binding energy and its components (enthalpy, enthropy), flexibility, solvatation, repulsive forces, shape of the molecules, stereoisomerism (configuration, conformation). Enthalpy-enthropy compensation. Isosterism, bioisosterism.

3rd week

Categories of drug targets. Receptors, characterization of small molecule-receptor complexes: affinity (dissociation constant), effectivity. Definition of agonists and antagonists, models.

4th week

Enzymes as drug targets. Characterization of enzyme catalysis on the molecular level. Cofactors, coenzymes and their ways of action.

5th week

Types of enzyme inhibitors: reversible (competitive, non-competitive, uncompetitive, transition-state analogues), irreversible (affinity labels, mechanism-based inactivators). Enzyme inhibitors in drug development.

6th week

Nucleic acids as drug targets. Interactions of small molecules with nucleic acids. Alkylation and chain splitting of DNA. Antisense therapy. Transport and structural proteins, lipids as drug targets.

7th week

Pharmacodynamics and pharmacokinetics. ADMET properties.

8th week

Drugs as merchandises. Chemical biology and drug design. The multi- and interdisciplinary process of drug design and development. Phases, current practice and problems of drug development.

9th week

Finding, discovery and design of drugs. Hits, lead molecules, optimized leads. Elements of the early drug development phase.

10th week

Optimization of pharmacodynamic properties.

11th week

Optimization of pharmacokinetic properties. Concept of prodrugs. *12th week* Structure-activity relationships. *13th week* Case studies. *14th week* Case studies.
Requirements: Attendance at **lectures** is recommended, but not compulsory. An oral exam to be absolved during the examination period closes the course. A list of topics is provided at the start of the semester, and at the exam two topics chosen randomly are discussed after an approx. 1 hour preparation time.
Person responsible for course: Dr. László Somsák, University Professor DSc, habil
Lecturer: Dr. László Somsák, University Professor DSc, habil

(3.) Title of Course: **Carbohydrate based drug design** **Code**: **TTKME4303_EN**	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 - practice: - - laboratory: - - home assignment: - - preparation for the exam: 32 Total: 60	
Year, semester: 1st year (fall)	
Prerequisite(s):	
Topics of course	
Basic carbohydrate chemistry: categories of carbohydrates; constitution, configuration and conformation of monosaccharides, ways for their depiction; basics of carbohydrate nomenclature; structural aspects of oligo- and polysaccharides; reactions of monosaccharides; protecting groups of carbohydrates; glycosylations; main transformations of the carbohydrate skeleton. Basics of glycobiology: overview of the biological roles of carbohydrates; carbohydrates in signaling and recognition processes; the sugar code; carbohydrates as antigens; glycoenzymes, lectins, glycoantibodies; multivalency in carbohydrate-protein interactions.	

Carbohydrate-based drugs and vaccines: identification of molecular targets, drug design, sugar-based therapeutic agents in the market and under investigations; case studies. Other pharmaceutical applications of carbohydrates. Utilization of cyclodextrins in the pharmaceutical industry.

Literature

Levy, D. E.; Fügedi, P. The Organic Chemistry of Sugars; CRC Press, 2006. (978-0-8247-5355-9)

Gabius, H.-J. (Ed.) The Sugar Code – Fundamentals of Glycosciences; Wiley-Blackwell, 2009. (978-3-527-32089-9)

C.-H. Wong (Ed.) Carbohydrate-based Drug Discovery; Wiley, 2006. (978-3-527-60578-1)

Transforming Glycoscience: A Roadmap for the Future - 2012 (978-0-309-26083-1)

(PDF is available from the National Academies Press at http://www.nap.edu/catalog.php?record_id=13446)

L. Cipolla (Ed.) Carbohydrate Chemistry: State of the Art and Challenges for Drug Development; Imperial College Press, 2016. (978-1-78326-719-4)

G. L. Patrick: An introduction to medicinal chemistry, 4th edition, Oxford University Press, New York, 2009. (978-0-19-923447-9)

Szejtli, J. Cyclodextrin Technology, Kluwer Academic Publ. 1988.

Szejtli, J. Cyclodextrins and their Inclusion Complexes, Akadémiai Könyvkiadó, Budapest, 1982.

Course objective/intended learning outcomes

a) Knowledge

- He/She knows the types, chemical properties and biological roles of carbohydrates.
- He/She acquires knowledge about the synthesis of carbohydrates, the design and synthesis of glycomimetics, the role of carbohydrates in classical and modern drugs, and other pharmaceutical applications of carbohydrates.
- He/she knows about the development potential of new materials and processes together with its characteristic methods.

b) Abilities

- He/She is able to critically interpret the literature results in the field of carbohydrates.
- He/She is able to understand syntheses in the field of carbohydrate chemistry, and to design basic transformations.
- He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary.

c) Attitude

- Building on this course he/she continues to expand his/her knowledge in the field of the carbohydrates and their pharmaceutical aspects.
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.

d) Autonomy and responsibility

- Based on the knowledge of the course, he/she makes suggestions on issues related to carbohydrate-based drug development, discusses and represents them in professional circles.
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week

Categorization and stereochemical properties of carbohydrates, ways for their depiction, basics of carbohydrate nomenclature.

2nd week

Chemical properties and transformations of free sugars.

3rd week

Reactivity of the hydroxyl groups, basics of the protecting group chemistry of carbohydrates.

4th week

Reactivity of the anomeric centre.

5th week
Transformations on non-anomeric carbons.
6th week
Glycosylation reactions. Methods of activating the anomeric center, possibilities of forming a glycosidic bond. Effects of the structure of the glycosyl donor and acceptor on the stereochemistry of the reaction.
7th week
Syntheses of oligosaccharides. General considerations, glycosylation strategies. Methods and techniques of glycosylation, possibilities for industrial implementation. Syntheses of human breast milk oligosaccharides.
8th week
Cyclodextins as special carbohydrates, their preparation by enzymatic degradation of starch, formation of the ring structure. Structural features of cyclodextrins, their molecular dimensions, polarity-based two-faced properties of the nano-sized cavities. Functional properties of cyclodextrins: formation of inclusion complexes, conditions and the equilibrium nature of complex formation, the apparent complex stability constants and their role in practice. Inclusion complexes of cyclodextrins as controlled release systems.
9th week
"Family tree" of cyclodextrins: some chemically and enzymatically modified cyclodextrins of practical importance. Why cyclodextrins need to be chemically modified? Synthesis of some important representatives, demonstration of their altered features by some products already on the market. Cyclodextrins, as stabilizing, solubility-enhancing and drug delivery aids (demonstration of important practical uses by approved products). Cyclodextrins as drugs: the example of Sugammadex / Bridion and the successful use of a cyclodextrin derivative in the treatment of a rare, incurable disease.
10th week
Carbohydrates among classical medicines. Biological roles of carbohydrates and their conjugates (e.g. glycoproteins, glycolipids). Carbohydrate-protein interactions, basics of the function of glycoenzymes and lectins, the role of multivalency. Carbohydrates and glycomimetics in drug design.
11th week
Antiviral neuraminidase inhibitors. The role of neuraminidase in influenza virus replication, mechanism of action. Zanamivir and oseltamivir, examples for the mechanism- and structure-based inhibitor design. Antidiabetic α-glucosidase (α-amylase) inhibitors. Carba- (e.g. acarbose, voglibose), aza/imino- (e.g. miglitol) and thiosugars as transition-state analogue enzyme inhibitors. Further examples for the clinical use of iminosugars.
12th week
Inhibitors of SGLT2 for the treatment of diabetes. The function of renal sodium-dependent glucose cotransporters (SGLT1, SGLT2) and their role in glucose homeostasis. The most important representatives of SGLT2 inhibitors (the natural *O*-glucoside phlorizin and its *O*- and *C*-glycosylated synthetic analogs) and their structural features. Synthesis of the marketed SGLT2 inhibitors. Glucose analogue inhibitors of glycogen phosphorylase as potential antidiabetics.
13th week
Carbohydrate-based anticoagulants. The heparin, the importance of the structural heterogeneity in heparin-protein interactions. The role of heparin in inhibiting blood clotting. Synthetic heparin analogue antithrombotics.

14th week
Application of polysaccharide-conjugate vaccines in the treatment of various pathogens (bacteria, viruses, parasites, fungi) and tumors. Carbohydrate-based lectin antagonists as potential drug candidates. Possible utilization of carbohydrate interactions in diagnostics: molecular imaging, microarray techniques.

Requirements:

Attendance at **lectures** is recommended, but not compulsory. An oral exam to be absolved during the examination period closes the course. A list of topics is provided at the start of the semester, and at the exam two topics chosen randomly are discussed after an approx. 1 hour preparation time.
Person responsible for course: Dr. László Somsák, University Professor DSc, habil
Lecturer: Dr. László Somsák, University Professor DSc, habil

(4.) Title of Course: **Environment-friendly and catalytic processes** **Code**: TTKME4402_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 14 hours - preparation for the exam: 18 hours Total: 60 hours	
Year, semester: 2nd year (fall)	
Prerequisite(s):	

Topics of course

-Overview of the so-called clean technologies. Protection of the purity of air and natural waters. Physico-chemical treatment of aqueous waste effluents. Wet oxidations.

-Detailed description of several clean technologies. Processes using supercritical fluids and ionic liquids as solvents. Aqueous and aqueous-organic biphasic processes. Catalytic processes in pharma industry.

-Role and importance of catalysts, their synthesis, characterization, study and possible modifications. Catalyst poisons. Reactors for catalytic processes. Questions of economy and profitability.

-Catalytic processes in environmental protection; removal/elimination of hazardous components from exhaust fumes of internal combustion engines; operation and role of fuel cells in environmental protection; hydrogen- and methanol-economy.

Literature

Compulsory:

A. Behr, P. Neubert: Applied Homogeneous Catalysis, Wiley-VCH, Weinheim, 2012.

G. Rothenberg: Catalysis. Concepts and Green Applications, 2nd ed, Wiley-VCH, Weinheim, 2017.

D. J. Adams, P. J. Dyson, S. J. Tavener, Chemisry in Alternative Reaction Media. Wiley-Interscience: Cambridge, 2004.

Recommended:

B. C. Gates, J. R. Katzer, G. C. A.Schuit: Chemistry of catalytic processes, McGraw-Hill, 1979

P. W. M. N. van Leeuwen, Homogeneous Catalysis. Understanding the Art. Kluwer, Dordrecht, 2004.

J. A. Moulijn, P. W. N. M. van Leeuwen, R. A. van Santen: Catalysis. An Integrated Approach to Homogeneous, Heterogeneous and Industrial Catalysis (Studies in Surface Science and Catalysis, Vol. 79), Elsevier, Amsterdam, 1993.

Course objective/intended learning outcomes

a) Knowledge

- He/she fundamentally knows principles and means of environmental protection.

- He/she expansively knows the basic questions of practical application of homogeneous catalysis in laboratory and in industrial processes.
- He/she is well informed about modern synthetic methods, particularly about green catalytic processes.

b) Abilities

- He/she is able to apply the most important terminology, theories and procedures of catalysis when analyzing relevant tasks of preventing pollution.
- He/she is able of system level understanding the problems of complex environment-friendly processes and is able to participate in professional discussions of such problems.
- He/she is able to process, organize, comprehensively analyse and draw conclusions from information collected through the operation of industrial chemical processes.

c) Attitude

- He/she is open to learn and accept professional, scientific and technological improvements and innovation in his/her profession and to refuse unscientific approaches.
- He/she makes a decision in complex and unexpected decision cases
- He/she constantly seeks to improve professional competencies.

d) Autonomy and responsibility

- Even in unexpected decision-making situations he/she is capable of considering complex, fundamental questions from his/her professional field and elaborating them on the basis of the given sources.
- In making decisions he/she takes into account the principles of environment protection, quality management, consumer protection, product liability.
- He/she considers in a responsible manner the environmental risks of technological processes and -in order to minimize such risks- evaluates the possible application of catalytic (homogeneous or heterogeneous) synthetic procedures, too.
- He/she is open to critical remarks which are professionally well-founded.

Schedule:

1st week

Historical developments of chemical industry; future possibilities.

Fundamental ideas and characteristics of green chemistry. The basic principles of green chemistry. Definitions of the yield and atom efficiency of a chemical reaction. The environmental factor (E-factor). Characteristics of an economical synthesis.

2nd week

Metal complex catalysis and technologies. Definition and classification of catalysis. Comparison of the characteristics of homogeneous and heterogeneous catalysis. Inhibition (catalyst poisoning). Autocatalysis and autoinhibition, self-catalysis and self-inhibition. Characterization of the activity and selectivity of catalysts. Definitions of turnover number (TON) and turnover frequency (TOF).

3rd week

Heterogeneous catalysis and its practical applications. Basic steps of heterogeneously catalyzed reactions. The Langmuir-Hinshelwood and the Eley-Rideal mechanisms of heterogeneous catalysis. The Haber-Bosch process of ammonia synthesis. The chemical basis of the Fischer-Tropsch synthesis. Zeolites and their industrial applications. Catalytic removal/elimination of hazardous components from exhaust fumes of internal combustion engines.

4th week

Basic steps of homogeneously catalyzed reactions (oxidative addition, reductive elimination b-hydride elimination, ligand migration). The 18 electron rule. Role of radical processes in metal complex catalyzed reactions. Conditions, mechanisms and catalysts of complex catalyzed asymmetric syntheses. Stereoselective hydrogenation. The synthesis of L-DOPA (Monsanto).

5th week

Reactions in liquid biphasic systems, phase transfer assisted complex catalyzed syntheses. Catalytic processes in biphasic reaction mixtures. Kinetic consequences of working in biphasic mixtures. Aqueous-organic organometallic catalysis in biphasic media - the effects of water on catalytic processes.

6th week

Catalytic reactions in alternative solvents. General properties and practical applications of ionic liquids. Definition of supercritical fluids and their use as solvents. Fluorous solvents and their most important properties and applications.
7th week
Industrial processes in aqueous reaction media. The Ruhrchemie-Rhône Poulenc process for propene hydroformylation in aqueous biphasic media. The Union Carbide process for hydroformylation of higher olefins. The Kuraray process for telomerization of butadiene and water.
8th week
Catalytic carbonylation. Catalysts and mechanisms. Synthesis of acetic acid by carbonylation of methanol; the Monsanto process. Synthesis of acetic acid by carbonylation of methanol; the Cativa process. Comparison of the characteristics of the two processes.
9th week
Catalytic oxidations. Catalysts and mechanisms. The Wacker (Wacker-Hoechst) process for manufacturing of acetaldehyde by oxidation of ethene. Wet oxidations.
10th week
Sonochemical, mechanical and microwave activation in synthesis as core processes of environment-friendly technologies.
11th week
Organocatalysis and biocatalysis.
Methods for fast optimization of reaction conditions. The H-Cube hydrogenation flow reactor.
12th week
Pollution of surface and ground waters. Major pollutants – emerging trends. Catalytic methods of water treatment (oxidation, reduction).
13th week
Basic safety considerations in planning and development of catalytic industrial processes. Advantages and disadvantages of the use of solvents. Major concerns and principles of choosing a solvent for a specific process.
14th week
Sustainability. Life-cycle assessment. Analysis of the responsibilities of major chemical companies along the value chain. Analysis of management sustainability reports.

Requirements:

- for a signature
Attendance at **lectures** is recommended, but not compulsory.

- for a grade
The course ends in a written **examination**.

The minimum requirement for the examination is 60%. Based on the score of the examination the grade is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the examination is below 60, students can take a retake exam in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS

Person responsible for course: Dr. Antal Udvardy, assistant professor, PhD

Lecturer: Dr. Antal Udvardy, assistant professor, PhD

(5.) **Title of Course**: **Pharmaceuticaland fine chemistry-technologies** **Code**: TTKME4304_EN	**ECTS Credit points: 3**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: 1 hours/week
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28
- practice: 14
- laboratory:
- home assignment: 14
- preparation for the exam: 40

Total: 96

Year, semester: 2nd year (spring)

Prerequisite(s):

Topics of course

- The history of the organic chemical industry.
- Industrial sources and uses of the BTX fraction.
- Use of asymmetric synthesis in drug chemistry.
- Fermentation and enzymatic industrial processes.
- Biorefinery
- Organometallic reagents and their applications.
- Preparation and interconversion of functional groups.

Literature

Compulsory:

lecture slides

Recommended:

1. Harold A. Wittcoff, Bryan G. Reuben; Jeffrey S. Plotkin; Industrial Organic Chemicals, 3rd edition; Wiley, 2013
2. Birgit Kamm, Patrick R. Gruber, Michael Kamm; Biorefineries: Industrial Processes and Products: Status Quo and Future Directions. Wiley, 2010
3. Ramesh N. Patel: Synthesis of chiral pharmaceutical intermediates by biocatalysis, Coord. Chem. Rev. 2008, 252, 659–701.
4. Uwe. T. Bornscheuer, Gjalt W. Huisman, Romas J. Kazlauskas, S. Lutz, J. C. Moore, K. Robins: Engineering the third wave of biocatalysis, Nature, 2012, 485, 185–194.
5. Guo-Qiang Lin, Yue-Ming Li, Albert S. C. Chan: Principles and Applications of Asymmetric Synthesis, Wiley, 2001.
6. Spessard, G.O., Miessler, G.L.; Organometallic Chemistry, 3rd edition Oxford University Press, 2015
7. de Meijere, A., Bräse, S., Oestreich, M.; Metal Catalyzed Cross-Coupling Reactions and More, 1st edition, Wiley-VCH, 2014
8. McMurry, J.; Organic Chemistry, 8th edition, Brooks Cole, 2011
9. Smith, J.G.; Organic Chemistry, 3rd edition, McGrow-Hill, 2011

Course objective/intended learning outcomes

a) Knowledge

- She/he knows the sources, applications and technologies of the most important aromatic raw materials.
- She/he knows the possibility of asymmetric chemical transformations in pharmaceutical chemistry, enzymatic and fermentation processes.
- She/he knows the processes of producing biomass-derived compounds.
- She/he is familiar with the possibilities of synthesis and applicatiosn of organometallic reagents as well as the possibilities of synthesis and interconversion the most important organic functional groups.
- He/she is well informed about modern synthetic methods, particularly about green catalytic processes.

b) Abilities

- She/he knows and is able to apply his/her knowledge to solve simple tasks on the field of pharmaceutical and fine chemistry.
- He/she is able to process, organize, comprehensively analyse and draw conclusions from information collected through the operation of industrial chemical processes.
- Be able to participate in the professional communication on the production, reactivity and the practical application of the learned compounds.
- She/he is able to expand and/or develop her/his knowledge from pharmaceutical and fin chemical technology.

c) Attitude

- He/she is open to getting new, scientifically proven knowledge on the subject, but to reject unsubstantiated or possibly misleading claims
- He/she takes an open approach to professional trainings in accordance with his/her ambitions.

d) Autonomy and responsibility

- He/she is able to independently perform the tasks of the course with professional guidance, and he/she can interpret and evaluate of the results obtained.
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week

An overview of the historical background of the organic chemical industry: artificial textile dyes, explosives, rubber, artificial rubber, cellulose and synthetic fibers, polymers, silicone-based plastics, petroleum, petroleum refining, naphtha.

