SVEUČILIŠTE U ZAGREBU
METALURŠKI FAKULTET

UNIVERSITY OF ZAGREB
FACULTY OF METALLURGY

SISAK

GRADUATE STUDY PROGRAM

„METALLURGY“

NOTE: revised study program in application from academic year 2017/2018

PROGRAM OF THE COURSES

Sisak, July, 2017

CONTENT

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169729
1.1. Course teacher	Assoc.Prof. Ljerka Slokar	1.6. Year of study	1.
1.2. Name of the course	**PHYSICAL METALLURGY**	1.7. Credit value (ECTS)	5
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	45+0+30+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Developing the ability to connect theoretical knowledge and properties of metals. Deepening the theoretical understanding of reactions between metals and in metals. Programming desired properties of metals.
2.2. Enrolment requirements and required entry competences for the course	
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Design the properties of metallic materials. Compare the procedures of material treatment with microstructure and useful properties.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Explain the classification, formation, structure and morphology of the important group of steels. Analyze and describe the procedures for designing the desired properties of metallic materials. Explain models and growth kinetics of selected metal materials. Describe the fatigue and fracture of metals from the standpoint of microstructure. Explain the characteristics and structural features of composite, nano and amorphous metals.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (45): Introduction. Classification of iron and steel according to the composition, manufacturing process, generic type, microstructure, final processing, the use of (4). Ferrite; the formation, structure and morphology. Ferritic steels. The influence of various elements on the properties of ferritic steels. The kinetics and mechanism of transformation. (4) Austenite; formation, kinetics, morphology. Austenitization in one-and two-phase area. Size and form of austenitic grain. The transformation of austenite during cooling. (4) Cementite; Primary, secondary and tertiary. The structure and morphology. Perlite, formation and forms. Interlamellar space and properties. (2) Ferrite-pearlite and pearlite steels. Hypo-and hyper eutectoid steels. Growth kinetics and structure (s) of pearlite. Intermediate precipitation. Spheroidization of pearlite. (4) Bainite. Mechanism of bainite forming. The upper and lower bainite. The morphology of specific types of bainite. Alloying elements impact. Bainitic steels. (4) Martensite. Characteristics and conditions of martensitic transformation. A crystallographic model of martensitic formation. Needle, thermoelastic martensite. Athermic and isothermal martensite. (4) Martensitic steels. Current martensitic transformation. Mechanically induced martensitic transformation. The kinetics of

	nucleation and growth in martensitic transformation. Memory forms in martensitic transformation. (4) Recovery and recrystallization of metals. (3) The precipitation hardening (or hardening) of metals. (2) Segregation of metals. Macro-and microsegregation types and causes of segregation. Distribution law. Zone refining of metals. Fatigue and fracture of metals. (4) Composite metals. Particle and fiber-reinforced composites, structural composites. Compatibility; physical, chemical, mechanical and electrical properties. (3) Amorphous metals and whiskery. Synthesis, structure and properties. Nanometals. Production, properties, use (3) EXERCISES (30): Auditory exercises: Phase diagram Fe-Fe_3C, determination of microconstituents in specific types of steel, computational tasks in the field of composite materials (6). Laboratory exercises: metallographic preparation of various types of steel, composites, amorphous metals (12), and their analysis by optical microscopy and scanning electron microscopy (12).

2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☒ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:

2.8. Student responsibilities	Attending lectures and auditory exercises (min.70%), committed reports from laboratory exercises.

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance	0.5	Research		Practical training	
	Experimental work	0.5	Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	2.0	Oral exam	1.0	(Other—describe)	
	Written exam	1.0	Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	The final grade is determined by score of three colloquiums and assessments of written and oral exams respectively.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	R. W. Cahn, Physical Metallurgy, Nort-Holland Publ. Comp., Amsterdam,1997.	1	CD
	R. E. Smallman, R. J. Bishop, Modern Physical Metallurgy and Materials Engineering, Butterworth, Oxford, 1999.	1	CD
	T. Matković, P. Matković, Lj. Slokar, Znanost o metalima – Zbirka rješenih zadataka, Sisak, 2010.		https://www.simet.unizg.hr/nastava/predavanja/preddiplomski-sveucilisni-studij-metalurgija/2-godina-preddiplomskog/Zadaci%20iz%20FM%20re-TNR-Boja-

			1.pdf/view
	T. Matković, P. Matković; Fizikalna metalurgija I (skripta), Metalurški fakultet, Sisak, 2009.		https://www.simet.unizg.hr/nastava/predavanja/preddiplomski-sveucilisni-studij-metalurgija/2-godina-preddiplomskog/Fizikalna%20metalurgija%20I.pdf/view
2.12. Optional literature (at the time of the submission of the study programme proposal)	W. D. Callister, Materials Science and Engineering, J. Wiley& Sons, New York, 1996. W. C. Leslie, Physical Metallurgy of Steels, McGraw-Hill, Tokyo, 1982.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Anonymous survey on the level of the Faculty and University. Analysis provided by system of quality assurance institutions. Analyses provided by quality assurance system and authorized offices of the University.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Explain the classification, formation, structure and morphology of the important group of steels.	1st colloquium, auditory exercises, laboratory exercises, written and oral exam
2	Analyze and describe the procedures for designing the desired properties of metallic materials.	1st colloquium, auditory exercises, laboratory exercises, written and oral exam
3	Explain models and growth kinetics of selected metal materials.	2nd colloquium, auditory exercises, written and oral exam
4	Describe the fatigue and fracture of metals from the standpoint of microstructure.	2nd colloquium, laboratory exercises, written and oral exam
5	Explain the characteristics and structural features of composite, nano and amorphous metals.	3rd colloquium, auditory exercises, laboratory exercises, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169730
1.1. Course teacher	Full Prof. Ladislav Lazić, PhD	1.6. Year of study	1
1.2. Name of the course	**INDUSTRIAL FURNACES**	1.7. Credit value (ECTS)	5
1.3. Associate teachers	Ivan Jandrlić, PhD	1.8. Type of instruction (number of hours L+S+E+e-learning)	45+0+30+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Acquire knowledge about the furnaces for production of metal materials. 2. Acquire knowledge about the special furnaces for production of metal materials. 3. Acquire knowledge about the furnaces and devices for heating of metal materials. 4. Acquire knowledge about the electric furnaces and devices for heating of metal materials. 5. Inform students about the current status and directions in development of industrial furnaces.
2.2. Enrolment requirements and required entry competences for the course	The acquired knowledge from the courses of undergraduate study: Metallurgy of iron, Steel metallurgy, Refractory and carbon materials, Engineering thermodynamics and Heat and mass transfer.
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Suggest new and improved technical and technological solutions. 2. Analyse the development and application of new technologies. 3. Analyse the production processes by applying thermodynamic laws. 4. Plan and manage metallurgical processes. 5. Analyse the material and thermal balance of metallurgical processes. 6. Formulate and suggest measures for increasing energy efficiency.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Analyze and identify problems in the work of the concrete industrial furnace and propose technical solutions. 2. Determine computationally the profile and dimensions of the furnace space. 3. Create individual structural elements of the furnace and select materials for their construction. 4. Calculate the individual periods and regimes of heating of metal materials. 5. Analyze and propose solutions for increasing the energy efficiency of a furnace. 6. Analyze and propose solutions for reducing emissions of pollutants into the environment. 7. Propose technical solutions for cleaning the waste gases.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (45): 1. General considerations about the requirements that the furnace should satisfy. The division of industrial furnaces. Furnaces of process industries. Furnaces of manufacturing industry. Classification of furnaces and individual features. Structural elements of the furnace. (3) 2. Furnaces of process industries. Blast furnaces. The structural elements of the blast furnace. Devices for filling-in (loading) of raw materials in the blast furnace. Air nozzles and slag outlet. Cleaning of furnace gas. Air preheat, cowpers and cowper systems. (3) 3. Cupola furnaces. The structural elements of cupola furnaces. Steel sheet, chimney and spark chaser. Annular chamber and air nozzles. Pre-small furnaces. Air preheating, conventional and radiation recuperators. (3)

	4. Converters. The construction of the converter operating in an oxygen mode. The sheet, ring, stands and mechanism for tilting. Spear for oxygen. Spear cooling. Cleaning of converter gas. Supplying of technical oxygen. (3) 5. Electric arc furnaces. The structural elements of electric arc furnaces. Portal support of vault. The device for carrying and lowering the electrodes. Electric regime of furnace. Highly efficient electric arc furnaces. Plasma-arc furnaces for remelting of metals. (3) 6. Induction electric furnace. High-frequency electric furnace. Electric resistance furnace. Furnaces with electron beam. Furnaces with plasma jet. (3) 7. Movable and immovable mixers. Construction of mixers. Mixer supplied with burners. Lining of mixers and their use. (3) 1st colloquium 8. Furnaces of manufacturing industry. Rolling mill soaking pits and their development. Contemporary soaking pits. Operating efficiency of furnace and fuel consumption. Rolling mill pusher furnace and their development. Constructional characteristics of the furnace. (3) 9. Thermal-technical zones of pusher furnaces. Temperature and thermal regime of furnace. Constructional characteristics of pusher furnaces. Arrangement of burners, heat exchangers and of their installation. (3) 10. Walking-beam furnaces and their development. Constructional characteristics of the furnace. The possibility of changing of dimensions and shape of the load. Furnaces with one-sided heating and two-sided heating (bottom firing). Thermal-technical zones of furnace and their conditionality. (3) 11. Rotary hearth furnaces for rolling mills of seamless pipes. Plate and ring furnaces. Thermal-technical zones of furnaces and their conditionality. Temperature and thermal regime of furnace. Sectional furnaces. (3) 12. Construction of segments and cylinder intermediate space. Profiled rollers for transporting the load. Heat exchangers. Electric furnace for heating of metal materials. The application of inductive heating in rolling mills. (3) 13. Forging furnaces in plants for metal forging. Directly and indirectly heating. Dualchamber furnaces for preheating and heating of material. Furnaces with annealing conditions. (3) 14. Construction of ceramic radiant tubes. Bell furnaces. Internal and external bell. The tightness of furnaces and the use of protective gas. Conveyor furnaces. Construction of conveyor and place its installation. The pit furnaces. (3) 15. Mathematical models of furnaces. Qualification of mathematical models. Structure of the furnace model. Checking the adequacy and adaptation of the model. (3) 2nd colloquium EXERCISES (30): The understanding of the material exposed in lectures is facilitated by solving the practical problems. The projects are selected so that they expand the presented theory and illustrate the application of theory to real problems.

2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☒ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)	2.7. Comments:
2.8. Student responsibilities	Attendance to Lectures and Exercises > 70 %		

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	1.25	Oral exam	2.0	(Other—describe)	

value of the course)*:*	Written exam		Project	1.25	(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Projects – 30% Class attendance – 5% Written exam – 30% Oral exam – 35%		
2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	J. Črnko, Industrijske peći, Metalurški fakultet, Sisak, 2010.	5	
	J. Črnko, Zbirka zadataka iz projektiranja industrijskih peći, Metalurški fakultet, Sisak, 2008.	2	
1.12. Optional literature (at the time of the submission of the study programme proposal)	P. Mullinger, B. Jenkins, Industrial and Process Furnaces, Elsevier, 2008. J. Ward, R. Collins, Industrial furnace technology, Centro de energia e technologia, Rio Tinto, 2003.		
1.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.		

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Analyze and identify problems in the work of the concrete industrial furnace and propose technical solutions.	1st colloquium, oral exam
2	Determine computationally the profile and dimensions of the furnace space.	1st colloquium, oral exam
3	Create individual structural elements of the furnace and select materials for their construction.	1nd colloquium, oral exam
4	Calculate the individual periods and regimes of heating of metal materials.	2nd colloquium, project, oral exam
5	Analyze and propose solutions for increasing the energy efficiency of a furnace.	2nd colloquium, oral exam
6	Analyze and propose solutions for reducing emissions of pollutants into the environment.	2nd colloquium, oral exam
7	Propose technical solutions for cleaning the waste gases.	2nd colloquium, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169731
1.1. Course teacher	Full Prof. Stoja Rešković, PhD	1.1. Year of study	1
1.2. Name of the course	**THEORY OF METAL FORMING**	1.2. Credit value (ECTS)	5
1.3. Associate teachers	Tin Brlić, mag.ing.met.	1.3. Type of instruction (number of hours L+S+E+e-learning)	30+30+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.4. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.5. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	2., 10%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Introduce students to the physical-chemical theory of deformation 2. Introduce students to the mechanical-mathematical theory of deformation 3. Introducing students to the scientific principles of deformation 4. Acquired knowledge applied to metal forming processes
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Design and apply the modelling of metallurgical and other processes. 2. Recognize and apply scientific principles important in the field of metallurgy. 3. Use the acquired theoretical knowledge in engineering practice.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Set a hypothesis on metal forming, 2. Create stress - strain diagram at the forming process, 3. Create dependence diagrams of stress and strain on process parameters, 4. Analyze the influential parameters on forming process, 5. Predict the behaviour of different metals during deformation, 6. Examine deformation resistance of metal materials, 7. Analyze process parameters at different deformation processes, 8. Valorise the deformation parameters at different deformation processes, 9. Apply theoretical knowledge to solve engineering problems in practice, 10. Set hypothesis on influence of individual factors of deformation process, design and conduct an experiment, analyze and present the results.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30) AND SEMINARS (30): 1. Introduction. 1 2. Physical and chemical theory. 1 3. Deformation of Monocrystal. Mechanisms of metal plastic flow (slip and twinning). 2 4. Defects of crystal lattice. Dislocations. 1 5. Deformation of polycrystalline. 1 6. Cold plastic deformation, hardening curves of I, II and III order. 2 7. Hot plastic deformation. Strengthening and softening mechanisms during deformation. 1 8. Interdependence of deformation, recovery and recrystallization. 1

	9. Seminar: Different topics from physical theory of deformation. 4 I Colloquium, chapters 1-8 10. Mathematical-mechanical theory of deformation: State of stress, stress 2 11. Stresses on an inclined plane. 1 12. Stresses in the body that rotates around its axis. 1 13. Seminar - determination of stress. 2 14. Main normal and main shear stresses. 2 15. Stress tensor. 1 16. Seminar - determination of the main normal and shear stresses for different stress state conditions. 4 17. Graphic method of determination of stress. 2 18. Seminar - graphical determination of stress. 4 19. Stress scheme and deformation scheme. The law of equilibrium. 1 20. Deformation theory. 1 21. Conditions of flow. The law of flow. 1 22. The strain rate. 1 23. Seminar - determining the connection between stress and strain for various conditions of stress state. 4 24. Non-uniformity of deformation. 1 25. Determination of deformation force. Slip line method. Deformation work Method. Method of modelling. 2 26. Seminar – determination of deformation force for different conditions of stress state. 4 27. Deformation work. 1 28. Seminar – determine the deformation work for different conditions of stress state. 4 II Colloquium, chapters 10-27 29. Theory of deformation process. Theoretical basis of rolling. 1 30. Theoretical basics of forging and pressing. 1 31. Theoretical basis of extrusion. Theoretical basics of drawing. 1 32. Seminar - defining stress state and calculation of deformation forces and deformation work for different technologies of shaping by deformation. 4
2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work ☒ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other) 2.7. Comments:
2.8. Student responsibilities	Attendance at lectures min.70%, individual work on all exercises and preparation and submission of reports from field of colloquium before writing the colloquium or the written exam.

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
Class attendance		Research		Practical training		
Experimental work	0.5	Report				
Essay		Seminar essay	0.5	(Other--describe)		
Tests	2.5	Oral exam	1.0	(Other—describe)		
Written exam		Project	0.5	(Other—describe)		

2.10. Grading and evaluation of student work over the course of instruction	During the classes are evaluated the presence and activity of students on classes. Students score participation on projects and their work on specific project.

and at a final exam	Score of written colloquium trough continuous monitoring (or written exam) and oral exam. Score of seminar paper.		
2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	S. Rešković, Teorija oblikovanja deformiranjem, Sveučilište u Zagrebu, Metalurški fakultet, Sisak 2014., peer reviewed lessons		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/1-godina-diplomskog-studija/S%20Reskovic%20TEORIJA%20OBLIKOVANJA%20DEFORMIRANJEM.pdf/view
	I. Mamuzić, Teorija plastične deformacije metala, MF, Sisak, 2000.	10	
	M. Čaušević, Teorija plastične prerade, Svjetlost, Sarajevo, 1979.	6	
2.12. Optional literature (at the time of the submission of the study programme proposal)	B. Grizelj, Oblikovanje metala deformiranjem, Sveučilište J. J. Strossmayera u Osijeku, Strojarski fakultet u Slavonskom Brodu. Professional journals, articles from this area.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the level of faculty and University. Analyses provided by quality assurance system of the institution. Analyses provided by quality assurance system and authorized office of the University.		

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Set a hypothesis on metal forming.	1st colloquium, seminar paper, written and oral exam
2	Create stress - strain diagram at the forming process.	Seminar paper, independent task
3	Create dependence diagrams of stress and strain on process parameters.	Seminar paper, independent task
4	Analyze the influential parameters on forming process.	2nd colloquium, written and oral exam
5	Predict the behaviour of different metals during deformation.	2nd colloquium, seminar paper, written and oral exam
6	Examine deformation resistance of metal materials.	Independent task
7	Analyze process parameters at different deformation processes.	Seminar paper, oral exam
8	Valorise the deformation parameters at different deformation processes.	Seminar paper, independent task, oral exam
9	Apply theoretical knowledge to solve engineering problems in practice.	Project task
10	Set hypothesis on influence of individual factors of deformation process, design and conduct an experiment, analyze and present the results.	3rd colloquium, seminar paper, project task

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169732
1.1. Course teacher	Assoc.Prof. Vladimir Grozdanić, PhD Assoc.Prof. Anita Begić Hadžipašić, PhD	1.6. Year of study	1
1.2. Name of the course	**THEORY OF METALLURGICAL PROCESSES**	1.7. Credit value (ECTS)	5
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+30+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	Introduction to application of thermodynamics and kinetics to metallurgical processes.		
2.2. Enrolment requirements and required entry competences for the course	-		
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice. 2.Analyse the production processes by applying thermodymanic laws. 3. Recognize and apply scientific principles important in the field of metallurgy. 4. Plan and manage metallurgical processes.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Analysing of oxidation reactions of impurities. 2. Explain reactions of desulfurization, deoxidation and degazation. 3. Comparison and estimate of defects during solidification. 4. Explain kinetics of metallurgical processes.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30) AND EXERCISES (30): 1. Introduction and review of subjects. 2.Classification of metallurgical processes. 3. Metals in liquid state. 4. Principles of refining of pig iron. 5. Oxidation of carbon. 6. Oxidation of silicon. 7. Oxidation of manganese. 8. Oxidation of phosphor. 9. Desulfurization. 10. Deoxidation and reoxidation. 11. Degazation. 12. Porosity and shrinkage cavity. 13. Kinetics of metallurgical processes. 14. Crystalization. 15. Sample theory and equilibrium constants of reactions.		

2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Conditions for signature: attendance to lectures and exercises min. 70 %. Conditions for taking: -					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	2.0	Oral exam	1.5	(Other—describe)	
	Written exam	1.0	Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Written exam: 50% Oral exam: 50%					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	A. Rosina, Teorija metalurških procesov, NTF, Ljubljana, 1994.	1	
	F. Oeters, Metalurgie der Stahlerstellung, Springer, Berlin, 1989.	1	
	T. Rosenquist, Principles of Extractive Metalurgy, 2nd ed., McGraw-Hill, Singapore, 1986.	1	

2.12. Optional literature (at the time of the submission of the study programme proposal)	B. Dobovšek, Metalurške žlindre, NTF, Ljubljana, 1989.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Internal student survey, analyses provided by quality assurance system. Survey on the level of faculty and University. Analyses provided by quality assurance system of the institution. Analyses provided by quality assurance system and authorized office of the University.

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Analysing of oxidation reactions of impurities.	Auditory exercises, written and oral exam
2	Explain reactions of desulfurization, deoxidation and degazation.	Auditory exercises, written and oral exam
3	Comparison and estimate of defects during solidification.	Oral exam
4	Explain kinetics of metallurgical processes.	Auditory exercises, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169733
1.1. Course teacher	Assoc.Prof. Natalija Dolić, PhD	1.6. Year of study	1
1.2. Name of the course	**NON-FERROUS METALS AND THEIR ALLOYS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Acquiring knowledge about the properties of non - ferrous metals (lead, zinc, cobalt, nickel, vanadium, molybdenum, mercury, titanium, beryllium, calcium, sodium, lithium, germanium, silver and gold), raw materials for their obtaining and application areas. 2. Acquisition and understanding the basic theoretical knowledge of modern production processes non-ferrous metals (lead, zinc, cobalt, nickel, vanadium, molybdenum, mercury, titanium, beryllium, calcium, sodium, lithium, germanium, silver and gold). 3. Acquiring knowledge about the most important alloys of non-ferrous metals (lead, zinc, cobalt, nickel, molybdenum, titanium, beryllium, silver and gold), their phase diagrams, properties and application areas. 4. Training students through computational tasks to establish the basic elements of technology estimates in the production of lead, zinc and nickel.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Combine the skills necessary for lifelong learning, including continued professional training. Plan and manage metallurgical processes. Analyse the material and thermal balance of metallurgical processes.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Explain the basic properties of non-ferrous metals (lead, zinc, cobalt, nickel, vanadium, molybdenum, mercury, titanium, beryllium, calcium, sodium, lithium, germanium, silver and gold), raw materials for their obtaining and application areas. 2. Recommend a given alloy of non-ferrous metals (lead, zinc, cobalt, nickel, molybdenum, titanium, beryllium, gold and silver) depending on the required properties and applications. 3. Describe modern processes for obtaining non-ferrous metals (lead, zinc, cobalt, nickel, vanadium, molybdenum, mercury, titanium, beryllium, calcium, sodium, lithium, germanium, silver and gold). 4. Calculate of rational composition of zinc and lead concentrates. 5. Present a seminar paper.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	**LECTURES (30):** Introduction to the plan course and the time schedule for the colloquium. The basic classification and characteristics of non-ferrous metals. Obtaining non-ferrous metals throughout history and their uses (1). **Heavy non-ferrous metals:** *Metallurgy of lead and its alloys (4)* Lead and its alloys: application, mineral raw materials, uses. Pyrometallurgycal and hydrometallurgical processes for lead

	production. Refining of crude lead. Modern processes for production lead. Lead alloys (Pb – Sb, Pb – Ca, Pb – Sn, Pb – Cu). *Metallurgy of zinc and its alloys (4)* Zinc and its alloys: application, mineral raw materials, uses. Pyrometallurgycal and hydrometallurgical processes for zinc production. ISP process. Refining of zinc. Zinc alloys (Zn - Al, Zn - Al – Cu). *Metallurgy of cobalt and its alloys (2)* Cobalt and its alloys: application, mineral raw materials, uses. Pyrometallurgycal and hydrometallurgical processes for cobalt production. Refining of cobalt. Cobalt alloys (Co – Cr, Co – Cr – Mo, Cobalt L-605, Sm – Co). *Metallurgy of nickel and its alloys (2)* Nickel and its alloys: application, mineral raw materials, uses. Production and refining of nickel. Nickel alloys. *Metallurgy of vanadium and its alloys (1)* Vanadium and its alloys: application, mineral raw materials, uses. Production vanadium from iron and titanum magnetite ores. Refining of vanadium. Vanadium alloys (ferrovanadium). *Metallurgy of molybdenum and its alloys (2)* Molybdenum and its alloys: application, mineral raw materials, uses. Production and refining of molybdenum. Molybdenum alloys. *Metallurgy of mercury (1)* Properties of mercury and its compounds, mineral raw materials for production mercury. Production of mercury. TESTS I **Light non-ferrous metals:** *Metallurgy of titanium and its alloys (4)* Titanium and its alloys: application, mineral raw materials, uses. Production of the metal titanium. Refining of titanium. Production of compact, ductile titanium from sponge or powder. Titanium alloys (Ti - Al - α-alloys, Ti - Al - Cr, V, Cu, Mo - α + β-alloys, Ti - Al - Mo, Cr, Zr - β-alloys). *Metallurgy of beryllium and its alloys (2)* Beryllium and its alloys: application, mineral raw materials, uses. Production of beryllium: electrolysis of melt, thermic reduction. Refining of beryllium. Beryllium alloys. *Metallurgy of calcium (1)* Calcium: application, mineral raw materials, uses. Production of calcium: electrolysis of melt, aluminothermy. *Metallurgy of sodium (1)* Properties of sodium and its compounds, mineral raw materials for production sodium. Production of sodium: electrolysis of NaOH, electrolysis of NaCl.

