CONTENTS SHORT DESCRIPTION	Discipline code	ECTS	year
1. Numerical and Optimization Methods in Environmental Engineering Approximate calculations and their evaluation. Numerical differentiation and integration. Approximately solving equations with one unknown, systems of linear and nonlinear equations and some classes of differential equations. Interpolation and approximation of functions. Calculation of final Differential Equations: An Introduction, solving linear homogeneous, linear and nonlinear nonhomogenous Differential Equations. Linear and nonlinear programming: defining the problem and its solution using graphical and analytical methods. Practical examples. Developing models for optimization, the basic concepts of optimization models, methods for optimizing functions with or without constraints and computer support optimization of processes MATLAB Optimization Toolbox. Application of the computer program (s) to solve problems of numerical optimization.	MAT/08	6	1

2. Environmental Systems Analysis Definition and elaboration of the concepts and methods of systems analysis as applied in planning, design, management and technologies for environmental protection in order to enable sustainable development. Description of the methods, and reasons for their introduction, their performance, context and implementation, scope of application, and limitations. General overview of methods: evaluation of environmental impacts (Environmental Impact Assessment - EIA), strategic environmental assessment (Strategic Environmental Assessment - SEA), positional analysis (Positional Analysis - PA), Cost-Benefit Analysis (Cost-Benefit Analysis - CBA), analysis of exergy (Exergy Analysis) analysis of emergy (Emergy Analysis), analysis of the movement of materials (MFA), analysis of the intensity of the material in terms of unit service (Material Intensity per Unit Service - MIPS analysis), analysis the total demand of material (Total Material Requirement - TMR analysis), ecological footprint (Ecological Footprint - EF), risk assessment (Risk Assessment - RA) for chemicals rate, life cycle (Life Cycle Assessment - LCA), estimating costs the life cycle (Life Cycle Cost Analysis - LCC).	ING-INF/04	6	1

3. Environmental Protection in Energy Production Overview of energy issues: major issues facing contemporary energy, energy, economy and development; Energy and Environment. Methods for efficiently and economically viable use of energy resources. Conversion, transport and use of energy, minimizing the effects on people and the environment. Common and advanced technologies for generating energy. Common and advanced processes and techniques for the control of pollution from power generating plants. Methods and analysis of the importance of advanced energy technologies to achieve two basic goals: energy security and environmental protection, including reducing the impact on climate change. Quantification of greenhouse and other gases (indicators) and decreasing dependence on fossil fuels. Analysis of the impact of a set of energy technologies on the environment.	ING-IND/09	9	1

4. Water and Wastewater Treatment Plants Parameters for determining water quality. Recommendations of WHO for drinking water quality. Treatment procedures. Earlier treatment, coagulation and flocculation, sedimentation, filtration, adsorption, disinfection, rapid sand filtration, activated carbon, ozonation, membrane filtration (reversed osmosis). Composition of the water quality and definition. Procedures for the treatment of water. Preliminary treatment (screening, measurement of flow), aeration (oxidation, reduction of iron, manganese, CO2, H2S and volatile organic compounds), coagulation and flocculation, sedimentation, filtration (general types of filters), adsorption (general adsorption and types of adsorption devices), refill (procedure with lime milk-Ca (OH) 2, CaO, Na2CO3 and ion exchange), disinfection (chlorine, ozonation and UV radiation) and membrane-separating processes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis). Characteristics of wastewater. Mechanical treatment. Biological processes to remove organic carbon. Elimination of nitrogen (nitrification, denitrification) and phosphorus. Designing facilities for treatment. Basics of designing systems with active sludge. Achieving the required efficiency of purification. Energy needs and performance of the machines. Classification and characterization of wastewater. Procedures for wastewater treatment. Preliminary treatment, Primary/mechanical treatment (separation of suspended particles, settling), secondary/ biological treatment (removal of dissolved organic matter and colloids, aeration), tertiary treatment (disinfection with NaOCl or CaOCl) and treatment active sludge (recirculation and disposal of surplus sludge, aerobic and anaerobic digestion, gravity thickening). Design, energy efficiency and economic optimization of plants for sewage treatment.	ICAR/03	6	2