2nd week

Aromatic hydrocarbons (benzene, toluene, ethylbenzene and o-m-, p-xylene): industrial sources and technologies; methods for recovering condensed aromatic hydrocarbons (naphthalene, anthracene, etc.).

3rd week

Industrial transformation of aromatic hydrocarbons: hydrodealkylation and disproportion of toluene; isomerization of m-xylene. Benzene as the most important aromatic raw material: ethylbenzene; styrene; cumene; production of cyclohexane.

4th week

Industrial synthetic methods and use of phenol. Other aromatic compounds: nitrobenzene, aniline. Synthesis and use of diisocyanates. Oxidation products of xylene and naphthalene: phthalic acid, isophthalic acid, terephthalic acid and their derivatives.

5th week

The importance of chirality in the pharmaceutical industry: basic concepts of stereochemistry, types of stereoisomerism. Review of chiral starting materials (amino acids, hydroxy acids, alkaloids, terpenes, carbohydrates). Functional group modifications provide chiral starting and auxiliary substances, enantiomerically pure / enantiomeric enriched target compounds without generating a new stereogenic unit. Principles of asymmetric synthesis, Cram Rule, Prelog Rule. Types of asymmetric syntheses include first generation (substrate-controlled), second-generation (excipient-controlled), third-generation (reagent-controlled), and fourth generation (catalyst-controlled) techniques. Multiple stereodifferentiation.

6th week

Enantioselective oxidation and reduction, concept and types of kinetic asymmetric transformations. Kinetic resolution. Enzyme catalyzed kinetic resolution. Asymmetric decompositions. Enanthioselective organocatalytic reactions, Stereoselective synthesis of chiral drugs, Fluorinated chiral drugs.

7th week

Fermentation methods in the synthesis of drugs. Differences between synthetic and fermentation drug production. The main steps of industrial fermentation. Basic metrics, reactor properties, and the ability to modify these parameters to determine the fermentation process.

8th week

Describing the economic and environmental benefits of enzymatic processes in some large-scale chemical processes (acrylamide production, polymer production). Use of enzymes in various industries (eg food industry, perfumes, cosmetics, detergents, production of pesticides). Advantages of enzymatic reactions against appropriate synthetic processes (milder reaction conditions, chemoagio and enantioselectivity). Comparing enzyme catalysis and chemical catalysis through examples. Enzyme types and reaction types important for the fine chemicals and pharmaceutical industries, the selectivity of enzymes. Demonstration of enzymatic reaction parameters as limiting factors through industrial examples. The market for enzymes used in industrial biocatalysis.

9th week

Biorefinery. Extraction and transformation of major carbohydrate components (sucrose, starch, cellulose, hemicellulose) of plant biomass into valuable chemical components or fuel. Pre-treatment of biomass (physical, chemical, biological, physicochemical), biorefinary of lignocelluloses.

10th week

Hydrolysis of polysaccharides (cellulose, hemicellulose) derived from biomass: acidic and enzymatic hydrolysis. Transformation of monosaccharides (glucose, mannose, xylose, arabinose, etc.) by chemical synthesis and fermentation into a value-added compound (methanol, ethanol, furfural and derivatives, hydroxymethylfurfural, levulinic acid, succinic acid, lactic acid, sorbitol, etc.).

11th week

Organometallic compounds I: Characterization of carbon-metal bond; Synthesis of organometallic compounds; direct metalliation of aromatic and heteroaromatic compounds. Preparation and use of lithium and magnesium organic reagents.

12th week

Organometallic compounds II: Transition-metal-catalyzed C-C bond formation reactions: coupling and cross-coupling reactions (types, comparisons: catalysts, ligands, functional group tolerance, etc.). C-H activation; use of coupling reactions in the manufacture of pharmaceuticals and pesticides (with examples).

13th week

Synthesic methods in pharmaceutical chemistry I.: (each transformation will be illustrated by specific pharmaceutical examples): Conversion of functional groups. Alkylation, acylation reactions (O-, N-, S-alkylations, acylations). C-alkylation and acylation reactions. Formation of a C-X bond (X: F; Cl; Br; I). Functionalization of aromatic compounds: acylation, alkylation, nitration, sulfonation.

14th week

Synthesic methods in pharmaceutical chemistry II.: Preparation of oxo compounds and use of their condensation reactions to form the C = C bond. Methods for preparing carboxylic acids and their derivatives include esterification, amination, interconversion of carboxylic acid derivatives. Oxidation methods in pharmaceutical chemistry: epoxidation, sulfoxidation, selective oxidation of alcohols. Reduction, selective reduction of carbon-carbon multiple bonds, nitro and oxo compounds, acid derivatives.

Person responsible for course: László Juhász, PhD, dr. habil, associate professor

Lecturers:
Éva Juhász-Tóth, PhD, assistant professor
László Juhász, PhD, dr. habil, associate professo
Dr. Máté Kicsák Assistant Professor

(1.) Title of Course: MSc Thesis I. (pharmaceutical) Code: TTKML4001_EN	ECTS Credit points: 15
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: - - practice: - - laboratory: 11 hours/week	
Evaluation (exam. / practice. / other): **practical grade**	
Workload (estimated), divided into contact hours: - lecture: - - practice: - - laboratory: 165 hours - home assignment: 285 hours - preparation for the exam: - Total: 450 hours	
Year, semester: 2nd year (fall)	
Prerequisite(s):	
Topics of course	
The purpose of the diploma work is to demonstrate that the graduate is prepared to perform independent chemical work. Thus, the diploma work is based on pharmaceutical industrial research performed by the graduate under the supervision of a senior staff member from the university or one of its pharmaceutical industrial partners. The corresponding thesis should include a literature survey, a detailed description of the experimental methods used, the results of the experiments and a thorough discussion of the data. The length of the thesis is 35 – 45 pages and it is evaluated by an independent reviewer who proposes a mark. The final mark is given by the final exam committee.	
Literature	
Literature is given by the supervisor. In most cases students need to find additional literature for their own project on the internet or in the library.	
Course objective/intended learning outcomes	
a) Knowledge - He/She knows the types, technical properties and economical roles of applied technologies - He/she knows the quality management methods in the chemical industry. **b) Abilities** - She/he knows and is able to apply his/her knowledge to solve complex tasks on the field of petrochemical industry. - He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary. - Be able to participate in the professional communication on the production, reactivity and the practical application of the learned techniques. **c) Attitude** - He/she is open to learn and accept professional, scientific and technological improvements and innovation in his/her profession and to refuse unscientific approaches. - He/she strives to plan and execute tasks alone or in a work team at a high professional level. **d) Autonomy and responsibility** - He/She is well aware about his/her propositions and its consequences.	

- He/she considers the principle and application of equal access opportunities, as well. - He/She is responsible for his/her own decisions, stand in for these decisions and ideologies.
Schedule: Students need to discuss it with their supervisors individually.
Requirements: *- for a signature* The student have to take part in the research project coordinated by the supervisor. *- for a grade* The work of the student is evaluated by the supervisor considering many aspects, e.g. the quality of the work in the laboratory or industry, the ability to work alone or in a team, the competence for process the literature about the given topic, the problem solving ability and the presentation of the results.
Person responsible for course: Prof. Dr. Tibor Kurtán, University Professor DSc, habil
Lecturer: supervisors are staff members of the Institute of Chemistry at University of Debrecen or specialists at the cooperating industrial partners (e.g. TEVA Pharmaceutical, Richter Gedeon), however in this case a co-supervisor from the Institute of Chemistry continously verifies the work.

(2.) Title of Course: MSc Thesis II (pharmaceutical) Code: TTKML4002_EN	ECTS Credit points: 15
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: - - practice: - - laboratory: 11 hours/week	
Evaluation (exam. / practice. / other): **practical grade**	
Workload (estimated), divided into contact hours: - lecture: - - practice: - - laboratory: 165 hours - home assignment: 285 hours - preparation for the exam: - Total: 450 hours	
Year, semester: 2nd year (spring)	
Prerequisite(s):TTKML4001-EN	
Topics of course	
The purpose of the diploma work is to demonstrate that the graduate is prepared to perform independent chemical work. Thus, the diploma work is based on pharmaceutical industrial research performed by the graduate under the supervision of a senior staff member from the university or one of its pharmaceutical industrial partners. The corresponding thesis should include a literature survey, a detailed description of the experimental methods used, the results of the experiments and a thorough discussion of the data. The length of the thesis is 35 – 45 pages and it is evaluated by an independent reviewer who proposes a mark. The final mark is given by the final exam committee.	
Literature	
Literature is given by the supervisor. In most cases students need to find additional literature for their own project on the internet or in the library.	
Course objective/intended learning outcomes	
a) Knowledge - He/She knows the types, technical properties and economical roles of applied technologies - He/she knows the quality management methods in the chemical industry. **b) Abilities** - She/he knows and is able to apply his/her knowledge to solve complex tasks on the field of petrochemical industry. - He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary. - Be able to participate in the professional communication on the production, reactivity and the practical application of the learned techniques. **c) Attitude** - He/she is open to learn and accept professional, scientific and technological improvements and innovation in his/her profession and to refuse unscientific approaches. - He/she strives to plan and execute tasks alone or in a work team at a high professional level. **d) Autonomy and responsibility** - He/She is well aware about his/her propositions and its consequences.	

- He/she considers the principle and application of equal access opportunities, as well. - He/She is responsible for his/her own decisions, stand in for these decisions and ideologies.
Schedule: Students need to discuss it with their supervisors individually.
Requirements: *- for a signature* The student have to take part in the research project coordinated by the supervisor. *- for a grade* The work of the student is evaluated by the supervisor considering many aspects, e.g. the quality of the work in the laboratory or industry, the ability to work alone or in a team, the competence for process the literature about the given topic, the problem solving ability and the presentation of the results.
Person responsible for course: Prof. Dr. Tibor Kurtán, University Professor DSc, habil
Lecturer: supervisors are staff members of the Institute of Chemistry at University of Debrecen or specialists at the cooperating industrial partners (e.g. TEVA Pharmaceutical, Richter Gedeon), however in this case a co-supervisor from the Institute of Chemistry continously verifies the work.

PLASTIC INDUSTRIAL AND PETROCHEMICAL SPECIALISATION

Knowledge: **Plastic industrial**

Credit range *(max. 12 cr.): **12***

Subjects:
1) Plastics processing technologies
2) Plastics processing technologies
3) Plastic-industry project I.
4) Plastic-industry project II.*

(1.) Title of Course: **Plastics processing technologies** **Code**: TTKME4610_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Year, semester: 2nd year (fall)	
Prerequisite(s):	
Topics of course	
The basics of the processing of different plastics. Classification of plastic types. Mixing and homogenization of plastics. Theory of extrusion, technological aspects. Extrusion of different product types (rod, tube, sheet, hollow bodies). Calendering, tube blowing, dry melt and wet spinning. Technology of injection molding. Compression molding. Thermoforming technologies (stretching, deep-drawing, pressure and vacuum forming). Forming methods without pressure (casting, die casting, centrifugal casting, rotational molding, dip-coating). Plastic coatings. Plastic foams, foaming. Basics of composites. Fixation of plastic components: adhesive bonding, screwing, welding, clamp joint. Liquid resin processes. Decorating and finishing.	
Literature	
Compulsory: - A.B. Strong: Plastics: Materials and Processing (Prentice Hall, 2006) ISBN: 9780131145580 - C.A. Harper: Handbook of Plastic Processes (Wiley, 2005) ISBN: 9780471662556 *Recommended:* - Z. Tadmor, C.G. Gogos: Principles of Polymer Processing (Wiley, 2006), ISBN: 0471387703	
Course objective/intended learning outcomes	
a) Knowledge: - Students acquire a deeper knowledge of technology problems in plastics and their solutions. - He/she thoroughly knows the properties of the most important industrial chemicals, their production and application. **b) Ability:** - Ability to understand system level, interpret basic plastics technology and be able to use the knowledge of the area. - He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.	

- It is able to engage in professional communication from the above area and their practical application.
- Ability to expand the knowledge of the plastics industry at basic level for new tasks and Improve.

c) Attitude:

- Open to get new knowledge about this topic. For accurate measurement and for accident protection, and to comply with the rules of safety technology, and it also shows an example of its own work.
- He/she checks for possibilities of setting research, development and innovation goals, and efforts to achieve them; committed to enrich the scientific field by up-to-date knowledge, scientific and technical results.

d) Autonomy and Responsibility:

- In addition to professional management, it can carry out larger tasks independently. Capable of basic plastics industry to perform and evaluate standard measurements. Make autonomous decisions.
- He/she has responsibility for sustainability, and environmental protection.

Schedule:

1st week

The basics of the processing of different plastics. Classification of plastic types.

2nd week

Mixing and homogenization of plastics.

3rd week

Theory of extrusion, technological aspects. Extrusion of different product types (rod, tube, sheet, hollow bodies).

4th week

Calandering, tube blowing, dry melt and wet spinning.

5th week

Technology of injection molding. Available plastics, formed products.

6th week

Compression molding with pressure or vacuum. Available plastics, formed products.

7th week

Thermoforming technologies (stretching, deep-drawing, pressure and vacuum forming).

8th week

Forming methods without pressure (casting, die casting, centrifugal casting, rotational molding, dip-coating).

9th week

Plastic coatings on different materials: metals, glass, plastics.

10th week

Plastic foams, foaming. Foaming agents and methods.

11th week

Basics of composites. Reinforcing fiber types, physico-chemical background.

12th week

Fixation of plastic components: adhesive bonding, screwing, welding, clamp joint.

13th week

Liquid resin processes.

14th week

Decorating and finishing

Requirements:

- for a signature

Attendance at **lectures** is recommended, but
not compulsory. Active participation is rewarded by the teacher in every class.
Students have to **submit an essay** about a given topic as scheduled minimum on a sufficient level.

During the semester there is one end-term test in the 15th week for an offered grade (optional). Students have to sit for the tests.

- for a grade

The course ends in an **examination**. Based on the average of the grades of the essay and the examination, the exam grade is calculated as an average of them:

The minimum requirement for the end-term test and the examination respectively is 50%. Based on the score of the test, the grade for the test and the examination is given according to the following table:

Score	Grade
0-49	fail (1)
50-61	pass (2)
62-74	satisfactory (3)
75-87	good (4)
88-100	excellent (5)

If the score the test is below 50, students can take a retake test in conformity with the Education and Examination Rules and Regulations.

-an offered grade:

it may be offered for students if the grade of both the essay and the end-term test is at least satisfactory (3). The offered grade is the average of them.

Person responsible for course: Prof. Dr. Sándor Kéki, University Professor DSc, habil

Lecturer: Prof. Dr. Sándor Kéki, University Professor DSc, habil

(2.) Title of Course: **Plastics processing technologies** **Code**: TTKML4610_EN	**ECTS Credit points: 4**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: -
- practice: -
- laboratory: 4 hours/week

Evaluation (exam. / practice. / other): **practical grade**

Workload (estimated), divided into contact hours:
- lecture: -
- practice: -
- laboratory: 56 hours
- home assignment: 64 hours
- preparation for the exam: -

Total: 120 hours

Year, semester: 2nd year (fall)

Prerequisite(s):

Topics of course

Extrusion of polymers. Determination of mechanical properties of plastics based on tensile tests. Dissolution tests. Foil extrusion of different polymer types. Impact resistance test of plastic films by the free-falling dart method. Determination of melt flow index (MFI) values. Measurement of the K value of PVC powders. Investigation of the polimer degradation by the measurement of volatile compounds.

Literature

Compulsory:
- A.B. Strong: Plastics: Materials and Processing (Prentice Hall, 2006) ISBN: 9780131145580
- C.A. Harper: Handbook of Plastic Processes (Wiley, 2005) ISBN: 9780471662556

Recommended:
- Z. Tadmor, C.G. Gogos: Principles of Polymer Processing (Wiley, 2006), ISBN: 0471387703

Course objective/intended learning outcomes

a) Knowledge:
- Students acquire a deeper knowledge of technology problems in plastics and their solutions.
- He/she thoroughly knows the properties of the most important industrial chemicals, their production and application.

b) Ability:
- Ability to understand system level, interpret basic plastics technology and be able to use the knowledge of the area.
- He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.
- It is able to engage in professional communication from the above area and their practical application.
- Ability to expand the knowledge of the plastics industry at basic level for new tasks and Improve**.**

c) Attitude:
- Open to get new knowledge about this topic. For accurate measurement and for accident protection, and to comply with the rules of safety technology, and it also shows an example of its own work.

- He/she checks for possibilities of setting research, development and innovation goals, and efforts to achieve them; committed to enrich the scientific field by up-to-date knowledge, scientific and technical results.

d) Autonomy and Responsibility:

- In addition to professional management, it can carry out larger tasks independently. Capable of basic plastics industry to perform and evaluate standard measurements. Make autonomous decisions**.**
- He/she has responsibility for sustainability, and environmental protection.

Schedule:

Practices are organized in 7-weeks blocks in the first or second part of the semester.

1st week

Extrusion of polymers.

2nd week

Determination of mechanical properties of plastics based on tensile tests.

3rd week

Dissolution tests. Investigation of the polimer degradation by the measurement of volatile compounds.

4th week

Foil extrusion of different polymer types.