	Metallurgy of lithium and its alloys (1) Lithium and its alloys: application, mineral raw materials, uses. Production of lithium: electrolysis of chloride, electrolysis of oxide and carbonate. Refining of lithium. Lithium alloys (Al - Li, Cu - Li, Zn - Li, Mg - Li, Mg - Al - Li, Li - Be). *Metallurgy of germanium* Germanium and its alloys: application, mineral raw materials, uses. Production of germanium. Germanium – semiconductor. **Noble metals:** *Metallurgy of silver and gold* Silver and gold and their alloys: application, mineral raw materials, uses. Production of silver and gold. Refining of silver and gold. Silver and gold alloys (Au - Ag-, Au - Cu, Au - Ni, Au - Pd, Au - Zn, Ag - Zn, Ag – Cd). TEST II **SEMINAR (15):** How to properly write seminar paper and make the best possible presentation!? (1). Phase diagrams of basic alloys (4). Preparation and presentation of seminar papers (8). Test I, II (2) **EXERCISES (15):** Calculation of charge for agglomeration roasting of lead concentrates. Processes of melting lead (5). Calculation of the rational composition of zinc concentrates. Roasting process of zinc concentrates, *distillation* of agglomerate of zinc (5). Agglomeration of concentrates of nickel. Electro melting agglomerates of nickel (3). Basic elements of technology budgets for the production of magnesium by electrolysis (2). (computational tasks)
2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work ☐ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☒ seminar paper
2.7. Comments:	
2.8. Student responsibilities	Conditions for signature: regular attendance (> 70 %), successful and timely written and exposed seminar paper (ppt).

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance		Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1		
	Tests		Oral exam	1	(Other—describe)	
	Written exam	2	Project		(Other—describe)	
2.10.Grading and evaluation of student work over the course of instruction and	**Continuous monitoring and evaluation of student:** The exam could be passed through two TESTS (written + oral). In case it is not passed one of the two tests, the student has the					

<table>
<tr><td>at a final exam</td><td colspan="3">right to take not passed test one more time. Both positive evaluation tests release the student of laying the final exam. At each tests student can achieve a maximum of 10 points for the question, number of questions is 5. For satisfactory accomplishment in each test student must collect more than 30 % of points for each question. If student fails the examination by tests, laying the final exam (written + oral).

Continuous monitoring and evaluation of student:
Tests (I + II), written + oral: 3 ECTS
Seminar paper: 1 ECTS</td></tr>
<tr><td rowspan="4">2.11.Required literature (available at the library and via other media)</td><td>Title</td><td>Number of copies at the library</td><td>Availability via other media</td></tr>
<tr><td>Z. Lenhard, Metalurgija obojenih metala I, Sveučilište u Zagrebu Metalurški fakultet, Sisak, 2008.</td><td></td><td>https://www.simet.unizg.hr/nastava/predavanja/preddiplomski-sveucilisni-studij-metalurgija/2-godina-preddiplomskog/metalurgija-obojenih-metala-i/view</td></tr>
<tr><td>Z. Lenhard, Metalurgija obojenih metala II, Sveučilište u Zagrebu Metalurški fakultet, Sisak, 2008.</td><td></td><td>https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/1-godina-diplomskog-studija/metalurgija-obojenih-metala-ii/view</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>2.1. Optional literature (at the time of the submission of the study programme proposal)</td><td colspan="3">A. Vignes, Extractive Metallurgy 1, Basic Thermodynamics and Kinetics, ISTE Ltd UK and John Wiley & Sons, Inc. SAD, 2011.
R. Ž. Vračar, Teorija i praksa dobivanja obojenih metala, Savez inženjera metalurgije Srbije, Beograd, 2010.
N. Štrbac, Ž. Živković, I. Mihajlović, Zbirka zadataka iz metalurgije obojenih metala, University of Belgrade Technical Faculty in Bor, Bor, 2004.
R. Vračar, Ekstraktivna metalurgija cinka, Naučna knjiga, Beograd, 1997.
R. Vračar, B. Nikolić, Ekstraktivna metalurgija olova, Naučna knjiga, Beograd, 1995.
Handbook of Extractive Metallurgy, Volume II: Primary Metals, Secondary Metals, Light Metals, ur. F. Habashi, WILEY-VCH, Weinheim – Chichester - New York - Toronto - Brisbane - Singapore, Germany, 1997.
C. B. Gill, Nonferrous Extractive Metallurgy, Robert E. Krieger Publishing Company, Malabar, Florida, 1988.</td></tr>
<tr><td>2.2. Methods of monitoring quality that ensure acquisition of exit competences</td><td colspan="3">Examination of students who have finished study.
Survey on the faculty and University level.
Analysis predicted by systems for insurance of institution quality.
Analysis predicted by systems for insurance quality from authorized University office.</td></tr>
</table>

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Explain the basic properties of non-ferrous metals (lead, zinc, cobalt, nickel, vanadium, molybdenum, mercury, titanium, beryllium, calcium, sodium, lithium, germanium, silver and gold), raw materials for their obtaining and application areas.	1st colloquium, 2nd colloquim, written and oral exam, seminar paper
2	Recommend a given alloy of non-ferrous metals (lead, zinc, cobalt, nickel, molybdenum, titanium, beryllium, gold and silver) depending on the required properties and applications.	1st colloquium, 2nd colloquim, written and oral exam, seminar paper
3	Describe modern processes for obtaining non-ferrous metals (lead, zinc, cobalt, nickel, vanadium, molybdenum, mercury, titanium, beryllium, calcium, sodium, lithium, germanium, silver and gold).	1st colloquium, 2nd colloquim, written and oral exam, seminar paper
4	Calculate of rational composition of zinc and lead concentrates.	1st colloquium, 2nd colloquim, written exam, auditory exercises
5	Present a seminar paper.	Seminar paper

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169734
1.1. Course teacher	Assist.Prof. Ivan Ivec, PhD	1.6. Year of study	1
1.2. Name of the course	**ENGINEERING MATHEMATICS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1) Use the tools of multivarable calculus in the engineering quantitative analysis. 2) Use basic statistical techniques to analyse, process and display data from engineering analysis, handling correctly the accuracy of measurement. 3) Apply techniques and tools of Excel in statistical analysis of data obtained by measurement or simple physical models.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	1) Use the acquired theoretical knowledge in engineering practice. 2) Plan and manage the competences of analysis and synthesis.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1) Collect, analyse and interprete data by statistical methods. 2) Explain the notion, properties and graphical interpretation of functions of several real variables. 3) Use directional derivatives of functions of several variables to analyse their local behaviour. 4) Use and interprete interpolation and approximation of given data with a mathematical model. 5) Use basic methods of numerical integration to solve simple differential equations. 6) Explain and discuss iterations in the process of solving equations. 7) Explain and use methods of chosen computer tool to solve nonlinear equations.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	1) Partial and directional derivatives - definitions, chain rule, differential, gradient. 2) Local extrema of function of several variables. 3) Conditional extrema - Lagrange multiplier method. 4) Curves and line integrals of differentials. 5) Numerical solutions of nonlinear equations - bisection method, secant method, tangent method. 6) Least squares approximation method. 7) Interpolation by polynomials - Lagrange and Newton method. 8) Numerical integration - trapezoidal rule, Simpson's rule. 9) Numerical solutions of differential equations - Euler method. 10) Graphical representation of data - histogram, frequency polygon. 11) Measures of central tendency - mean, median, mode. 12) Measures of dispersion - variance, standard deviation.

	13) Basics of probability - probability space, conditional probability, random variables. 14) Discrete random variables - binomial and Poisson distribution. 15) Continuous random variables - normal distribution.					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:		
2.8. Student responsibilities	Conditions for signature: attendance to lectures and exercises min. 70%.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	1	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests		Oral exam	1	(Other—describe)	
	Written exam		Project	2	(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Project: 60% Oral exam: 40%					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Ivan Slapničar, Matematika 2, Fakultet elektrotehnike, strojarstva i brodogradnje u Splitu, Split, 2008.	0	http://lavica.fesb.hr/mat2/PDF/predavanja.pdf
	Ivan Slapničar, Josipa Barić i Marina Ninčević, Matematika 1 – zbirka zadataka, Fakultet elektrotehnike, strojarstva i brodogradnje u Splitu, Split, 2012.	20	
	B. P. Demidovič: Zadaci i riješeni primjeri iz više matematike s primjenom na tehničke nauke, Tehnička knjiga, Zagreb, 1986.	7	

2.12. Optional literature (at the time of the submission of the study programme proposal)	A. Jazbec, Osnove statistike, Sveučilišna tiskara, Zagreb, 2007. F. M. Brückler, R. Pezer, Inženjerska matematika – skripta (online).
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the level of faculty and University. Analyses provided by quality assurance system of the institution. Analyses provided by quality assurance system and authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Collect, analyse and interprete data by statistical methods.	Project task, oral exam
2	Explain the notion, properties and graphical interpretation of functions of several real variables.	Project task, oral exam
3	Use directional derivatives of functions of several variables to analyse their local behaviour.	Oral exam
4	Use and interprete interpolation and approximation of given data with a mathematical model.	Project task, oral exam
5	Use basic methods of numerical integration to solve simple differential equations.	Project task
6	Explain and discuss iterations in the process of solving equations.	Project task, oral exam
7	Explain and use methods of chosen computer tool to solve nonlinear equations.	Project task

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169735
1.1. Course teacher	Full Prof. Damir Hršak, PhD	1.6. Year of study	1
1.2. Name of the course	**HYDROMETALLURGY**	1.7. Credit value (ECTS)	3
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION						
2.1. Course objectives	Course objective is that students learn the theoretical basis of hydrometallurgical processes and systematization of mineral raw materials suitable for hydrometallurgical leaching. Achieving leadership skills for hydrometallurgical processes.					
2.2. Enrolment requirements and required entry competences for the course	Knowledge of basic techniques of chemical analysis.					
2.3. Learning outcomes at the level of the study programme to which the course contributes	Plan and manage metallurgical processes. Use the acquired theoretical knowledge in engineering practice.					
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Explain the theoretical basis of hydrometallurgy. Categorize leaching of mineral raw materials. Appraise hydrometallurgical technologies. Use purification and concentration of leaching solutions.					
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Theory of hydrometallurgy (4), Hydrometallurgical technologies (5), First colloquium (1), Hydrometallurgical leaching of mineral raw materials (9), Second colloquium (1), Purification and concentration of leaching solutions (5), Precipitation of metals and metal compounds (4), Third colloquium (1). EXERCISES (15): Stoichiometry in hydrometallurgy (6), Reactivity of hydrometallurgical raw materials (3), Use of hydrometallurgical leaching agents (6).					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☒ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:			
2.8. Student responsibilities	Attendence a minimum of 70% lectures. Successfully finished laboratory exercises.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal	Class attendance		Research		Practical training	
	Experimental work	1	Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	1	Oral exam	1	(Other—describe)	

to the credit value of the course)*:*	Written exam		Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Evaluation of student activity in class and laboratory, evaluation of laboratory exercises, exam through continuous monitoring (three colloquiums and oral exam) or final exam.					

	Title	Number of copies at the library	Availability via other media
2.11. Required literature (available at the library and via other media)	D. Hršak, Hydrometallurgy, Metalurški fakultet Sveučilišta u Zagrebu, Zagreb, 2008.	10	
2.12. Optional literature (at the time of the submission of the study programme proposal)	F. Habashi, Metals from Ores, Metallurgie Extractive Quebec, Sainte-Foy, 2003.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Analysis of colloquiums and exams. Survey on the level of faculty and University. Analyses provided by quality assurance system of the institution. Analyses provided by quality assurance system and authorized office of the University.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Explain the theoretical basis of hydrometallurgy.	1st colloquium, oral exam
2	Categorize leaching of mineral raw materials.	2nd colloquium, laboratory exercises, oral exam
3	Appraise hydrometallurgical technologies.	1st colloquium, oral exam
4	Use purification and concentration of leaching solutions.	3rd colloquium, laboratory exercises, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169736
1.1. Course teacher	Assoc.Prof. Anita Begić Hadžipašić, PhD	1.6. Year of study	1
1.2. Name of the course	**METAL CORROSION AND PROTECTION**	1.7. Credit value (ECTS)	5
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+30+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Introducing to the basic principles of chemical and electrochemical degradation of structural metals. Introducing students with mechanisms of different corrosion types of engineering metallic materials in real operating conditions. Introducing to the principles of corrosion protection.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Suggest new and improved technical and technological solutions. Combine social, ethical and business principles and norms in the professional field. Compare the procedures of material treatment with microstructure and useful properties.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Distinguish the corrosion behaviour of metallic materials in exploitation. Calculate corrosion rate on the basis of data obtained by measuring in the laboratory and in the practice. Evaluate and compare the individual forms of corrosion defects of metallic materials. Investigate the resistance of structural steels to hydrogen embrittlement on the basis of determination of hydrogen physical-chemical parameters. Recognize the corrosion conditions and recommend an optimal engineering material for real service conditions. Recommend the measures of corrosion protection.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): 1. Introduction. 2h 2. Temperature dependence of corrosion rate. Corrosion in gasses. 2h 3. Electrochemical corrosion. 2h 4. Kinetics of electrochemical processes. The polarization curves. Depolarization processes. The types of anode and cathode polarization. 2h 5. Kinetics of electrochemical processes. Hydrogen depolarization in acid medium. Hydrogen depolarization in alkaline/neutral medium. Oxygen depolarization. 1h 6. The external and internal factors that determine the rate of electrochemical corrosion. 1h 7. 1st colloquium. 1h 8. The passivity of metals. The passivity theories. The mechanism of the formation and maintenance of the passive layer. 2h

	9. The corrosion inhibitors: anode, cathode, organic, inorganic and VCI. 2h 10. The corrosion stimulators: anode and cathode stimulators. 2h 11. Electrochemical protection of metals. The anode and cathode electrochemical protection of metals. 2h 12. Electrochemical protection of metals with non-metallic coatings. 1h 13. 2nd colloquium. 1h 14. The types of corrosion testings and application of appropriate standards. 2h 15. Atmospheric corrosion. The controlling processes of atmospheric corrosion of metals. 2h 16. Corrosion in the soil. The effect of microorganisms on the corrosion in the soil. The corrosion by stray currents. 1h 17. The protection coatings. 3h 18. 3rd colloquium. 1h LABORATORY EXERCISES (30): 1. Chemical (hightemperature, gaseous) corrosion. 4h 2. Electrochemical corrosion and galvanic couples. 2h 3. The influence of impurities in zinc on the corrosion rate in an electrolyte solution. 3h 4. Stress corrosion cracking: corrosion of stressed metal in an electrolyte solution. 4h 5. Hydrogen depolarization and hydrogen embrittlement. 3h 6. Potentiodynamic polarization of metal in solution. 2h 7. Cathode protection of metals. 2h 8. Obtaining of nonmetal coatings by chemical method: browning of steel. 3h 9. Testing of galvanic baths. 2h 10. Obtaining of metal coatings by chemical method. 2h 11. Galvanization and metal coatings: nickel plating of steel. 3h
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work ☐ independent study ☐ multimedia and the internet ☒ laboratory ☐ work with the mentor ☐ (other) 2.7. Comments:
2.8. Student responsibilities	Attendance min. 70 %, completed laboratory exercises, submitted work diary of laboratory exercises.

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
Class attendance		Research		Practical training		
Experimental work	1.5	Report	0.5			
Essay		Seminar essay		(Other--describe)		
Tests	3.0	Oral exam		(Other—describe)		
Written exam		Project		(Other—describe)		

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Passed three colloquiums through continuous monitoring or final examination by oral exam.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	E. Stupnišek-Lisac, Korozija i zaštita konstrukcijskih materijala, Fakultet kemijskog inženjerstva i tehnologije, Zagreb, 2007.	1	
	I. Esih, Z. Dugi, Tehnologija zaštite od korozije I, Školska knjiga,	1	

	Zagreb, 1990.		
	I. Esih, Z. Dugi, Tehnologija zaštite od korozije II, Sveučilište u Zagrebu, Zagreb, 1992.	1	
	J. Malina, Vježbe iz korozije i zaštite metala, interna skripta, Metalurški fakultet, Sisak, 2004.		Merlin sustav za e-učenje
	F. Sebenji, L. Hakl, Korozija metala u teoriji i praksi, prijevod s engleskog, Tehnička knjiga, Beograd, 1980.	8	
	S. Mladenović, Korozija materijala, Tehnološko-metalurški fakultet, Beograd, 1978.	4	
	B. Jarić, A. Rešetić, Korozija i katodna zaštita, Korexpress, Zagreb, 2003.	1	
2.12. Optional literature (at the time of the submission of the study programme proposal)	S. Martinez, I. Štern, Korozija i zaštita-eksperimentalne metode, HINUS, Zagreb, 1999. M. Gojić, Površinska obradba materijala, Metalurški fakultet Sveučilišta u Zagrebu, Denona d.o.o., 2010. T. Filetin, K. Grilec, Postupci modificiranja i prevlačenja površina, Hrvatsko društvo za materijale i tribologiju, Zagreb, 2004. I. Esih, Osnove površinske zaštite, Sveučilište u Zagrebu, Fakultet strojarstva i brodogradnje, Zagreb, 2003.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	The survey at the level of faculty and University. Analysis predicted by the system of institution quality assurance. Analysis predicted by the system of quality assurance and authorized bureau of university.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Distinguish the corrosion behaviour of metallic materials in exploitation.	Oral exam
2	Calculate corrosion rate on the basis of data obtained by measuring in the laboratory and in the practice.	Laboratory exercises
3	Evaluate and compare the individual forms of corrosion defects of metallic materials.	Laboratory exercises, oral exam
4	Investigate the resistance of structural steels to hydrogen embrittlement on the basis of determination of hydrogen physical-chemical parameters.	Laboratory exercises, oral exam
5	Recognize the corrosion conditions and recommend an optimal engineering material for real service conditions.	Laboratory exercises, oral exam
6	Recommend the measures of corrosion protection.	Oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169737
1.1. Course teacher	Assoc.Prof. Ljerka Slokar, PhD Assoc.Prof. Tamara Holjevac Grgurić, PhD	1.6. Year of study	1
1.2. Name of the course	**MATERIALS CHARACTERIZATION**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+30+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	Acquisition of knowledge and acquirements for characterization of different kinds of materials. Introducing with experimental techniques for investigation of content and structure of materials, their implementation and interpretation. Overwhelm with experimental techniques for determination of thermal, mechanical, rheological and tribological properties. Acquirement of competences for selection of appropriate experimental technique, defining conditions for material preparation and experimental procedure as well as interpretation of results.		
2.2. Enrolment requirements and required entry competences for the course	-		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Plan and manage the competences of analysis and synthesis. Suggest appropriate methods for material quality analysis. Design professional elaborates and professional projects in metallurgy.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Define and classify the experimental techniques. Determine different groups of materials. Analyze the chemical composition of different groups of materials. Prepare samples for specific experimental technique. Apply techniques of structure testing and analyze the results obtained from the morphology of different materials. Select the appropriate technique of analysis of specific material properties and interpret measurement results. Autonomously organize and manage the measurement under optimal conditions and interpretate the results.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Introduction to material characterization. Classification of measuring techniques. Classification of materials. (2) Analysis of chemical content and structure by Fourier Transform Infrared Spectroscopy (FTIR); sample preparation, methodology and interpretation. (3) Spectrometry: quantitative and qualitative analysis. Analysis of chemical composition by atomic absorption spectrometer (AAS), etc.; sample preparation, methodology, interpretation. (3) Nuclear magnetic resonance; sample preparation, methodology and interpretation. (2) Structure analysis by X-Ray Diffraction (XRD); sample preparation, methodology and interpretation. (3)		

	Microstructure analysis by electron microscopy (SEM) and optical microscopy (OM). Interpretation of results. (3) Thermal analysis of materials. Differential scanning calorimetry (DSC). Differential thermal analysis (DTA). Sample preparation, methodology and interpretation. (3) Thermogravimetry (TG). Simultaneous techniques of thermal analysis. (3) Dilatometry (DIL). Thermomechanical analysis (TMA). (2) Mechanical and dynamic-mechanical analysis. Mechanical testing (3) Investigation of tribological properties. Equipment for surface scratching (micro- and nano-scratch tester). Determination of penetration depth, residual depth and recovery. Abrasion. (3) LABORATORY EXERCISES (30): Analysis of chemical composition by atomic absorption spectrometer (4). Analysis of the microstructure of different types of material by optical microscopy and scanning electron microscopy and interpretation of results (7). Structure analysis by X-Ray Diffraction, results interpretation (4). Analysis of the chemical composition of bentonite, polymers and other materials by FTIR method (3). Analysis of metal alloys by differential scanning calorimetry: determination of transformation temperature, the determination of the enthalpy (3). Analysis of polymers, ceramics and composites by differential scanning calorimetry: glass transition temperature, melting point, enthalpy (3). Determination of weight change through oxidation of metal by thermogravimetry (3). Monitoring of changes of module stiffness, loss modulus and tangent of the angle of loss by dynamic -mechanical analysis: metals, polymers, composites (3).
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work ☐ independent study ☐ multimedia and the internet ☒ laboratory ☐ work with the mentor ☐ (other) 2.7. Comments:
2.8. Student responsibilities	Attendance to lectures and exercises min. 70 %. Lab reports.