5. Environmental Fluid Mechanics Applications of fluid mechanics to natural flows of water and air in environmentally relevant systems. Viscous fluid flow. Models to describe and calculate the turbulence. Multistage flows. Two-component flows. Flows in porous environment. Gravitational and pressurized flows in technical systems. Flows in open channels. Nonstationary flows. Computational Fluid Dynamics methods for numerical computation. **Course Objectives** • Ability to perform mass, momentum and energy balances in natural fluid systems • Ability to perform a stability analysis of a particular fluid flow • Advanced understanding of hydraulics	ICAR/01	6	2

6. Automation of Environmental Processes Study of the most commonly used types of control algorithms (sequential, continually, On-Off and feedforward control, feedback (P, PI, PID control), advanced control algorithms: adaptive, nonlinear, on-going model control) Analysis and synthesis of complex control systems in the closed configuration, design of regulators applying the criterion of frequency response, design of control systems using compensation syllables, specifications of multivariable control systems in environmental engineering; Design of digital control systems; analysis and synthesis of discrete systems, design of regulators for discrete systems (digital version of PID, PID/IMC) Examples of implementation of control algorithms for plants for drinking water purification (Basic model: control stations with pump control, coagulation dosing, with pH, with purification and sedimentation, filtration, chlorination), plants for waste water treatment (dissolved oxygen control, system for control of the time of particles retention, control of the depth in the mud refiner) and general control algorithms in the plants for drinking water purification, Control Systems Architecture. Supervisory Control and Data Acquisition Systems (SCADA) and Digital Control Systems (DCS) (Introduction, SCADA / DCS Software, Hardware of the Control Systems (PLC, RTU, Networks), OPC); Application of SCADA control equipment for wastewater treatment systems. Measuring instruments for pressure, flow, temperature, level, viscosity and other specific environmental process parameters. Design process-control schemes in environmental engineering. Analysis and synthesis of control systems for environmental processes using the software package MATLAB/Control ToolBox / Simulink and Lab View.	ING-INF/04	6	2

7. Environmental Monitoring Systems Define the needs for monitoring and control of environmental pollution. Analysis of air, water and soil pollutants. Methodology and techniques of continuous measurement of pollutants: Infrared absorption, ultraviolet absorption, UV-fluorescent analyzers. Instruments for the determination of total carbon, hydrogen, nitrogen, sulfur and oxygen. Carbon analyzers with different methods, gas chromatography, photoionization. Analysis of the advantages and disadvantages of continuous environmental monitoring. Comparison of sensors and instruments for continuous monitoring and field measurement and analysis systems for continuous monitoring and control of environmental pollution. Monitoring of surface waters: Electrochemical measurements, pH, electrical conductivity, redox potential. Turbidity, hardness, inorganic and organic contaminants, total dissolved solids (TDS), suspended solids (SS), flow and level, dissolved oxygen. Monitoring and control of municipal and industrial wastewater, analysis of monitored parameters, measurement techniques, placement of automated measuring stations. Monitoring of air pollutants analysis, measurement techniques, analysis of measurement stations for continuous monitoring of air quality.	ING-IND/12	6	2

8. Renewable Energy Technologies Solar radiation energy: technology to transform solar radiation into thermal and electrical energy, transformation efficiency. Systems for heating water, heating and cooling air; drying and desalination of seawater. Systems for accumulation of solar radiation. Geothermal energy and geothermal sources. Direct use of geothermal sources for residential, commercial and industrial purposes: greenhouse production, heating, drying and aquaculture. Technologies for transformation into electricity. Impact on the environment. Bioenergy: Production and classification of biomass. Energy potential of biomass. Technologies for transformation of biomass into liquid, gaseous and solid fuels. Plants utilizing bio-energy: small, medium capacity and cogeneration plants. Wind Energy: Transforming the energy of the wind into mechanical energy. Basic elements of the wind turbine. Designing wind turbine blades. Control and management. Cost, reliability and availability. Impact on the environment. Hydropower: Energy of water flows. Technologies for transformation of the water flow energy into mechanical and electrical energy. Selection of the turbine type and turbine control. Cavitation. Calculation of speeds and dimensions of the water turbines. Operating characteristics of turbines. Systems for automatic control. Hydro Power Plants.	ING-IND/09	6	2