5th week

Impact resistance test of plastic films by the free-falling dart method.

6th week

Determination of melt flow index (MFI) values.

7th week

Measurement of the K value of PVC powders.

Requirements:

- for a signature

Participation at **practice classes** is compulsory. A student must attend the practice classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. A student can’t make up any practice with another group. Attendance at practice classes will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student’s behaviour or conduct doesn’t meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

During the semester there is one test, the end-term test in the 8th week. Students have to sit for the tests.

- for a grade

The course ends with signature and mark. The mark is based on the result of the test scored according to pre-set maximum points for each sub-problems.

The minimum requirement for the mark is 60%, based on the score of the tests separately, the grade for the tests is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Person responsible for course: Prof. Dr. Sándor Kéki, University Professor DSc, habil
Lecturer: Prof. Dr. Sándor Kéki, University Professor DSc, habil

(3.) Title of Course: Plastics industry project I. Code: TTKML4611_EN	ECTS Credit points: 3

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: -
- practice: -
- laboratory: 4 hours/week

Evaluation (exam. / practice. / other): **term grade**

Workload (estimated), divided into contact hours:
- lecture: -
- practice: -
- laboratory: 60 hours
- home assignment: 30 hours
- preparation for the exam: -

Total: 90 hours

Year, semester: 1st year (spring)

Prerequisite(s):

Topics of course

The student need to solve problems related to the petrochemical or plastic industry. It can be a literature search, a measurement or an analytical/synthetical research project. Topics are given by researchers or industries operating on petrochemical or plastic industry field, therefore topics are different for each student in each semester. Most important partners of the University of Debrecen are MOL Petrochemistry and BorsodChem, they provide most of the topics and supervisors.

Literature

Literature is given by the supervisor of the topic for each student. It can be a technological or operational guide, a textbook or a scientific paper. In many cases students need to find literature for their own project on the internet or in the library.

Course objective/intended learning outcomes

a) Knowledge:
- He knows the conditions of safe work in the laboratory and in the field of working plant. He knows the principle of individual measurements and the possibilities of practical implementation both in the laboratory and in the plant. You are aware of the technical solutions to increase the accuracy of the measurements.
- He/she is well informed about modern synthetic methods, particularly about green catalytic processes.
- He/she has an insight into the main industrial processes and technologies within the scope of his/ her expertise.

b) Ability:
- Able system level to see through, interpret basic mechanical measurements and can use knowledge of this area. It can also solve industrial problems.
- It is able to engage in professional communication from the above area and their practical application.
- He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.
- Ability to expand/enhance knowledge of plastics ' properties at basic level for new tasks.

c) Attitude:

- Open to get new knowledge about this topic. He asks his colleagues for accurate measurement and compliance with the rules of accident protection and safety technology, as well as an example of his own work. - As a leader he/she makes important decisions considering the opinions and arguments of colleagues. **d) Autonomy and Responsibility:** - In addition to professional management, it can perform chemical and technical tasks independently. It can perform basic measurements for standard performance and evaluation. You understand the language of the standards. - He/she considers the principle and application of equal access opportunities, as well.
Schedule: Students need to discuss it with their supervisors individually
Requirements: The supervisor considers the grade based on the value of the student's work, the attitude and diligence during the literature search, a measurement or working on an analytical/synthetical research project.
Person responsible for course: Prof. Dr. Sándor Kéki, University Professor DSc, habil
Lecturer: supervisors are staff members of the Institute of Chemistry at University of Debrecen or specialists at the cooperating industrial partners (e.g. MOL Petrochemistry, BorsodChem), however in this case a co-supervisor from the Institute of Chemistry continously verifies the work.

(4.) Title of Course: Plastics industry project II. Code: TTKML4612_EN	ECTS Credit points: 3

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: -
- practice: -
- laboratory: 4 hours/week

Evaluation (exam. / practice. / other): **term grade**

Workload (estimated), divided into contact hours:
- lecture: -
- practice: -
- laboratory: 60 hours
- home assignment: 30 hours
- preparation for the exam: -

Total: 90 hours

Year, semester: 2nd year (fall)

Prerequisite(s):TTKML4611_EN

Topics of course

The student need to solve problems related to the petrochemical or plastic industry. It can be a literature search, a measurement or an analytical/synthetical research project. Topics are given by researchers or industries operating on petrochemical or plastic industry field, therefore topics are different for each student in each semester. Most important partners of the University of Debrecen are MOL Petrochemistry and BorsodChem, they provide most of the topics and supervisors.

Literature

Literature is given by the supervisor of the topic for each student. It can be a technological or operational guide, a textbook or a scientific paper. In many cases students need to find literature for their own project on the internet or in the library.

Course objective/intended learning outcomes

a) Knowledge:
- He knows the conditions of safe work in the laboratory and in the field of working plant. He knows the principle of individual measurements and the possibilities of practical implementation both in the laboratory and in the plant. You are aware of the technical solutions to increase the accuracy of the measurements.
- He/she is well informed about modern synthetic methods, particularly about green catalytic processes.
- He/she has an insight into the main industrial processes and technologies within the scope of his/ her expertise.

b) Ability:
- Able system level to see through, interpret basic mechanical measurements and can use knowledge of this area. It can also solve industrial problems.
- It is able to engage in professional communication from the above area and their practical application.
- He/she is able to apply integrated approach in the development, control and design of chemical technological processes and systems, and in the related research.
- Ability to expand/enhance knowledge of plastics ' properties at basic level for new tasks.

c) Attitude:

- Open to get new knowledge about this topic. He asks his colleagues for accurate measurement and compliance with the rules of accident protection and safety technology, as well as an example of his own work.
- As a leader he/she makes important decisions considering the opinions and arguments of colleagues.

d) Autonomy and Responsibility:

- In addition to professional management, it can perform chemical and technical tasks independently. It can perform basic measurements for standard performance and evaluation. You understand the language of the standards.
- He/she considers the principle and application of equal access opportunities, as well.

Schedule: Students need to discuss it with their supervisors individually

Requirements: The supervisor considers the grade based on the value of the student's work, the attitude and diligence during the literature search, a measurement or working on an analytical/synthetical research project.

Person responsible for course: Prof. Dr. Sándor Kéki, University Professor DSc, habil

Lecturer: supervisors are staff members of the Institute of Chemistry at University of Debrecen or specialists at the cooperating industrial partners (e.g. MOL Petrochemistry, BorsodChem), however in this case a co-supervisor from the Institute of Chemistry continously verifies the work.

Knowledge: **Applied material science**

Credit range: *(max. 12 cr.):* ***11***

Subjects: **1) Instrumental and material analysis**

2) Materials science

3) Modern petrochemistry

(1.) Title of Course: **Instrumental and material analysis** **Code**: TTKME4502_EN	**ECTS Credit points: 2**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory:-	
Evaluation (exam. / practice. / other): **examination**	
Workload (estimated), divided into contact hours: - lecture: 48 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 42 Total: 90 hours	
Year, semester: 1st year (spring)	
Prerequisite(s):	

Topics of course

The course surveys the history, methods, theories, fundamentals and some practical aspects of analysis of several instrumental analytical methods and techniques. Important additional topics are the sampling, electrophoresis, atomic spectrometry, sensors, immunoanalysis, labelling methods, thermal analysis, polarography. The course is connected to some topics of the Instrumental Analysis laboratory practices and complete the knowledge acquired in BSc level.

Literature

Daniel C. Harris: Quantitative Chemical Analysis, 7th Ed., 2007, Freeman and CoH.H.
Willard, L.L. Merritt, J.A. Dean, F.A. Settle: Instrumental methods of Analysis, Wadsworth Publ. Co., Belmont, 1988.
Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch: Fundamentals of Analytical Chemistry, 8th. ed., 2004, Brooks/Cole

Course objective/intended learning outcomes

a) Knowledge

- He/she fundamentally knows principles and means of instrumental analysis, sample pretreatment, data evaluation and validation of the measurements.
- He/she expansively knows the operating principles of the instrumental analysis, auxiliary devices.
- He/she knows the most recent results and approaches of technological development.

b) Abilities

- He/she is able to apply the most important terminology, theories, procedures of the given instrumental analysis field when completing the relevant tasks.
- He/she is able to find solutions for the analytical problems.
- He/she is able to solve problems of quality management, metrology and process control in the chemical industry and chemical technological systems.
- He/she is prepared for the administration of technological activities, as well as for cooperation in teamwork in the chemical industry and other professional fields.

c) Attitude

- He/she is open to learn and accept professional, analytical improvement and innovation in his/her profession and convey it genuinely.
- He/she checks for possibilities of setting research, development and innovation goals, and efforts to achieve them; committed to enrich the scientific field by up-to-date knowledge, scientific and technical results.
- He/she makes a decision in complex and unexpected decision cases by completely taking into account legal and ethical norms.

d) Autonomy and responsibility

- Under supervision he/she is responsible in collaboration with other professionals (especially from the field of analytical and environmental economy and safety).
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.
- He/she confesses and represents the value system of the instrumental analytical profession with responsibility. He/she is open to critical remarks which are professionally well-founded.

Schedule:

1st week:

Quality ensurance, validation parameters, evaluation methods (2h)

2nd week:

Sampling, storing samples (2h)

3rd week:

Sample pretreatment methods (2h)

4th week:

Atomic emission methods. ICP-AES. Laser ablation sample introduction. ICP-MS. Graphite furnace atomic absorption methods. Background correction methods (2h)

5th week:

Labelling analytical methods. Immunoanalysis. ELISA (2h)

6th week:

Ion exchange chromatography. Ion chromatography. Supercrtitical fluid chromatography. (2h)

7th week:

Gel electrophoresis. Capillary electrophoresis. Electroosmosis. Detection on gels. (2h)

8h week:

Microfluidic application in analytical chemistry. Lab-on-a-chip. Bioanalyzer 2100 (2h)

9th week:

Characterization and classification of sensors. Electrochemical and semiconductive sensors (2h)

10th week:

Attenuated total reflexion spectrometry. Surface plasmon resonance spectroscopy. Molecularly imprinted polymers and their analytical applications. (2h)

11th week:

Fundamentals and instrumentation of polarography. Methods of polarography. Cyclic voltammetry. Inverse voltammetry. Bipotentiometry. (2h)

12th week:
Continuous analysis. Kinetic analytical methods. (2h)
13th week:
Methods of the thermal analysis (TG, DTG, DTA, DSC) (2h)
14th week:
Consultations. Survey and classification of the analytical methods. (2h)

Requirements:
Attendance at lectures is recommended, but not compulsory.
The course ends in an examination (written test).
The minimum requirement for the examination is 50%. Based on the score of the test, the grade is given according to the following table:

Score	Grade
0-50	fail (1)
50-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

Person responsible for course: Dr. Attila Gáspár, University Professor DSc, habil

Lecturer: Dr. István Fábián, University Professor DSc, habil

Title of course: Instrumental analysis II **Code**: TTKML4502_EN	**ECTS Credit points:** 4
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: - - practice: - - laboratory: 4 hours/week	
Evaluation: practice grade	
Workload (estimated), divided into contact hours: - lecture: - - practice: 56 hours - laboratory: - - home assignment: 36 hours - preparation for the exam: Total: 92 hours	
Year, semester: 1st year, 1st semester	
Its prerequisite(s):	
Further courses built on it:	

Topics of course

The series of laboratory practices are based on the topics of different intsrumental analysis like electrophoresis, atomic spectrometry, electroanalysis, validation, ion chromatography, circular dichroism. The instrumental laboratories are connected to the topics of the Instrumental Analysis lecture and the those complete the knowledge acquired in BSc level.

Literature

1. Daniel C. Harris: Quantitative Chemical Analysis, 7th Ed., 2007, Freeman and CoH.H.
2. Willard, L.L. Merritt, J.A. Dean, F.A. Settle: Instrumental methods of Analysis, Wadsworth Publ. Co., Belmont, 1988.
3. Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch: Fundamentals of Analytical Chemistry, 8th. ed., 2004, Brooks/Cole
4. Syllabuses provided by the tutor.

Course objective/intended learning outcomes

a) Knowledge

- He/she fundamentally knows principles and means of instrumental analysis, sample pretreatment, data evaluation and validation of the measurements.
- He/she expansively knows the operating principles of the analytical instruments, auxiliary devices.

b) Abilities

- He/she is able to apply the most important terminology, theories, procedures of the given instrumental analysis field when completing the relevant tasks.
- He/she is able to find solutions for the analytical problems.

c) Attitude

- He/she is open to learn and accept professional, analytical improvement and innovation in his/her profession and convey it genuinely.

- He/she makes a decision in complex and unexpected decision cases by completely taking into account legal and ethical norms.

d) Autonomy and responsibility

- Under supervision he/she is responsible in collaboration with other professionals (especially from the field of analytical and environmental economy and safety).
- He/she confesses and represents the value system of the instrumental analytical profession with responsibility. He/she is open to critical remarks which are professionally well-founded.

Schedule:

1st week:

Introductory guidance, accident protection (4h)

2nd week:

Capillary electrophoresis (6h)

3rd week:

Graphite furnace atomic absorption spectrometry (6h)

4th week:

Cyclic voltammetry (6h)

5th week:

Validation of analytical methods (8h)

6th week:

Circular dicroism spectroscopy (6h)

7th week:

Ion chromatography (6h)

8th week:

Gas chromatography- mass spectrometry (6h)

9h week:

High performance liquid chromatography II (6h)

9h week:

Final test (2h)

Requirements:

- for a signature

Participation at practices is compulsory. A student must attend every practices during the semester. Attendance at practices will be recorded by the practice leader. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented. Missed practice classes should be made up for at a later date, to be discussed with the tutor. Active participation is evaluated by the teacher in every class. If a student's behavior or conduct doesn't meet the requirements of active participation, the teacher may evaluate his/her participation as an absence because of the lack of active participation in class.

- for a grade

Grading is given by the average of 3 separate grades:

- the average grade of the short tests written at the beginning of the instrumental analysis lab practices (an average of at least 2.0 is necessary to avoid a 'fail' final grade)

- the average grade of evaluation of the analytical data measured by the instrument, the laboratory notebook prepared by the student and final discussion/conclusion made between the student and the supervisor at the end of the lab practice (an average of at least 2.0 is necessary to avoid a 'fail' final grade)

- the grade of the final test

The grade of the final test is calculated according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

Person responsible for course: Dr. Melinda Andrasi Assistant Professor DSc

Lecturer: Dr. István Fábián, University Professor DSc, habil

(2.) Title of Course: Material science Code: TTKME4608_EN	ECTS Credit points: 2

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: -
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment: 12 hours
- preparation for the exam: 20 hours

Total: 60 hours

Year, semester: 2nd year (fall)

Prerequisite(s):

Topics of course

Phase equilibriums, phase transitions. Phase diagrams. Statistical description of two-component solid solutions. Grain boundaries and boundary layers. Mutual diffusion and solid-state physics. Deformation and fracture mechanisms of solid bodies. Precipitation (nucleation and growth), spinodal decomposition. Surfacial segregation. Ordered-disordered phase transition. Domain magnetism. Shape memory alloys (martensitic phase transitions). Physico-chemical principles of the preparation of shape memory polymers, their properties and applications. Self-healing polymers.

Literature

Compulsory:
- A. Sauveur: The metallography and heat treatment of iron and steel. University Press, Cabridge, USA, 1916.
- Metallography – Handbook for Sintered Components. Höganäs AB (publ.), 2015 / 0886HOG

Recommended:
- Advances in shape memory polymers, Woodhead Publishing, 2013 ISBN:978-0-85709-852-8)
- Liu Y et al.(2007). Review of progress in shape-memory polymers. J. Mater. Chem. 17: 1543–1558.

Course objective/intended learning outcomes

a) Knowledge:
- He/shes acquires a deeper knowledge of material science problems, such as the status diagrams through the plasticity, fracture mechanisms, knowledge of the basics of technical magnetism.
- He/she has comprehensive knowledge on materials science and technology.

b) Ability:
- He/she is able to understand system level, interpret basic materials science technologies and use knowledge in this area.
- He/she is able to apply and develop methods, models and information technologies to plan, organize and operate chemical industrial systems and processes.
- He/she is able to engage in professional communication from the above area and their practical application.
- He/she is able to expand and further develop knowledge of the environmental area at basic level for new tasks.

c) Attitude:

- Open to get new knowledge about this topic. He asks his colleagues for accurate measurement and compliance with the rules of accident protection and safety technology, as well as an example of his own work.
- He/she aims to enforce all known disciplines and requirements of safety, sustainability, environmental protection and energy efficiency.

d) Autonomy and Responsibility:

- In addition to professional management, he/she can carry out larger tasks independently. He/she is able to perform and evaluate basic material science measurements in standard. Make autonomous decisions
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week

Phase equilibriums, phase transitions.

2nd week

Phase diagrams.

3rd week

Statistical description of two-component solid solutions.

4th week

Grain boundaries and boundary layers.

5th week

Mutual diffusion and solid-state physics.

6th week

Deformation and fracture mechanisms of solid bodies.

7th week

Precipitation (nucleation and growth), spinodal decomposition.

8th week

Surfacial segregation.

9th week

Ordered-disordered phase transition.

10th week

Domain magnetism.

11th week

Shape memory alloys (martensitic phase transitions).

12th week

Physico-chemical principles of the preparation of shape memory polymers, their properties and applications.

13th week

Self-healing polymers.

14th week

Influence of the microstructure on the properties of steel.

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory.

During the semester there is a written end-term test in the 14th week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points.

- for a grade

The course ends in a **written or oral examination**. Based on the result of the examination questions scored according to pre-set maximum points for each sub-questions. The type of the examination (written or oral) is the choice of the student.

The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or the examination is given according to the following table:

- Score Grade
- 0-59 fail (1)
- 60-69 pass (2)
- 70-79 satisfactory (3)
- 80-89 good (4)
- 90-100 excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

-*an offered grade:*

It may be offered for students on the basis of the result of the end-term test if the grade is at least satisfactory (3).