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
Class attendance	0.4	Research		Practical training		
Experimental work	0.3	Report	0.3			
Essay		Seminar essay		(Other--describe)		
Tests	1.0	Oral exam	1.0	(Other—describe)		
Written exam	1.0	Project		(Other—describe)		

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	The final grade is determined by score of two colloquiums and assessments of written and oral exams respectively.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	J. B. Sibilia, Materials Characterization and Chemical Analysis, Wiley-VCH, 1996.		https://www.amazon.com/Guide-Materials-Characterization-Chemical-Analysis/dp/0471186333
	P. J. Heines, Thermal Methods of Analysis, Principles and Aplication, Blackie Academic & Professional, 1995.	1	
	T. H. Grgurić, Eksperimentalne tehnike u termodinamici materijala, Metalurški fakultet,		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/1-godina-diplomskog-

	Sisak		studija/eksperimentalne-tehnike-u-termodinamici-materijala/view
2.12. Optional literature (at the time of the submission of the study programme proposal)	E. F. Kaufmann, Characterization of Materials, Wiley-Interscience, 2003. R. Divakar, P. J. Blau, Wear Testing of Advanced Materials, ASTM Committee G-2 on Erosion and Wear, 1992. J. Goldstein et al., Scanning Electron Microscopy and X-Ray Microanalysis, Third Edition, Springer, USA, 2003.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Anonymous survey on the level of the Faculty and University. Analysis provided by system of quality assurance institutions. Analyses provided by quality assurance system and authorized offices of the University.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Define and classify the experimental techniques.	1st colloquium, laboratory exercises, written and oral exam
2	Determine different groups of materials.	1st and 2nd colloquium, laboratory exercises, written and oral exam
3	Analyze the chemical composition of different groups of materials.	1st and 2nd colloquium, independent task, laboratory exercises, written and oral exam
4	Prepare samples for specific experimental technique.	1st and 2nd colloquium, independent task, laboratory exercises, written and oral exam
5	Apply techniques of structure testing and analyze the results obtained from the morphology of different materials.	1st and 2nd colloquium, independent task, laboratory exercises, written and oral exam
6	Select the appropriate technique of analysis of specific material properties and interpret measurement results.	1st and 2nd colloquium, laboratory exercises, written and oral exam
7	Autonomously organize and manage the measurement under optimal conditions and interpretate the results.	1st and 2nd colloquium, independent task, laboratory exercises, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169738
1.1. Course teacher	Full Prof. Ladislav Lazić, PhD Assoc.Prof. Zdenka Zovko Brodarac, PhD	1.6. Year of study	1
1.2. Name of the course	**AUTOMATION AND COMPUTER CONTROL OF PRODUCTION PROCESSES**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Acquire knowledge of process automation, process control and computerization process. 2. Acquire knowledge about the degree of automation and methods of application of process computers. 3. Acquire knowledge on levels of process control and automation functions. 4. Acquiring knowledge about the structures of automation. 5. Acquire knowledge about what is a programmable logic controller (PLC) and how it is used.
2.2. Enrolment requirements and required entry competences for the course	
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Plan and manage metallurgical processes. 2. Use the acquired theoretical knowledge in engineering practice. 3. Suggest new and improved technical and technological solutions. 4. Analyse the development and application of new technologies. 5. Suggest solutions for the optimization of metallurgical processes. 6. Combine the skills necessary for lifelong learning, including continued professional training.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Use repeatable and predictable control of the process. 2. Suggest and implement overall better control of the process. 3. Implement the improvement of process efficiency. 4. By controlling the process in order to achieve a higher quality of products. 5. By controlling the process easier to detect and eliminate errors.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): 1. Production systems, industrial plant and its types. The task of managing the process and stratification of management tasks. Man-machine interface. (2) 2. Computer application for process control. Informatization and automation of the production system. The basic structure of the system for automatic process control. Examples from practice. (2) 3. The system for measurement and display of process variables. The system of automatic control. The advantages of digital regulators. (4) 4. PLC properties and their programming. (4)

	5. Connecting a process computer with the process. Process (operating) unit - central unit system for automatic process control. Structural units for simple and complex systems. (4) 6. Central, decentral, hierarchical and distributed structures. Control unit - subsystem for communication operator-production system. Equipment for the implementation of process and control unit. (4) 1. colloquium 7. Communication systems in industry. Transfer technologies / standards of general purpose underlying some industrial communication standards. (2) 8. Fieldbus communication technologies; ASI, PROFIBUS, CAN, BITBUS. (2) 9. PLC specialized networks; Melsecnet, SINEC, DataHighway. Software in automation systems (SCADA). (2) 10. Programming tools. PC as a monitoring unit. Integrating office packages / applications in system automation. (2) 11. Designing and maintaining automation systems. (2) LABORATORY EXERCISES (15): Examples of computer application for process control and automatic control. SEMINAR (15): The understanding of the material exposed in lectures is facilitated by solving the given projects. The projects are selected so that they expand the presented theory and illustrate the application of theory to real problems.

2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☒ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:
2.8. Student responsibilities	Attendance to Lectures and Exercises > 70 %		

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
Class attendance	0.2	Research		Practical training		
Experimental work		Report				
Essay		Seminar essay		(Other--describe)		
Tests	0.8	Oral exam	1.2	(Other—describe)		
Written exam	0.8	Project	1.0	(Other—describe)		

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Projects – 30% Class attendance – 5% Written exam – 30% Oral exam – 35%

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	N. Perić, Automatizacija postrojenja i procesa - predavanja, Zavodska skripta, FER, Zagreb, 2000.	5	
	N. Perić, I. Petrović, M. Vašak, Procesna automatizacija, Sveučilište u Zagrebu, Fakultet elektrotehnike i računarstva, Zagreb, 2013.		https://www.fer.unizg.hr/_download/repository/Skripta_Proaut_veljaca_2013.pdf

	I. Gašparac, M. Vražić, Projektiranje i automatizacija industrijskih postrojenja, Sveučilište u Zagrebu, Fakultet elektrotehnike i računarstva, Zagreb, 2012.		https://www.fer.unizg.hr/_download/repository/skripta_PIAIP_ver1.pdf
	I. Erceg, T. Šimić, Automatizacija industrijskih postrojenja, Uvod u PLC-ove.		http://www.ieee.hr/_download/repository/AIP_-_PLC_prezentacija.pdf
2.12. Optional literature (at the time of the submission of the study programme proposal)	A. J. Crispin, Programmable Logic Controllers and their Engineering Applications, McGraw-Hill Publishing Company, 1997. G. Smiljanić, Računala i procesi, Školska knjiga, Zagreb, 1991.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Use repeatable and predictable control of the process.	1st colloquium, oral exam
2	Suggest and implement overall better control of the process.	1st colloquium, project, oral exam
3	Implement the improvement of process efficiency.	2nd colloquium, oral exam
4	By controlling the process in order to achieve a higher quality of products.	2nd colloquium, oral exam
5	By controlling the process easier to detect and eliminate errors.	2nd colloquium, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169739
1.1. Course teacher	Assoc.Prof. Zdenka Zovko Brodarac, PhD	1.6. Year of study	1
1.2. Name of the course	**THEORY OF METALS SOLIDIFICATION**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Understanding of the solidification mechanism and development of the primary structure. Definition of thermodynamics and solidification phenomena. Knowledge of solidification model, crystal growth and melt treatment. Theory of Al-Si and Fe-C eutectic solidification.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Suggest new and improved technical and technological solutions. Plan the production and casting processes of ferrous and non-ferrous metals.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Evaluate the thermodynamic parameters of materials in the process of solidification. Present the importance of heterogeneous nucleation and the related practice of melt treatment. Present the importance of eutectic system and the basic mechanisms of solidification and growth of Al-Si eutectic. Present the importance of eutectic system and the basic mechanisms of solidification and growth of Fe-C eutectic.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Introduction to the subject curriculum, method of mastering the material. (1) The requirements of the market and trends in production of casting and importance of solidification related to the properties of casting - primary microstructure. (2) Interpretation of the microstructure of the casting alloy. (1) Interpretation of the microstructure of the casting alloys. Correlation of technology, primary microstructure and properties of casting (2) The mechanisms of heat transfer at the interface melt-mold. The transformation of physical condition. Characteristic transformations during solidification of metals and alloys. (2) The solidification of single-phase alloys. Thermodynamics of phase transformation of liquid-solid. The driving force for solidification, simple thermal analyzes. Recallescence. The kinetics of phase transitions. (2) The theory of nucleation. The homogeneous nucleation rate. Terms of homogeneous nucleation. Heterogeneous nucleation rate. (2) The characteristics of the grain refiners. Inoculation practice. Nucleation and inoculation of commercial casting alloys. The mechanisms of nucleation, grain refinement. The structure of crystals boundary surface, crystal growth, microstructure development. Graphite growth from cast iron melt, kinetics and growth forms of graphite. (4)

	Solidification alloys. The distribution of the solute elements. The solidification in steady state. The growth of dendrites. Constitutional undercooling. (2) Segregation in ingots and castings. Macro and microsegregation. Gravitational segregation. Consequences of microsegregation - occurrence of unexpected phase. Development of the primary structure of the castings. The emergence of the structural zones. The transition from columnar to equiaxed crystallization. (2) Eutectic solidification, eutectic zones. Competitive growth of dendrites and eutectic. Solidification of alloys outside the eutectic composition. Modification of the eutectic. Eutectic growth in Fe-C and Al-Si alloys. The effect of inoculation and modification on the properties of eutectics. (4) Peritectic solidification. Mechanisms of peritectic solidification. Solidification, the development of primary microstructure and technological properties: shrinkage, blistering, castability. The use of simple and simultaneous thermal analysis in interpretation of solidification. Solidification interval, the sequence of phase transitions. (4) SEMINAR (15): The study of relevant scientific and technical literature (10). Presentation of knowledge from scientific and professional articles (5)

2.6. Type of instruction			2.7. Comments:
	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☒ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)	

2.8. Student responsibilities	
	Attending the classes >70%. Seminar essay and presentation.

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance	1	Research		Practical training	
	Experimental work		Report	1		
	Essay		Seminar essay		(Other--describe)	
	Tests	2	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	
	Examination through continuous monitoring: 1. colloquium after the unit Graphite growth from cast iron melt, kinetics and growth forms of graphite. 2. colloquium after the unit Solidification interval, the sequence of phase transitions. Examination through final exam: written and oral. Make a project task.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Metals Handbook, Volume 15, CASTING, ASM International, Metals Park, Ohio, 1988. Dopunska literatura (1 do 5) 1 2	1	
	W. Kurz, D. J. Fisher, Fundamentals of solidification, Trans Tech Publications LTD, Aedermannsdorf, 1986.	1	
	D. A. Porter, K. E. Easterling, Phase transformations in metals and alloys,	1	

	Chapman & Hall, London, 1992.		
	D. M. Stefanescu, Science and engineering of casting solidification, Kluwer Academic /Plenum Publishers, New York, 2002.	1	
2.12. Optional literature (at the time of the submission of the study programme proposal)	T. Nishizawa, Thermodynamics of microstructures. ASM International, Materials Park, Ohio, 2008. J. Campbell, Castings, Butterworth Heinemann, Oxford, 1991.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the Faculty and University level. Analysis provided the quality assurance system of the institution. Analysis provided the quality assurance system and authorized Office of the University		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Evaluate the thermodynamic parameters of materials in the process of solidification.	1st colloquium, written and oral exam
2	Present the importance of heterogeneous nucleation and the related practice of melt treatment.	1st colloquium, written and oral exam
3	Present the importance of eutectic system and the basic mechanisms of solidification and growth of Al-Si eutectic.	2nd colloquium, seminar paper, written and oral exam
4	Present the importance of eutectic system and the basic mechanisms of solidification and growth of Fe-C eutectic.	2nd colloquium, seminar paper, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169740
1.1. Course teacher	Full Prof. Ladislav Lazić, PhD	1.6. Year of study	1
1.2. Name of the course	**HEATING TECHNOLOGY OF INDUSTRIAL FURNACES**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	Ivan Jandrlić, PhD	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Enable students to calculate energy balance, determine the energy efficiency and evaluate the rational use of energy. 2. Enable students to determine the overall heat transfer coefficient in the furnace workspace. 3. Enable students to distinguish individual cases of material heating and determine the calculating method of heating (cooling) in a particular case. 4. Enable students to regulate the temperature of combustion gases, stop the furnace operation and perform a preliminary review of the furnace.
2.2. Enrolment requirements and required entry competences for the course	Passed the exams of course Industrial Furnaces.
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice. 2. Suggest new and improved technical and technological solutions. 3. Analyse the development and application of new technologies. 4. Analyse the production processes by applying thermodynamic laws. 5. Plan and manage metallurgical processes. 6. Design professional elaborates and professional projects in metallurgy. 7. Design and apply the modelling of metallurgical and other processes. 8. Analyse the material and thermal balance of metallurgical processes. 9. Suggest solutions for the optimization of metallurgical processes. 10. Formulate and suggest measures for increasing energy efficiency.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Calculate the heat transfer inside the furnace to heated material.. 2. Suggest conditions of heating metal materials, predict the amount of oxidation loss of material in these conditions, and choose the composition of the necessary protective or reaction gas. 3. Calculate thermal stress of the heated material and choose the allowed rate of heating metal material. 4. Calculate the required dimensions of the heating surfaces of the heat exchanger and boiler utilizer. 5. Design the optimal thickness of walls furnaces. 6. Suggest measures for reducing pollutant emissions into the environment.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): 1. Thermo-technical processes in industrial furnaces. Requirements to be met by the furnace. Melting, heating and heat treatment furnaces. (2) 2. Processes of heating and cooling. Furnaces heated with fossil fuels, electric energy, and solar energy. (2)

	3. Energy balance and energy efficiency of the furnace. Oxidation of the heated material. Protective and reaction gases. (2) 4. Heat transfer by convection and radiation, radiation of flame, overall coefficient of heat transfer in the workspace of furnace. (2) 5. The heating of metal materials. Thin and massive bodies. Numerical calculation methods. (2) 6. Rules relating to the massive bodies. Graphical method for plate-shaped bodies. Other calculation methods for heating materials. (2) 7. Heating (cooling) of massive bodies at: q=const., dT/dt=const., Tw_0 =const. (2) 1st colloquium 8. Thermal stresses in heated body. Tensile and compressive stresses. (2) 9. Classification of steel into groups according to heating conditions. (2) 10. Heat exchangers. Classification and types. Calculation of heating surface. (4) 11. Utilizer boiler. Project calculation. (2) 12. Fuel combustion, fuel / air ratio, calculation of composition and amount of combustion gases. Cleaning of waste gases. (2) 13. Preheating of combustion air. Efficiency of combustion. (2) 14. Assessment of furnace condition. Preliminary review of furnace. Repair and overhaul of furnace. (2) 2nd colloquium EXERCISES (15): The understanding of the material exposed in lectures is facilitated by solving the given projects. The projects are selected so that they expand the presented theory and illustrate the application of theory to real problems.

2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☒ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)	2.7. Comments:
2.8. Student responsibilities	Attendance to Lectures and Exercises > 70 %.		

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
Class attendance	0.4	Research		Practical training		
Experimental work		Report				
Essay		Seminar essay		(Other--describe)		
Tests	1.0	Oral exam	1.6	(Other—describe)		
Written exam		Project	1.0	(Other—describe)		

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Projects – 30% Class attendance – 5% Written exam – 30% Oral exam – 35%

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	W. Lehnert, Toplotehničke osnove za industrijske peći, Metalurški fakultet, Sisak, 2001.	3	

2.12. Optional literature (at the time of the submission of the study	P. Mullinger, B. Jenkins, Industrial and process furnaces: principles, design and operation, Elsevier, Oxford, 2008. J. Ward, R Collins, Industrial furnace technology, Centro de energia e technologia, Rio Tinto, 2003.

programme proposal)	
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Calculate the heat transfer inside the furnace to heated material.	1st colloquium, oral exam
2	Suggest conditions of heating metal materials, predict the amount of oxidation loss of material in these conditions, and choose the composition of the necessary protective or reaction gas.	1st colloquium, oral exam
3	Calculate thermal stress of the heated material and choose the allowed rate of heating metal material.	2nd colloquium, oral exam
4	Calculate the required dimensions of the heating surfaces of the heat exchanger and boiler utilizer.	2nd colloquium, project, oral exam
5	Design the optimal thickness of walls furnaces.	2nd colloquium, oral exam
6	Suggest measures for reducing pollutant emissions into the environment.	2nd colloquium, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169741
1.1. Course teacher	Full Prof. Ladislav Lazić, PhD Assist.Prof. Martina Lovrenić-Jugović, PhD	1.6. Year of study	1
1.2. Name of the course	**NUMERICAL MODELLING OF METALLURGICAL PROCESSES**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Develop the ability to apply numerical methods in the analysis of metallurgical processes. 2. Qualify students to formulate an independent computer programs based on the finite difference method 3. Enabling students to use modern software packages based on finite difference or finite element methods of analysis some problem.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice. 2. Design and apply the modelling of metallurgical and other processes. 3. Plan and manage metallurgical processes. 4. Suggest solutions for the optimization of metallurgical processes.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Apply appropriate modeling techniques in guiding, monitoring and optimization of metallurgical processes. 2. Formulate numerical models for planning, process analysis, design and optimization of existing technologies in metallurgy. 3. Use commercial software packages based on finite elements to determine the temperature distribution over the cross section of the body, to analyze the thermal stress and to determine the speed of heating and cooling systems in metallic materials. 4. Analyze and choose the optimal mode of heating the material during metallurgical processes. 5. Calculate the adiabatic temperature and equilibrium composition of the combustion products of well-known type of fuel, the ratio of fuel to air, temperature and pressure. 6. Formulate and use of mathematical models for the development of new technologies in metallurgy.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): 1. Basic division of models: physical modeling, mathematical modeling, Experimental plant (2). 2. The types of mathematical models and their applicability for modeling metallurgical processes (4). 3. Numerical methods: Finite difference, finite element method, finite volume method, the boundary element method (4). 4. The application of finite difference modeling of steady and unsteady heat conduction (6). 5. 1st preliminary exam: includes the units 1-4 6. The method of finite element method for modeling of steady and unsteady heat transfer analysis with thermal stress when heating or cooling a metal cartridge (6).

	7. Combustion and thermochemistry: stoichiometry, Standard thermodynamic conditions, enthalpy of formation, absolute enthalpy, enthalpy of combustion and heat value, adiabatic flame temperature (4). 8. Chemical equilibrium complex systems (2). 9. A numerical model for calculation of adiabatic temperature and the equilibrium composition of the combustion products (2). 10. 2nd preliminary exam: includes the units 6-9 EXERCISES (15): Application software package for thermal analysis of metallurgical processes. Application software package HPFLAME budget adiabatic temperature and the equilibrium composition of the combustion products, the known type of fuel, the ratio of fuel to air, temperature and pressure, in solving practical problems in order to increase energy efficiency and reduce the emissions of industrial fuel combustion devices.

2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)	2.7. Comments:

2.8. Student responsibilities	Conditions for signature: - attendance on Lectures and Exercises > 70% - program task Conditions for taking: -

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance	0.4	Research		Practical training	
	Experimental work		Report		Program task	1.2
	Essay		Seminar essay		(Other--describe)	
	Tests	1.2	Oral exam	1.2	(Other—describe)	
	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Projects (program tasks) – 30% Attendance – 10% Written exam – 30% Oral exam – 30%

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	L. Lazić, Numeričke metode u toplinskoj analizi, Sveučilište u Zagrebu, Sisak, 2007.	10	-
	V. Hari i drugi, Numerička analiza, PMF-MO, Zagreb, 2003.	0	https://web.math.pmf.unizg.hr/~rogina/2001096/num_anal.pdf

2.12. Optional literature (at the time of the submission of the study	S. P. Ketkar, Numerical Thermal Analysis, ASME Press, New York, 1999. T. Young, M. J. Mohlenkamp, Introduction to Numerical Methods and Mathlab Programming for Engineers, Ohio University,

programme proposal)	2011. D. Vučina, Primjena računala u inženjerskoj analizi, FESB, Split, 2007. I. Ivanušić, Numerička matematika, ISBN: 953-197-526-4, Element, Zagreb, 2002. Y. Jaluria, Computer Methods for Engineering, Allyn and Bacon Inc., Massachusetts, 1988.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Internal: Student survey input. Numerical analysis of tests and exams according to scoring task by task at the level of course. External: Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Apply appropriate modelling techniques in guiding, monitoring and optimization of metallurgical processes.	Oral exam
2	Formulate numerical models for planning, process analysis, design and optimization of existing technologies in metallurgy.	Oral exam
3	Use commercial software packages based on finite elements to determine the temperature distribution over the cross section of the body, to analyze the thermal stress and to determine the speed of heating and cooling systems in metallic materials.	Program task, 1st colloquium
4	Analyze and choose the optimal mode of heating the material during metallurgical processes.	Oral exam
5	Calculate the adiabatic temperature and equilibrium composition of the combustion products of well-known type of fuel, the ratio of fuel to air, temperature and pressure.	Program task, 2nd colloquium
6	Formulate and use of mathematical models for the development of new technologies in metallurgy.	Oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE: 169742
1.1. Course teacher	Full Prof. Mirko Gojić, PhD Assoc.Prof. Stjepan Kožuh, PhD	1.6. Year of study	1
1.2. Name of the course	**TECHNIQUES OF JOINING AND CUTTING**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	30
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	Knowing of students with the basic procedures of joining and cutting of metallic materials. Training for the selection of the appropriate process joining or cutting depending on the particular case of use. Training to avoid basic mistakes during joining and cutting and appropriate selection and recommendation of safety at work.		
2.2. Enrolment requirements and required entry competences for the course	-		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Suggest new and improved technical and technological solutions. Suggest solutions for the optimization of metallurgical processes.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Define of the most important procedures for fusion welding. Diferentiate of weld joints types of metallic materials. Suggest of optimal parameters for arc welding processes. Differentiate of base material for welding. Compare of bonding metal material with soldering and bonding. Analyze of defects in welded joints.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Week 1: Overview of joining processes: welding, soldering and bonding (2). Week 2: Power sources for welding. Welding positions and types of weld joints (2). Weeks 3-6: Gas welding, manual electro arc, TIG-tungsten inert gas, MIG-metalk inert gas, MAG-metal active gas, under the protection of powder, electroresistance welding (spot, seam, high frequency), other fusion welding processes (electron beam, laser beam, under slag, aluminotermic welding), pressure welding (cold, diffusion, explosion, under friction, ultrasound) (8). Week 7: Weldability (2). Weeks 8 and 9: The behavior of iron alloys (steel, cast iron) and non-ferrous metals and alloys during welding (4). Week 10: Soldering: types of joint, solder, fluxes. (2) Week 11: The procedures of soldering (gas, electro-resistance, induction, hand soldering and others) (2). Week 12: Methods of cutting: gas, oxygen, electroarc, plasma, laser, electron beam, water etc. (2). Week 13: Bonding. The types of adhesives and joints (2). Week 14: Surface preparation and basic methods for bonding. (2)		

	Week 15: Mistakes during joining and cutting. Safety at work (2). LABORATORY EXERCISES (15): Individual and group doing of certain procedures of joining and cutting (MAW, TIG, and MIG / MAG procedures). Surface preparation for soldering and bonding. Hand soldering. Bonding metal.					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☐ independent study ☐ multimedia and the internet ☒ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Students must attend over 70% of lectures and exercises.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work	1.0	Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	2.5	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	- evaluation of students activities in course, - evaluation of written examination (two colloquiums) through continuous monitoring or final examination (written and oral), - evaluation of exercises activity.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	M. Gojić, Tehnike spajanja i razdvajanja materijala, Metalurški fakultet, Sisak,2003.	10	
	Z. Lukačević: Zavarivanje, Strojarski fakultet Slavonski Brod, Slavonski Brod,1998.	3	

2.12. Optional literature (at the time of the submission of the study programme proposal)	I. Juraga, K. Ljubić, M. Živčić, Pogreške u zavarenim spojevima, HDTZ, Zagreb,1998. S. Kralj, Š. Andrić, Osnove zavarivačkih i srodnih postupaka, Fakultet strojarstva i brodogradnje, Zagreb, 1992.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Input and output student survey. Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Define of the most important procedures for fusion welding.	1st colloquium, written and oral exam
2	Diferentiate of weld joints types of metallic materials.	1st colloquium, written and oral exam
3	Suggest of optimal parameters for arc welding processes.	1st colloquium, written and oral exam, laboratory exercises
4	Differentiate of base material for welding.	2nd colloquium, written and oral exam, laboratory exercises
5	Compare of bonding metal material with soldering and bonding.	2nd colloquium, written and oral exam
6	Analyze of defects in welded joints.	2nd colloquium, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Mirko Gojić,PhD Assoc.Prof. Stjepan Kožuh, PhD	1.6. Year of study	2
1.2. Name of the course	**HEAT TREATMENT AND SPECIAL STEELS**	1.7. Credit value (ECTS)	5
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	45+15+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	Getting insight into the properties and microstructure of metal after heat treatment. Studying of the relationship between heat treatment and properties of metals. Deepening knowledge in important areas in relation to the properties, microstructure and application of special steels. Understanding and identifying the basic types of steel and their properties.		
2.2. Enrolment requirements and required entry competences for the course	-		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Analyse the development and application of new technologies. Design the properties of metallic materials.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Predict of individual transformation products during cooling of austenite, Relate of recrystallization processes and the heat treatment, Compare certain procedures of thermo-chemical treatment processes, Compare different types of steel to the characteristics and functions, Develop thermomechanical treatment with the goal of designing the properties of special steels, Predict the application of tool steels for specific loading conditions.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (45): Week 1 and 2: Definition and classification of steel, Influence of alloying elements, Phase transformations. Decomposition of austenite during cooling (pearlite, bainite, martensite) (6 hours). Week 3: The protective atmospheres in heat treatment. Property of hardenability (3 hours). Week 4: Chemical-thermal treatment procedures (3 hours). Week 5: Special methods of heat treatment. Thermomechanical treatment (3 hours). Week 6: Heat treatment of non-ferrous metals and alloys (3 hours). Week 7: Construction steels: properties and classification, Basic unalloyed and low alloyed construction steels, General construction steels (bearing structures, machine), Designation of steel (3 hours). Week 8: Fine-grained microalloyed steels: Basic processes for increasing of steel strength, Precipitation hardening, Hardening		

	with fined grains (3 hours). Week 9: Microalloyed normalized fine grain steels, Improved fine grain steels, Construction steels with low content of pearlite or without pearlite, Steels for springs (3 hours). Week 10: Steels with improved cutting performance (steels for automated machines), Steels for nitriding, Techniques for nitriding of steels, Special constructional steels (classification) (3 hours). Week 11: Corrosion resistant (stainless) steels, ferrite, austenite, austenite-ferrite (duplex), and martensite stainles steels (3 hours). Week 12: Steels resistant to wear, Steels for use at elevated and high temperatures, Heat-resistant steels, Steel for use at low temperatures (3 hours). Week 13: High-strength steels: Low-alloyed and low-tempered steels, High-alloyed and high-tempered (Cr-Mo-V) steels, Precipitation hardening steels, Thermomechanical treated steels, Cold working unalloyed and low-alloyed steels, Maraging steels (3 hours). Week 14: Fundamentals of tool steels: classification, Unalloyed (carbon) tool steels, Alloyed tool steels, Low alloyed tools steels for cold working [W-V, W-Cr-(Si)-V, Cr-steels, Mn-Cr-V, Mn-Cr-W], High-alloyed tool steels for cold working, Tool steels for hot working (3 hours). Week 15: High-speed steels, Sintered tool steels. Trends in the development of special steels (3 hours). EXERCISES (15): Testing of hardenability (Jominy test). Determination of the austenite grain size. Determination parameters of recrystallization. Annealing, quenching and tempering. Cementing and nitriding. Thermomechanical treatment. SEMINAR (15): The selection of topics and seminar work in writing form by a mentor system (10 hours). Preparation and presentation of the seminar and discussions in relation to the topic of the present paper (5 hours).