9. Environmental Risk Management This course covers Environmental Risk Assessment (ERA) from a public health perspective and an environmental risk management perspective. Emphasis is given to the decision tree methodologies and their potential to facilitate the analysis and identification of optimum remedial risk management alternatives. Students will be focused on the vulnerability and risk assessment methodologies for natural disasters and man made events. Vulnerability assessment is the process of identifying and quantifying vulnerabilities in a system (e.g., physical facility such as a chemical plant, or infrastructure component such as a power plant). Vulnerability assessment has many common methodological elements with human/ecological risk assessment, during the course these commonalities and differences will be underlined. By successfully finishing this course, the students are expected to: - be able to apply commonly used hazard, vulnerability and risk assessment methodologies. - critically review existing hazard and risk based standards/guide-lines. - formulate remedial hazard and (emergency) risk management plans based on decision tree methodologies. - consult and communicate effectively with stakeholders, interest groups, and regulatory bodies concerned with the hazards and risks posed by natural and man made events.		5	2

10. Environmental Impact Assessment and Management The course covers Environmental Impact Assessment (EIA) as a significant, anticipatory, environmental management tool. EIA should be enhanced to meet the challenges of sustainable development and demands for scientifically robust integrated and participative decision-making. This course presents practice by contributing an international, multidisciplinary, ready-reference source approach. The courses addresses EIA principles, process and methods. Part of the course maps the EIA process and its impact on decision, and positions EIA in the context of sustainable development as well as the other decision tools, including economic valuation. It also positions strategic environmental assessment (SEA) in a similar way. The other part of the course addresses the elements of the EIA process and significant impact assessment topics (air, water, ecological, social, risk, landscape and visual), not only in terms of good practice but also methodological evolution. This part concludes by addressing cumulative impact assessment and SEA methods. The **aim of this course** is to provide a thorough, stimulating and practical post-graduate education in EIA and its related areas. Its specific objectives are to: • provide an integrated programme of studies to equip students to undertake the planning and management tasks associated with the principal stages of environmental assessment, • provide an opportunity for students to pursue particular aspects of environmental assessment, or wider environmental management, in greater depth by choice of assignments and by undertaking research on an individually selected dissertation topic. The course gives students a sound basic knowledge of the relevant aspects of the process of EIA, environmental science, and environmental planning before it builds upon this with more specialist teaching. Students therefore gain a thorough grounding in EIA procedures and current practice and an introduction to the rapidly growing environmental management field. The course trains students in EIA project management skills that involve the co-ordination of the contributions of technical specialists, decision-makers and consultees. Students acquire appropriate analytical and communication skills, and flexibility of approach - thus graduating with expertise highly valued by employers.		5	2

11.	**Course program for the second level (second cycle - postgraduate) of studies**					
1.	Course title		Selected topics in Mathematics and Informatics			
4.	The organizer of the study program (unit, institute, department)		"Ss. Cyril and Methodius" University in Skopje, Faculty of Mechanical Engineering - Skopje			
6.	Academic year / semester		I / winter	7.	ECTS credits	6
9.	Prerequisites for enrolling the course		None			
10.	Course objectives (competences): Introduction to selected topics in applied mathematics, probability and statistics and selected software for solving engineering problems.					
11.	Course content: Selected chapters in linear algebra, numerical methods, optimization methods, complex analysis, probability and statistics with emphasis on solving technical problems. Using specific programming techniques, software and basics of organizing data and intelligent systems.					
12.	Study methods: lectures, lab, project assignments, individual assignments, self-study.					
13.	Total hours		6 ECTS x 30 = 180 hours			
14.	Hours allocation per activity:		30+30+30+30+60 = 180 hours			
15.	Lectures/Lab	15.1.	Lectures (15 weeks x 2)			30 hours
		15.2.	Lab (student work)			30 hours
16.	Project Work/Assignments	16.1.	Project assignments			30 hours
		16.2.	Individual assignments			30 hours
		16.3.	Self-study			60 hours
17.	Points/Marks:					
	17.1.	Exams				50
	17.2.	Projects				40
	17.3.	Attendance				10
18.	Grading scale		Under 50			5 (five) (F)
			51 - 64 points			6 (six) (E)
			65 - 74 points			7 (seven) (D)
			75 - 84 points			8 (eight) (C)
			85 - 94 points			9 (nine) (B)
			95 - 100 points			10 (ten) (A)
19.	Prerequisites for taking the final exam		Activity 16.1, 16.2, 16.3			
20.	Language		English			
21.	Course evaluation		Student questionnaire			