Person responsible for course: Prof. Dr. Sándor Kéki, University Professor DSc, habil

Lecturer: Prof. Dr. Sándor Kéki, University Professor DSc, habil

(3.) Title of Course: **Modern petrochemistry** **Code**: TTKME4609_EN	**ECTS Credit points: 3**

Classification of the subject: compulsory

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: -
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment: 12 hours
- preparation for the exam: 50 hours

Total: 90 hours

Year, semester: 2nd year (fall)

Prerequisite(s):

Topics of course

Crude Petroleum Oil. Petroleum Products and Test Methods. Processing Operations in a Petroleum Refinery. Lubricating Oil and Grease. Petrochemicals. Off Sites, Power, and Utilities. Material and Energy Balances. Heat Exchangers and Pipe-Still Furnaces. Distillation and Stripping. Extraction. Reactor Calculations. Elements of Pipeline Transfer Facilities. Instrumentation and Control in a Refinery. Plant Management and Economics.

Literature

Compulsory:
- Uttam Ray Chaudhuri: Fundamentals of Petroleum and Petrochemical Engineering, CRC Press Taylor & Francis Group, 2011.
- Harold A. Wittcoff, Bryan G. Reuben, Jeffrey S. Plotkin: Industrial Organic Chemicals, John Wiley & Sons, Inc., 2013.

Recommended:
- Ullmann's Encyclopedia of Industrial Chemistry, 6th Edition, Wiley & Sons, Inc., 2002.

Course objective/intended learning outcomes

a) Knowledge:
- He/she knows the basics of petrochemical technologies.
- He/she has comprehensive knowledge on the process control of the chemical industry and technology.
- He/she understands the processes and the significance of the technologies.
- Recognises the correlation between different technologies.

b) Ability:
- He/she is able to understand the importance of each technology and the main links to the technologies**.**
- He/she is able to participate substantially in professional communication in the context of the learned technologies
- He/she is able to utilize the complex planning and management of technical, economic, environmental and human resources in the chemical industry.
- He/she is able to expand/improve your knowledge of learned technologies

c) Attitude:

- He/she seeks to ensure that its self-training is consistent with its continuous and professional objectives in the field of chemical engineering.
- He/she strives to plan and execute tasks alone or in a work team at a high professional level.

d) Autonomy and Responsibility:

- It is necessary, if possible, to develop and introduce new professional solutions**.**
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week

Crude Petroleum Oil. Composition of Crude Oil. Physical Properties of Crude Oil. Origin of Hydrocarbons. Exploration Techniques. Resource Estimation. Oil Field Development. Well Logging. Oil Production Processes. Crude Conditioning and Storage. Transportation and Metering of Crude Oil. Gas Hydrates. Coal Bed Methane.

2nd week

Petroleum Products and Test Methods. Crude Oil Analysis. Domestic Fuels. Automotive Fuels. Aviation Fuels. Furnace Fuels. Lubricating Oils. Miscellaneous Products.

3rd week

Processing Operations in a Petroleum Refinery. Crude Oil Receiving. Desalting of Crude Oil. Distillation and Stripping. Stabilisation. Amine Absorption. De-Ethaniser. Meroxing and Caustic Wash. Liquified Petroleum Gas Splitter. Naphtha Redistillation. Naphtha Pretreatment (Nhds). Naphtha Platinum Reforming (Platforming). Kerosene Hydrodesulfurisation. Diesel Hydrodesulfurisation. Vacuum Distillation. Solvent Extraction. Propane Deasphalting. Solvent Dewaxing. Hydrofinishing. Catalytic Processes for Lube Oil Base Stock Manufacture. Hydrocracking. Mild Hydrocracking. Hydrogen Generation. Fluid Catalytic Cracking. Bitumen Blowing. Vis-Breaking. Coking.

4th week

Lubricating Oil and Grease. Components of Finished Lubricating Oils. Automotive Oils. Industrial Lubricants. Aviation Lubricants. Marine Lubricants. Greases. Lube Blending and Grease Manufacture. Environmental Impact of Lubricants. Reclamation of Used Lubricants. Power Consumption in a Blending Tank

5th week

Petrochemicals. Defintions of Petrochemicals. Naphtha Cracking. Conversion Processes for Selected Petrochemicals. Petrochemical Complex. Processing of Plastic, Rubber, and Fibre.

6th week

Off Sites, Power, and Utilities. Layout of Petroleum and Petrochemical Plants. Processing Units. Offsite Facilities. Power and Steam Generating Plant. Cooling Tower. Water Conditioning Plant

7th week

Material and Energy Balances. Measurement of Quantity of Crude Oil and Products. Measurement of Gases in Closed Vessels. Material Balance in a Plant. Energy Balance in a Plant.

8th week

Heat Exchangers and Pipe-Still Furnaces. Heat Exchangers. Theory of Heat Exchange. Fouling. Plate Type Heat Exchanger. Extended Surface Exchanger. Scraped Surface Exchanger. Heat Exchanger Train. Pipe-Still Furnace. Pipe-Still Furnace Elements. Operation of a Furnace. Draught in a Furnace. Furnace Design by Wilson, Lobo, and Hottel Method.

9th week

Distillation and Stripping. Processes of Distillation and Stripping. Batch Distillation. Boiling Point and Equilibrium Diagrams. Theory of Distillation. Continuous Distillation. McCabe-Thiele Method. Enthalpy Balance Method. Gap and Overlap. Packie’s Correlation.

10th week

Extraction. Extraction Principle. Extraction Process. Definition of Terms Related to Extraction. Phase Equilibrium in the Extraction Process. Batch Extraction. Continuous Extraction

11th week

Reactor Calculations. Reactors in Refineries and Petrochemical Plants. Reaction Stoichiometry, Mechanism, and Pathways. Rate of Reaction and Kinetic Equations. Batch, Continuous Stirred Tank Reactor, and Plug Flow Reactor Concepts. Naphtha Reformer Calculations. Calculations for a Fluidised Catalytic Cracking Reactor.

12th week

Elements of Pipeline Transfer Facilities. Pipes and Tubes. Fittings and Supports. Crude Oil Transfer Lines. Product Transfer Lines. Gas Transfer Lines. Pumps and Compressors. Power Calculations for Pumping and Compression.

13th week

Instrumentation and Control in a Refinery. Control Hardware. Control Loops. The Process Piping and Instrumentation Diagram. Control Software. Distributed Control System. The Control Room. Crude Throughput Control. Desalter Control. Atmospheric Distillation Column Control. Vacuum Distillation Control. Reformer Unit Control. Fluid Catalytic Cracking Unit Control. Fail-Safe Devices. Standard Signals in Process Control

14th week

Plant Management and Economics. Cost of Equipment. Cost of a Plant. Operating Cost. Product Cost. Profit and Product Price. Taxes and Duties. Breakeven Point, Payout Period, and Rate of Return. Linear Programming. Material Audit. Energy Audit.

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory.

During the semester there is a written end-term test in the 14th week. Students have to sit for the tests. The material of the test is the same as the exam. All questions cover several parts of the topics of the lectures and the sub-questions are scored according to the given points.

- for a grade

The course ends in a **written or oral examination**. Based on the result of the examination questions scored according to pre-set maximum points for each sub-questions. The type of the examination (written or oral) is the choice of the student.

The minimum requirement for the examination is 60%. Based on the score of the tests separately, the grade for the tests and/or the examination is given according to the following table:

- Score — Grade
- 0-59 — fail (1)
- 60-69 — pass (2)
- 70-79 — satisfactory (3)
- 80-89 — good (4)
- 90-100 — excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

-an offered grade:

It may be offered for students on the basis of the result of the end-term test if the grade is at least satisfactory (3)

Person responsible for course: Prof. Dr. Sándor Kéki, University Professor DSc, habil

Lecturer: Prof. Dr. Sándor Kéki, University Professor DSc, habil

(1.) Title of Course: **MSc Thesis I. (Petrochemical and Plastic-industri project)** **Code**: TTKML4003_EN	**ECTS Credit points: 15**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: - - practice: - - laboratory: 11 hours/week	
Evaluation (exam. / practice. / other): **practical grades**	
Workload (estimated), divided into contact hours: - lecture: - - practice: - - laboratory: 165 hours - home assignment: 285 hours - preparation for the exam: - Total: 450 hours	
Year, semester: 2nd year (fall)	
Prerequisite(s):	
Topics of course	
The purpose of the diploma work is to demonstrate that the graduate is prepared to perform independent chemical work. Thus, the diploma work is based on petrochemical or plastic-industrial research performed by the graduate under the supervision of a senior staff member from the university or one of its petrochemical and plastic-industrial partners. The corresponding thesis should include a literature survey, a detailed description of the experimental methods used, the results of the experiments and a thorough discussion of the data. The length of the thesis is 35 – 45 pages and it is evaluated by an independent reviewer who proposes a mark. The final mark is given by the final exam committee.	
Literature	
Literature is given Ay the supervisor. In most cases students need to find additional literature for their own project on the internet or in the library.	
Course objective/intended learning outcomes	
a) Knowledge - He/she knows the types, technical properties and economical roles of applied technologies - He/she knows the quality management methods in the chemical industry. **b) Abilities** - She/he knows and is able to apply his/her knowledge to solve complex tasks on the field of petrochemical industry. - He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary. - He/she is able to participate in the professional communication on the production, reactivity and the practical application of the learned techniques. **c) Attitude**	

- He/she is open to learn and accept professional, scientific and technological improvements and innovation in his/her profession and to refuse unscientific approaches.
- He/she strives to plan and execute tasks alone or in a work team at a high professional level.

d) Autonomy and responsibility

- He/she is well aware about his/her propositions and its consequences.
- He/she considers the principle and application of equal access opportunities, as well.
- He/She is responsible for his/her own decisions, stand in for these decisions and ideologies.

Schedule: Students need to discuss it with their supervisors individually

Requirements:

- *for a signature*

The student have to take part in the research project coordinated by the supervisor.

- *for a grade*

The work of the student is evaluated by the supervisor considering many aspects, e.g. the quality of the work in the laboratory or industry, the ability to work alone or in a team, the competence for process the literature about the given topic, the problem solving ability and the presentation of the results.

Person responsible for course: Prof. Dr. Sándor Kéki, University Professor DSc, habil

Lecturer: supervisors are staff members of the Institute of Chemistry at University of Debrecen or specialists at the cooperating industrial partners (e.g. MOL Petrochemicals, BorsodChem), however in this case a co-supervisor from the Institute of Chemistry continously verifies the work.

(2.) Title of Course: **MSc Thesis II. (Petrochemical and Plastic-industri project)** **Code**: TTKML4004_EN	**ECTS Credit points: 15**
Classification of the subject: compulsory	
Type of teaching, contact hours - lecture: - - practice: - - laboratory: 11 hours/week	
Evaluation (exam. / practice. / other): **practical grade**	
Workload (estimated), divided into contact hours: - lecture: - - practice: - - laboratory: 165 hours - home assignment: 285 hours - preparation for the exam: - Total: 450 hours	
Year, semester: 2nd year (spring)	
Prerequisite(s):TTKML4003_EN	
Topics of course	
The purpose of the diploma work is to demonstrate that the graduate is prepared to perform independent chemical work. Thus, the diploma work is based on petrochemical or plastic-industrial research performed by the graduate under the supervision of a senior staff member from the university or one of its petrochemical and plastic-industrial partners. The corresponding thesis should include a literature survey, a detailed description of the experimental methods used, the results of the experiments and a thorough discussion of the data. The length of the thesis is 35 – 45 pages and it is evaluated by an independent reviewer who proposes a mark. The final mark is given by the final exam committee.	
Literature	
Literature is given by the supervisor. In most cases students need to find additional literature for their own project on the internet or in the library.	
Course objective/intended learning outcomes	
a) Knowledge - He/she knows the types, technical properties and economical roles of applied technologies - He/she knows the quality management methods in the chemical industry. **b) Abilities** - She/he knows and is able to apply his/her knowledge to solve complex tasks on the field of petrochemical industry. - He/she is able to perform, evaluate and document analyses and tests in the field, and also to develop new methods, if necessary. - He/she is able to participate in the professional communication on the production, reactivity and the practical application of the learned techniques. **c) Attitude** - He/she is open to learn and accept professional, scientific and technological improvements and innovation in his/her profession and to refuse unscientific approaches.	

- He/she strives to plan and execute tasks alone or in a work team at a high professional level.

d) Autonomy and responsibility

- He/she is well aware about his/her propositions and its consequences.
- He/she considers the principle and application of equal access opportunities, as well.
- He/she is responsible for his/her own decisions, stand in for these decisions and ideologies.

Schedule: Students need to discuss it with their supervisors individually.

Requirements:

- for a signature

The student have to take part in the research project coordinated by the supervisor.

- *for a grade*

The work of the student is evaluated by the supervisor considering many aspects, e.g. the quality of the work in the laboratory or industry, the ability to work alone or in a team, the competence for process the literature about the given topic, the problem solving ability and the presentation of the results.

Person responsible for course: Prof. Dr. Sándor Kéki, University Professor DSc, habil

Lecturer: supervisors are staff members of the Institute of Chemistry at University of Debrecen or specialists at the cooperating industrial partners (e.g. MOL Petrochemicals, BorsodChem), however in this case a co-supervisor from the Institute of Chemistry continously verifies the work.

Knowlegde: Optional courses
Credit range: 6 cr

Title of Course: **Nanosystems – Colloids** **TTKME4403_EN**	**ECTS Credit points: 3**
Classification of the subject: optional course	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - laboratory:	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - laboratory: - home assignment: 40 hours - preparation for the exam: 26 hours Total: 94	
Year, semester: 1st year (spring)	
Prerequisite(s):TTKME4401_EN; TTKML4401_EN	
Topics of course	
The goal of this series of lectures is to give knowledge to the students about the relation between size, physico-chemical properties and industrial application. Students are expected to get acquainted with the behaviour of nanosized particles, the role of the interfaces and their possible applications.	
Literature	
Compulsory: - Lecture slides downloadable from the e-learning system of University of Debrecen - Barnes, GT, Gentle, IR: Interfacial Science. Oxford UP. ISBN 0-a19-a927882-a2, 2005 - Pashley, RM, Karaman, M: Applied Colloid & Surface Chemistry. Wiley&Sons, ISBN 0-a470-a86883-aX, 2004 - Cosgrove T.: Colloid science. Blackwell Publishing ISBN:978-a14051-a2673-a1, 2005 *Recommended:* - The importance of colloid chemistry in industrial practice, in Progress in Colloid & Polymer Science 111:9-16, 1998	
Course objective/intended learning outcomes	
a) Knowledge - He/She knows the main models of formation and stability of dispersed particles, thermodynamic and kinetic stability and self-asssembly. - He/she knows the design and evaluation methods of experiments. - He/She has a knowledge to solve problems on the field of industrial processes, using nanosized particles, and understanding the chemical background of living and non living nano systems. **b) Abilities** - He/She is able to use the previously obtained knowledge on the field of chemical industrial studies to solve practical problems.	

- He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning.
- He/She is able to argue on scientific problems by his/her knowledge

c) Attitude

- He/She is ready to solve problems on the field of chemical and other related industry alone or with professionals.
- He/she constantly seeks to improve professional competencies.
- He/she is able to represent his/her own personal scientific ideology toward professional and unprofessional groups.

d) Autonomy and responsibility

- He/she can make reasonable evaluations about his/her own work comparing to others to the same field.
- He/she takes individual initiatives in solving professional problems.
- He/she stands for his/her opinion in professional discussions about short or long term decisions.

Schedule:

1st week

Introduction. The notion of colloids and the classification of colloid systems. Synthesis of colloids. Relation between colloids and nanotechnology. Basics of nanotechnology. Average and types of average

2nd week

Molecular interactions. Review of knowledge on electrostatic and van der Waals interactions, their role in the synthesis of colloids. Lennard-Jones potentials. Hydrophilic and hydrophobic interactions.

3rd week

Review of notion and characterization of interfaces. Fluid interfaces. Interfacial phenomena, the theory and concept of surface tension. The Eötvös-Ramsay-Shields rule. Laplace pressure, importance of curved surfaces and connection to nanotechnology.

4th week

Nonfluid interfaces. Contact angle, wetting and spreading. Adhesion and cohesion. Adsorption at fluid interfaces, the Gibbs isotherm. Basics of coating: Langmuir and Langmuir-Blodgett layers

5th week

Adsorption at solid-liquid interfaces. Adsorption isotherms. Formation of charged interfaces and their significance. Chromatographies and environmental impacts of sorpőtion.

6th week

Review of formation of the electrostatic double layer without exzernal potential, its structure and description. Comparison of the Helmholtz, Gouy-Chapman and Stern models. Electrokinetic potentials (zeta potential) and applications in environmental and medical industry.

7th week

Electrokinetic phenomena. Electrophoretic mobility. The phenomenon of electroosmosis and its practical use in capillary electrophoresis. Application in pharmaceutical and health industry.

8th week

Stabilization and destabilization of lyophobic colloids. The Hamaker model. The DLVO theory. Sterical stabilization. Salting out. Destabilization of lyophilic colloids. The technology of butter- and cheese-making.

9th week

Gas-liquid disperse systems. Stability, preparation and importance of aerosols. Stability, preparation and practical use of foams.

10th week

Liquid-liquid disperse systems. Preparation and breaking of emulsions. Emulsifiers, the HLB value. The types and and applications of emulsions.

11th week

Solid-liquid disperse systems. Their preparation, stabilization, kinetic description of their formation. Bottom to top and top to bottom proicedures. Hydrophobic colloids in pharmaceutical industry and nanotechnology. Sol-gel technology.

12th week

Association colloids. Surface activity. Amphiphilic molecules and micelles. Micelle formation, the critical micelle concentration. Surfactants, detergents and the cleaning technologies.

13th week

Types of macromolecular colloids. Macromolecules and plastics. Drug transport and targeted drug delivery. Nanocapsulation.

14th week

Basics of rheology. Viscosity and its measurement. Viscosity- and flow curves. Basic rheological types and their application. Regulation of rheological properties of products.

Requirements:

- for a signature

Attendance at lectures is recommended, but not compulsory**.**

- for a grade

The course ends in an examination. The minimum requirement for the examination is 50%. The grade for the examination is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

If the score of any test is below 50%, students can make a retake test in conformity with the education and examination rules and regulation issued by the facoulty.