2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☒ laboratory ☒ work with the mentor ☐ (other)	2.7. Comments:
2.8. Student responsibilities	Students must attend over 70% of lectures and are required to complete a seminar in writing form and orally present.		

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1.5	(Other--describe)	
	Tests	3.0	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	- evaluation of students activities in course, - evaluation of written examination (two colloquiums) through continuous monitoring or final examination (written and oral), - evaluation of seminar paper and presentation.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	M. Novosel i dr., Posebni čelici, Strojarski fakultet	9	

	Slavonski Brod, Slavonski Brod, 1998.		
	S. Kožuh, Specijalni čelici-skripta, Sveučilište u Zagrebu Metalurški fakultet, Sisak, 2010.		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/2-godina-diplomskog-studija/specijalni-celici/view
	J. Pirš, Toplinska obrada metala, Tehnički fakultet Rijeka, Rijeka, 1992.	3	
	ASM Handbook.pdf		Electronic form
2.12. Optional literature (at the time of the submission of the study programme proposal)	C. R. Brooks, Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels, ASM International, Materials Park, 1996. M. Novosel, F. Cajner, D. Krumes, Alatni materijali, Strojarski fakultet, Slavonski Brod, 1996. Grupa autora: Inženjerski priručnik 4, prvi svezak: Materijali, Školska knjiga, Zagreb, 1998. M. Gojić, Metalurgija čelika, Sveučilište u Zagrebu Metalurški fakultet, Sisak, 2006. R. A. Lula, Stainless Steel, ASM, Metals Park, Ohio, 1985. Y. Lakhtin, Engineering Physical Metallurgy and Heat-Treatment, Mir Publishers, Moskva, 1990.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Input and output student survey. Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Predict of individual transformation products during cooling of austenite.	1st colloquium, written and oral exam, laboratory exercises
2	Relate of recrystallization processes and the heat treatment.	1st colloquium, written and oral exam, seminar paper
3	Compare certain procedures of thermo-chemical treatment processes.	1st colloquium, written and oral exam
4	Compare different types of steel to the characteristics and functions.	2nd colloquium, written and oral exam, seminar paper
5	Develop thermomechanical treatment with the goal of designing the properties of special steels.	2nd colloquium, written and oral exam
6	Predict the application of tool steels for specific loading conditions.	2nd colloquium, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Zoran Glavaš, PhD Assoc.Prof. Anita Štrkalj, PhD	1.6. Year of study	2
1.2. Name of the course	**SECONDARY METALLURGY AND CONTINUOUS CASTING**	1.7. Credit value (ECTS)	5
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	45+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	Capability for managing the steelmaking processes. Understanding of treatment processes of steel in the ladle. Understanding of the continuous casting process of steel.		
2.2. Enrolment requirements and required entry competences for the course	-		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Plan and manage metallurgical processes. Plan the production and casting processes of ferrous and non-ferrous metals.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Explain the chemical reactions that occur during treatment of steel in the ladle. Describe and explain the secondary steelmaking processes in ladle. Analyze the results of the applied secondary steelmaking process and propose measures to increase its efficiency. Describe and explain the process of continuous casting of steel. Explain the solidification of continuously cast products. Analyze the quality of continuously cast products and propose measures to improve their quality. Select measures to increase steel cleanliness during the production process in the steelworks.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (45): Definition, importance and classification of secondary steelmaking processes (with and without vacuum). The basic characteristics of secondary steelmaking processes. (2); Fundamentals of thermodynamics: laws of thermodynamics, chemical equilibrium, Gibbs free energy, activity, activity – composition relationship, the equilibrium constant of the reaction, the structure and physicochemical properties of the slag, basicity and capacities of slag. (2); Tapping of the steel: reactions that occur during tapping, the influence of furnace slag on the quality of steel, the change in temperature of the steel. Ladle: refractory lining, preheating, mixing, steel reheating, control of the steel flow from bottom of the ladle. (2); Deoxidation of liquid steel: thermodynamics of simple and complex oxidation, kinetics of deoxidation reaction, kinetics of deoxidation product removal from liquid steel. (2); Degassing and decarburisation of liquid steel in a vacuum: thermodynamics of reactions during degassing and decarburisation, fluid flow and mixing during degassing and decarburisation, kinetics of degassing and decarburisation in a vacuum, the production of steel with ultra-low carbon content and stainless steel, thermodynamics of decarburisation of high-chromium steel melts. (4); Desulphurization in secondary steelmaking: thermodynamics of desulfurization, desulfurization with		

	synthetic slag on top of liquid steel, desulfurization with powdered reagents. (5); Phosphorus control in secondary steelmaking. Alloy additions. Nonmetallic inclusions and cleanliness of steel: the origin of inclusions, the influence of inclusions on the properties of steel, methods for detection of inclusions and assessment of steel cleanliness, measures to improve the cleanliness of steel during secondary steelmaking, inclusion modification. (4); Continuous casting of steel: caster types, the basic components of caster and principle of operation. Solidification of steel during continuous casting: the structure of continuously cast products, analysis of macrostructure and microstructure of continuously cast products. (3); Tundish: construction, the refractory lining, methods for detection of slag from the ladle, protection of the steel stream from the ladle to the tundish, protection of the top surface of liquid steel in the tundish, flow control of the liquid steel from the tundish to the mould. (3); Tundish: nozzles, flow-modifying devices, temperature control, control of steel level, nonsteady-state. (2); Mould: heat transfer, growth of solid shell, melt flow, mould powder (types, properties, consumption, melting rate, lubrication). (4); Mould: mould types, mould oscillation, mould level control, breakout. (4); Secondary cooling: heat transfer, influence of secondary cooling and casting speed on the metallurgical length, secondary cooling control. (3); Electromagnetic methods for continuous casting: electromagnetic stirrers for billet and bloom casters, electromagnetic equipment for slab casters. (2); Ductility of steel at high temperatures. Surface defects on continuously cast products. Internal defects in continuously cast products. (3). EXERCISES (15): Visits to plants for secondary steelmaking and continuous casting of steel - monitoring of the production process and the casting of steel.
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work ☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other) 2.7. Comments:
2.8. Student responsibilities	Conditions for signature: Students must attend lectures and exercises (> 70 %).

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	4.5	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Exam of the course: Through continuous monitoring - student needs to pass 2 colloquiums. If the student has passed all colloquiums, the final score is determined as the average score of the colloquiums. Through the final exam: written exam for students who have not passed the exam through continuous monitoring or are not satisfied with the success that are achieved through continuous monitoring or have not decided on this method of examination. Conditions for access to the exam: -

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Z. Glavaš, A. Štrkalj, Sekundarna metalurgija i kontinuirano lijevanje, text of the lectures placed on website of Faculty of Metallurgy, Faculty of Metallurgy, Sisak, 2015.		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/2-godina-diplomskog-studija/sekundarna-metalurgija-i-kontinuirano-lijevanje/view

2.12. Optional literature (at the time of the submission of the study programme proposal)	G. Stolte, Secondary Metallurgy – Fundamentals, Processes, Applications, Verlag Stahleisen GmbH, Düsseldorf, 2002. ..., The making, shaping and treating of steels, 11th edition, Steelmaking and refining volume The AISE Steel Foundation, 1988. ..., The making, shaping and treating of steels, 11th edition, Casting Volume The AISE Steel Foundation, 2003. M. Gojić, Metalurgija čelika, Faculty of metallurgy, Sisak, 2006. Z. Pašalić, Metalurgija čelika, Faculty for metallurgy and materials, Zenica, 2002.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the level of faculty and university. Analysis predicted in the quality assurance system of institution. Analysis predicted in the quality assurance system and authorized office of the university.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Explain the chemical reactions that occur during treatment of steel in the ladle.	1st colloquium, written exam
2	Describe and explain the secondary steelmaking processes in ladle.	1st colloquium, written exam
3	Analyze the results of the applied secondary steelmaking process and propose measures to increase its efficiency.	1st colloquium, written exam
4	Describe and explain the process of continuous casting of steel.	2nd colloquium, written exam
5	Explain the solidification of continuously cast products.	2nd colloquium, written exam
6	Analyze the quality of continuously cast products and propose measures to improve their quality.	2nd colloquium, written exam
7	Select measures to increase steel cleanliness during the production process in the steelworks.	1st and 2nd colloquium, written exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Ladislav Lazić, PhD	1.6. Year of study	2
1.2. Name of the course	**ENERGY MANAGEMENT**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Acquire knowledge about the particular forms of energy. 2. Acquire knowledge about types of energy conversion from one form to another. 3. Acquire knowledge about importance and ways of achieving the optimal energy efficiency in industrial processes by giving importance to thermal processes. 4. Acquire knowledge about the possibilities of reducing emissions of polluting gases.
2.2. Enrolment requirements and required entry competences for the course	The acquired knowledge from the courses of graduate study: Industrial furnaces, Heating technology of industrial furnaces, Numerical modelling of metallurgical processes, Theory of metal forming.
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice. 2. Suggest new and improved technical and technological solutions. 3. Analyse the development and application of new technologies. 4. Analyse the production processes by applying thermodynamic laws. 5. Suggest solutions for the optimization of metallurgical processes. 6. Formulate and suggest measures for increasing energy efficiency.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Analyze and compare the ways of converting the individual of energy forms. 2. Analyse and plan energy consumption at individual aggregate or plant. 3. Assess the impact of the combustion process on the environment. 4. Apply techniques for improving the energy efficiency of the combustion process and reducing emissions of polluting gases. 5. Analyse and choose the methods for optimization of energy processes in industry. 6. Evaluate the energy and environmental efficiency of applied methods or procedure.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): 1. General information about significance of energy management (2) 2. Energy, basic forms of energy and their division, energy sources (4) 3. Processes of energy conversions (2) 4. Energy consumption in the world, emissions of carbon dioxide caused by burning the fossil fuels, general strategy for reducing the consumption of fossil fuels and greenhouse gas emissions (4) 1st colloquium 5. Possible ways of reducing the energy consumption in industry (optimization of industrial furnaces, steam generators, pumping systems, electric machines) (8) 6. Contemporary trends in the improvement of energy efficiency of the combustion process and reducing the emissions of

	polluting gases (4) 7. Optimization of combustion processes: regulation of the air-fuel ratio, combustion air preheating, oxygen enrichment of combustion air (4) 2nd colloquium SEMINAR (15): The understanding of the material exposed in lectures is facilitated by solving the given projects. The projects are selected so that they expand the presented theory and illustrate the application of theory to real problems.

2.6. Type of instruction			2.7. Comments:
	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☒ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)	

2.8. Student responsibilities	Attendance to Lectures and Seminars > 70 %

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance	0.4	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1.0	(Other--describe)	
	Tests	1.0	Oral exam	1.6	(Other—describe)	
	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Projects – 30% Class attendance – 5% Written exam – 30% Oral exam – 35%

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	L. Lazić, Materials from lectures	0	Merlin system for e-learning
	H. Požar, Osnove energetike, Školska Knjiga, Zagreb, 1992	2	
	B. Udovičić, Energetika, Školska Knjiga, Zagreb, 1993.	3	

2.12. Optional literature (at the time of the submission of the study programme proposal)	J. G. Wunning, A. Milani, Handbook of Burner Technology for Industrial Furnaces, Vulkan-Verlag GmbH, 2009.

2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Analyze and compare the ways of converting the individual of energy forms.	1st colloquium, oral exam
2	Analyse and plan energy consumption at individual aggregate or plant.	1st colloquium, oral exam
3	Assess the impact of the combustion process on the environment.	2nd colloquium, oral exam
4	Apply techniques for improving the energy efficiency of the combustion process and reducing emissions of polluting gases.	2nd colloquium, seminar paper, oral exam
5	Analyse and choose the methods for optimization of energy processes in industry.	2nd colloquium, oral exam
6	Evaluate the energy and environmental efficiency of applied methods or procedure.	2nd colloquium, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Zoran Glavaš, PhD	1.6. Year of study	2
1.2. Name of the course	**CASTING OF FERROUS METALS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Introduce students with properties and types of ferrous casting alloys. Understanding the correlation of process parameters, melt quality, pouring and conditions during solidification with microstructural and service properties of ferrous castings. The ability to define the production of metal castings from unalloyed and alloyed cast irons and cast steels.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Plan and manage metallurgical processes. Plan the production and casting processes of ferrous and non-ferrous metals.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Describe the casting and solidification process of ferrous metal castings in expendable moulds. Relate microstructural and service properties of cast irons and cast steels. Relate chemical composition, metallurgical quality of melt and condition during solidification with resulting microstructural and service properties of castings. Select charge materials for melting aggregates according to casting type and required properties of castings. Select the melt treatment parameters based on chemical composition and metallurgical quality of melt. Select the appropriate quality of cast iron and cast steel depending on the conditions of application of castings. Solve complex problems in metallurgy of cast irons and cast steels.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Classification of ferrous casting alloys. (1); Gray cast iron: basic features, properties, application, standards, nucleation and growth of flake graphite, types of flake graphite, transformations in solid state, the influence of chemical composition on microstructure and properties, melt production, inoculation, heat treatment of castings, alloyed gray cast irons, quality control of the melt, quality control of castings. (6); Ductile cast iron: basic features, properties, application, standards, nucleation and growth of spheroidal graphite, irregular graphite forms, transformations in solid state, the influence of chemical composition on microstructure and properties, base melt production, nodularizers, magnesium treatment methods, inoculation, heat treatment of castings, ausferritic ductile cast iron (ADI), alloyed ductile cast irons, quality control of the base melt, quality control of treated melt, quality control of castings. (6); Compacted graphite cast iron: basic features, properties, application, standards, nucleation and growth of compacted graphite, factors influencing properties of compacted graphite cast iron, base melt production, production processes of compacted graphite cast iron, control of the production process of compacted graphite cast iron. (3); Risering gray, compacted graphite and ductile iron castings: volume changes during the cooling and solidification of graphitic cast irons, casting modulus, risering techniques, increasing the efficiency of the riser. (4); Gating systems for gray,

	compacted graphite and ductile iron castings: basic components, types of gating systems, the principles of designing a pressurized, non-pressurized and hybrid gating systems in horizontally parted moulds, the principles of designing a gating systems in vertically parted moulds, application of filters. (4); Malleable cast iron: basic features, properties, application, standards, chemical composition, production of whiteheart and blackheart malleable cast iron. (1); White cast irons: basic features, properties, application, standards, pearlitic abrasion resistant cast irons, nickel-chromium abrasion resistant cast irons (Ni-Hard 1, 2, 3 and 4), high-chromium abrasion resistant cast irons, specialty abrasion resistant cast irons, solidification, heat treatment of casting, production. (2); Cast steels: cast carbon steels (basic features, low-carbon cast steels, medium-carbon cast steels, high-carbon cast steels, properties, application), cast low-alloy steels (basic features, cast low-alloy steels for structural components with high strength, hardenability and toughness, cast low-alloy steels for components that need to have wear resistance, abrasion or corrosion resistance during application at low or high temperatures, properties, application), cast high-alloy steels (basic features, cast corrosion-resistant steels, cast heat-resistant steels, cast wear-resistant steels, properties, application), production of cast steel melt. (3). EXCERCISES (15): Designing a gating and risering system for gray, compacted graphite and ductile iron castings. (3); Analysis of casting microstructure. (2); Analysis of cooling curves of gray, compacted graphite and ductile cast iron. (2); Visits to cast irons and cast steels foundries. (8).
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work ☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)
2.7. Comments:	
2.8. Student responsibilities	Conditions for signature: Students must attend the lectures and exercises (> 70 %).

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
Class attendance	0.5	Research		Practical training	
Experimental work		Report			
Essay		Seminar essay		(Other--describe)	
Tests	3.5	Oral exam		(Other—describe)	
Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Exam of the course: Through continuous monitoring - student needs to pass 2 colloquiums. If the student has passed all colloquiums, the final score is determined as the average score of the colloquiums. Through the final exam: written exam for students who have not passed the exam through continuous monitoring or are not satisfied with the success that are achieved through continuous monitoring or have not decided on this method of examination. Conditions for access to the exam: -

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Z. Glavaš, F. Unkić, Lijevanje željeznih metala, text of the lectures placed on website of Faculty of Metallurgy, Faculty of Metallurgy, Sisak, 2008.		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/2-godina-diplomskog-studija/lijevanje-zeljeznih-metala/view
	…, Metals Handbook, Volume 15, Casting, ASM International, Metals Park Ohio, 2008.		CD

2.12. Optional literature (at the time of the submission of the study programme proposal)	…, Cast Iron, ASM International, Materials Park, 1999. G. Laird, R. Gundlach, K. Röhrig, Abrasion-Resistant Cast Iron Handbook, American Foundry Society, 2000. Steel Castings Handbook, 6th Edition, editors: N. Blair, T. L. Stevens, ASM International, 1995.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the level of faculty and university. Analysis predicted in the quality assurance system of institution. Analysis predicted in the quality assurance system and authorized office of the university.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Describe the casting and solidification process of ferrous metal castings in expendable moulds.	1st and 2nd colloquium, written exam
2	Relate microstructural and service properties of cast irons and cast steels.	1st and 2nd colloquium, written exam
3	Relate chemical composition, metallurgical quality of melt and condition during solidification with resulting microstructural and service properties of castings.	1st and 2nd colloquium, written exam
4	Select charge materials for melting aggregates according to casting type and required properties of castings.	1st and 2nd colloquium, written exam
5	Select the melt treatment parameters based on chemical composition and metallurgical quality of melt.	1st and 2nd colloquium, written exam
6	Select the appropriate quality of cast iron and cast steel depending on the conditions of application of castings.	1st and 2nd colloquium, written exam
7	Solve complex problems in metallurgy of cast irons and cast steels.	1st and 2nd colloquium, written exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Zdenka Zovko Brodarac, PhD	1.6. Year of study	2
1.2. Name of the course	**CASTING OF NON-FERROUS METALS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Introduce students to properties and types of nonferrous casting alloys. Understanding the correlation of process parameters, melt quality, pouring and conditions during solidification with microstructural and service properties oF nonferrous castings. The ability to define the production of metal castings based on unalloyed and alloyed cast irons and steels and nonferous metal castings ((aluminum, magnesium, copper, metal matrix composites).
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Plan the production and casting processes of ferrous and non-ferrous metals. Compare the procedures of material treatment with microstructure and useful properties.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Describe the casting and solidification process of nonferrous metal castings in expendable and permanent moulds. Relate microstructural and service properties of nonferrous metal castings. Relate the chemical composition, metallurgical quality of melt and solidification condition with resulting microstructural and usage properties of castings. Select charge materials for melting aggregates according to casting type and required properties of castings. Select the melt treatment parameters.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Introduction to the subject curriculum, method of mastering the material. (1) Classification of non-ferrous casting alloys. Aluminium casting alloys in general. Application of alloys. (5) Classification of alloys: norms. Solubility of elements. Metallurgical state: Heat treatment. Criterions for alloy selection. Properties of Al-casting alloys. Influence of alloying and trace elements. Microstructures overview. (4) Melt treatment of Al-casting alloys: degassing, filtration, circulation. (4) Methods of melt treatment of Al-casting alloys: grain refinement, modification of microstructure. (4) Solidification and development of cast microstructure. Fundamentals of nucleation. Crystal growth. Solidification types. Determination of nucleation potential and solidification kinetics. Classification of casting processes of aluminum alloys. (4) Implementation of new strategies and concepts in production projection. Disadvantages of conventional casting processes. Innovative casting processes. Recycling of aluminium alloys. Technology of recycling. Casting defects. (3) Magnesium and copper alloys: classification and designation, properties and application, production processes, heat treatment,

	corrosion protection. (3) Casting of metal matrix composites. (2) EXERCISES (15): Visit to the relevant foundries casting of non-ferrous metals (15).					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☒ field work		☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Attending the classes >70%.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	1	Research		Practical training	
	Experimental work		Report	1		
	Essay		Seminar essay		(Other--describe)	
	Tests	2	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Class attendance. Examination through continuous monitoring: 1. Colloquium-after the unit Methods of melt treatment of Al-casting alloys: grain refinement, modification of microstructure, 2. Colloquium-after the unit Casting of metal matrix composites or final examination: written and oral.					
2.11. Required literature (available at the library and via other media)	**Title**			**Number of copies at the library**	**Availability via other media**	
	Metals Handbook, Volume 15, CASTING, ASM International, Metals Park, Ohio, 1988.			1		
	J. G. Kaufman, E. L. Rooy, Aluminum Alloy Castings Properties, Processes and Applications, ASM International, Metals Park, Ohio, 2005.			1		
	Aluminum and Aluminum Alloys. ASM Specialty Handbook, ASM International, ed. J. R. Davis, Materials Park, Ohio, USA, 2002.			1		
	Aluminum Casting Technology, American Foundrymen's Society, Illinois, 1997.			1		
2.12. Optional literature (at the time of the submission of the study programme proposal)	T. Nishizawa, Thermodynamics of microstructures. ASM International, Materials Park, Ohio, 2008 J. Campbell, Castings, Butterworth Heinemann, Oxford, 1991.					
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the Faculty and University level. Analysis provided the quality assurance system of the institution. Analysis provided the quality assurance system and authorized Office of the University					

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Describe the casting and solidification process of nonferrous metal castings in expendable and permanent moulds.	1st colloquium, auditory exercises, written and oral exam
2	Relate microstructural and service properties of nonferrous metal castings.	1st colloquium, auditory exercises, written and oral exam
3	Relate the chemical composition, metallurgical quality of melt and solidification condition with resulting microstructural and usage properties of castings.	1st colloquium, auditory exercises, written and oral exam
4	Select charge materials for melting aggregates according to casting type and required properties of castings.	2nd colloquium, auditory exercises/field work, written and oral exam
5	Select the melt treatment parameters based on chemical composition and metallurgical quality of melt.	2nd colloquium, auditory exercises/field work, written and oral exam
6	Describe the casting and solidification process of nonferrous metal castings in expendable and permanent moulds.	2nd colloquium, auditory exercises/field work, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Anita Štrkalj, PhD Assoc.Prof. Tamara Holjevac Grgurić, PhD	1.6. Year of study	2
1.2. Name of the course	**EXPERIMENTAL TECHIQUES IN METALLURGY**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	To adopt a basic knowledge about experimetal techniques in the area of metallurgy. To introduce new technological methods for investigation of materials in foundry and steel works. To train students for autonomous experimental work.		
2.2. Enrolment requirements and required entry competences for the course			
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Suggest appropriate methods for material quality analysis. Plan and manage metallurgical processes.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Plan the technological investigations of metallurgical materials. Determine radioactivity of the scrap. Analysis of flue gas/chimney content. Analyze the quality and stability of the material in the foundry industry. Define experimental techniques for measurement of pressure, temperature and flow. Select and apply appropriate experimental technique for monitoring of metallurgical processes.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Theoretical basics of experimetal techniques. (3) Analysis of metallurgical slag, electric arc-furnace dust and foundry sand. (4) Gravimetry (the content of solid particles in flue gases) (4) Measuring of radioactivity in the steel scrap. (4) Measuring of oxygen activity in the melt. (3) Experimetal techniques for measurement of pressure. (4) Experimental techniques for measurement of temperature. (4) Experimental techniques for mesurement of flow. (4) Two colloquiums through continuos monitoring. LABORATORY EXERCISES (15): Measuring of pH value of metallurgical materials.		