12.	Course program for the second level (second cycle - postgraduate) of studies					
1.	Course title	Modeling and Simulations of Energy Systems				
4.	The organizer of the study program (unit, institute, department)	"Ss. Cyril and Methodius" University in Skopje, Faculty of Mechanical Engineering - Skopje				
5.	Level (first, second, third degree)	Second				
6.	Academic year / semester	I / winter	7.	ECTS credits	6	
9.	Prerequisites for enrolling the course	None				
10.	Course objectives (competences): Advanced knowledge of methods for energy planning and modeling energy systems. Advanced level of numerical modeling, engineering approach towards modern techniques of modeling and simulations. training for creating and using software applications for design, analysis and solving steady, unsteady and dynamic systems in the field thermal engineering and energetics. Training for making a mathematical model of a thermal power plant, object or process. applying suitable techniques for numerical modeling and simulations, analysis and interpretation of results, accuracy, stability and reliability of the model.					
11.	Course content: Introduction to modeling energy systems. Numerical thermal analysis. Mathematical modeling of thermal processes - in general. Approach in modeling. Basic equations of dynamic processes and fluid flow. Basic equations for heat transfer and defyning boundary conditions and types of boundary conditions. Method of finite volumes, solving discrete equations. Computational domain, geometry and numerical mesh. Validating mathematical models and solutions. Methods for modeling unsteady processes. Modeling, simulations and optimization of thermal processes and systems using computer tools. Using software tools for improving energy efficiency. Modeling processes related to emission and concentration of harmful substances from thermal processes. Specific functions and models for modeling thermal processes.					
12.	Study methods: lectures, lab, project assignments, individual assignments, self-study.					
13.	Total hours	6 ECTS x 30 = 180 hours				
14.	Hours allocation per activity:	30+30+10+10+100 = 180 hours				
15.	Lectures/Lab	15.1.	Lectures (15 weeks x 2)	30 hours		
		15.2.	Lab (student work)	30 hours		
16.	Project Work/Assignments	16.1.	Project assignments	10 hours		
		16.2.	Individual assignments	10 hours		
		16.3.	Self-study	100 hours		

13.	Course program for the second level (second cycle - postgraduate) of studies						
1.	Course title	Advanced Course in Energy Transformation					
4.	The organizer of the study program (unit, institute, department)	"Ss. Cyril and Methodius" University in Skopje, Faculty of Mechanical Engineering - Skopje					
5.	Level (first, second, third degree)	Second					
6.	Academic year / semester	I / winter	7.	ECTS credits	6		
9.	Prerequisites for enrolling the course	None					
10.	Course objectives (competences): Learning advanced methods for renewable energy usage. Specific knowedge of small hydro, wind, tidal, wave, solar, geothermal and biomass energy transformation						
11.	Course content: Overview of advanced renewable energy resources. Energy of inland water bodies. Tidal energy development. Methods and parameters for selection and design of wind turbines. Numerical modeling. State-of-the-art trends and designs in renewable energy. Production price. Solar energy panels with and without radiation concentration. Types of geothermal energy sources, Technologies and drilling equipment. Low temperature energy sources. Biomass sources. Forests, agriculture, municipal and industrial waste. Energy potential. Biogas fuels.						
12.	Study methods: team work on project assignments, selfrunning assignments						
13.	Total hours	10 ECTS x 30 hours = 300 hours					
14.	Hours allocation per activity:	45+45+45+45+120=300					
15.	Lectures/Lab	15.1.	Lectures	45 hours			
		15.2.	Lab (student work)	45 hours			
16.	Project Work/Assignments	16.1.	Project assignments	45 hours			
		16.2.	Individual assignments	45 hours			
		16.3.	Self-study	120 hours			
17.	Points/Marks:						
	17.1.	Exams	40				
	17.2.	Projects	50				
	17.3.	Attendance	10				
21.	Course evaluation	Student questionnaire					