Person responsible for course: Dr. Levente Novák, assistant professor, PhD

Lecturer: Dr. István Bányai, University Professor DSc, habil

Title of course:Nuclear Analysis I. **Code**: TTKME0523_EN	**ECTS Credit points:** 3
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation: exam	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
Year, semester: 2nd year, 1st semester	
Its prerequisite(s): -	
Further courses built on it: TTKML0523_EN	

Topics of course

- Formation of nuclear, atomic and particle radiations. their interaction with matter, and analytical aspects.
- Application of natural stable and radioactive isotope in natural sciences.
- Tracer methods.
- Nuclear and radioanalytical methods using the interactions of radiation with matter.

Literature

Compulsory:

- Kónya, J., Nagy N.M., 2012, 2018. Nuclear and Radiochemistry, Elsevier, Oxford.
- Choppin, G.R., Liljenzin, J-O., Rydberg, J. Ekberg, C., 2013. Radiochemistry and Nuclear Chemistry, 4th Edition, Elsevier, Amsterdam.
- Kratz, J.-V., Lieser, K.H., 2013. Nuclear and Radiochemistry: Fundamentals and Applications, 3rd Edition, Wiley-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany,

Schedule:

1st week

Formation and production of nuclear, atomic and particle radiation.

2nd week

Interaction of nuclear, atomic and particle radiation with matter.

3rd week

Analytical methods using natural radioactivity: determination of geological and historical ages.

4th week

Separation of isotopes. Physical, chemical, geological, and biological information obtained by observing isotope separations.

5th week
Basic rules of tracer studies
6th week
Selection of tracers. Production of tracer isotopes.
7th week
Chemical radioanalytical methods: isotope dilution analysis, radiometric titration, radio gravimetry, radiochemical separation methods.
8th week
Radioanalysis in living organisms: in-vitro and in-vivo methods.
9th week
Industrial radioanalysis.
10th week
Nuclear and radioanalytical methods based on radiation-matter interactions: classification, characterization on the basis of the irradiation and emitted particles/photons.
11th week
Applications of neutrons: activation analytical methods, neutron radiography and tomography, neutrons scattering.
12th week
Application of electromagnetic radiation with high energy (gamma, X-ray): X-ray fluorescence analysis, Mössbauer spectroscopy
13th week
Application of beta and electron radiation: beta backscattering, electron microscopes and microprobes.
14th week
Application of ions: Rutherford backscattering, particles induced X-ray and gamma spectroscopy.

Requirements:
- for a signature
Attendance at **lectures** is recommended, but not compulsory.
- for a grade
The course ends in an **examination**. Based on the examination, the exam grade is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the examination is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.
-an offered grade:
It may be offered for students if they write a test on the 14th week and the score of it is at least 60%. The offered grade is calculated as the exam grade (see above).

Person responsible for course: Prof. Dr. Noémi Nagy, university professor, DSc

Lecturer: Prof. Dr. Noémi Nagy, university professor, DSc

Title of Course: Environmental risk assessment and bioremediation Code: TTKME4807_EN	ECTS Credit points: 2

Classification of the subject: optional course

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: 0
- laboratory: 0

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice:
- laboratory:
- home assignment:
- preparation for the exam: 60 hours

Total: 88 hours

Year, semester: 1st year (fall)

Prerequisite(s):

Topics of course

Possibilities of detecting and eliminating environmental damages. Physical, chemical and biological methods for treating contaminated media (water, soil, sludge). Detailed knowledge of biological methods (phytoremediation and microbiological remediation). The advantages and disadvantages of different methods. Presentation of the effectiveness of remediation on the basis of case studies.

Literature

Compulsory:
- ICSS (2006): Manual for biological remediation techniques.ICSS, Berlin. (https://www.umweltbundesamt.de/sites/default/files/medien/publikation/long/3065.pdf)
- Meuser, H. (2013): Soil Remediation and Rehabilitation. Treatment of Contaminated and Disturbed Land. Springer-Verlag, London. ISBN 978-94-007-5751-6
- Rong, Y. (2018): Fundamentals of Environmental Site Assessment and Remediation. CRC Press. ISBN 9781138105157

Recommended:
- Singh, A., Ward, O.P. (2004): Biodegradation and Bioremediation. Springer-Verlag ISBN 3-540-21101-2

Course objective/intended learning outcomes

a) Knowledge
- He/she knows the damages caused by pollution in the geological environment, surface water and groundwater.
- He/she knows about the development potential of new materials and processes together with its characteristic methods.
- He/she knows the basics of remediation methods.

b) Abilities
- He/she has the skills to identify and solve environmental problems.
- He/she is able to apply theories in practice.
- He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning.
- He/she is capable of processing and evaluating environmental data.

c) Attitude
- He/she tries for understanding problems caused by pollution best possible.
- He/she attempts to further develop their professional knowledge.

- He/she works with a systematic and process-oriented, complex approach.
- He/she is sensitive to pollution problems.
- He/she behaves in an environmentally conscious manner and tries to encourage others to do so.

d) Autonomy and responsibility

- He/she is able to work with other professionals.
- He/she takes responsibility for her/his decisions.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.
- He/she feels responsibility for the consequences of environmental problems and for solving them.

Schedule:

1st week

Survey of environmental status, exploration of environmental pollution. Methods for measuring environmental damages. Determining of changes in the ecological status of the area.

2nd week

Remediation process: fact finding, technical intervention, monitoring. Risk assessment and components. Preventing and eliminating extreme pollution by presenting a case study.

3rd week

Definition of remediation. Types of remediation methods. Physico-chemical remediation methods: isolation from the environment, hydraulic protection, aeration methods, thermal methods, adsorption, phase separation, soil washing, stabilization, electrochemical methods, ion exchange, extraction, precipitation, oxidation reduction, dehalogenation.

4th week

Biological remediation methods. In situ biological methods: reduction of pollution through natural processes, bioventing, tillage treatment, cometabolic process, intensified bioremediation, phytoremediation.

5th week

Ex situ biological methods: agrotechnical process, biobed, composting, bioreactors, use of constructed wetlands. Advantages and disadvantages of biological methods.

6th week

Types of constructed wetlands established for the treatment of contaminated waters, their characterization, advantages and disadvantages of their use. Operation of free-water and underground flow systems. Types of phytoremediation. Phytoextraction, phytofiltration, phytovolatization, phytostabilisation, phytodegradation.

7th week

Phytoremediation of pollutants: phytoremediation of metals and organic pollutants. Problems of application of phytoremediation.

8th week

Remediation using microorganisms. The basics and influencing factors of microbiological remediation procedures. Biostimulation. Bioaugmentation.

9th week

Microbiological degradation of contaminants in soil and groundwater (petroleum-derived hydrocarbons, PAH, phenols)

10th week

Decomposition of chlorinated compounds (volatile chlorinated CH, PCBs, PCDD and PCDF) and TNT. Bioremediation of metals.

11th week

Applicability and environmental risks of microbiological remediation technologies. Examining the effectiveness of biological remediation. Opportunities for developing procedures.

12th week

Aspects of choosing remediation technology, factors that influence the decision. Technological aspects and economic aspects. Technological decision scheme. *13th week* Remediation cas studies. *14th week* Pretesting.
Requirements: **-** *for a signature* Attendance at lectures is recommended, but not compulsory. - *for a grade* The course ends in an written examination. 2 (Pass) grade: 50% of the maximum points available. If the score of any test is below 50%, students can take a retake test. -*an offered grade:* There are at least two test during the semester, and the offered grade is the average of them.
Person responsible for course: Dr. Magdolna Kaszáné Kiss, assistant professor, PhD
Lecturer: Dr. Magdolna Kaszáné Kiss, assistant professor, PhD

Title of Course: **Complexes of macrocyclic ligands** **Code**: TTKME0212_EN	**ECTS Credit points: 3**

Classification of the subject: optional course

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: -
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment: 20 hours
- preparation for the exam: 40 hours

Total: 88 hours

Year, semester: 2nd year (fall)

Prerequisite(s):

Topics of course

Discovery, types, and nomenclature of macrocyclic compounds. Synthesis of macrocyclic compounds (high dilution techniques, Richman-Atkins synthesis, template synthesis, "the peptide route", zip reactions, combination of techniques). Preparation of C- and N-functionalized and substituted macrocycles, Derivatization of macrocyclic ligands. Types and production of bifunctional ligands. The complexation properties of the macrocyclic ligands (crown ethers, cryptands and functionalized, macrocycles), the structure of the complexes. Basics of supramolecular chemistry. Selectivity of the macrocyclic ligands and the macrocyclic effect. The role of the functional groups (linked to the macrocycles) in selectivity and stability of complexes. Methods applied for the studies of macrocyclic ligands and their complexes. Factors influencing the stability and selectivity of the macrocyclic ligand complexes (cavity size, quality of donor atoms, etc.). Formation and dissociation kinetics of the complexes of macrocyclic ligands. Tuning the physico-chemical properties of the macrocyclic ligand complexes (stability, selectivity, formation and dissociation kinetic parameters) by careful ligands design. Practical applications of macrocyclic ligand complexes: analytical (determination of metal ion concentration, separation / extraction of metal ions), biomedical applications (contrast agents for MRI, NMR shift reagents, diagnostic and therapeutic radiopharmaceuticals, optical imaging probes), selective complex formation (removal of toxic metal ions), organic chemistry (phase transfer catalysts, ionophores, etc.) applications.

Literature

Compulsory:

1. Melson G. A., Coordination Chemistry of Macrocyclic Compounds, Springer, **1979.**
2. Lindoy L.F., Chemistry of macrocyclic ligand complexes, Cambridge University Press, **1989.**
3. Bradshaw, J. S., Krakowiak, K. E., Izatt, R M. Aza-crown macrocycles, John Wiley and Sons, **1993.**

Recommended:

1. Gloe, K., Macrocyclic Chemistry: Current Trends and Future Perspectives, Springer, Dordrecht, The Netherlands, **2005.**
2. Dodziuk, H., Cyclodextrins and Their Complexes: Chemistry, Analytical Methods, Applications, John Wiley and sons, Weinheim, Germany, **2006.**
3. Diederich, F., Stang, P. J., Tykwinski R. R., Modern Supramolecular Chemistry, ohn Wiley and sons, Weinheim, Germany, **2008.**
4. Suchy, M. Hudson, R. H. E., *Eur. J. Org. Chem*, **2008,** *29*, 4847–4865.

5. Lattuada, L. Barge, A., Cravotto, G., Giovenzana, G. B., Tei, L., *Chem. Soc. Rev.*, **2011,** *40*, 3019-3049.

Course objective/intended learning outcomes

a) Knowledge

- He/she fundamentally knows principles and means of macrocyclic ligand design, synthesis and methods applicable for the characterization of macrocyclic ligand complexes.
- Have systematic knowledge on the subjects associated with the macrocycles and their complexes.
- He/she knows the most recent results and approaches of technological development.

b) Abilities

- He/she is able to apply the most important terminology, theories, methods, procedures of the given field when completing the relevant tasks.
- He/She is able to argue on scientific problems by his/her knowledge.
- He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning.

c) Attitude

- He/she is open to learn and accept professional, technological improvement and innovation in his/her profession and convey it genuinely.
- He/she works with a systematic and process-oriented, complex approach.
- He/she makes a decision in complex and unexpected decision cases by completely taking into account legal and ethical norms.

d) Autonomy and responsibility

- Even in unexpected decision-making situations he/she is capable of considering complex, fundamental questions from his/her professional field and elaborating them on the basis of the given sources.
- He/she confesses and represents the value system of the engineering profession with responsibility. He/she is open to critical remarks which are professionally well-founded.
- He/she has responsibility for sustainability, and environmental protection.

Schedule:

1st week

Historical aspects of macrocyclic ligands: discovery of macrocyclic ligands, history of their production. Types of macrocyclic compounds and their nomenclature.

2nd week

Comparative overview of synthetic methods used in the synthesis of macrocycles (high dilution techniques, Richman-Atkins synthesis, template synthesis, “the peptide route”, zip reaction, combination of techniques, etc.).

3rd week

Preparation of C- and N-functionalized and substituted macrocycles, derivatization of macrocycles.

4th week

Synthesis of mono-, bis-, tris- and tetra-substituted triaza and tetraaza macrocyclic ligands.

5th week

Types of bifunctional ligands, their synthesis and comparative characterization. The effect position of the reactive functional group on the major physico-chemical properties of the complexes.

6th week

The complexation properties of the macrocyclic compounds (crown ethers, cryptands and functionalized macrocycles), structure of complexes. Basics of supramolecular chemistry. Molecular legos.

7th week

Selectivity of the macrocyclic ligands and the macrocyclic effect. The role of the functional groups (linked to the macrocycles) in selectivity and stability of complexes.

8th week

Methods of studies of macrocyclic ligands and their complexes.

9th week

Factors influencing the stability and selectivity of the macrocyclic ligand complexes (cavity size, quality of donor atoms, etc.). Formation and dissociation kinetics of the complexes of macrocyclic ligands.

10th week

Tuning the physico-chemical properties of the macrocyclic ligand complexes (stability, selectivity, formation and dissociation kinetic parameters) by careful ligands design.

11th week

Practical applications of macrocyclic ligand complexes 1: analytical (determination of metal ion concentration, separation / extraction of metal ions), selective complex formation (removal of toxic metal ions), organic chemistry (phase transfer catalysts, ionophores, etc.) applications.

12th week

Practical applications of macrocyclic complexes 2: biomedical applications (MRI contrast agents, NMR shift reagents, radiopharmaceuticals, contrast media for optical imaging methods).

13th week

Application oriented design and synthesis of macrocyclic ligands and their complexes.

14th week

Student reports / presentations.

Requirements:

Attendance at lectures is recommended, but not compulsory.

The course ends in an examination (summary of a selected topic in written form and its presentation to the audience (the tutor and the students) in a form of an oral talk/conference).

The minimum requirement for the examination is 50%. Based on the score of the test, the grade is given according to the following table:

Score	Grade
0-50	fail (1)
50-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the summary or presentation (or both) is below 50%, students can take a retake the exam in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS

Person responsible for course: Dr. Gyula Tircsó University professor, PhD

Lecturer: Dr. Gyula Tircsó, University professor, PhD

Title of Course: Dangerous and special materials Code: TTKME0206_EN	ECTS Credit points: 3
Classification of the subject: optional course	
Type of teaching, contact hours - lecture: 2 hours/week - practice: 0 - laboratory: 0	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 42 hours - preparation for the exam: 20 hours Total: 90 hours	
Year, semester: 1st year (fall/spring); 2nd year (fall)	
Prerequisite(s):	
Topics of course	
The students will learn about all special and dangerous materials that were used in the history in war times as well as in the peace time. The students will learn about special classes of materials like narcotics, illicit drugs, different kinds of chemical weapons, flame materials, explosives, pheromones, and the special measurement techniques associated with them. They will learn the properties of the dangerous materials, and how to recognize them, how to avoid accidents or catastrophes. The lecture gives information on the social effects and the legal aspects of such materials.	
Literature	
Compulsory: - Lecture slides *Recommended:* - The great pheromone myth / Richard L. Doty, 2010, The Johns Hopkins University Press 2715 North Charles Street, Baltimore, Maryland, ISBN-13: 978-0-8018-9347-6 − A history of chemical warfare / Kim Coleman, 2005, Palgrave Macmillan Press, ISBN-10: 1–4039–3459–2 − Chemical warfare agents : chemistry, pharmacology, toxicology, and therapeutics / editors, James A. Romano Jr. and Brian J. Lukey. -- 2nd ed., 2008, CRC Press, Taylor & Francis, ISBN 978-1-4200-4661-8 − High Energy Materials: Propellants, Explosives and Pyrotechnics, Jai Prakash Agrawal, 2010 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 978-3-527-32610-5 − Acid Dreams. The Complete Social History of LSD: The CIA, The Sixties, and Beyond, Martin A. Lee, Bruce Shlain, Publisher: Grove Press, 1985 , ISBN: 0-802-13062-3 − Pharmacology and Abuse of Cocaine, Amphetamines, Ecstasy and Related Designer Drugs, Enno Freye, 2009, Sringer, ISBN 978-90-481-2447-3 − On Speed. The Many Lives of Amphetamine, Nicolas Rasmussen, New York University Press, ISBN-13: 978-0-8147-7601-8	
Course objective/intended learning outcomes	
a) Knowledge	

- He/She has a chemical and technical knowledge to recognize dangerous materials of several classes, and to describe the expected effects of such materials on the personal health or the environment.
- He/she knows the documentation standards of the profession.
- He/She has a knowledge to recognize and/or solve problems, or give advice on their handling, which are associated with the presence or effects of dangerous materials.
- He/She can understand and communicate professionally on subjects of special and dangerous materials in English.

b) Abilities

- He/She is able to use the previously obtained knowledge on any relation with the chemistry or effects of special and dangerous materials to solve the problems associated with their presence, or to estimate their effect or to project expected behaviour.
- He/she is capable of the safe operation of technological systems without risks to health, considering the effects on human health, and taking the necessary steps of prevention.

c) Attitude

- He/She is ready to discuss problems arising with the presence or effect or expected behaviour of dangerous materials with professionals.
- He/She is able to represent his/her own personal scientific ideology toward professional and unprofessional groups.
- He/she is committed to quality work at high standards, and efforts to transmit this approach to colleagues.

d) Autonomy and responsibility

- He/She stands for his/her opinion or ideology in professional discussions.
- He/she has responsibility for sustainability, and environmental protection.

Schedule:

1st week
Definition of drugs and narcotics. Classification of drugs. General effects, addictology, withdrawal symptoms, methods of withdrawal. Change of behaviour, social effects.

2nd week
Opium, morphine, heroine.

3rd week
Cocaine. History, preparation, production, use, effects. Narcotic plants and animals.

4th week
Cannabis, cannabinoids. Legalization questions.

5th week
Discovery of LSD, synthesis. Life of Albert Hoffmann, hippy movements, social effects. Ties with the Vietnam war.

6th week
Dimethyl tryptamine, the molecule of spirit. Natural hallucinogenic materials.

7th week
Speed, ice, extasy, love drug and other amphetamine derivatives. Structure and activity relationships.

8th week
Modern synthetic drugs, designer drugs. Dangers and effects.

9th week
Chemical weapons I. Tear gases, Lung and blood agents.