	Determination of acid demand value of foundry sands. Determination of chromite content in silicon sands. Determination of mass loss by calcination of chromite. Determination of chemical content of flue gas. Measuring of temperature (solid, fluid). Mesuring in steel works. Measuring in foundry. Characterization of bentonites and sands as well as thermal stability of metallurgical materials (DSC/TG).					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☒ mixed e-learning ☐ field work		☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8.Student responsibilities	Attendence to lectures min 70 %. Attendance to lab practice min. 70 %. Lab reports.					
2.9.Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	1	Research		Practical training	
	Experimental work	1	Report			
	Essay		Seminar essay		(Other--describe)	
	Tests		Oral exam	1	(Other—describe)	
	Written exam	1	Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Two colloquiums through continuos monitoring and oral exam or final exam: written and oral.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Mold & Core Test Handbook, American Foundry Society, Inc. 2006.	1	

2.12. Optional literature (at the time of the submission of the study programme proposal)	R. Halmshaw, Non-destructive Testing, Buttervorth-Heinemann Ltd., 1991. J. L. Taylor, Basic Metallurgy for Non-Destructive Testing, British Institute for Non-dstructive Testing, 1996. Occurance and Testing of Foundry Mouding Sands, L.H. Cole, Nabu Press, 2010.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Student survey input and output. Numerical analysis of tests and exams according to scoring task by task at the level of course. Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Plan the technological investigations of metallurgical materials.	1st and 2nd colloquium, laboratory exercises, written exam
2	Determine radioactivity of the scrap.	1st colloquium, written exam
3	Analysis of flue gas/chimney content.	1st and 2nd colloquium, written exam, oral exam
4	Analyze the quality and stability of the material in the foundry industry.	1st colloquium, laboratory exercises, written exam, oral exam
5	Define experimental techniques for measurement of pressure, temperature and flow.	1st and 2nd colloquium, laboratory exercises, written exam, oral exam
6	Select and apply appropriate experimental technique for monitoring of metallurgical processes.	1st and 2nd colloquium, laboratory exercises, written exam, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Zdenka Zovko Brodarac, PhD	1.6. Year of study	2
1.2. Name of the course	**OPTIMISATION OF CASTINGS FORMING**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	Getting acquainted with modern concepts of design and development of metal castings using computer packages. Optimization of construction castings, tools, models and prototypes by application of informatics technology. Macro and micro modelling of commercial alloys solidification. The use of computers in planning and quality assurance. Product data management.		
2.2. Enrolment requirements and required entry competences for the course	-		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Analyse the development and application of new technologies. Plan the production and casting processes of ferrous and non-ferrous metals.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Elaborate technological phases of casting production. Select the method of rapid prototyping. Optimization of the casting, models and tools construction using informatics technology. Analyse cast product data.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Introduction to the plan and syllabus of the course, and ways for successful overcoming. (1) Introduction in of contemporary conceptions of production of castings. (5) Optimization of castings, of tools, models constructions by applying informatics technology. Optimization of prototypes constructions by applying informatics technologies. (4) Rapid prototyping. (3) Simulations of mold filling and solidification processes. Stochastic modeling solidification. (5) Optimization melts quality via informatics technologies: expert systems. Optimization melts quality via informatics technologies: methods of artificial inteligency. Optimization quality melt via information technologies: computer aided thermal analysis. (5) Macro and micro modeling solidification of commercial alloys: commercial alloys. (5) Application of computers in planning and quality assurance. Product data management. (2) EXERCISES (15): Making stl model default casting (5). Numerical simulation of casting and solidification (7). Prediction and correction of errors (1). Optimization of the casting process (2).		

2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☒ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:
2.8. Student responsibilities	Attending the classes. 1. colloquium Project and presentation.		

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	1	Research		Practical training	
	Experimental work		Report	1		
	Essay		Seminar essay		(Other--describe)	
	Tests	2	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Attending the classes. Project task. One tests through continuous monitoring or final examination (written and oral).

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Metals Handbook, Volume 15, CASTING, ASM International, Metals Park, Ohio, 1988	1	
	TMS, Modelling of casting, welding and advanced solidification processes, Illinois, 1998	1	
	J. P. Womack, D. T. Jones, D. Roos, The machine that changed the world, New York, 1991.	1	
	M. Imaj, Kaizen, Ključ japanskog poslovnog uspjeha, Beograd, 2008.	1	

2.12. Optional literature (at the time of the submission of the study programme proposal)	-
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the Faculty and University level. Analysis provided the quality assurance system of the institution. Analysis provided the quality assurance system and authorized Office of the University

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Elaborate technological phases of casting production.	1st colloquium, auditory exercises, written and oral exam
2	Select the method of rapid prototyping.	1st colloquium, auditory exercises, written and oral exam
3	Optimization of the casting, models and tools construction using informatics technology.	Laboratory exercises/independent work, written and oral exam
4	Analyse cast product data.	Independent work, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assist.Prof. Tahir Sofilić, PhD Assoc.Prof. Ivan Brnardić, PhD Assoc.Prof. Tamara Holjevac Grgurić, PhD	1.6. Year of study	2
1.2. Name of the course	**THE BEST AVAILABLE TECHNIQUES IN METALLURGY**	1.7. Credit value (ECTS)	5
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	45+15+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	To enable engineers for managing of the metallurgical processes, effective control of metallurgical industrial activities giving priority to intervention at source in the production plant, ensuring management of natural resources according to the economic situation and specific characteristics of the local area. Introduction to the industrial emissions directive 2010 / 75 / EU and to the integrated approach to prevention and control of environmental emissions, waste management as well as energy efficiency and accident prevention. Introduction to European reference documents (BREF) with review of the best available techniques (BAT) relating to the metallurgical processes, especially the processes of iron and steel production, as well as processes of production of non-ferrous metals.		
2.2. Enrolment requirements and required entry competences for the course			
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Suggest solutions for the optimization of metallurgical processes. Formulate and suggest measures for increasing energy efficiency.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Define and explain the concept of the best available techniques (BAT). To choose BAT in the metallurgical process. Use legislation of environmental protection in the metallurgical processes. Understand application of the best available techniques to protect the environment.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (45): Trends of iron and steel production in the world, EU and Republic of Croatia. (1) Management of raw materials and energy in the iron and steel production. (1) Consumption of materials and energy in the metallurgical processes. (1) Emissions of pollutants. (2) Emissions into the air. (1) Materials management. (1) Storage and handling of raw materials. (1) Management of production residues. (1)		

	Management of waste water. (1) Introduction and selection of the best available techniques in metallurgy. (1) Techniques to increase energy efficiency. (1) Techniques for optimizing consumption of fuels. (1) Techniques for improving effectivnes of waste heat. (1) Consumption of materials and energy as well as emissions in iron production by blast furnace process. (1) The emission of pollutants into the environment during blast furnace processes. (1) The best available techniques in blast furnace process. (2) The formation of slag and its treatment (granulation and pelletizing). (2) Storage and handling of raw materials in electric arc furnace process (EAF). (1) Pre-treatment of the ingot for steel production in the EAF. (1) Pre-heating of the steel charge for steel production in the EAF. (1) Smelting, refining and casting. (1) Secondary metallurgy. (1) The formation of slag (EP and LP) and its treatment. (1) Consumption of materials and energy in the steel production process. (1) Pollutant emissions from steel production process. (2) Emissions of pollutants into the air from the steel production process. (1) Water management and waste water from the steel production process. (1) Noise emissions. (1) Soil pollution. (1) The best available techniques in the steel production process. (2) Consumption of raw materials and energy as well as emissions from cooper production. (1) The best available techniques in the cooper production process. (2) Consumption of raw materials and energy as well as emissions from aluminium production. (1) The best available techniques in the aluminium production process. (2) Consumption of raw materials and energy as well as emissions from production of lead and tin. (1) The best available techniques in the production of lead and tin. (1) Consumption of raw materials and energy as well as emissions from production of zinc and cadmium. (1) The best available techniques in the production of zinc and cadmium. (1) SEMINAR(15): Instructions for the preparation of the seminar. (2) Presentation of seminar topics and the selection (1) Individual students work under supervision. (6) Written seminar and preparation of ppt presentation. (1) Oral presentations. (5) EXERCISES(15): Auditory exercises - comparison of monitoring results of air emissions from the steel production process in Croatia with related BREF data. (5) A comparison of production waste (waste and / or by-products) from the steel production process in the Republic of Croatia with related BREF data. (3) Field work: metallurgical industrial processes and introduction to applied BAT. (7)

	PRELIMINARY EXAMS: 1.preliminary exam. Pollutant emissions in the production of iron and steel, emissions of pollutants into the air from the production processes, raw materials management, storage and handling of raw materials, waste residues, waste water management, review and selection of the best available techniques in metallurgy, techniques for increasing energy efficiency, techniques for optimizing the consumption of fuels, techniques for improving waste heat utilization, consumption of materials and energy as well as emissions in iron production by blast furnace process, the emission of pollutants into the environment during blast furnace processes, the best available techniques in blast furnace process, formation of slag and its treatment (granulation and pelletizing). 2.preliminary exam. Storage and handling of raw materials in electric arc furnace process (EAF), pre-treatment of the ingot for steel production in the EAF, pre-heating of the steel charge for steel production in the EAF, smelting, refining and casting, secondary metallurgy, formation of slag (ELP and LP), consumption of materials and energy in the steel production process, pollutant emissions from steel production process, emissions of pollutants into the from the steel production process, water management and waste water from the steel production process, noise emissions, soil pollution, the best available techniques in the steel production process. 3.preliminary exam. Consumption of raw materials and energy as well as emissions from cooper production, the best available techniques in the cooper production process, consumption of raw materials and energy as well as emissions from aluminium production, the best available techniques in the aluminium production process, consumption of raw materials and energy as well as emissions from production of lead and tin, the best available techniques in the production of lead and tin, consumption of raw materials and energy as well as emissions from production of zinc and cadmium, the best available techniques in the production of zinc and cadmium.

2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☒ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)	2.7. Comments:
2.8. Student responsibilities	Attendance to lectures min 70 %. Attendance to seminar min 70 %. Written seminar and oral presentation.		

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance		Research		Practical training	
	Experimental work	1	Report			
	Essay		Seminar essay	1	(Other--describe)	
	Tests	3	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Seminar, results of preliminary exams as well as written and oral exams.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**

	Best Available Techniques (BAT) Reference Document for Iron and Steel Production		http://eippcb.jrc.ec.europa.eu/reference/BREF/IS_Adopted_03_2012.pdf
	Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries		http://eippcb.jrc.ec.europa.eu/reference/BREF/NFM_Final_Draft_10_2014.pdf
	DIREKTIVA 2010/75/EU EUROPSKOG PARLAMENTA I VIJEĆA od 24. studenoga 2010. o industrijskim emisijama (integrirano sprečavanje i kontrola onečišćenja)		http://eur-lex.europa.eu/legal-content/HR/TXT/?uri=celex:32010L0075
2.12. Optional literature (at the time of the submission of the study programme proposal)	Sofilić T., Jendričko J., PCDDs/Fs Pollution from Metallurgical Processes in the Town of Sisak, Croatia, Archives of metallurgy and materials, **59**, 1 (2014) 293-297. Sofilić T., Unkić F., Direktiva IPPC (96/61/EC) i njezin značaj za hrvatske čeličane i ljevaonice, Ljevarstvo, **50**, 4 (2008) 107-117. Sofilić T., Rastovčan-Mioč A., Šmit Z., Čeličanska elektropeć kao izvor emisije polikloriranih dibenzo-*p*-dioksina i dibenzofurana u svijetlu Direktive Vijeća (96/61 EC) o cjelovitom sprječavanju i kontroli onečišćenja, Kem.Ind. **57**, 1 (2008) 9-18.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Student survey input and output. Numerical analysis of tests and exams according to scoring task by task at the level of course. Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Define and explain the concept of the best available techniques (BAT)	1st colloquium, seminar, written and oral exam
2	To choose BAT in the metallurgical process	1st colloquium, 2nd colloquium, seminar, written and oral exam
3	Use legislation of environmental protection in the metallurgical processes	2nd colloquium, 3rd colloquium, seminar, written and oral exam
4	Understand application of the best available techniques to protect the environment	3rd colloquium, seminar, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Stoja Rešković, PhD Assoc.Prof. Natalija Dolić, PhD	1.6. Year of study	2
1.2. Name of the course	**SHAPING OF NON-FERROUS METALS AND THEIR ALLOYS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	Assist.Prof. Ivan Jandrlić, PhD	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	2., 10%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Introducing students to the properties of non-ferrous metals 2. Introducing students with the theoretical bases of forming by deformation 3. Introducing students with technologies of shaping by deformation
2.2. Enrolment requirements and required entry competences for the course	Passed exam from Theory of metal forming
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice. 2. Analyse and combine metal forming processes. 3. Suggest solutions for the optimization of metallurgical processes.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Apply scientific principles important to the formation of non-ferrous metals, 2. Create parameters of forming non-ferrous metal by deformation, 3. Calculate and evaluate the influential parameters on forming process, 4. Recommend individual metal forming processes.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30) AND EXERCISES (15): 1. Introduction. Overview of methods for shaping non-ferrous metals. 2 2. Technology of industrial casting of aluminum and aluminum alloys intended for further processing. Horizontal ("HDC") and vertical ("VDC") casting process by direct cooling water. 2. 3. Homogenization of casted aluminium ingots. Technology for casting aluminum billets by direct cooling with water. 2 4. Exercise: Control of casting parameters, constancy and repeatability casting parameters (examples from practice). 1 5. I Colloquium, chapters 2, 3 and 4 6. Properties of non-ferrous metals. 2 7. Laboratory exercises. Determination of deformation resistance of non-ferrous metals and their alloys. 4 8. Characteristics of the plastic processing and properties of Al and Al-alloys. 1 9. Hot and cold deformation. 2 10. The rolling of aluminium or aluminium alloy: Rolling of profiles. 2 11. Rolling of sheet. Rolling of foil. Other rolled products. 2

	12. New Al-alloys. 1 13. Pressing with extrusion and flow. The deep drawing. 2 14. Auditory exercises. Calculation of the rolling Al-alloys. 5 15. II Colloquium, chapters 1, 6-13 16. Characteristics of the plastic processing and properties of Cu and Cu-alloys. 2 17. Hot and cold deformation. 2 18. Rolling of Cu-alloys. 2 19. Pressing with extrusion and flow. The deep drawing. 2 20. Auditory exercises. Calculation of extrusion of Cu-alloy. 5 21. Other non-ferrous metals and alloys. Overview on procedures of plastic deformation. 3 22. Technical and economic indicators of the process of plastic processing of nonferrous metals and their alloys. 1 23. III Colloquium, chapters 16 – 19

2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:

2.8. Student responsibilities	Attendance at lectures 70%, individual work on all exercises and preparation and submission of reports from field of colloquium before writing the colloquium or the written exam.

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
Class attendance		Research	0.5	Practical training		
Experimental work	1	Report				
Essay		Seminar essay		(Other--describe)		
Tests	1	Oral exam	1	(Other—describe)		
Written exam		Project	0.5	(Other—describe)		

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	The presence and activity of students on classes during the classes are evaluated. Students score participation on projects. Score on written colloquiums trough continuous monitoring (or written exam) and oral exam. Score of seminar paper.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	A. Tripalo, Tehnologija prerade aluminija, Tehnička knjiga, Beograd, 1966.	2	
	D. G. Eskin, Physical Metallurgy of Direct Chill Casting of Aluminium Alloys, CRC Press/Taylor and Francis Group, Boca Raton, 2008.	3	
	S. Rešković, Tehnologija oblikovanja deformiranjem- nastavna građa, Sisak 2011.	10	

2.12. Optional literature (at the time of the submission of the study programme proposal)	S. Rešković, Teorija oblikovanja deformiranjem, Sveučilište u Zagrebu, Metalurški fakultet, Sisak 2014., peer reviewed lessons. Professional journals, Metallurgy, Mechanical Engineering - articles from this area.
2.13. Methods of monitoring quality that ensure acquisition of exit	Survey on the level of faculty and University. Analyses provided by quality assurance system of the institution.

competences	Analyses provided by quality assurance system and authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Apply scientific principles important to the formation of non-ferrous metals.	1st colloquium, written and oral exam
2	Create parameters of forming non-ferrous metal by deformation.	Laboratory exercises, auditory exercises, project task
3	Calculate and evaluate the influential parameters on forming process.	2nd colloquium, auditory exercises, independent task, written and oral exam
4	Recommend individual metal forming processes.	3rd colloquium, seminar paper, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Mirko Gojić, PhD Assoc.Prof. Stjepan Kožuh, PhD	1.6. Year of study	2
1.2. Name of the course	**SURFACE TREATMENT**	1.7. Credit value (ECTS)	3
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Knowing the basic physical-chemical principles of modification and coating. Gaining insight into the many benefits of individual methods of surface treatment. Selecting the best methods for appropriate application conditions of the machine parts and tools
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Design the properties of metallic materials. Compare the procedures of material treatment with microstructure and useful properties.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Define the concept of surface treatment material. Compare the most important characteristics of each surface treatment process. Categorize and interfuse the individual actions of modification and coating of metal surfaces. Create the appropriate procedure for the protection of materials and structures. Analyze the properties of metallic coatings. Compare methods for non-metallic inorganic and organic coatings.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Week 1 and 2: Classification of processes. Surface preparation for surface treatment (4 hours). Weeks 3 and 4: The mechanical modification (sandblasting). Methods for heat hardening of surfaces (flame, induction, surface hardening by laser and electron beam) (4 hours). Week 5-7: High temperature thermomechanical processes of surface hardening (carbonising, nitration, boronising) (6 hours). Week 8-10: Surface modification and deposition of thin films (ion implantation - 2 hours, deposition from the vapor phase by physical way-2 hours, the vapor phase deposition by chemical way- CVD and plasma CVD method-2 hours) Week 11: Hot dipping (galvanizing, application of aluminium and tin) (2 hours). Week 12: Electroplating (plating with zinc, nickel, tin, copper, chromium) (2 hours). Week 13: Enameling. Deposition of precious metals (Au, Ag, etc.) (2 hours). Week 14: Browing. Anodising. Phosphating. Deposition of chromium. Patination (2 hours). Week 15: Organic coatings (coloring, varnishing, plastification, bitumenizing) (2 hours). SEMINAR (15): The selection of topics and seminar work in writing form by a mentor system (10 hours). Preparation and

	presentation of the seminar and discussions in relation to the topic of the present paper (5 hours).					
2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☐ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Students must attend over 70% of lectures and are required to complete a seminar in writing form and orally present.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.3	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	0.5	(Other--describe)	
	Tests	2.2	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	- evaluation of students activities in course, - evaluation of written examination (two colloquiums) through continuous monitoring or final examination (written and oral), - evaluation of seminar paper and presentation.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	M. Gojić, Površinska obradba materijala, Metalurški fakultet, Sisak, 2010.	10	
	I. Esih, Osnove površinske zaštite, Fakultet strojarstva i brodogradnje, Zagreb, 2003.	3	
	ASM Handbook.pdf		Electronic form

2.12. Optional literature (at the time of the submission of the study programme proposal)	T. Filetin, K. Grilec, Postupci modificiranja i prevlačenja površina, Hrvatsko društvo za materijale i tribologiju, Zagreb, 2004. D. Krumes: Površinske toplinske obrade i inženjerstvo površine, Strojarski fakultet Slavonski Brod, Sveučilište u Osijeku, Slavonski Brod, 2004.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Student survey input and output. Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided by quality assurance system and authorized office of the University.