14.	**Course program for the second level (second cycle - postgraduate) of studies**					
1.	Course title		Waste management			
4.	The organizer of the study program (unit, institute, department)		"Ss. Cyril and Methodius" University in Skopje, Faculty of Mechanical Engineering - Skopje			
5.	Level (first, second, third degree)		Second			
6.	Academic year / semester		I / summer	7.	ECTS credits	6
9.	Prerequisites for enrolling the course		None			
10.	Course objectives (competences): Able to organize and run efficient (environmental, energy and economically) system for waste management in industry. Understanding the chain of actions for waste management system of a product or a solution for the industry or community. Understanding the applicable technologies for reducing waste, reusing waste or turning waste in to a raw material for further processes.					
11.	Course content: Exploring technical models, equipment and units, regulations for efficient waste management. Systems for waste management in communities and industry. Cain of actions in waste management. Examples for waste reduction. Examples for reusing waste, turning waste in to energy etc.					
12.	Study methods: Interactive lectures, auditory and/or laboratory practice, selfrunning and/or team work on project assignments, selfrunning assignments					
13.	Total hours		6 ECTS x 30 = 180 hours			
14.	Hours allocation per activity:		30 + 15 + 45 + 45 + 45=180 hours			
15.	Lectures/Lab	15.1.	Lectures (15 weeks x 2)			30
		15.2.	Lab (student work)			15
16.	Project Work/Assignments	16.1.	Project assignments			45
		16.2.	Individual assignments			45
		16.3.	Self-study			45
17.	Points/Marks:					
	17.1.	Exams				30
	17.2.	Projects				60
	17.3.	Attendance				10
19.	Prerequisites for taking the final exam		Presented projects			
20.	Language		English			
21.	Course evaluation		Student questionnaire			

15.	**Course program for the second level (second cycle - postgraduate) of studies**					
1.	Course title		Design of fluid conveying and hydro power system			
4.	The organizer of the study program (unit, institute, department)		"Ss. Cyril and Methodius" University in Skopje, Faculty of Mechanical Engineering - Skopje			
5.	Level (first, second, third)		Second			
6.	Academic year / semester		I / summer	7.	ECTS credits	6
9.	Prerequisites		None			
10.	Course objectives (competences): Introduction to systems for hydraulic and pneumatic convey of fluids. Developing mathematical models for hydraulic calculation of the systems and their components. Introduction to systems for hydro power. Developing mathematical models for hydraulic calculation of the systems and their components.					
11.	Course content: Physical properties of fluids, water, oil, gas and mixtures of fluid - solid particles. Hydraulic and Pneumatic Conveying: calculation, devices and equipment, Hydro power systems: pump stations and hydro power plants: calculation, devices and equipment Techno-economical calculation and economic parameterization					
12.	Study methods: lectures, lab, project assignments, individual assignments, self-study.					
13.	Total hours		6 ECTS x 30 = 180 hours			
14.	Hours allocation per activity:		30 + 15 + 40 + 30 + 65 = 180 hours			
15.	Lectures/Lab	15.1.	Lectures (15 weeks x 2)			30 hours
		15.2.	Lab (student work)			15 hours
16.	Project Work/Assignments	16.1.	Project assignments			40 hours
		16.2.	Individual assignments			30 hours
		16.3.	Self-study			65 hours
17.	Points/Marks:					
	17.1.	Exams				40
	17.2.	Projects				50
	17.3.	Attendance				10
19.	Prerequisites for taking the final exam		Activity 16.1			
20.	Language		English			
21.	Course evaluation		Student questionnaire			