10th week
Chemical weapons II. Blistering agents (classical and modern versions).

11th week
Chemical weapons III. Nerve agents.

12th week
Explosives, classification, general properties. Detonation and deflagration. Chemical structures, compositions. Flame materials.

13th week Gunpowders and brizant explosives. Special characterization techniques. 14th week Pheromones and other chemical signaling molecules with wartime potential.
Requirements: *- for a signature* Attendance at **lectures** is recommended, but not compulsory. During the semester a 10 min PowerPoint presentation has to be prepared and presented from a selected or given topic. *- for a grade* The course ends with a PowerPoint file submitted to the lecturer in a ppt or pptx form. The presentation must be the extended and corrected version of the presentation that was given for the signature, and must contain an up-to-date lists of literature, as well as the list of other sources used for the preparation of the presentation. A grade will be issued based on the completeness of the work-up, unique and distinctive character of the slides, and fulfilments of the formal requirements.
Person responsible for course: Dr. István Lázár, Associate Professor of Chemistry
Lecturer: Dr. István Lázár, Associate Professor of Chemistry

Title of Course: **Biological colloid science** **Code**: TTKME0411_EN	**ECTS Credit points: 3**
Classification of the subject: optional course	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 22 hours - preparation for the exam: 40 hours Total: 90 hours	
Year, semester: 2nd year (spring)	
Prerequisite(s):	
Topics of course	
The goal of this series of lectures is to give knowledge about the relationship between biological sciences and colloid/surface phenomena. A further goal is to deepen colloid chemical knowledge of students about biological phenomena related to colloids. It makes them able to approach biological problems from a colloid chemical perspective and to solve possible problems and tasks in this context.	
Literature	
Compulsory: - Lecture slides downloadable from the e-Learning homepage (http://elearning.unideb.hu) under the course code. *Recommended:* - D. Fennell Evans, Hakan Wennerstrom: The Colloidal Domain: Where Physics, Chemistry and Biology Meet, 2nd Ed. ,Wiley, 1999 - Pashley, R. M.: Applied Colloid & Surface Chemistry. Wiley&Sons, ISBN 0-a470-a86883-aX, 2004 - Cosgrove T.: Colloid science. Blackwell Publishing, ISBN 978-a14051-a2673-a1, 2005	
Course objective/intended learning outcomes	
a) Knowledge: - He/she knows the significance of the colloids and superficial phenomena for the formation and functioning of the living material, can apply your existing knowledge of these processes in everyday life, as well as during your later work in workflows or jobs, Dealing with biological systems, organisms or live material. - - He/she knows about the development potential of new materials and processes together with its characteristic methods. **b) Ability:** - He/she is Capable of synthesizing the way through, interpret the relationships between biological and colloidal systems. - He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning. - He/she is able to use his acquired knowledge at theoretical and practical levels. - He/she is capable of interworking in a professional discussion with regard to the biological aspects of the colloidy, logically arguing.	

- He/she is able to continuously expand the knowledge of the biolloidy by studying the literature.

c) Attitude:

- He/she is open to the adoption of scientifically substantiated allegations and a critical sense to reject unfounded statements. The need for continuous self-training to get to know the latest results.
- He/she works with a systematic and process-oriented, complex approach.

d) Autonomy and Responsibility:

- He is able to plan, execute and correct explanations for the observed phenomena based on what they have learned. He can make independent decisions, see the consequences of his decisions and take responsibility for them
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.
- He/she makes prudent decisions independently, by consultation with experts in other areas (not only technical) and takes responsibility for them.

Schedule:

1st week

Importance of colloidal state in biology. Hypotheses about the origin of life in the past and nowadays. Occurrence of organic matter in space. Hyperresistant organisms and survival under the conditions found in space. Shadow biosphere and "artificial life".

2nd week

Formation of interfaces. Films and membranes. Langmuir-Blodgett films and liquid crystals. Membrane models, structure of the cell membrane.

3rd week

Diffusion and transport phenomena through membranes, osmosis and dialysis. Transport phenomena in living organisms. Function of the kidneys, artificial kidney.

4th week

Adsorption phenomena in biological systems, processes in biotechnology and separation sciences.

5th week

Surface tension and its importance in nature. Motion of striders on the surface of water. Reproduction using surface tension: ballistospores of fungi. Wetting, contact angle, influencing the surface tension. Capillarity, water transport in plants and the transpiration-adhesion-tension-cohesion hypothesis. The importance of capillarity under arid climates. Adhesion to smooth surfaces. Atherosclerosis and interfacial influences leading to atherosclerosis.

6th week

Association colloids, micelles and inverse micelles. Critical micelle concentration and its importance. Detergents and their uses. Biological detergents in the digestion: bile acids. Solubilization with polar molecules. Lung surfactants and their role in breathing.

7th week

Modern instrumental methods in the study of biomacromolecules (ultracentrifugation, electrophoresis, size exclusion chromatography, scanning confocal microscopy, electron microscopy, scanning probe microscopy, surface plasmon resonance, X-ray diffraction, NMR).

8th week

Macromolecules, types and importance of macromolecules. Characterization and importance of dispersity, shape, and conformation.

9th week

Important and interesting biomacromolecules, their properties, importance and uses (*polysaccharides*: cellulose, starch, chitin, etc.; *proteins*: collagen, silk, green fluorescent protein, etc.; *others*: lignin, chlorophylls, hemoglobin, etc.).

10th week

Dispersion colloids in nature. Bioaerosols and smokes. Importance of foams, emulsions, sols and their biological relevance. Making and breaking of dispersions in different biological, medical, pharmaceutical, etc. processes.

11th week

Coherent systems and lyogels. The eye as a natural lyogel system. Biocomposites: structure and formation of bones. A complex disperse system: the soil.

12th week

Electrokinetic effects, precipitation from liquids. Epitaxis. Kidney and bile stones, processes of their formation.

13th week

Flow properties. Biorheology. Rheology of blood and its importance in blood coagulation.

14th week

Nanotechnology and its development. Nanostructures from non-living matter. Natural nanostructures: diatoms and the fine structure of butterfly scales. Nanodevices. Natural nanomotors: kinesins, dyneins, the actomyosin complex. DNS machines, active molecular tweezers.

Requirements:

- *for a signature*

Attendance at **lectures** is recommended, but not compulsory.

- *for a grade*

The course ends in an **examination**. The minimum requirement for the examination is 50%. The grade for the examination is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

If the score of any test is below 50%, students can make a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS

Person responsible for course: Dr. Levente Novák, assistant professor, PhD

Lecturer: Dr. Levente Novák, assistant professor, PhD

Title of Course: **Dosimetry, radiation health effects** **Code**: TTKME0432-EN	**ECTS Credit points: 3**
Classification of the subject: optional course	
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation (exam. / practice. / other): **exam**	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 30 hours - preparation for the exam: 32 hours Total: 90 hours	
Year, semester: 1st year (spring)	
Prerequisite(s):	

Topics of course

- The interactions of radiation with matter. Radiation detectors. Dose concepts. Devices for dosimetry.
- Constituents of population dose. The biological effects of radiation. Forms of radiation damage. Principles of nuclear safety. Protection against external radiation sources.
- Preparation for participating in handling nuclear incidents.
- System of dose limits. Requirements for staffing and equipments.
- Documentation, supervision by the authorities. Classification of isotope labs. Handling unsealed radioactive materials.
- Handling radioactive waste; decontamination.

Attending the classes and passing the exam entitles the student to obtain an official certificate on radiation protection, advanced level, valid for 5 years.

Literature

Compulsory: Diagnostic Radiology Physics
http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1564webNew-74666420.pdf
Related chapters:
Chapter 1. Fundamentals of Atomic and Nuclear Physics
Chapter 2. Interactions of Radiation with Matter
Chapter 3. Fundamentals of Dosimetry
Chapter 20. Radiation Biology
Chapter 21. Instrumentation for Dosimetry
Chapter 24. Radiation Protection

Course objective/intended learning outcomes

a) Knowledge
- He/she is familiar with the physical characteristics and biological effects of ionizing radiation, the principles, methods and tools of radiation protection.
- He/she possesses knowledge on the analytical and test methods for the research, development and operation of chemical processes and technologies.

b) Abilities
- He/she is able to comprehend the tasks of radiation protection;
- He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning.
- He/she ia able to organize and control the radiation protection system of a research or medical isotope laboratory.
- He/she is able to apply the tools and methods of radiation protection in the practice.

c) Attitude
- He/she strives for safe work.
- He/she aims to enforce all known disciplines and requirements of safety, sustainability, environmental protection and energy efficiency.

He/she is open to form his/her working habits to meet the requirements of radiation protection.
- He/she Searches for the possibility to aquire and utilize new knowledge, apply new procedures and techniques, in order to decrease the risk of radiation to him/herself and co-workers.
- He/she effectively communicates with co-workers to form their means of work safer.

d) Autonomy and responsibility
- He/she comprehends the danger and risks of working with ionizing radiation, and is prepared for an independent activity so that he/she does not impose a health risk to him/herself, co-workers and the population more than inevitable.
- In making decisions he/she takes into account the principles of environment protection, quality management, consumer protection, product liability.

Schedule:

Week	*Topic*
1	Types and origin of ionizing radiation Interactions of charged particles with matter
2	Interactions of electromagnetic radiation with matter Detection of X-ray, gamma and beta radiation by inducing light
3	Gas ionization detectors Dose concepts and dosimeters
4	Consultation: physics of ionizing radiation How to use dosimeters (practice)
5	Biological effects of radiation Forms of radiation injury
6	Constituents of population dose Radiation protection rules, dose limits
7	How to work with unsealed radioactive preparations? Protection against external radiation
8	Classification and equipment of workplaces applying ionizing radiation. Handling of radioactive waste.
9	Radiation protection of patients. Consultation: radiation biology and protection
10	Nuclear safety. Operations in case of nuclear/radiological incidents
11	Radiation protection in and around a cyclotron facility. Demonstration of the radiation protection system.
12	Requirements for staffing.
13	Decay schemes and tables. Decontamination (practical)
14	Radiation protection of patients in nuclear medicine.

Visit to the "in vivo" NM center
Requirements: Attendance of at least 75% of the classes. Usable understanding of the basic physical phenomena, the concepts of radiation effects and protection, as well as the regulations and practical solutions is required. Chance *"A"* is a computer-based exam. Chance *"B"* and *"C"* are oral.
Person responsible for course: István Hajdu, PhD, Assistant Professor
Lecturer: István Hajdu, PhD, Assistant Professor; József Varga, PhD, Associate Professor

Title of Course: **Environmental chemistry II.** **Code**: **TTKME0414_EN**	**ECTS Credit points: 4**

Classification of the subject: optional course

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: 1 hour/week
- laboratory: 1 hour/week

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: 14 hours
- laboratory: 14 hours
- home assignment: 20 hours
- preparation for the exam: 40 hours

Total: 116 hours

Year, semester: 2nd year (spring)

Prerequisite(s):

Topics of course

The aim of the subject is to recognize the physical chemical principles in the natural processes of the atmo-, hydro- and lithosphere, and to apply the acquired knowledge for the description of these processes. Methods of model calculations, correct usage of thermodynamic tables are studied. The lectures review the physical chemistry of energy and work production and supply (internal- and external-combustion engines, electric engines, etc.) and deal with hydrogen and methanol economy and biofuels as well. "Mental pollution" of the environment, i.e. the interpretation of deceiving information about environmental problems is also discussed. The practical part includes thermodynamic calculations, calculations in equilibrium and complex formation processes, speciation, chemical kinetics, transport processes, using the knowledge of the chemical processes in the atmo-, hydro- and lithosphere.
In the laboratory, being connected with the lectures and using the acquired knowledge two environmental problems are studied through experimental work, data evaluation, and discussion of the results.

Literature

Compulsory:
- Gary W. vanLoon, Stephen J. Duffy (2010): Environmental Chemistry: A global perspective, Oxford Univ. Press. ISBN 9780199228867
- Peter Brimblecombe, Julian E. Andrews, Tim D. Jickells, Peter Liss, Brian Reid (2003): An Introduction to Environmental Chemistry, Blackwell Publishing. ISBN 0-632-05905-2
- Ian Williams (2005): Environmental Chemistry, Wiley. ISBN 978-0-471-48942-9

Recommended:
- Thomas G. Spiro, Kathleen L. Purvis-Roberts, William M. Stigliani (2011): Chemistry of the Environment, Univ. Sci. Books.ISBN 978-1-891389-70-2

Course objective/intended learning outcomes

a) Knowledge
- He/she fundamentally knows principles, definitions main questions and problems of environmental chemistry.
- He/she knows the most recent results and approaches of technological development.
- He/she expansively knows the physico-chemical background of phenomena in our environment.

- He/she knows the theory and practice necessary for modelling chemical problems in the environment end elaborating possible solutions.
- He/she knows the specific properties of environmental chemistry compared to the other fields of chemistry.

b) Abilities

- He/she understands the phenomena of environmental chemistry and their physical chemical background. He/she is able to apply the principles in practice.
- He/she is capable of creative problem handling and flexible solution of complex tasks, is able to follow the concepts of open-mindedness and value-based lifelong learning.
- He/she is able to grasp the importance of problems associated with environmental chemistry and to judge them and the possible solutions.
- He/she is able to collect, record, evaluate and discuss environmental chemical data on the basis of the acquired methods. With the help of data he/she is able to model the environmental problems and elaborate possible solutions.

c) Attitude

- He/she is open to learn and accept the theories and principles of environmental chemistry. He/she recognizes the relationships of the environmental problems with the other fields of chemistry and associated sciences.
- He/she is open to solve environmental problems on the basis of the acquired knowledge and methods.
- He/she works with a systematic and process-oriented, complex approach.
- He/she is open to acquire new scientific knowledge in this topic, but decline unestablished, deceptive statements.

d) Autonomy and responsibility

- He/she is capable of considering with responsibility the risk of chemical processes polluting and loading the environment.
- He/she has responsibility for sustainability, and environmental protection.
- He/she use the literature of environmental chemistry on his/her own.

Schedule:

1st week

Definitions, development, significance, researching methods and relations of environmental chemistry to the other fields of science and economy. Principles of green chemistry. Basics of physical chemistry.

2nd week

Usage of thermodynamic tables, model calculations. “Mental pollution” of the environment, i.e. deceiving information about environmental problems.

3rd week

Physical chemistry of energy and work production and supply: internal- and external-combustion engines, electric motors, hydrogen and methanol economy, biofuels.

4th week

Composition and regions of the Earth’s atmosphere. Properties of thermosphere, mesosphere, stratosphere and troposphere. Calculation of atmospheric pressure and energy of the light in the thermosphere.

5th week

Definition of climate. Application of the Planck-equation. Energy spectrum of solar radiation, calculation of the surface temperature. Greenhouse effect.

6th week

Definitions of smog types. Reactions and explanations in photochemical smog. Thermodynamic calculations of NO formation considerations of further reactions.

7th week

The chemistry and role of the stratospheric ozone. Environmental problems of ultraviolet radiation, chemical UV protection. Formation and depletion of ozone, an influencing factors. Stationary kinetics, principles of photochemistry. Kinetic modelling of ozone formation.

8th week

Composition of the hydrosphere, water resources. Sea water and fresh water. Solubility of gases, liquids and solids in water. Speciation in aqueous systems.

9th week

Chemical kinetics in the environment. Transport processes: flux, viscosity, diffusion. Cyan pollution on the Tisza river. Role of colloids in transport processes.

10th week

Characterization and significance of interfaces: surface charge and adsorption. Causes, effects, solution and elimination possibilities of the red sludge disaster.

11th week

Water treatment technologies: Arsenic removal and the treatment of arsenic sludge.

Laboratory practise 1. Treatment and elimination of water treatment arsenic sludge, measurements using mobile analytical methods.

12th week

Properties and composition of soils. Weathering processes, soil colloids. Soil colloids. Chemical properties of soils, acid/base buffer capacity. Calculations associated with soil pollution.

13th week

Structure and interfacial reactions of clay minerals.

Laboratory practise 2. Soil-forming minerals: particle size, metal adsorption, effect of pH.

14th week

Lithosphere, formation of rocks and minerals. Chemical aspects of volcanic activities.

Requirements:

- *for a signature*

Attendance at **lectures** is compulsory, since the **practical part** is integrated into the classes. A student must attend the classes and may not miss more than three times during the semester. In case a student does so, the subject will not be signed and the student must repeat the course. Attendance at practice classes will be recorded by the lecturer. Being late is equivalent with an absence. In case of further absences, a medical certificate needs to be presented.

Students have to **submit a report task** at the end of the semester, the topic of which is chosen from a list. The grade of the report task reflects the processing of the literature and the creative solution of the relating model calculation.

During the semester there are two **laboratory practises** (11th and 13th weeks), where the attendance is compulsory. The students get grades for the lab reports.

- *for a grade*

The course ends in an **examination**. Based on the average of the grade of the report task, lab reports and the examination, the exam grade is calculated as a weighted average of them:

- the grade of the report task (25%)
- the average grade of the lab reports (25%)
- the result of the examination (50%).

The minimum requirement for the examination is 50%. Based on the score of exam test, the grade is given according to the following table:

Score	Grade
0-35	fail (1)
36-44	pass (2)
45-53	satisfactory (3)
54-62	good (4)
63-70	excellent (5)

If the score is below 35, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.
Person responsible for course: Dr. Mónika Kéri, assistant professor, PhD
Lecturer: Dr. Mónika Kéri, assistant professor, PhD , Dr. István Bányai, full professor

Title of course: Computational Quantum Chemistry **Code**: TTKMG0902_EN	**ECTS Credit points:** 3
Type of teaching, contact hours - lecture: - - practice: 2 hours/week - laboratory: -	
Evaluation: mid-semester grade	
Workload (estimated), divided into contact hours: - lecture: - - practice: 28 hours - laboratory: - - home assignment: 32 hours - preparation for the exam: 30 hours Total: 90 hours	
Year, semester: 1st /2nd year, 2nd semester	
Its prerequisite(s): minimum 12 credits of mathematics	
Further courses built on it: -	

Topics of course
- Hartree-Fock Theory. Density Functional Theory. Basis sets. Solvent effect, Polarizable Continuum Model. Geometry optimization. Structural analysis. Calculating energies of chemical reactions
Literature
Compulsory: https://maker.pro/linux/tutorial/basic-linux-commands-for-beginners http://gaussian.com/keywords/ *Recommended:* http://barrett-group.mcgill.ca/tutorials/Gaussian%20tutorial.pdf

Schedule:

1st week

Basic theory of the Hartree-Fock method: approximations, LCAO-MO theory. Building structures by the GaussView program.