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Define the concept of surface treatment material.	1st colloquium, written and oral exam
2	Compare the most important characteristics of each surface treatment process.	1st colloquium, written and oral exam
3	Categorize and interfuse the individual actions of modification and coating of metal surfaces.	1st colloquium, written and oral exam
4	Create the appropriate procedure for the protection of materials and structures.	2nd colloquium, written and oral exam, seminar paper
5	Analyze the properties of metallic coatings.	2nd colloquium, written and oral exam
6	Compare methods for non-metallic inorganic and organic coatings.	2nd colloquium, written and oral exam, seminar paper

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Ivan Brnardić, PhD	1.6. Year of study	2
1.2. Name of the course	**CORPORATE SOCIAL RESPONSIBILITY**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	20
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION			
2.1. Course objective	1. To introduce students with corporate socially responsible. 2. To introduce with the strategy of sustainable development in the Croatia. 3. To train for self-employment and / or presentation of the institution / company / community / city / county in matters of sustainable development.		
2.2. Enrolment requirements and required entry competences for the course	Knowledge on industrial ecology and idea of sustainable development and work on computers.		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Compare and choose individual technological process. Combine the skills necessary for lifelong learning, including continued professional training.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Define and explain the concepts of corporate social responsibility. 2. Know the guidelines of the strategy of sustainable development in Croatia. 3. How to use regulations and scientific-technical literature in the field of corporate social responsibility. 4. Understand and advocate for consistent application of the principles of corporate social responsibility. 5. Design and implement environmentally, economically and socially responsible business practices and socially responsible investment community.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): What is corporate social responsibility. 3h Sustainable Development Strategy of the Croatia. 8h Customer relationship management with the aim of fitting social responsibility in marketing activities. 4h Responsible operations in work safety improving. 2h The development and the state of CSR in Croatia and abroad. 3h Examples from practice. 10h SEMINAR (15): Example seminar work and preparation and presentation of seminar paper.		
2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety	☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor	2.7. Comments:

	☐ mixed e-learning ☐ field work		☐ (other)			
2.8. Student responsibilities	Regular attendance of lectures (min. 70% of the lectures) and seminar work.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1.0	(Other--describe)	
	Tests		Oral exam	1.25	(Other—describe)	
	Written exam	1.25	Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Attendance on classes, preparation and presentation of seminar paper, continuous monitoring – 2 preliminary exams or written and oral exam.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	I. Brnardić, Lectures from Corporate social responsibility, Sisak, 2016.		Merlin system for e-learning
	L. Pavić Rogošić, Corporate social responsibility, Odraz, Zagreb, 2015.		http://www.odraz.hr/media/21845/dop.pdf
	Strategy of sustainable development of the Republic Croatia, OG 110/07, RH, 2009.		http://narodne-novine.nn.hr/clanci/sluzbeni/2009_03_30_658.html
	A. Glavočević, A. Radman Peša, Corporate social responsibility in CRM as a way of social responsibility integrating in marketing activity, Oeconomica Jadertina 2/2013.		https://www.google.hr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjCksTLxvzNAhXG8RQKHcxPBRYQFggcMAA&url=http%3A%2F%2Fhrcak.srce.hr%2Ffile%2F170022&usg=AFQjCNG-XJcdIxpIamFJaP7CuEp6aYdRg
	V. Nikolić, S. Savić, J. Taradi, Models of corporate social responsibility in function of occupational safety and sustainable development, 14. International symposia on quality, Rovinj, 21.-22.3.2013.		https://bib.irb.hr/datoteka/623168.Sijakovic_Savic_Nikolic_Taradi_HDMK-14.pdf
	M. A. Omazić et al., A collection of case studies of corporate social responsibility, Zagreb, 2012.		http://www.hup.hr/EasyEdit/UserFiles/Granske_udruge/Global%20Compact/zbirka_studija_slucaja_DOP.pdf

2.12. Optional literature (at the time of the submission of the study programme proposal)	Available scientific literature on the subject of corporate social responsibility.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the faculty and University level. Analysis predicted by systems for insurance of institution quality. Analysis predicted by systems for insurance quality from authorized University office.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Define and explain the concepts of corporate social responsibility.	1st colloquium, seminar, written and oral exam
2	Know the guidelines of the strategy of sustainable development in Croatia.	1st colloquium, seminar, written and oral exam
3	How to use regulations and scientific-technical literature in the field of corporate social responsibility.	2nd colloquium, seminar, written and oral exam
4	Understand and advocate for consistent application of the principles of corporate social responsibility.	2nd colloquium, seminar, written and oral exam
5	Design and implement environmentally, economically and socially responsible business practices and socially responsible investment community.	2nd colloquium, seminar, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Zoran Glavaš, PhD	1.6. Year of study	2
1.2. Name of the course	**ANALYSIS OF CASTING DEFECTS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION			
2.1. Course objectives	The ability to recognize and analyse casting defects. The ability to find the possible causes of casting defects. The ability to define measures to prevent the formation of casting defects.		
2.2. Enrolment requirements and required entry competences for the course	-		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Plan and manage the competences of analysis and synthesis. Plan the production and casting processes of ferrous and non-ferrous metals.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Recognize the type of casting defect. Describe the mechanism of the formation of casting defect. Analyse the causes of the formation of casting defect. Propose measures to prevent the formation of defect in casting. Evaluate the success of measures implemented to prevent the formation of defect in casting.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Classification of casting defects. (1); The influence of defects on casting properties. (1); Methods for analysis and detection of casting defects. (4); Metallic projections on the castings. (2); Cavities. (5); Discontinuities. (1); Defective surface. (4); Incomplete casting. (1); Incorrect dimensions or shape. (1); Inclusions or structural anomalies. (10); EXCERCISES (15): Examples of castings with different defects. (3); Metallographic analysis of defects - interpretation of the results, determining the cause of the defect and suggestions for avoiding the formation of casting defects. (12).		
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:
2.8. Student responsibilities	Conditions for signature: Students must attend the lectures and exercises (> 70 %).		

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal						
	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	3.5	Oral exam		(Other—describe)	

to the credit value of the course)*:*	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Exam of the course: Through continuous monitoring - student needs to pass 2 colloquiums. If the student has passed all colloquiums, the final score is determined as the average score of the colloquiums. Through the final exam: written exam for students who have not passed the exam through continuous monitoring or are not satisfied with the success that are achieved through continuous monitoring or have not decided on this method of examination. Conditions for access to the exam: -		
2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Z. Glavaš, Analiza grešaka na odljevcima, text of the lectures placed on website of Faculty of Metallurgy, Faculty of Metallurgy, Sisak, 2009.		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/2-godina-diplomskog-studija/analiza-gresaka-na-odljevcima/view
2.12. Optional literature (at the time of the submission of the study programme proposal)	S. Hasse, Pogrješke na odljevcima, Croatian Foundry Association, Zagreb, 2003. M. T. Rowley, International Atlas of Casting Defects, AFS, 1990. …, Aluminium Permanent Mold Handbook, AFS, Des Plaines, Illinois, 2001. W. G. Walkington, Die Casting Defects – Causes and Solutions, NADCA, USA, 2003.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the level of faculty and university. Analysis predicted in the quality assurance system of institution. Analysis predicted in the quality assurance system and authorized office of the university.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Recognize the type of casting defect.	1st and 2nd colloquium, written exam
2	Describe the mechanism of the formation of casting defect.	1st and 2nd colloquium, written exam
3	Analyse the causes of the formation of casting defect.	1st and 2nd colloquium, written exam
4	Propose measures to prevent the formation of defect in casting.	1st and 2nd colloquium, written exam
5	Evaluate the success of measures implemented to prevent the formation of defect in casting.	1st and 2nd colloquium, written exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Zdenka Zovko Brodarac, PhD	1.6. Year of study	2
1.2. Name of the course	**MODERN TECHNOLOGIES OF METAL CASTING**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Introduction to the procedures and the characteristics of the methods of casting metal castings. Introduction to modern concepts of individual and mass production of castings. Awareness of the possibility of optimizing the castings production using computer modeling
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Analyse the development and application of new technologies Plan the production and casting processes of ferrous and non-ferrous metals.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Analyse of the casting and solidification process and on the basis of ferrous and non-ferrous metals in green sand and permanent molds. Relate microstructure and performance characteristics of castings. Select casting technology according to the required properties of the castings.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Introduction to the course content and modes of knowledge acquisition. (1) Review of modern technologies of metal casting The requirements and expectations placed in front of foundry industry, i.e. industry of transport vehicles - automobile, railway, shipbuilding. (2) Production process and casting tolerances. (4) The concept of near net shape casting. An integrated approach to the production of metal castings. The concept of simultaneous engineering. (6) Improving the quality of the castings through the development of technology of smelting and casting.Casting construction, optimization of cast components with FEM and CAD systems. (4) Optimization of molding processes, elimination method "trial and error". The use of computer modeling in order to optimize of casting and feeding processes. The concept of virtual production castings. Rapid prototyping: proceedings of FDM, SLS, SLA, DSPC, ... Modern technologies of metal casting: Replicast, Low-pressure casting in sand molds. Modern technologies of metal casting: Cosworth, FM, CLA procedures. (7) Modern technologies of metals castings: Direct and indirect "squeeze casting" process. Casting metal in semi-solid state - Rheocasting process. Casting metal in semi-solid state - Thixocasting procedure (6).

	EXERCISES (15): Visit to the relevant economic entities.					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☒ field work		☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Attending the classes. 1. colloquium.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	1	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	3	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Attending the classes. One test through continuous monitoring or final examination (written and oral).					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Metals Handbook, Volume 15, CASTING, ASM International, Metals Park, Ohio, 1988.	1	
	Aluminum ans Aluminum Alloys, ASM Speciality Handbook, ASM International, ed. J. R. Davis, Materials Park, Ohio, USA, 2002.	1	
	Metals Handbook, Volume 1, Properties and Selection: Irons and Steels, ASM International, Metals Park, Ohio, 1978.	1	

2.12. Optional literature (at the time of the submission of the study programme proposal)	-
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the Faculty and University level. Analysis provided the quality assurance system of the institution. Analysis provided the quality assurance system and authorized Office of the University

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Analyse of the casting and solidification process and on the basis of ferrous and non-ferrous metals in green sand and permanent molds.	1st colloquium, auditory exercises, written and oral exam
2	Relate microstructure and performance characteristics of castings.	1st colloquium, auditory exercises, written and oral exam
3	Select casting technology according to the required properties of the castings.	Independent work, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Vladimir Grozdanić, PhD	1.6. Year of study	2
1.2. Name of the course	**SOLIDIFICATION SIMULATION**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	compulsory	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Introduction to mathematical modelling of solidification of castings of different geometry. Using of numerical methods for solidification simulation by means of computer.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice. 2. Recognize and apply scientific principles important in the fild of metallurgy. 3. Plan and manage metallurgical processes. 4. Design and apply the modelling of metallurgical and other processes.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Design methods of castings feeding with simulations, MPR programme. 2. Application of numerical methods of analysis of pouring and feeding of castings. 3. Prediction of possibility of appearance of defects and measures of prevention. 4. Formulation of model of solidification in chosen programe language.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30) AND EXERCISES (15): 1. Introduction to mathematical modelling. 2. Review of computer software for solidification simulation of castings. 3. Computers and programme languages, numerical methods. 4. Solidification simulation of castings of different geometrical complexity. 5. Heat during solidification, energy balance, energy transfer for cast steel. 6. Methods of modelling in foundry. 7. Explicit and implicit methods of finite difference applied to periodical cooling and heating of slab. 8. Implicit alternating direction method applied to solidification of L, T, H castings, blank gears, railway wheel. 9. Saulyev explicit method applied to L-shaped castings and comparison with ADI method. 10. 3D finite element method, derivation of Brians method in the case of L problem. 11. Methods of prediction of casting defects on the basis of time of solidification and temperature gradient. 12. Modelling of flow. Solve Navier-Stokes equation and application to flow of melt in ranning system. 13. Heat and mass transfer. 14. Principles of modelling and microstructure of castings. 15. Computer optimization of design. Location and prevention casting defects with different ticknes of wall, inclination with exotermic padding, chills, dimensioning of feeders.

2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Conditions for signature: attendance to lectures and exercises min. 70%. Conditions for taking:-					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.4	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	1.6	Oral exam	1.2	(Other—describe)	
	Written exam	0.8	Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Written exam: 50% Oral exam: 50%					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	R. I. Esman, N. P. Žmakin, L. I. Šub, Rasčoti processov litja, Višejšaja škola, Minsk, 1977.	1	
	G. D. Smith, Numerical Solution of Partial Differential Equations, University Press, Oxford, 1974.	1	
	B. Carnahan, H. A. Luther, J. O. Wilkes, Applied Numerical Methods, John Willey, New York, 1969.	1	

2.12. Optional literature (at the time of the submission of the study programme proposal)	P. R. Sham, P. N. Hansen, Numerical Simulation and Modelling of Casting and Solidification Processes for Foundry and Cast-House, CIATF, Zurich, 1984.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Internal students survey, analysis anticipated by system of ensure quality. Survey of the level of faculty and University. Analysis anticipated by system of ensure quality of institution. Analysis anticipated by system of ensure quality and entitled office of University.

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Design methods of castings feeding with simulations, MPR programme.	Colloquium
2	Application of numerical methods of analysis of pouring and feeding of castings.	Written exam
3	Prediction of possibility of appearance of defects and measures of prevention.	Oral exam
4	Formulation of model of solidification in chosen programe language.	Colloquium, written exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Ljerka Slokar, PhD	1.6. Year of study	2
1.2. Name of the course	**POWDER METALLURGY AND SINTER MATERIALS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	Presenting the historical development of production of powders and connectivity of technology to properties. Introduction to methods of production of sinterable metal powders, methods for their compaction and sintering, as well as studies of obtained compacts. Developing the ability to analyze and synthesize of the profession basic knowledge. The ability to apply acquired knowledge in practice.		
2.2. Enrolment requirements and required entry competences for the course			
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Analyse the development and application of new technologies. Design the properties of metallic materials.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Describe the methods of production of sinterable metal powders, and methods of compacting and sintering. Analyze the microstructure and properties of powders and compacts. Define the best technology to obtain certain sinterable powder. Assess the economic parameters to justify the selected technology.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Introduction. Brief history, definitions, applications and advantages of powder metallurgy. (2) Production of powder. Techniques: mechanical, electrolytic, chemical, atomization. Producing specific and ultradispersive metal powders. (4) Powder characterization: sampling, determining the particle size and particle size distribution, determining the shape of particles, the specific surface area, interparticulate friction, chemical characterization. (4) Preparation of powders and compacting: mixing powders, friction, phenomenology and theoretical foundations of compaction, conventional compacting, the influence of the characteristics of powder, technologies. (6) Sintered materials: definition, sintering theory, the impact of compaction on sintering, the sintering effect on the properties of sintered powder mixture, the atmospheres and the sintering furnaces. (4) Methods to achieve full density: the basics, benefits, procedures. (2) Characterization of the compact: microstructure, mechanical properties, surface, physical properties. (4) Application: powder-technology-properties dependence. (4) LABORATORY EXERCISES (15): Compacting powders. Characterization of powders and compacts. Compacting-sintering-		

	properties dependence.					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☒ field work		☐ independent study ☐ multimedia and the internet ☒ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Attending lectures and auditory exercises (min. 70%), laboratory work performed 100% and committed to paper.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	1.5	Oral exam	1.0	(Other—describe)	
	Written exam	1.0	Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	The final grade is determined by score of three colloquiums and assessments of written and oral exams respectively.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Lj. Slokar, Metalurgija praha i sinter materijali, Metalurški fakultet, Sisak, 2015.		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/2-godina-diplomskog-studija/METALURGIJA%20PRAHA%20I%20SINTER%20MATERIJALI.pdf/view
	R. M. German, Powder Metallurgy Science, Metal Powder Industries Federation,Princeton, New Yersey, 1984.		CD
	D. Schulze, Powders and Bulk Solids, Springer, Berlin, 2008.		CD
	G. S. Upadhyaya, Powder Metallurgy Technology, Cambridge International Science Publishing, Cambridge, 2002.		CD
	F. Thümmler, R. Oberacker, An Introduction to Powder Metallurgy, The Institute of Materials, London, 1993.		CD
2.12. Optional literature (at the time of the submission of the study programme proposal)	ASM Handbook Volume 7, Powder Metal Technologies and Applications, ASM International, 1998. B. D. Fahlan, Materials Chemistry, Springer, London, 2011. B. S. Mitchell, An Introduction to Materials Engineering and Science, John Wiley & Sons, Inc. Hoboken, New Jersey, 2004.		

2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the level of the Faculty and University. Analysis provided the quality assurance system of the institution. Analysis provided the quality assurance system and authorized Office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Describe the methods of production of sinterable metal powders, and methods of compacting and sintering.	1st colloquium, written and oral exam
2	Analyze the microstructure and properties of powders and compacts.	2nd colloquium, laboratory exercises, written and oral exam
3	Define the best technology to obtain certain sinterable powder.	3rd colloquium, laboratory exercises, written and oral exam
4	Assess the economic parameters to justify the selected technology.	3rd colloquium, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Ljerka Slokar, PhD	1.6. Year of study	2
1.2. Name of the course	**ADVANCED METALLIC MATERIALS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	Achieve an understanding of the basic laws in the process of obtaining the advanced metallic materials. Provide an overview of contemporary trends in their development.		
2.2. Enrolment requirements and required entry competences for the course			
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Design the properties of metallic materials. Compare the procedures of material treatment with microstructure and useful properties.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Explain the basic principles and methods for the preparation of advanced metallic materials. Evaluate, compare and select the advanced metallic materials for specific application conditions. Describe the types and examine metal composites and materials with shape memory effect. Analyze the physical-chemical and mechanical properties of advanced metallic materials.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Magnetic materials. Diamagnetism, paramagnetism, ferromagnetism, antifero- and ferimagnetizam. The magnetic field, strength of the field, the flux density. Magnetostriction and magnetization. The soft and hard magnetic materials, use. (4) Metal foams. Porous metals and metal foams. The filling process. Methods of production. Mechanical and physical properties. The use of metal foams. (4) Amorphous metals (metallic glasses). The crystal and amorphous state. "Structure" and properties. Obtaining amorphous metals. Application. (4) Metal composites. Basic principles and definitions. The composites with particles, dispersion and filamentary materials. The laminar composites. The influence of the matrix. Reinforced plastic and metal matrix. The hybrid composites. (4) Materials with shape memory effect. Introduction. Martensitic transformation by twins formation and deformation. Pseudoelasticity and superelasticity. Types and characterization. Producing and training of the materials. Use. (4) Nanostructured materials. Nanoparticles and nano powders. Nanocapsules and nanoporous materials. Nano fibers, fullerenes and nanowires. Nano carbon tubes. (6) The development of metallic materials. Tendencies of development. Ecomaterials. Materials for secondary sources of energy. Materials with extreme physical and mechanical properties. (4)		

	LABORATORY EXERCISES (15): Determination of physical-chemical and mechanical properties of selected advanced metallic materials. The characterization of these materials by optical and electron microscopy.					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☒ field work		☐ independent study ☐ multimedia and the internet ☒ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Attending classes (min. 70%), laboratory work performed and committed to paper.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	1.5	Oral exam	1.0	(Other—describe)	
	Written exam	1.0	Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	The final grade is determined by score of three colloquiums and assessments of written and oral exams respectively.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	M. Oruč, R. Sunulahpašić, Suvremeni metalni materijali, Fakultet za metalurgiju i materijale, Zenica, 2005.	2	
	T. Filetin, I. Kramer, G. Marić: "Metalne pjene", Hrvatsko društvo za materijale i tribologiju, Zagreb, 2003.		http://titan.fsb.hr/~tfiletin/pdf/metalne_pjene_tehn_razvoj.pdf
	R. E. Smallman, R. J. Bishop, Modern Physical Metallurgy and Materials Engineering, Oxford, 1999.	1	http://www.sim.utcluj.ro/stm/download/Alba/ModernPhysicalMetallurgy.pdf

2.12. Optional literature (at the time of the submission of the study programme proposal)	Lj. Slokar, Metalurgija praha i sinter materijali, Metalurški fakultet, Sisak, 2015. W. D. Callister, Materials Science and Engineering, J. Wiley & sons, New York, 1994.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the level of the Faculty and University. Analysis provided the quality assurance system of the institution. Analysis provided the quality assurance system and authorized Office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Explain the basic principles and methods for the preparation of advanced metallic materials.	1st, 2nd and 3rd colloquium, laboratory exercises, written and oral exam
2	Evaluate, compare and select the advanced metallic materials for specific application conditions.	1st, 2nd and 3rd colloquium, laboratory exercises, written and oral exam
3	Describe the types and examine metal composites and materials with shape memory effect.	2nd and 3rd colloquium, laboratory exercises, written and oral exam
4	Analyze the physical-chemical and mechanical properties of advanced metallic materials.	3rd colloquium, laboratory exercises, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Stjepan Kožuh, PhD	1.6. Year of study	2
1.2. Name of the course	**MODERN TOOL STEELS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Deepening knowledge in field related to the properties, microstructure and the application of modern tool steels. Understanding the basic principles of making, classifying and heat treatment of tool steel.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Analyse the development and application of new technologies.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Analyze the properties of tool steels. Predict the type of tool steel for a particular practical application. Compare tool steels from the standpoint of wear and usability. Differentiate a new types of tool steels.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Week 1: Basic terms and definitions. (2) Week 2: The work principle of the tool. The types of tools. Processing and properties of tool steels. The influence of alloying elements. (2) Week 3: Overview of making processes for tool steels. Special processes of remelting. (2) Week 4: Non-alloy (carbon) tool steels. (2) Weeks 5 and 6: Tool steels for cold work. Low alloyed tool steels (W-V steels, W-Cr (Si) -V steels, Cr steels, Mn-Cr-V and Mn-Cr-W steels). (4) Week 7: High alloyed tool steels (High-Carbon ledeburite steels, martensitic stainless steels). (2) Week 8 and 9: Tool steels for hot work (low alloy steels, high-alloyed Cr-Mo steels, high-alloyed W-Cr-V steel). High-speed steels. (4) Week 10: Maraging tool steels. Precipitation hardened tool steels. (2) Weeks 11 and 12: Sintered tool steels (steels: ISOMATRIX PM, ASP, CPM, martensitic steels, precipitation hardened steels). (4) Week 13: Other materials in the tool application. (2) Weeks 14 and 15: Heat treatment of tool steel. (4)

	SEMINAR (15): The selection of topics and seminar work in writing form by a mentor system (10 hours). Preparation and presentation of the seminar and discussions related to the topic of the present paper (5 hours).					
2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☐ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Students must attend over 70% of lectures and are required to complete a seminar in writing form and orally present.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1.0	(Other--describe)	
	Tests	2.5	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	- evaluation of students activities in course, - evaluation of written examination (two colloquiums) through continuous monitoring or final examination (written and oral), - evaluation of seminar paper and presentation.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	M. Gojić, Metalurgija čelika, Sveučilište u Zagrebu Metalurški fakultet, Sisak, 2006.	15	
	M. Novosel, F. Cajner, D. Krumes, Alatni materijali, Sveučilište J. J. Strossmayera u Osijeku, Strojarski fakultet u Slavonskom Brodu, Slavonski Brod, 1996.	3	
	S. Kožuh, Specijalni čelici-skripta, Sveučilište u Zagrebu Metalurški fakultet, Sisak, 2010.		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/2-godina-diplomskog-studija/specijalni-celici/view
	J. Pirš, Toplinska obrada metala, Tehnički fakultet Rijeka, Rijeka, 1992.	3	
	ASM Handbook.pdf		Electronic form

2.12. Optional literature (at the time of the submission of the study programme proposal)	V. Đukić, Alatni čelici, Naučna knjiga, Beograd, 1990. B. Jocić, Steels and cast Irons, BIO-TOP, Dobja Vas, 2008. C. R. Brooks, Principles of the Heat Treatment of Plain Carbon and Low Alloy Steels, ASM International, Materials Park, 1996. Scientific and professional papers in refereed journals and conference proceedings.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Questionnaire at Faculty and University. The analyzes provided a system of quality assurance institutions. The analyzes provided a system of quality and authorized office of University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Analyze the properties of tool steels.	1st colloquium, written and oral exam
2	Predict the type of tool steel for a particular practical application.	2nd colloquium, written and oral exam, seminar paper
3	Compare tool steels from the standpoint of wear and usability.	1st and 2nd colloquium, written and oral exam
4	Differentiate a new types of tool steels.	2nd colloquium, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Ladislav Lazić, PhD	1.6. Year of study	2
1.2. Name of the course	**METAL FORMING MACHINES**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	Assist.Prof. Ivan Jandrlić, PhD	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Knowing the names, division, characteristics and functions of machines and equipments for plastic forming of metals. 2. Knowing the conditions that determine the shape, size and material of each element of a machine or device. 3. Knowing the type of transport means, their function and basis of their design.
2.2. Enrolment requirements and required entry competences for the course	Passed the exams of course Theory of metal forming.
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice. 2. Suggest new and improved technical and technological solutions. 3. Design professional elaborates and professional projects in metallurgy. 4. Formulate and suggest measures for increasing energy efficiency.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Analyze the characteristics of machines and equipment for plastic forming of metal materials in solving optimization problems of existing processes. 2. Judge the characteristics of machines and equipment for plastic forming of metal materials in solving problems related to the use of new materials and technologies. 3. Analyze and integrate metal forming processes and propose solutions to optimize metallurgical processes. 4. Propose optimal choice and use of transport means.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): 1. Systematization of machines and equipments for plastic forming of the metals. (2) 2. Classification according to the cold and hot forming processes. (2) 3. Hammer machines: air, steam and drop hammer, gag (eccentric) and friction presses, hydraulic presses. (6) 4. Plastic forming tools. (4) 1st colloquium - Submission of the program for the calculation of the power needed for the operation of a machine or device 5. Strands of rolls: division according to the temperature rolling, rolling method and arrangement of machines and equipments. (4) 6. Rolling machines: rolling stand parts (rolls, roll bearings, roll adjusting equipments, drive of rolling mills). (6) 7. Conveying devices: Analysis of the material flow of internal and external transport, Auxiliary load-holding equipment, Constructive parts of transport systems, Drive of transport devices, Conveyors, Cranes, Winches. (6)