2nd week

Basic Linux commands, using the WinSCP and Putty programs, connecting by SFTP. Using the Gaussian program package, optimizing simple molecules.

3rd week

Geometry optimizations by different basis sets, comparing and calibrating the methods by structural parameters.

4th week

Frequency analysis, calculating Gibbs free energies of simple reactions. Scanning a reaction pathway, finding the transition state, identifying the stationary points of the Potential Energy Surface.

5th week

Basic theory of the post-Hatree-Fock theories. Recalculating the previously studied systems and comparing them to the HF results.

6th week

Solvent effect, using Polarizable Continuum Models to refine the energies.

7th week

Basic theory of the Density Functional Theory. Recalculating the previously studied systems and comparing them to the (post-)HF results.

8th week

Systems with explicit solvent molecules.

9th week

Calculation on more difficult systems: metal complexes and relativistic effects.

10th week

Mid-term exam about calculations by using Gaussian.

11th week

Conformation analysis, more Linux commands.

12th week

Writing simple scripts in b shell.

13th week

Generating input files by scripts.

14th week

Exam of writing scripts in b shell.

Requirements:

- for a signature

Attendance is recommended, maximum 3 absences are accepted.

- for a grade

Class performance (33%)

Final examination (67%)

Based on the sum of the final practical exam of performing calculations and the class performance the practical grade is calculated.

The final grade is given according to the following table:

Score (%)	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

If the score of the final grade is below 50%, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Person responsible for course: Dr. Oldamur Hollóczki professor, PhD
Lecturer: Dr. Oldamur Hollóczki, professor, PhD Dr. Attila Mándi, assistant professor, PhD

Title of course: Physical chemistry of living systems **Code**: TTKME0417_EN	**ECTS Credit points:** 3
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation: exam	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: - - preparation for the exam: 62 hours Total: 90 hours	
Year, semester: ***1st/2nd year, 2nd semester***	
Its prerequisite(s): **-**	
Further courses built on it: **-**	

Topics of course

The subject of biophysics-chemistry, thermodynamic concepts. Structure of macromolecules,interactions with small molecules. The concept of chemical potential, its effect on thermodynamic parameters, the properties of solutions.Definition and interpretation of pH in biological systems. The significance of electron transfer reactions in live systems. Simple and complex reactions, kinetic description of enzymatic catalysed reactions. Basic concepts related to biochemical pathwaysNMR spectroscopy in biological systems

Literature

Compulsory:
lecture material on the Department of Physical Chemistry website
Recommended:
- P. W. Atkins: Physical Chemistry (8th ed.) Oxford University Press for, 2006. ISBN: 0-7167-8759-8
- P. W. Atkins. J. de Paula: Physical Chemistry for the Life Sciences (2nd ed.) Oxford University Press, 2011, ISBN:978-0-19-956428-6

Schedule:
1st week
The subject of bio-physical chemistry. Environmental and environmentally-independent constraints of biological systems. The basics of thermodynamics. The system and the surroundings. Thermodynamic first

and second law. Concept of internal energy, work, heat, enthalpy, entropy, Gibbs energy. Applications in biological systems: calculation of mechanical, electrical, extension work. (Bio)chemistry reactions, energy, enthalpy, and Gibbs energy changes. Introduction of standard conditions. Hess law The thermodynamics of ATP.

2nd week

First, secondary, tertiary and quaternary structures of proteins. Secondary interactions that determine the tertiary structure of proteins. Interactions between hydrophobic side chains - the role of water. Elevation and repression of proteins change in entropy during conformational change. First and secondary structure of nucleic acid, interactions that determine the secondary structure. Changing of the Gibbs energy while the the double-single DNA threads (fibers) transform.

3rd week

The concept of chemical potential, used to calculate a change in the free-enthalpy accompanying a chemical reaction or a transport process. Concentration dependence of the free-enthalpy, reaction rate and equilibrium constant. Temperature dependence of equlibrium constant.

4th week

Measuring the thermodynamic quantities of the reactions. Binding of small molecules to macromolecules, independent binding, cooperation. Dissociation macro- and microconstants. Average ligand number, saturation degree, number of binding sites. Hughes-Klotz-representation. Scatchard-representation.

5th week

Autoprotolysis of water. Acid-base theory Arrhenius and Bronsted. The pH scale in chemical and biochemical systems. Conjugated acids and bases. Determination of the strength of acids and bases, the concept of pK. Dissociation degree. pK values of free amino acids, pH change its charge, isoelectric focusing. Change of pK with (bio) chemical environment. pH control in biochemical systems: buffer systems, ion transport

6th week

Electron transition reaction. Electrochemical cell: Danielle cell. Electrodes, halfcell-reaction, electromotive force. Standard electrode potential and their application: electrochemical line. Concentration dependence of electromotive force: Nernst equation, hydrogen electrode, glass electrode, combined glass electrode. Electrochemical discussion of terminal oxidation.

7th week

Specifications of solutions. Chemical potential of the solvent. Colligative properties: boiling-point elevation, freezing point depression, osmosis. Vegetable water transport and water potential. Determination of the molecular weight of protein according to their osmotic properties. Osmolarity and tonicity of the solution. Chemical potential of the solute. pH determination with weak acids and bases penetrating the membrane. Membrane potential. Electrochemical gradient as energy storage in the cell. Theory of chemio-osmosis. Stoichiometry of proton pump and ATP synthesis during oxidative phosphorylation.

8th week

Ideal and real system. Properties of the perfect gas. Ideal solution features. Discussing a real, dilute solution. Activity coefficient and affecting its value in solution containing ions: Debye-Hückel's theory. The role of ion strength in practice.

9th week

Chemical reaction rates – kinetics. Thermodynamic and kinetic stability. Specify the velocity of a chemical reaction. The concentration dependence of the chemical reaction rate. Rate equation. Temperature dependence of chemical reaction rate. Ionic strength dependence of the reaction rate. Isotope substitution method for detecting the mechanism of the reaction. Effect of pH on reaction rate. Kinetics of sequential, parallel and reversible reactions.

10th week

Kinetics of enzymatic catalyzed reactions. Catalysis concept, catalysts. Classification of enzymes. Energy profile of enzyme catalysis. Use of steady-state approximation in enzyme-catalyzed reactions. The application and limitations of the Michaelis-Menten approach. Determination of K_M and V_{max}. Expression of catalytic activity of enzymes. Temperature dependence of the rate of enzymatic catalysis. pH dependent on the rate of enzymatic catalysis reactions.

11th week

Kinetics of multi-substrate enzymes. Activation parameters of multi-substrated enzymatic catalyzed reactions. The role of antigen-specific antibodies in the formation of "artificial enzymes". Discussion of kinetics of dual substrate enzyme catalyzed reaction, three-molecule complex approach and ping-pong mechanism. Inhibition in the enzyme reactions. Interpretation of different inhibition types, changes in K_M and V_{max} for different types of inhibition. The Dixon representation and the information that can be gained from it.

12th week

Industrial utilization of enzymatic catalysis: applications. Myths and facts about the industrial enzyme application area. Basics of enzyme immobilization. Use of ionic liquids as a reaction medium. Enzyme catalysis in non-aqueous medium (ionic liquids): regioselectivity, enantioselectivity.

13th week

Associated chemical reactions and biochemical pathways. Consecutive (serial) coupling of chemical reactions. Parallel coupling of chemical reactions. Structure of biochemical pathways from coupled reactions. Kinetic and thermodynamic control of biochemical pathways. Systemic analysis of kinetic control of biochemical pathways. Metabolic control analysis: control coefficient, elasticity coefficient.

14th week

Briefly about quantum mechanics: particles, waves, quantization of energy. Limitations of classical mechanical description. Interaction of molecules by electromagnetic radiation. General characterization of spectroscopic methods. Electro-dissemination spectra and their biochemical applications. The basics of NMR spectroscopy and its biochemical, medical applications.

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory.

- for a grade

The course ends in an oral or written **examination**. The minimum requirement for the examination is 50%. The grade for the examination is given according to the following table:

Score	Grade
0-49	fail (1)
50-59	pass (2)
60-74	satisfactory (3)
75-89	good (4)
90-100	excellent (5)

If the score of any test is below 50%, students can make a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

- offered grade

It may be offered for students if the student gives a 10-15 minute presentation related to the topic of the subject. The possible topics are discussed with the lecturer. The offered grade can be satisfactory (3) or better, in case of lower evaluation exam should be taken.

Person responsible for course: Dr. Réka Borsi-Gombos, assistant professor, PhD

Lecturer: Dr. Réka Borsi-Gombos, assistant professor, PhD

Title of course: Metal Complex Catalyzed Organic Syntheses **Code**: TTKME0420_EN	**ECTS Credit points:** 3
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: -	
Evaluation: exam	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: - - home assignment: 28 hours - preparation for the exam: 34 hours Total: 90 hours	
Year, semester: $1^{st}/2^{nd}$ year, 1^{st} semester	
Its prerequisite(s): -	
Further courses built on it: -	

Topics of course

- General questions of activation of small molecules (H_2, HCN, $HSiR_3$, CO, CO_2, O_2). Oxidative addition, reductive elimination. The 18 electron rule. Role of radical processes in metal complex catalyzed reactions.
- Practice of homogeneously catalyzed organic synthesis. Recovery of the catalyst. Heterogenized complex catalysts, biphasic reactions, phase transfer assisted complex catalyzed syntheses.
- Regio-, stereo-, and enantioselective catalysis. Hydrogenation, hydrocyanation, hydrosilylation of alkenes. Telomerization reactions. Hydrogenation and hydrosilylation of ketones, nitrocompounds and imines. Reductive amination. Dehydrogenation. Hydrogenolysis of C-X bonds (X: oxygen, halogen). Hydroformylation, carbonylation and decarbonylation. Oxidation.
- Selected examples of complex catalyzed reactions for synthesis of biologically active compounds including heterocyclic derivatives (quinolines, beta-lactams, lactones, etc.).

Literature

Compulsory:
- P. W. M. N. van Leeuwen, *Homogeneous Catalysis. Understanding the Art.* Kluwer, Dordrecht, 2004.
- D. J. Adams, P. J. Dyson, S. J. Tavener, *Chemistry in Alternative Reaction Media*. Wiley-Interscience: Cambridge, 2004.

Recommended:
- A. Behr, P. Neubert: Applied Homogeneous Catalysis (Wiley-VCH, Weinheim, Germany, 2012)

Schedule:

1st week Definition and characteristics of catalysis. Catalysis as efficient means of green chemistry. General questions of activation of small molecules (H_2, HCN, $HSiR_3$, CO, CO_2, O_2), relation between molecular structure and reactivity.

2nd week Characteristic steps and mechanisms of homogeneous catalysis.Oxidative addition, reductive elimination. The 18 electron rule. Role of radical processes in metal complex catalyzed reactions.

3rd week Practice of homogeneously catalyzed organic synthesis. Recovery of the catalyst. Heterogenized complex catalysts, methods of heterogenization on solid supports.

4th week Reactions in liquid biphasic systems, phase transfer assisted complex catalyzed syntheses. Alternative solvents, their properties and their effect on catalytic processes.

5th week Selectivity of catalytic reactions. Explanation of selectivity. Enantioselective reactions. Kinetic resolvation.

6th week Hydrogenation, hydrocyanation and hydrosilylation of alkenes. Catalytic dehydrogenation. Hydrogen transfer reactions. Catalytic isomerization of alkenes. Applications.

7th week Hydrogenation of aldehydes and ketones. Hydrosilylation of ketones. Reductive amination. Hydrogenation of nitrocompounds and imines. Redox isomerization of allylic alcohols.

8th week Hydrogenolysis of C-X (X: oxygen, halogen) bonds. Applications in destruction of environmentally harmful substances. Hydration of alkynes and alkenes. Telomerization.

9th week Hydroformylation. Cobalt-, rhodium- and platinum-based catalysts. Mechanisms of hydroformylations. Asymmetric hydroformylation. Industrial applications.

10th week Carbonylation and decarbonylation. Catalysts and mechanisms. Applications in manufacturing of fine chemicals.

11th week Homogeneously catalyzed oxidations. Catalysts and mechanisms. Practical applications.

12th week Formation of C-C bonds via homogeneous catalysis (Sonogashira-, Suzuki, Heck-cross couplings and other name reactions for catalytic C-C bond formation).

13th week Alkene metathesis. The various ways and mechanisms of the reaction. Most frequently used catalysts.

14th week Organic syntheses based on catalytic reactions of carbon dioxide: production of methanol, formic acid and its derivatives (formate esters, formamides), lactones and polycarbonates. Methods for fast optimization of reaction conditions.

Requirements:
- for a signature
Attendance at **lectures** is recommended, but not compulsory.

- for a grade

The course ends in a written **examination**.

The minimum requirement for the examination is 60%. Based on the score of the examination the grade is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the examination is below 60, students can take a retake exam in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Person responsible for course: Dr. Gábor Papp, associate professor, PhD

Lecturer: Dr. Gábor Papp, associate professor, PhD

Title of course:Structure determination by X-ray diffraction
Code: TTKME0423_EN

ECTS Credit points: 3

Type of teaching, contact hours
- lecture: 2 hours/week
- practice: -
- laboratory: -

Evaluation: exam

Workload (estimated), divided into contact hours:
- lecture: 28 hours
- practice: -
- laboratory: -
- home assignment: 30 hours
- preparation for the exam: 32 hours

Total: 90 hours

Year, semester: 1st/2nd year, 2nd semester

Its prerequisite(s): -

Further courses built on it: -

Topics of course

The series of lectures are based on the topics of X-ray diffraction. The purpose of the course to give strong theoretical background for the students on the methodology and applications of single crystal structure determination via X-ray diffraction. Part of the course of learning basic usage of software tools. Application of single crystal diffraction in preparative chemistry, interpretation and presentation of the results as well as use of crystallographic databases are also discussed. Fields of protein crystallography, polymorphism research as well as powder diffraction are also reviewed.

Literature

Compulsory:

- J. P. Glusker, K. N. Trueblood (2010): Crystal Structure Analysis: a Primer (IUCR Texts on Crystallography), Oxford University Press, ISBN 13 978-0199576357
- http://www.iucr.org/education/pamphlets
- Lecture notes and teaching material available via the e-learning system

Recommended:

- W. Massa (2000): Crystal Structure Determination, Springer, ISBN 3-540-65970-6

Schedule:

1st week X-ray radiation

Properties of X-rays, practical applications. Diffraction methods in general. Place of single crystal structure determination among structural studies. Fourier transformation and its properties. Least square methods.

2nd week Symmetry

Structure of solids. Crystals. Unit cell, asymmetric unit, Miller indexes. Symmetry notation of IUCR, systematic absences. Reciprocal space. The most frequent space groups and symmetry operators.

3rd week Crystal growing

Thermodynamics and kinetics of crystallization. Methods to grow single crystals. Applications of crystallization in pharmaceutical industry. Basics of neutron diffraction.

4th week X-ray diffraction methods

Generation of X-rays. Development of X-ray diffraction methods. Main parts of the diffractometer. Types of detectors, advantages and disadvantages. Area detectors.

5th week Structure determination

The main steps of structure determination by single crystal diffraction. Determination of the unit cell. Data collection, data/parameter ratio. Symmetry effects in data collection. Phase problem and methods to solve the phase problem for small molecules. Refinement of the structure.

6th week Publication

The Crystallographic Information Format and its advantages. Publication of single crystal structure determination results. Validation of the results. Interpretation and use of crystallographic results. Steps of publication in case of major journals.

7th week Computer programs in structure determination

Basic usage of WINGX and PLATON packages. The MERCURY program. The construction of shelx .ins files.

8th week Cambridge Structural Database

Basic terms of usage of CSD. Computer practice to search the database and making crystallographic calculations. Computer practice.

9th week Powder diffraction

Powder methods. Data collection, geometry, optics, possibility of structure determination from powder data.

10th week Polymorphism

Polymorphism phenomena. Definition of polymorphic forms. Consequences in pharmaceutical industry. Thermodynamic and structural considerations. Polymorphism in everyday life.

11th week Protein crystallography

Comparison of protein and small molecule crystallography. Solving the phase problem for proteins. Refinement of protein structures. Structural motifs and function of proteins. Intrinsically disordered proteins.

12th week Practical class

Determination of crystal and molecular structure for a relatively simple organometallic compound. Group work.

13th week Chirality and X-ray diffraction

Concepts and definitions. Types of chirality. Determination of absolute configuration. Anomalous dispersion.

14th week Student works

The student give short presentation on their chosen topic in the field of X-ray structure determination.

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory.

- for a grade

The course ends in an **examination**. Based on the average of the grades of the **written test or oral exam** the exam grade is calculated. It is the choice of the student to give written or oral exam.

Based on the scores, the grade for the tests and the examination is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of any test is below 60, students can take a retake test in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

-an offered grade:

it may be offered for students if the student prepare a short written report on literature search in the field of X-ray diffraction. The possible topics are discussed with the lecturer and preliminary versions of the paper are iterated to correct errors. The report should have a minimum of 10 A4 sheet and it should be presented at the last class. The offered grade can be satisfactory (3) or better, in case of lower evaluation exam should be taken.

Person responsible for course: Dr. Attila Bényei associate professor, PhD

Lecturer: Dr. Attila Bényei, associate professor, PhD

Title of course:Reaction Kinetics/Catalysis **Code**: TTKME0437_EN	**ECTS Credit points:** 4
Type of teaching, contact hours - lecture: 2 hours/week - practice: - - laboratory: 2 hours/week	
Evaluation: exam	
Workload (estimated), divided into contact hours: - lecture: 28 hours - practice: - - laboratory: 28 hours - home assignment: 28 hours - preparation for the exam: 36 hours Total: 120 hours	
Year, semester: 1st/2nd year, 2nd semester	
Its prerequisite(s): -	
Further courses built on it: -	

Topics of course

- Basic principles, analysis of kinetic data.
- Lindemann theory of unimolecular reactions; theory of associative reactions.
- Specific kinetic effects characteristic to reactions in solution.
- Basic principles and equations related to composite reactions.
- Kinetics of photochemical reactions; governing principles.
- Phenomenon, development and significance of catalysis.
- Most important features of homogeneous and heterogeneous catalysis. Discussion of the importance if catalysis through industrial examples.
- Major kinetic features of enzymatic catalysis and demonstration of its significance through examples.
- Green chemistry and application of catalysis in green chemical processes.