	2nd colloquium - Submission of the constructional calculation and drawing of the machine part for plastic forming or transport device EXERCISES (15): The understanding of the material exposed in lectures is facilitated by solving the given projects. The projects are selected so that they expand the presented theory and illustrate the application of theory to real problems.					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☒ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Attendance on Lectures and Exercises > 70 %.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.4	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	1.0	Oral exam	1.6	(Other—describe)	
	Written exam		Project	1.0	(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Projects – 30% Class attendance – 5% Written exam – 30% Oral exam – 35%					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	H. Lippmann, O. Mahrenholtz, Plastomechanics der Umformung metallisher Werkstoffe, Springer Verlag, Berlin, 1967.	1	
	L. Lazić, ELEMENTI STROJEVA, Sveučilišna skripta, broj: 02-1484/3-2000, UDK 62-2(075.8), Sisak, 2001.	13	

2.12. Optional literature (at the time of the submission of the study programme proposal)	E. G. Thomas, C. T. Yang, S. Kobayashi, Mechanics of Plastic Deformation in Metals Processing, Macmillan, New York, 1965. W. Beitz, K. H. Kuttner, Dubbel-Taschenbuch fur den Machinenbau, Springer Verlag, Berlin, 1986
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Analyze the characteristics of machines and equipment for plastic forming of metal materials in solving optimization problems of existing processes.	1st colloquium, oral exam
2	Judge the characteristics of machines and equipment for plastic forming of metal materials in solving problems related to the use of new materials and technologies.	1st colloquium, oral exam
3	Analyze and integrate metal forming processes and propose solutions to optimize metallurgical processes.	2nd colloquium, oral exam
4	Propose optimal choice and use of transport means.	2nd colloquium, project, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Stoja Rešković, PhD	1.6. Year of study	2
1.2. Name of the course	**ROLL FORMING OF METALS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	Tin Brlić, mag.ing.met.	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	2., 10%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. To introduce students with the basic theoretical knowledge formatting rolling. 2. To introduce students with the technology of rolling. 3. To introduce students with the basic characteristics of industrial plants.
2.2. Enrolment requirements and required entry competences for the course	Passed exam from Theory of metal forming
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Analyse the development and application of new technologies. 2. Plan and manage metallurgical processes. 3. Analyse and combine metal forming processes.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Understand today's situation and development trends of the procedures for processing of metallic materials by forming. 2. To calculate the parameters of rolling process. 3. Compare the various technologies of shaping by rolling. 4. Monitor the development and application of new technologies.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30) AND SEMINAR (15): 1. The definition of the rolling process, the elements of the deformation zone, material griped by rolls. 2 2. Computational parameters during rolling, deformation, strain rate. 2 3. 1. Seminar: Calculation of deformation zone elements. 2 4. Acceleration (overtaking). 2 5. Friction in the rolling process. Elements that affect the size of friction. 2 6. Spread, the factors that influence the spread, calculation of spreading during rolling. 2 7. Normal contact and tangential stresses. 2 8. Metal pressure on the rollers: Distribution of specific pressure, differential equation of specific pressure. Middle specific pressure by Celikov and Ekelend. 2 9. 2. Seminar; Calculation of acceleration, deformation and strain rate. Calculation of metal pressure on rollers. 2 10. 3. Seminar: Calculation of constants of continuous production lines for the production of the strips. Technology of rolling strips on continuous line (rolling pre-strip on the block rolling mill, rolling strips on the final line). 2 11. I Colloquium, Chapters 1-10 12. Elements of the rolling line. Types of rolling mills in relation to the number of rollers, space distribution of rolling mills. 2 13. Rolling of semi-finished products. Profile rolling. Classification of profiles, rolling heavy profiles, middle profiles

	and small profiles. 4 14. Rolling wire and manufacturing of special profiles. 4 15. Rolling flat profiles: Hot rolling of thick and medium plates. Rolling thin sheets. Cold rolling of sheets and strips. Rolling sheets and strips of non-ferrous metals. 4 16. Specifics of rolling metals. 2 17. 4. Seminar: Assignments of calibration of rollers: Concept and distribution of calibres. Calibres system. Calibration of rollers for rolling profiles. 2 18. 5. Seminar: Calibration rollers - flat profiles. 2 19. 6. Seminar: Checking calibration in practice. 5 20. II Colloquium, chapters 12-19

2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☒ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:

2.8. Student responsibilities	Attendance at lectures min. 70%, individual work on all exercises and preparation and submission of reports from field of colloquium before writing the colloquium or the written exam.

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance		Research	0.2	Practical training	
	Experimental work	0.2	Report	0.2		
	Essay		Seminar essay	0.2	(Other--describe)	
	Tests	2.0	Oral exam	1.0	(Other—describe)	
	Written exam		Project	0.2	(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	The presence and activity of students on classes during the classes are evaluated. Students score participation on projects. Score on written colloquium trough continuous monitoring (or written exam) and oral exam. Score of seminar paper.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Čaušević, Obrada metala valjanjem, Veselin Masleša, Sarajevo, 1983.	2	
	S. Rešković, Teorija oblikovanja deformiranjem, Sveučilište u Zagrebu, Metalurški fakultet, Sisak 2014., peer reviewed lessons.		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/1-godina-diplomskog-studija/S%20Reskovic%20TEORIJA%20OBLIKOVANJA%20DEFORMIRANJEM.pdf/view
	S. Rešković, Tehnologija oblikovanja deformiranjem-nastavna građa, Sisak, 2011.	10	
2.12. Optional literature (at the time of	R. Križanić, Valjanje metala, Faculty of Metallurgy, Sisak, 1985. (internal script).		

the submission of the study programme proposal)	Professional journals, articles from this area.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the level of faculty and University. Analyses provided by quality assurance system of the institution. Analyses provided by quality assurance system and authorized office of the University

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Understand today's situation and development trends of the procedures for processing of metallic materials by forming.	1st colloquium, seminar paper, written and oral exam
2	To calculate the parameters of rolling process.	1st colloquium, seminar paper, written and oral exam
3	Compare the various technologies of shaping by rolling.	seminar paper, independent task, oral exam
4	Monitor the development and application of new technologies.	2nd colloquium, seminar paper, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Stoja Rešković, PhD	1.6. Year of study	2
1.2. Name of the course	**METAL TUBE AND PROFILE FORMING**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	Assist.Prof. Ivan Jandrlić, PhD	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	2., 10%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. To introduce students to the importance and the trend of production of pipes and profiles in the world. 2. Introduce students with the technologies of production of pipes and profiles 3. Students become familiar with the basic characteristics of industrial plants 4. Acquired knowledge will enable the student to recognize and solve problems in the process of production of pipes and profiles.
2.2. Enrolment requirements and required entry competences for the course	Passed exam from Theory of metal forming
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice 2. Suggest new and improved technical and technological solutions 3. Analyse and combine metal forming processes
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Analyze the situation and development trends of the manufacturing processes of pipes and profiles, 2. Calculate the technological parameters of the production of seamless pipes, 3. Calculate the technological parameters of the production of welded pipes, 4. Calculate the technological parameters of the production of profiles, 5. Apply the scientific principles relevant to the manufacturing process of pipes.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30) AND SEMINAR (15): 1. Introduction. The present state and development trends in the technologies of production of pipes and profiles. 2 2. The technology of production of seamless pipes. 2 3. Preparation and heating of bilet. Production of semi-hollow. 2 4. Hot rolling tubes. 2 5. Finishing tubes. Special procedures. 2 6. 1. Seminar: The rolling seamless pipes. 5 7. 1. Colloquium, chapters 1-6 8. The technology of production of welded tubes. 2 9. Welding in furnace. High-frequency welding. 2 10. Final treatment of tubes. Special procedures. 2 11. 2. Seminar: The rolling of welded pipes. 5 12. Cold rolling of tube. 4

	13. 2. Colloquium, chapters 8-12 14. Profile rolling. Simple profiles. The complex profiles. 4 15. Special features of the profile calibration. 4 16. 3. Seminar: The profile rolling programs. 5 17. Modern technologies in the production of pipes and profiles. 2 18. 3. Colloquium, chapters 14-17					
2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☒ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Attendance at lectures min. 70%, individual work on all exercises and preparation and submission of reports from field of colloquium before writing the colloquium or the written exam					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance		Research	0.2	Practical training	
	Experimental work	0.2	Report	0.2		
	Essay		Seminar essay	0.2	(Other--describe)	
	Tests	2.0	Oral exam	1.0	(Other—describe)	
	Written exam		Project	0.2	(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	During the classes the presence and activity of students on classes are evaluated. Students score participation on projects. Score on written colloquium trough continuous monitoring (or written exam) and oral exam. Score of seminar paper.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	S. Rešković, Teorija oblikovanja deformiranjem, Sveučilište u Zagrebu, Metalurški fakultet, Sisak 2014., peer reviewed lessons,		https://www.simet.unizg.hr/nastava/predavanja/diplomski-sveucilisni-studij-metalurgija/1-godina-diplomskog-studija/S%20Reskovic%20TEORIJA%20OBLIKOVANJA%20DEFORMIRANJEM.pdf/view
	I. Mamuzić, V. M. Drujan, Teorija, materijali, tehnologija čeličnih cijevi, Hrvatsko metalurško društvo, Zagreb 1996.	34	
	B. Iharoš, Proizvodnja čeličnih cijevi, MF, Sisak, 1987. (interna skripta).	16	
	S. Rešković, Tehnologija oblikovanja deformiranjem- nastavna građa, Sisak, 2011.	10	

2.12. Optional literature (at the time of the submission of the study programme proposal)	Professional journals, articles from this area.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the level of faculty and University. Analyses provided by quality assurance system of the institution. Analyses provided by quality assurance system and authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Analyze the situation and development trends of the manufacturing processes of pipes and profiles.	1st colloquium, seminar paper, written and oral exam
2	Calculate the technological parameters of the production of seamless pipes.	1st colloquium, seminar paper, independent task
3	Calculate the technological parameters of the production of welded pipes.	2nd colloquium, seminar paper, independent task
4	Calculate the technological parameters of the production of profiles.	3rd colloquium, seminar paper, independent task, written and oral exam
5	Apply the scientific principles relevant to the manufacturing process of pipes.	Seminar paper, project task, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Tamara Holjevac Grgurić, PhD	1.6. Year of study	2
1.2. Name of the course	**NANOSTRUCTURED MATERIALS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Acquisition of knowledge about nanomaterials; structure, properties and processing. Defining the effect of processing parameters on structure and properties. Introducing with specific areas of application of nanomaterials.
2.2. Enrolment requirements and required entry competences for the course	
2.3. Learning outcomes at the level of the study programme to which the course contributes	Design the properties of metallic materials. Suggest appropriate methods for material quality analysis. Use the acquired theoretical knowledge in engineering practice.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	To define and classify nanomaterials. To apply different processing methods. To define one-dimensional, two-dimensional and special nanostructured materials. To analyse different types of metal based nanocomposites. To understand relationship between structure and properties of nanocomposites. To correlate content, structure and properties of nanomaterials with application requirements.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Introduction to nanoscience. Defining of nanostructures. Physical-chemical properties of solids. (2) Synthesis of nanostructured materials. Metal matrix nanomaterials. (3) Nanocomposites by Metal Alloying. (2) Nanocomposites from Sol-Gel Synthesis. (2) Nanocomposites by Thermal Spray Synthesis. (2) 1.preliminary exam Nanocomposites with metal matrix. Ceramic-metal nanocomposites. (4) One-dimensional and two-dimensional nanomaterials. Nanowires and thin films. (2) Special nanomaterials. Carbon nanotubes. (3) Polymer-metal nanocomposites. Nanoscale fillers. (2) 2.preliminary exam Structure and dispersion of nanoparticles in matrix, nucleation mechanisms and stabilisation. (2) Stabilisation of interphase. Characterisation of nanomaterials. Properties of nanomaterials. (2) Nanocomposites for optical and electric applications. (2)

	Nanocomposites for biomedical application. (2) 3.preliminary exam LABORATORY EXERCISES (15).					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☒ mixed e-learning ☐ field work		☐ independent study ☐ multimedia and the internet ☒ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Attendence to lectures min. 70 %. Attandance to lab practice 100 % (compesation of 2 exercies). Lab reports.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	1	Research		Practical training	
	Experimental work	1	Report			
	Essay		Seminar essay		(Other--describe)	
	Tests		Oral exam	1	(Other—describe)	
	Written exam	1	Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Lab reports, results of preliminary exams as well as written and oral exams. Written exam could be replaced with successful preliminary exams.		
2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	P. M. Ajayan, L. S. Schadler, P. V. Braun, Nanocomposite Science and Technology, Wiley-VCH, Verlag, 2003.	1	
	L. Nicolais, N. Carotenuto, Metal-Polymer Nanocomposites, John Wiley &Sons, 2005.		http://samples.sainsburysebooks.co.uk/9780471695424_sample_386645.pdf
2.12. Optional literature (at the time of the submission of the study programme proposal)	Kohler, W. Fritzsche, Nanotechnology, Wiley-VCH Verlag, 2005.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Internal student survey. Analysis of attendance to lectures and exercises, results of preliminary exams as well as oral exams. Survey on the level of faculty and University. Analyses provided by quality assurance system of the institution.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	To define and classify nanomaterials.	1st colloquium, written and oral exam
2	To apply different processing methods.	1st colloquium, written and oral exam
3	To define one-dimensional, two-dimensional and special nanostructured materials.	2nd colloquium, written and oral exam
4	To analyse different types of metal based nanocomposites.	2nd and 3rd colloquium, written and oral exam, exercises
5	To understand relationship between structure and properties of nanocomposites.	3rd colloquium, written and oral exam, exercises
6	To correlate content, structure and properties of nanomaterials with application requirements.	1st, 2nd and 3rd colloquium, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Natalija Dolić, PhD	1.6. Year of study	2
1.2. Name of the course	**SEMICONTINUOUS CASTING OF ALUMINIUM ALLOYS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Introduce students with the technologies of industrial casting of aluminum and aluminum alloys intended for further processing: horizontal ("HDC") and vertical ("VDC") casting process by direct cooling with water. 2. Acquisition of knowledge of solidification and microstructure evolution in ingot and billet during “DC” casting. 3. Define the basic casting parameters. 4. Train students how to recognize the basic phases in the microstructure of aluminum alloys on the optical microscope in cast and homogenized condition and how to determine the grain size. 5. Recognizing surface defects in casting aluminum ingots casting by "VDC".
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Combine social, ethical and business principles and norms in the professional field. Plan and manage metallurgical processes. Compare the procedures of material treatment with microstructure and useful properties.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Outline the Al-Mg phase diagram. 2. Analyze the basic casting parameters in production of aluminium ingots by "VDC" process. 3. Detect the surface defects on semicontinuously cast aluminum semi-finished products. 4. Identify the individual phases in the microstructure of samples cast by "VDC" process on the optical microscope. 5. Demonstrate the principle of determining the grain size by semiautomatic method on aluminum alloys.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	**LECTURES (30):** Introduction to the plan course and the time schedule for the colloquium. Aluminium and their alloys. System for designation aluminium and wrought aluminium alloys. Basic standards (2). Technology of industrial casting of aluminum and aluminum alloys intended for further processing. Horizontal ("HDC") and vertical ("VDC") casting process by direct cooling with water (2). Direct-Chill (“DC”) casting: solidification and structure patterns (2). Microsegregation. Macrosegregation in “DC” casting of aluminium alloys. Porosity (3). Grain refinement in aluminium alloys (2). The solidification of Al-Mg system (2). Tests I.

	Melting. Alloying. Purification of the melt. Inclusions in aluminum (5). Casting. Casting parameters (2). Surface defects in ingots casting by "VDC" process. Possible causes, measures for removal (2). Homogenization of aluminium ingots (2). Technology for casting aluminum billets by direct cooling with water (6). Test II. **EXERCISES (15):** Metallographic examination of aluminium samples series 5xxx (EN 5083, EN 5754, EN 5052) at cast and homogenized state at the optical microscope (examination microstructures and determination of grain size by semiautomatic method) (6). Measuring the effectiveness of removing inclusions and degassing melt (examples from practice) (2). Control and influence of casting parameters (examples from practice) (5). Tests I, II (2).

2.6. Type of instruction			2.7. Comments:
	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☒ laboratory ☒ work with the mentor ☐ seminar paper	

2.8. Student responsibilities	Regular attendance (> 70 %).

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
Class attendance		Research		Practical training (optical microscope)	1
Experimental work		Report			
Essay		Seminar essay			
Tests		Oral exam	1	(Other—describe)	
Written exam	2	Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	**Continuous monitoring and evaluation of student:** The exam could be passed through TESTS (writing + oral). In case it is not passed one of the two tests, the student has the right to take not passed test one more time. Both positive evaluation tests release the student of laying the final exam. At each tests student can achieve a maximum of 10 points for the question, number of questions is 5. For satisfactory accomplishment in each tests student must collect more than 30 % of points for each question. If student fails the examination by tests, laying the final exam (written + oral). *Continuous monitoring and evaluation of student:* Tests (I + II), writing + oral: 3 ECTS Practical training (optical microscopy): 1 ECTS

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	D. G. Eskin, Physical Metallurgy od Direct Chill Casting od Aluminium Alloys, CRC Press/Taylor and Francis Group, Boca Raton, 2008.	1	

2.12. Optional literature (at the time of the submission of the study programme proposal)	
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Examination of students who have finished study. Survey on the faculty and University level. Analysis predicted by systems for insurance of institution quality. Analysis predicted by systems for insurance quality from authorized University office.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Outline the Al-Mg phase diagram.	1st colloquium, written and oral exam exam
2	Analyze the basic casting parameters in production of aluminium ingots by "VDC" process.	2nd colloquim, written and oral exam
3	Detect the surface defects on semicontinuously cast aluminum semi-finished products.	2nd colloquim, written and oral exam
4	Identify the individual phases in the microstructure of samples cast by "VDC" process on the optical microscope.	Laboratory exercises, written and oral exam
5	Demonstrate the principle of determining the grain size by semiautomatic method on aluminum alloys.	Laboratory exercises

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Ivan Brnardić, PhD	1.6. Year of study	3
1.2. Name of the course	**THE LIFE CYCLE OF METAL PRODUCTS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION			
2.1. Course objectives	To introduce students with the general principles, concepts, frameworks, methods and challenges of life cycle analysis. To able to set goals, scope, limits and to collect data for the analysis of the life cycle. To acquire knowledge about explaining and research evaluation of lifecycle.		
2.2. Enrolment requirements and required entry competences for the course	Knowledge on metal materials, work on computers and with computer applications.		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Analyse the present situation, identify problems, formulate and recommend the optimal technological solution by using the knowledge acquired. Manage metallurgical production residues.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Explain and understand the importance of the life cycle analysis. 2. Know how to set goals, scope and limits for assessments. 3. Able to collect quality data for analysis. 4. Able to explain the results and derive conclusions of the analysis.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Introduction, objectives, scope and methodology for life-cycle analysis. 3h Introduction to the project of the life cycle of world steel production and objectives. Description of the project through a description of the system, setting boundaries, data collection, explanation and critical review. The quality of the data, the life cycle model, evaluation of results, analysis, explanations and conclusions. 9h Introduction to LCA methodology for metals, objectives and scope. The boundaries of the system, by-products, recycling and impact of life cycle. 9h Example of a comparative analysis of the life cycle on truck wheel from aluminum and steel. The objectives, scope and lifecycle analysis and assessment. Explanation of analysis results. 9h SEMINAR (15): Example seminar work and preparation and presentation of seminar paper.		
2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning	☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:

	☐ field work					
2.8. Student responsibilities	Regular attendance of lectures (70% of the lectures) and seminar work.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1	(Other--describe)	
	Tests		Oral exam	1.25	(Other—describe)	
	Written exam	1.25	Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Attendance on classes, preparation and presentation of seminar paper, continuous monitoring – 2 preliminary exams or written and oral exam.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	I. Brnardić, Lectures from The life cycle of metal products, Sisak, 2016.		Merlin system for e-learning
	Life Cycle assessment methodology report, World steel association, Brussels, Belgium, 2011.		https://www.worldsteel.org/dms/internetDocumentList/bookshop/LCA-MethodologyReport/document/LCA%20Methodology%20Report.pdf
	Comparative Life Cycle Assessment of Aluminum and Steel Truck Wheels, PE INTERNATIONAL, Inc., Boston, USA, 2012.		http://www.alcoawheels.com/alcoawheels/north_america/en/pdf/Alcoa_Comparative_LCA_of_Truck_Wheels_with_CR_statement.pdf
	Harmonization of LCA Methodologies for Metals, PE INTERNATIONAL, Inc., Boston, USA, 2014.		https://www.icmm.com/document/6657

2.12. Optional literature (at the time of the submission of the study programme proposal)	Available scientific literature on the subject of life-cycle analysis.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the faculty and University level. Analysis predicted by systems for insurance of institution quality. Analysis predicted by systems for insurance quality from authorized University office.

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Explain and understand the importance of the life cycle analysis.	1st colloquium, seminar paper, written and oral exam
2	Know how to set goals, scope and limits for assessments.	1st colloquium, seminar paper, written and oral exam
3	Able to collect quality data for analysis.	2nd colloquium, seminar paper, written and oral exam
4	Able to explain the results and derive conclusions of the analysis.	2nd colloquium, seminar paper, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Ivan Brnardić, PhD Assist.Prof. Tahir Sofilić, PhD	1.6. Year of study	2
1.2. Name of the course	**UTILIZATION OF METALLURGICAL PRODUCTION REMAINS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION			
2.1. Course objectives	1. To acquaintance students with remains from metallurgical production, its occurrence, possibilities of recovery until the final disposal. 2. To get insight in creation and maintenance of metallurgical residues management system.		
2.2. Enrolment requirements and required entry competences for the course	Knowledge of metallurgical processes, waste management and work on computer.		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Apply logical conclusion and precision in data processing. Compare and choose individual technological process. Manage metallurgical production residues.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Define waste according to properties and place of origin in metallurgical processes. 2. Enumerate ways for waste treatment. 3. Enumerate actions for avoiding and reducing of waste and reducing its dangerous properties. 4. Propose resource recovery from waste. 5. Suggest recycling of water and reagents in processes.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Introduction. Waste characterization. 4h Physical and physico-chemical processes, material preparation, gravity separation processes, Magnetic and electrostatic separation, shredding systems. 4h Uses hydrometallurgical processes, biotechnological and pyrometallurgical processing. 7h Metal recycling, ferrous and non-ferrous. Metallurgical slags, dust and fumes. By-product processing and utilization. 7h Resource recovery from process wastes. Recycling of water and reagents. Emerging new technologies. 8h SEMINAR (15): Example seminar work and preparation and presentation of seminar paper.		
2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning	☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:

	☐ field work					
2.8. Student responsibilities	Regular attendance of lectures (70% of the lectures) and seminar work.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1.0	(Other--describe)	
	Tests		Oral exam	1.25	(Other—describe)	
	Written exam	1.25	Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Attendance on classes, preparation and presentation of seminar paper, continuous monitoring – 2 preliminary exams or written and oral exam.		
2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	S. Ramachandra Rao, Resource recovery and recycling from metallurgical wastes, Elsevier, Amsterdam, The Netherlands, 2006.	1	
	I. Brnardić, T. Sofilić, Predavanja iz Iskorištavanje metalurških proizvodnih ostataka, Sisak, 2016.		Merlin system for e-learning
2.12. Optional literature (at the time of the submission of the study programme proposal)	Available scientific literature on the subject of utilization of metallurgical production remains.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the faculty and University level. Analysis predicted by systems for insurance of institution quality. Analysis predicted by systems for insurance quality from authorized University office.		