Every student has to work out the 4 laboratory practices (4 hours each) listed in the detailed course schedule. In these laboratory assignments they will use various methods and equipments, such as flow reactors, and will make measurements on acid-, metal ion-, metal complex-, and enzyme-catalyzed reactions.

Literature

Compulsory:
- M. J. Pilling, P. W. Seakins: Reaction Kinetics, Oxford University Press, Oxford, UK, 1995
- P. W. Atkins: Physical Chemistry, 6th ed., Oxford University Press, Oxford, UK

Recommended:
- K. J. Laidler, Physical Chemistry, 2nd ed., Houghton Mifflin Co., Boston, 1995
- B. C. Gates: Catalytic Chemistry, Wiley, 1991.
- G. Rothenberg: Catalysis, Wiley, 2008.

Schedule:

1st week Basic principles and analysis of kinetic results: order of reactions, molecularity. Determination of rate constants and coefficients. Analysis of kinetic results: integral and differential methods, isolation method, method of half lives. Temperature dependence of the reaction rate. Connection between reaction kinetics and thermodynamics.

Iodination of acetone:: determination of the order of reactants (or that of the activation energy of the reaction) using iodometry.

2nd week Kinetics and mechanism: principle of reaction mechanism. Rules for explanation of relation of the rate equation and reaction mechanism. Kinetically equivalent reaction schemes.

Catalytic decomposition of H_2O_2: Study of the effect of copper(II)-ion, of various anions, and that of the pH in decomposition of H_2O_2 catalyzed by iron-ions. Determination of H_2O_2 concentration by iodometry..

3rd week Lindemann theory of unimolecular reactions. Comparison of the theory to experimental results. Extrapolation to infinite pressure. Activation and the rate of dissociation. Theory of associative reactions.

4th week Kinetics of solution reactions. Role of the solvent: the cage effect. Formation of a collision complex. Diffusion controlled reactions. Kinetically controlled reactions. Effects of ionic strength and pressure on the rate coefficient.

*5th week*Kinetics of composite reactions: application of the Bodenstein-principle and that of the fast preequilibria for kinetic description of reaction systems. Parallel and consecutive reactions. Reactions leading to equilibrium. The most important reactions taking place in the atmosphere.

6th week Theory of chain reactions: general scheme of chain reactions. Definition of chain length. Reactions with open chain: hydrogen-halogen reactions, alkane pyrolysis, radical polymerizations. Thermal explosions. Chain reactions with branching: the $H_2 + O_2$ reaction, oxidation of hydrocarbons.

7th week Oscillating chemical reactions in closed systems. The Belouszov-Zhabothinsky reaction and the Field-Körös-Noyes mechanism. The Oregonator model and its dynamics. Chemical chaos.

8th week Kinetics of photochemical reactions: formation and decay of electronically excited molecules. Kinetic laws of photochemistry: Quantum yield coefficient. Lifetimes of fluorescence and phosphorescence. Stern-Volmer diagram.

9th week Definition and characteristics of catalysis. Historical overview of the most important catalytic processes. Principles of green chemistry and comparison of traditional and green processes.
Green chemistry and catalysis. Atom efficiency and environmental factor (E-factor) – with examples

10th week Selectivity of catalytic processes. Explanation of selectivity. Enantioselective reactions. Kinetic resolutions.

11th week Characteristic steps and mechanisms of homogeneous catalytic reactions. Examples of industrial homogeneous catalytic processes.

12th week Heterogeneous catalytic reactions. Langmuir-Hinshelwood and Ealy-Rideal mechanisms. Examples of industrial heterogeneous catalytic processes..

13th week Fast optimization of reaction conditions. Flow reactors: the H-Cube hydrogenation reactor. Multiple work-place reactors.
Application of the H-Cubehydrogenation reactor. Demonstration. Hydrogenation of alkynes, the effects of flow rate, temperature and H_2-pressure on the rate and selectivity of the reaction.

14th week Catalysis by enzymes. Classification and general properties of enzymes. Quantification of enzyme activity and its dependence on the temperature and the pH. Kinetics of enzyme reactions. The Michaelis-Menten approach, methods for determination of K_M and V_{max}. Unique and multiple substrate enzymes and their way of action.
Enzyme kinetics and kinetics of enzyme inhibition: decomposition of lactose in the presence of constant amount (activity) of β-galactosidase enzyme in cases of various substrate and inhibitor concentrations and at various pH. Determination of the kinetic parameters, pH-dependence, the type of inhibition and kinetic parameters of inhibition. Dependence of the reaction rate on the amount of enzyme.

Requirements:
- for a signature
All four **laboratory practices** must be finished with the grade: pass. Attendance at **lectures** is recommended, but not compulsory.
- for a grade
The course ends in a written **examination**.
The minimum requirement for the examination is 60%. Based on the score of the examination the grade is given according to the following table:

Score	Grade
0-59	fail (1)
60-69	pass (2)
70-79	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

If the score of the examination is below 60, students can take a retake exam in conformity with the EDUCATION AND EXAMINATION RULES AND REGULATIONS.

Person responsible for course: Prof. Dr. Gyula Tircsó University Professor, Dr. Csaba Gábor Papp Associate Professor,

Lecturer: Prof. Dr. Gyula Tircsó University Professor, Dr. Csaba Gábor Papp associate professor, PhD, habil.

Title of Course: **Chemistry of secondary metabolites I.** **Code**: TTKME0331_EN	**ECTS Credit points: 3**

Classification of the subject: optional course

Type of teaching, contact hours

- lecture: 2 hours/week
- practice:
- laboratory: -

Evaluation (exam. / practice. / other): **exam**

Workload (estimated), divided into contact hours:

- lecture: 28 hours
- practice:
- laboratory: -
- home assignment: 20 hours
- preparation for the exam: 40 hours

Total: 88

Year, semester: 1st/2nd year (fall)

Prerequisite(s):

Topics of course

- Classification of metabolic processes, and review the major building blocks, and basic reactions.
- Isolation and structural determination of natural compounds.
- The function of natural compounds and application them as lead compounds in in drug development.
- Discussion of the retrosynthetic analysis and laboratory synthesis of natural compounds through the processing of selected examples.

Literature

Compulsory:

1. K. C. Nicolaou, E. J. Sorensen: Classics in Total Synthesis I., 4th edition (Reprint), Wiley, 2003.
2. K. C. Nicolaou, S. E. Snyder: Classics in Total synthesis II., 1st edition, Wiley, 2003.
3. K. C. Nicolaou, E. J. Sorensen: Classics in Total synthesis III., 1st edition , Wiley, 2011.
4. Selected article by the lecturer

Course objective/intended learning outcomes

a) Knowledge

- He/she knows the method of the retrosynthetic analysis and the processes which can be used to the synthesis of the complex natural organic compounds, they are aware of the predictable pitfalls of chemical synthesis, the use of protective groups and reagents used.
- He/she knows the design and evaluation methods of experiments.

b) Abilities

- He/she is able to apply basic knowledge of simple natural compounds, to plan the synthesis of this type of compounds.
- He/she is able to improve the chemical and chemical industrial knowledge base with original ideas and results.
- He/she is able to participate in professional communication on the field of isolation, synthesis and application of secondary metabolites.
- He/she is able to expand and/or develop his/her knowledge from the natural products.

c) Attitude

- He/she is open to getting new, scientifically proven knowledge on the subject, but to reject unsubstantiated or possibly misleading claims

- He/she strives to plan and execute tasks alone or in a work team at a high professional level.

d) Autonomy and responsibility

- He/she is able to independently perform the tasks of the course with professional guidance, and he/she can interpret and evaluate of the results obtained.
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week

Classification of the most important metabolic processes and metabolites The definition of primary and secondary metabolites. The building blocks and biosynthetic processes of primary metabolites.

2nd week

The building blocks and biosynthetic processes of secondary metabolites. Isolation and structural elucidation of natural compounds. The function of natural compounds and application them as lead compounds in in drug development.

3rd week

Retrosynthetic analysis of the menthol and periplanone-B, bio- and chemical synthesis.

4th week

Retrosynthetic analysis and synthesis of the strychnine and quinine.

5th week

Retrosynthetic analysis of progesterone and estrone, bio- and chemical synthesis.

6th week

Retrosynthetic analysis of prostaglandins, bio- and chemical synthesis.

7th week

Retrosynthetic analysis of β-lactam antibiotics (Penicillin V, Thienamycin) and bio- and chemical synthesis.

8th week

Retrosynthetic analysis and chemical synthesis of rapamycine, indalizomycine

9th week

Retrosynthetic analysis and chemical synthesis of dynemicine.

10th week

Retrosynthetic analysis and chemical synthesis of Bisorbicillinoids.

11th week

Retrosynthetic analysis and chemical synthesis of Taxol

12th week

Retrosynthetic analysis and chemical synthesis of (-)-FR182877

13th week

Retrosynthetic analysis and chemical synthesis of Azaspiracid – I

14th week

Retrosynthetic analysis and chemical synthesis of Littoralisone, Oseltamivir (Tamiflu®), and Hirsutellone B

Requirements:

- for a signature

Attendance at **lectures** is recommended, but not compulsory. A student may not miss the lecture more than three times during the semester. In case of further absences, a medical certificate needs to be presented. In case a student does not do this, the subject will not be signed and the student must repeat the course.

- for a grade

The course ends in an oral exam in the exam period.

Person responsible for course: László Dr. Juhász, associate professor, PhD, dr. habil

Lecturer: László Dr. Juhász, associate professor, PhD, dr. habil.

Title of Course: Chemistry of secondary metabolites II. Code: TTKML0332_EN	ECTS Credit points: 3

Classification of the subject: optional course

Type of teaching, contact hours
- lecture: -
- practice: 4 hours/week
- laboratory: -

Evaluation (exam. / practice. / other): **term grade**

Workload (estimated), divided into contact hours:
- lecture:
- practice: 72 hours
- laboratory: -
- home assignment: 28 hours
- preparation for the exam:

Total: 100

Year, semester: 1st/2nd year (fall)

Prerequisite(s):

Topics of course

Isolation and derivatization of nicotine; Isolation of coffein; Isolation and hydrolysis of piperine; Essenes of the rosary resin; Isolation and derivatization of carvone; Isolation of betulin from birch bark, Isolation and derivatization of cholesterol; isolation of anethol and anisic acid; cinnamic acid and cinnamaldehyde; isolation of rutin and quercetin; Isolation and derivatization of hesperidine. Synthesis of azelaic acid; Triglyceride of nutmeg; Isolation of thymol.

Literature

Compulsory:
- Satyajit D. Sarker, Zahid Latif, Alexander I. Gray; Natural Products Isolation, 2nd edition, Humana Press, 2006
- Corrado Tringali, Bioactive Compounds From Natural Sources: Isolation, characterisation and biological properties; Taylor and Francis, 2001.
- Corrado Tringali, Bioactive Compounds From Natural Sources: Natural Products as Lead Compounds in Drug Discovery, 2nd edition, CRC Press, 2012
- Jerry R. Mohrig, David Alberg, Gretchen Hofmeister, Paul F. Schatz, Christina Noring Hammond; Laboratory Techniques in Organic Chemistry; 4th edition; W. H. Freeman and Company

Course objective/intended learning outcomes

a) Knowledge
- He/she knows theoretical backgrounds and devices of the classical isolation methods of the natural compounds and he/she can apply it.
- He/she knows the design and evaluation methods of experiments.

b) Abilities
- He/she is able to select and apply the required isolation technique.
- He/she is able to improve the chemical and chemical industrial knowledge base with original ideas and results.
- He/she is able to participate in professional communication on the isolation of natural compounds.
- He/she is able to expand and/or develop his/her knowledge.

c) Attitude

- He/she is open to getting new, scientifically proven knowledge on the subject, but to reject unsubstantiated or possibly misleading claims.
- He/she strives to plan and execute tasks alone or in a work team at a high professional level.

d) Autonomy and responsibility

- He/she is able to independently perform the experiments of the lab course with professional guidance, and he/she can interpret and evaluate of the results obtained.
- He/she takes individual initiatives in solving professional problems.

Schedule:

1st week

Isolation of nicotine from Tobacco leaves and derivatization with picric acid. Characterization of the product and calculation of nicotine contain of tobacco leaves.

2nd week

Isolation of coffein from tea leaves and characterization of the product and calculation of coffein contain of tea leaves.

3rd week

Isolation of piperine from black pepper and hydrolysis into piperic acid. Characterization of the product and calculation of piperine contain of black pepper

4th week

Isolation of essential oil from the rosin resin and characterization of the product.

5th week

Isolation of carvone from caraway and derivatization with 2,4-dinitrophenylhydrazone. Characterization of the product and calculation of carvone contain of caraway.

6th week

Isolation of betulin from birch bark and characterization of the product

7th week

Isolation of cholesterol from gall stone and transformation into dibromo derivatives. Characterization of the products.

8th week

Isolation of anethol from anise and transformation into anisic acid. Characterization of the products.

9th week

Isolation of cinnamic aldehyde from cinnamon and transformation into cinnamic acid. Characterization of the products.

10th week

Isolation of rutin from Japanese acacia flowers and transformation into quercetin. Characterization of the products.

11th week

Isolation of hesperidin from orange peel and transformation into hesperetin. Characterization of the products.

12th week

Isolation of azelaic acid from castor oil. Characterization of the products.

13th week

Isolation and saponification of the glyceride of nutmeg. Characterization of the products.

14th week

Isolation of thymol from thyme. Characterization of the products.

Requirements:

A student must attend the laboratory classes and may not missed during the semester. In case of absences, a medical certificate needs to be presented, otherwise the subject will not be signed, and the student must repeat the course. Being late is equivalent with an absence. The knowledge of the students is controlled every week with a short written test at the beginning of the lab. The results of the experiments must be summarized in the laboratory notebook, which is checked and graded at the end of each practice.

- *for a signature*

Attendance at **laboratory** is compulsory. The student must be writing every short test and the laboratory notebook.

- *for a grade*

The minimum requirement for the short written tests respectively is 50%. Based on the score of the tests separately, the grade for the tests is given according to the following table:

Score	Grade
0-49	fail (1)
50-65	pass (2)
66-80	satisfactory (3)
80-89	good (4)
90-100	excellent (5)

The final mark will be calculated as an average of the grades of tests and laboratory notebooks

Person responsible for course:.László Dr Juhász, associate professor, PhD, dr. habil

supervisor: László Dr Lázár, associate professor, PhD, dr. habil.

Internship

Title of Course: **Internship** **TTKMX4601_EN**	**ECTS Credit points: 0**
Classification of the subject: compulsory	
Type: continuous, 2nd semester	
Period of time: 4 weeks	
Evaluation (exam. / practice. / other): **signature**	
Year, semester: Every 2nd semester (spring)	
Prerequisite(s):	
Topics of course	
Internship is an ideal opportunity to apply existing skills and to develop new ones whilst getting a practical insight into working life in chemical industry, it gives real world experience, and a possible step in a career and provides with the opportunities for the future. All these experiences greatly enhance career prospects for when students graduate. The students get acquainted with the principles of instruments in chemical industries and technologies, and their operative parts, and their design. The students get acquainted with the concepts and methods of environmental sustainability in the chemical industry. The students get acquainted with those directives that necessary to operate instruments and control processes in a safe, cost effective way as well as avoid any problems. The students get acquainted with the operation and the structural organization of the factory. The process of "Ipar 4.0." in the chemical industry.	
Requirements	
The students are expected to write a report on the work accomplished during the internship.	
Partnerships with companies	
In the recent years we have cooperation with about 50 companies in the field of chemical engineering. The more important ones: Teva Pharmaceutical Industries Ltd. MOL Petrochemicals Ltd. BorsodChem Gedeon Richter Plc. Alkaloida Ltd. Coloplast Hungary Ltd. Evonik Agroferm Ltd. Henkel Hungary Ltd. Pipelife Ltd. Unilever Hungary Ltd.	
Organizing, supervising, and controlling the internship	
The heads of the External Departments of Pharmaceuticals (TEVA) and Petrochemistry and Polymer Technology (MOL) organize and control the internship. The persons responsible for internship at the company and in the university organize and control internship together.	
Course objective/intended learning outcomes	

a) Knowledge:

- He/she knows the operating principles of equipment, devices, structural units and the basics of their design, used in the chemical and chemical technologies and related laboratories.
- He/she knows principles, methods and practices relating to the sustainability, safety and environmental impact of chemical and chemical systems, workplace health and health promotion.
- He/she is aware of the possible developmental trends and boundaries of chemistry and the chemical industry.

b) Ability:

- He/she is capable of applying and improving the processes, models, information technologies and processes used in the design, organisation and operation of Chemical and chemical technology systems and procedures.
- He/she is capable of quality assurance of chemical and chemical technology systems, technologies and processes, to solve metrology and process control tasks.
- He/she is capable of solving creative problems and flexible solutions to complex tasks, as well as lifelong learning, keeping openness and value-based.
- He/she is able to recognise the effects of technological systems on the non-endangering and safe functioning of human health and the use of the necessary preventive action toolkit.

c) Attitude:

- He/she seeks to validate and communicate with others the requirements of sustainability, safety, environmental protection and energy efficiency.
- He/she endeavours to plan and carry out its tasks professionally at a high level individually or in a working group.
- He/she carries out its work in A complex approach based on a systemic and process-oriented way of thinking.

d) Autonomy and Responsibility:

- He/she acts independently and in an initiative to solve professional problems.
- He/she is responsible for sustainability and environmental protection.
- He/she makes decisions with caution, with appropriate autonomy and in consultation with representatives of other (not only technical) fields of expertise, as appropriate.

Person responsible for course: Dr. Ákos Kuki, associate professor, PhD