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Define waste according to properties and place of origin in metallurgical processes.	1st colloquium, seminar, written and oral exam
2	Enumerate ways for waste treatment.	1st colloquium, seminar, written and oral exam
3	Enumerate actions for avoiding and reducing of waste and reducing its dangerous properties.	1st colloquium, seminar, written and oral exam
4	Propose resource recovery from waste.	2nd colloquium, seminar, written and oral exam
5	Suggest recycling of water and reagents in processes.	2nd colloquium, seminar, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Ladislav Lazić, PhD	1.6. Year of study	2
1.2. Name of the course	**RENEWABLE ENERGY SOURCES**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	1. Provide students the informations about renewable energy sources and issues related to their development, implementation, and impact on the environment. 2. Obtain basic knowledge for independent critical thinking about technical and economic perspective of the applicability of alternative energy sources. 3. Acquire the ability to solve problems in the field of application and use of renewable energy sources.
2.2. Enrolment requirements and required entry competences for the course	Passed the exams of course Energy management.
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice. 2. Analyse the development and application of new technologies. 3. Suggest new and improved technical and technological solutions. 4. Formulate and suggest measures for increasing energy efficiency.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Distinguish between conventional and non-conventional energy sources. 2. Estimate the amount of energy which can give a source. 3. Evaluate the harmful impact of a source of energy on the environment. 4. Determine the safety and economic profitability of using a source of energy.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): 1. Conventional and non-conventional energy sources. Renewable energy sources. (2) 2. Geothermal energy: Geothermal energy of underground fluids, Geothermal energy of dry rocks, Social and ecological aspects. (4) 3. Solar energy: Solar radiation, Solar collectors, Storage of solar energy, Solar heating and cooling, Producing of electricity, Bioconversion. (10) 1st colloquium 4. Wind energy: Wind speed, Energy and power of wind, Wind turbine, Wind power plants. (4) 5. Biomass and biofuels: Classification of biofuels, Production of biomass, Direct combustion, Pyrolysis, Alcoholic fermentation, Anaerobic digestion, Processing of waste and scrap, Vegetable oils and biodiesel, Sociological and ecological aspects. (10) 2nd colloquium

	EXERCISES (15): Solution of practical problems. The understanding of the material exposed in lectures is facilitated by solving the two programs. The programs are selected so that they expand the presented theory and illustrate the application of theory to real problems.					
2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Attendance on Lectures and Exercises > 70 %					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.4	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	1.0	Oral exam	1.6	(Other—describe)	
	Written exam		Project	1.0	(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Projects – 30% Class attendance – 5% Written exam – 30% Oral exam – 35%					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	V. Knapp, P. Kulišić, Novi izvori energije, Školska knjiga Zagreb, 1985.	1	
	P. Kulišić, Novi izvori energije, Školska knjiga, Zagreb, 1991.	1	

2.12. Optional literature (at the time of the submission of the study programme proposal)	A. V. da Rosa, Fundamentals of renewable energy resources, Elsiver, Amsterdam, 2005. J. Twidel, T. Weir, Renewable energy resources, Taylor & Francis, London and New York, 2006.
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.

Ordinal number	**Expected learning outcomes at the level of the course (4-10)**	**Methods for monitoring of the achievement of learning outcomes**
1	Distinguish between conventional and non-conventional energy sources.	1st colloquium, oral exam
2	Estimate the amount of energy which can give a source.	1st colloquium, oral exam
3	Evaluate the harmful impact of a source of energy on the environment.	2nd colloquium, oral exam
4	Determine the safety and economic profitability of using a source of energy.	2nd colloquium, seminar paper, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assist.Prof. Tahir Sofilić, PhD	1.6. Year of study	2
1.2. Name of the course	**CIRCULAR ECONOMY**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Familiar students with the existing development level of productive capacity and development level of the system values, in which material resources are not always exploited sufficiently. Students need to understand that it is therefore necessary to improve the use of resources, as in the production process and their management especially part which is in the production process not embodied in the product, which is commonly referred as waste. Explain to students that the process, in which the economy of the primitive accumulation of capital and the industrial revolution grew on the principle: "take, make, consume, throw" and that was a so-called "Linear model" which is based on the assumption of unlimited and easy availability of resources, it is necessary to transform. This transformation represents the transition from "linear" to the concept of "circular economy" and is necessary to achieve a program for successful using of material resources in the context of the Europe 2020 strategy, which only can ensure sustainable and inclusive growth.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Combine social, ethical and business principles and norms in the professional field. Suggest solutions for the optimization of metallurgical processes. Combine the skills necessary for lifelong learning, including continued professional training.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Describe the differences between linear and circular economy. Explain the circular economy as alternative for a linear economy guided by principles,, take, make, consume, throw ". Illustrate the possibility of increasing the productivity of resources in parallel with the existing EU policy objectives such as the reduction of carbon dioxide emissions, increase energy efficiency etc. Propose to increase resource productivity while reducing potential adverse effects on the environment and greenhouse gas emissions on the example of a metallurgical process.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Limiting the negative environmental footprints of the existing European economy and reducing the cost of the economic activities with a aim of economic growth; 2h The Europe 2020 strategy, 2h. The priorities of the 2020 strategy (Smart growth: development of the economy based on knowledge and innovation; Sustainable growth: promoting an economy that effectively exploit resources, which is greener and more competitive, and Inclusive growth: fostering economy with high employment that delivers social and territorial cohesion), 4h. The concept of a linear economy, 1h The transition of the linear concept to circular economy, 1h

	The transition from the existing linear to circular economy ie. economic model that ensures sustainable management of resources and the extension of the lifetime of materials and products as a central part of the 2020 strategy; 2h Circular economy as a kind of alternative to worn model of a linear economy guided by principles ,, take, make, consume, throw'', 2h Fundamentals of smart, sustainable and inclusive economy growth (efficient use, recovery, recycling and reuse of resources), 2h Systematically reducing the generation of waste to a minimum during the entire life cycle of the product and its components, 2h. The importance and contribution to waste management policy in terms of reducing its creation through the development of a functioning waste management system, which aims to use waste as a valuable resource, 2h. In systems of circular economy added value of products is retain as long as possible and does not create waste, 2h. Resources retain in the economy after the end of the product lifetime how they can be productively used, thus creating new value, 2h. Possibilities of improving ongoing sustainable growth by increasing integration of economic growth, resource use and its effects, 2h. Increasing the productivity of resources parallel with the existing EU policy objectives (reduction in carbon dioxide emissions, increase energy efficiency, ensuring access to raw materials), 2h. Increasing resource productivity while reducing potential adverse effects on the environment and greenhouse gas emissions, 2h. SEMINAR (15): Instructions for the preparation of the seminar (2h) Topics presentation and selection (1h) Creating individual seminar work, supervision and corrections (6) Making PPT of seminar work and preparing for presentation (1h) Presentation of seminar work (5h) TESTS: 1. Test Limiting the negative environmental footprints of the existing European economy and reducing the cost of the economic activities with aim for economic growth; The Europe 2020 strategy, smart growth and the development of economy based on knowledge and innovation; Sustainable growth and promote a more efficient economy that exploits resources, inclusive growth and nurturing of the economy with high employment that delivers social and territorial cohesion; The concept of a linear economy, the concept of a linear transition in circular economy. 2. Test The transition from the existing linear to circular economy ie. economic model that ensures sustainable management of resources and the extension of the lifetime of materials and products as a central part of the 2020 strategy; Circular economy as a kind of alternative to old model of a linear economy, basic postulates of smart, sustainable and inclusive economy growth (efficient use, recovery, recycling and reuse of resources), systematically reducing the generation of waste to a minimum during the entire life cycle of the product and its components , significance and contribution to waste management policy in terms of reducing its creation through the development of a functioning waste management system. 3. Test Systems of circular economy in the function of keeping resources in the economy after the end of the product lifetime to be used productively, thus creating new value, Possibilities of improving ongoing sustainable growth by increasing integration of economic growth, resource use and its effects, increase in productivity of resources in parallel with the existing EU policy objectives (reduce carbon emissions, increase energy efficiency, ensuring access to raw materials), increasing resource

	productivity while reducing potential adverse effects on the environment and greenhouse gas.					
2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☒ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)		2.7. Comments:	
2.8. Student responsibilities	Students must attend more than 70% of lectures and make seminar.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance		Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1	(Other--describe)	
	Tests	3	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Seminar work, continuous monitoring through 3 mid tests or written and oral exam.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	M. Krišto, Kružna ekonomija za brži razvoj, Gospodarstvo i okoliš, Hrvatski poslovni savjet za održivi razvoj **11**, 41 (2015).	1	
	TOWARDS THE CIRCULAR ECONOMY-Economic and business rationale for an accelerated transition, vol **1** (2013).		https://www.ellenmacarthurfoundation.org/assets/downloads/publications/Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf http://www.c2c-centre.com/sites/default/files/Towardsa%20Circular%20Economy.pdf
	Europska Komisija, EUROPA 2020 - Europska strategija za pametan, održiv i uključiv rast, Bruxelles, 2010.		http://www.strukturnifondovi.hr/UserDocsImages/Documents/Strukturni%20fondovi%202014.%20%E2%80%93%202020/eu_hr.pdf

2.12. Optional literature (at the time of the submission of the study programme proposal)	T. Sofilić, ZDRAVLJE I OKOLIŠ, skripta, Sveučilište u Zagrebu, Metalurški fakultet, 2015. T. Sofilić, ODRŽIVO GOSPODARENJE OTPADOM, skripta, Sveučilište u Zagrebu, Metalurški fakultet, 2015. COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS, Towards a circular economy: A zero waste programme for Europe, Brussels, 2.7.2014 COM(2014) 398 final, http://ec.europa.eu/environment/circular-economy/pdf/circular-economy-communication.pdf

2.13. Methods of monitoring quality that ensure acquisition of exit competences	Students survey input and output. Numerical analysis of tests and exams by scoring task by task at the course level. Survey on the faculty and University level. Analysis predicted by systems for insurance of institution quality.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Describe the differences between linear and circular economy.	1st colloquium, seminar, written and oral exam
2	Explain the circular economy as alternative for a linear economy guided by principles,, take, make, consume, throw ''.	1st and 2nd colloquium, seminar, written and oral exam
3	Illustrate the possibility of increasing the productivity of resources in parallel with the existing EU policy objectives such as the reduction of carbon dioxide emissions, increase energy efficiency etc.	2nd and 3rd colloquium, seminar, written and oral exam
4	Propose to increase resource productivity while reducing potential adverse effects on the environment and greenhouse gas emissions on the example of a metallurgical process.	3rd colloquium, seminar, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assist.Prof. Tahir Sofilić, PhD Assoc.Prof. Ivan Brnardić, PhD	1.6. Year of study	2
1.2. Name of the course	**ENVIRONMENTAL LAW**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	Acquaintance students with directions of sustainable development which insure economic development of community and at the same time insure conditions for protection of natural resources. Explain and adopt the principle of environmental law and environmental law sources in the Republic of Croatia. Acquaintance with skills which will conciliate opposite interests of industry and economy in global with requirements for the environmental protection.		
2.2. Enrolment requirements and required entry competences for the course	-		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Combine social, ethical and business principles and norms in the professional field. Combine the skills necessary for lifelong learning, including continued professional training. Recognize and apply scientific principles important in the field of metallurgy.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	To define base questions regarding the environmental law. To distinguish quality of life from life quality. To describe ecology policy and ecology strategy. To illustrate protection of specially worth parts of nature. To compare the environmental protection in Croatian legal system with EU. To explain obligations of economic operators toward current legislation.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Base questions regarding environmental law, current situation in environmental law, 2h Principals of the environmental law, sources of the environmental law in RH, 2h Ecology policy and ecology strategy, quality of life and life quality, 2h Normative institutions of ecology policy, institutions for the environmental protection in RH, 2h The environmental protection in Croatian legal system, 2h The protection of specially worth parts of the nature, 2h The protection and improvement of forests, 2h The protection of agricultural soil, 2h The protection of air, 2h		

	The protection of soil, 2h The protection of water, 2h The protection from noise, 2h. The protection from radiation, 2h The environmental protection in international legal system, 2h Economic operators and their obligations toward current legislation., 2h SEMINAR (15): Instructions for the preparation of the seminar (2h) Topics presentation and selection (1h) Creating individual seminar work, supervision and corrections (6) Making PPT of seminar work and preparing for presentation (1h) Presentation of seminar work (5h) TESTS 1. TEST: Basic issues of environmental law, the current state of environmental law, principles of environmental law, sources of environmental law in the Republic of Croatia, environmental policy and environmental strategies, quality of life or life quality, Normative institutions of environmental policy, environmental institutions in Croatia, Environmental Protection in the Croatian legal system. 2. Test: Protection of particularly valuable natural areas, protection and promotion of forests, protection of agricultural land, protection of air, soil protection, water protection, noise protection, radiation protection 3. Test: Environmental protection in the international legal system, economic operators and their obligations under the applicable legislation, examples of satisfying of legal obligations of various economic entities depending on the type of activity and the applicable regulations.

2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☒ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)	2.7. Comments:

2.8. Student responsibilities	Students must attend more than 70% of lectures and make seminar.

2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*						
	Class attendance		Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1	(Other--describe)	
	Tests	3	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Seminar work, continuous monitoring through 3 mid tests or written and oral exam.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at**	**Availability via other media**

		the library	
	T. Sofilić, PRAVO OKOLIŠA, skripta, Sveučilište u Zagrebu, Metalurški fakultet, 2015.		https://www.simet.unizg.hr/nastava/predavanja/preddiplomski-sveucilisni-studij-metalurgija
2.12. Optional literature (at the time of the submission of the study programme proposal)	O. Lončarić-Horvat, L. Cvitanović, I. Gliha, T. Josipović, D. Medvedović, J. Omejec, M. Seršić, Pravo okoliša, 3. izmijenjeno i dopunjeno izdanje, Ministarstvo zaštite okoliša i prostornog uređenja i Organizator (Pub), Zagreb, 2003. Deklaracija o zaštiti okoliša u Republici Hrvatskoj (NN br. 34/92) Zakon o zaštiti prirode (NN br. 80/13) Zakon o zaštiti okoliša (NN br. 80/13) Zakon o zaštiti zraka (NN br. 130/11,47/14) Zakon o održivom gospodarenju otpadom (NN br. 94/13) Zakon o vodama (NN br. 153/09,63/11,130/11,56/13,14/14), Zakon o kemikalijama (NN br.18/13)		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Students survey input and output. Numerical analysis of tests and exams by scoring task by task at the course level. Survey on the faculty and University level. Analysis predicted by systems for insurance of institution quality.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	To define base questions regarding the environmental law.	1st colloquium, seminar, written and oral exam
2	To distinguish quality of life from life quality.	1st colloquium, seminar, written and oral exam
3	To describe ecology policy and ecology strategy.	2nd colloquium, seminar, written and oral exam
4	To illustrate protection of specially worth parts of nature.	2nd colloquium, seminar, written and oral exam
5	To compare the environmental protection in Croatian legal system with EU.	3rd colloquium, seminar, written and oral exam
6	To explain obligations of economic operators toward current legislation.	3rd colloquium, seminar, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Ladislav Lazić, PhD	1.6. Year of study	2
1.2. Name of the course	**LOW – EMISSION COMBUSTION**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e--learning)	30+0+15+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%
2. COURSE DESCRIPTION			
2.1. Course objectives	1. Acquire knowledge about certain types of pollutant emissions into the environment as a result of the combustion process. 2. Acquire knowledge on the mechanisms of formation of NO_X and methods of their reduction during the combustion process. 3. Acquire knowledge on the mechanisms of formation of SO_2 and methods of their reduction during the combustion process. 4. Acquiring knowledge about the formation and reduction of CO_2 emissions. 5. Acquiring knowledge about the formation and methods of reducing polycyclic aromatic hydrocarbons.		
2.2. Enrolment requirements and required entry competences for the course	The acquired knowledge from the course of graduate study: Industrial furnaces, Heating technology of industrial furnaces, Energy management.		
2.3. Learning outcomes at the level of the study programme to which the course contributes	1. Use the acquired theoretical knowledge in engineering practice. 2. Suggest new and improved technical and technological solutions. 3. Analyse the development and application of new technologies. 4. Combine the skills necessary for lifelong learning, including continued professional training.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Identify the type of pollutant emissions into the environment as a result of the combustion process. 2. Analyse the causes of certain pollutant emissions. 3. Suggest a method for reducing certain pollutant emission. 4. Evaluate the effectiveness of applied method.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): 1. Ecological noxiousness of combustion product. (2) 2. Formation of the emission of nitrogen oxides in the course of combustion: Thermal nitrogen oxide, Prompt nitrogen oxide, Nitrogen oxide generated by N_2O, Fuel nitrogen oxide generated by fuel, Mechanisms of the formation of fuel NO, Formation of NO_2, Generalisation of the description of the mechanisms of NO_X generation. (4) 3. Abatement of the emission of nitrogen oxides in the course of combustion: Staged combustion, Supply of ammonia or urea to the combustion chamber, Decrease of temperature in the combustion zone, High Temperature Air Combustion (HITAC) technology of flameless combustion, The influence of the fundamental operation parameters on the emission of NO_X. (6) 1st colloquium 4. Formation and reduction of SO_2 emission in the course of combustion (4): Sulphur compounds in fuels, Transformation of fuel sulphur in the course of rapid preheating, Oxidisation of sulphur compounds in the flame, High-temperature binding of SO_2 in the course of combustion with a shortage of oxygen, Influence of additives on the degree of binding of SO_2 in		

	the combustion gases. (4) 5. Emission of carbon oxide, Mechanisms of the formation and oxidation of CO. (2) 6. Emission of carbon dioxide: Greenhouse effect, Formation and decrease of CO_2 emission. (2) 7. Formation and emission of combustible solid particles. (2) 8. Formation and emission of polycyclic aromatic hydrocarbons during the combustion. (2) 9. Noxious substance occurring in minute quantities in combustion processes: Chlorine and fluorine compounds, Heavy metal compounds. (2) 2nd colloquium EXERCISES (15): Solving the practical problems. The understanding of the material exposed in lectures is facilitated by solving the two program tasks. The program tasks are selected so that they expand the presented theory and illustrate the application of theory to real problems.

2.6. Type of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)	2.7. Comments:

2.8. Student responsibilities	Attendance on Lectures and Exercises > 70 %					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.4	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay		(Other--describe)	
	Tests	1.0	Oral exam	1.6	(Other—describe)	
	Written exam	1.0	Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Projects – 30% Class attendance – 5% Written exam – 30% Oral exam – 35%					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	Ryszard Kazimierz, Low-emission combustion, Wydawnictwo Politechniki Slaskiej, Gliwice, 2002.	1	

2.12. Optional literature (at the time of the submission of the study programme proposal)	-
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Identify the type of pollutant emissions into the environment as a result of the combustion process.	1st colloquium, oral exam
2	Analyse the causes of certain pollutant emissions.	1st colloquium, oral exam
3	Suggest a method for reducing certain pollutant emission.	2nd colloquium, oral exam
4	Evaluate the effectiveness of applied method.	2nd colloquium, seminar paper, oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Full Prof. Mirko Gojić, PhD Assoc.Prof. Stjepan Kožuh, PhD	1.6. Year of study	2
1.2. Name of the course	**PACKAGING MATERIALS**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION	
2.1. Course objectives	Introducing students with different types of packaging materials and methods of their making. Clarification of interaction product-package-environment. Training for risk avoidance or basic mistakes during the selection and application of certain packaging materials.
2.2. Enrolment requirements and required entry competences for the course	-
2.3. Learning outcomes at the level of the study programme to which the course contributes	Use the acquired theoretical knowledge in engineering practice. Analyse the development and application of new technologies.
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	Define the terms, types and classification of packaging materials. Predict the function of packaging. Compare the properties of different packaging materials. Predict of packaging for various products. Analyze the properties of metal packaging. Explain the role of recycling packaging materials.
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Week 1: Introduction. Definitions, importance and role of packaging. The legislation for packaging. (2) Week 2: Elements of packaging design. The classification of packaging. (2) Week 3: Packaging functions (security, storage-transport, marketing, usage, environmental). (2) Week 4: The properties of packaging materials. Classification of packaging materials. (2) Weeks 5 and 6: Metal packaging (steel, tinplate, galvanized steel, aluminum). Analysis of metal packaging. (4) Week 7: Tree. Paper, paperboard and cardboard. Glass. (2) Week 8: Polymeric materials. (2) Week 9: Surface treatment of packaging materials. (2) Week 10: Laminates (composites). Biodegradable materials. New materials. (2) Week 11: Packaging forms (cover, boxes, cans, jars etc.). (2) Week 12: The technology of production of packaging. Design and innovation. (2) Week 13: Packaging and environmental protection. Environmentally friendly packaging. (2) Week 14: The degradation of ecological materials. Eco-labeling with regard to the type of packaging materials. (2) Week 15: Recycling and ecological disposal of packaging materials. (2)

	SEMINAR (15): The selection of topics and seminar work in writing form by a mentor system (10 hours). Preparation and presentation of the seminar and discussions related to the topic of the present paper (5 hours).

2.6. Type of instruction	☒ lectures ☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work	☐ independent study ☐ multimedia and the internet ☐ laboratory ☒ work with the mentor ☐ (other)	2.7. Comments:

2.8. Student responsibilities	Students must attend over 70% of lectures and are required to complete a seminar in writing form and orally present.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1.0	(Other--describe)	
	Tests	2.5	Oral exam		(Other—describe)	
	Written exam		Project		(Other—describe)	

2.10. Grading and evaluation of student work over the course of instruction and at a final exam	- evaluation of students activities in course, - evaluation of written examination (two colloquiums) through continuous monitoring or final examination (written and oral), - evaluation of seminar paper and presentation.

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	M. Gojić, Metalurgija čelika, Sveučilište u Zagrebu Metalurški fakultet, Sisak, 2006.	15	
	M. Gojić, Površinska obrada, Sveučilište u Zagrebu Metalurški fakultet, Sisak, 2010.	10	
	N. Stipanelov Vrandečić, Ambalaža-interna skripta, Sveučilište u Splitu, Kemijsko tehnološki fakultet, Split, 2010.		Electronic form
	K. Galić, N. Ciković, K. Berković, Analiza ambalažnog materijala-skripta, Priručnici Sveučilišta u Zagrebu, HINUS		http://www.hinus.hr/wp-content/knjige/2011/10/ANALIZA-AMBALAZNOG-MATERIJALA.pdf
	W. D. Callister, D.G. Rethwisch, Materials Science and Engineering: An introduction, John Willey&Sons, inc. Hoboken, 2010.	1	

2.12. Optional literature (at the time of the submission of the study programme proposal)	S. Rocco, Upravljanje proizvodom, kreiranje marke i dizajn-elektronska skripta, Visoka poslovna škola Zagreb, Zagreb, 2015. N. Stričević, Suvremena ambalaža 2, Školska knjiga, Zagreb, 1983. N. Stričević, Suvremena ambalaža 1, Školska knjiga, Zagreb, 1982. I. Budak, J. Hodolič, M. Stević, Đ. Vukelić, B. Kosec, B. Karpe, Označavanje proizvoda o zaštiti životne sredine, Fakultet tehničkih nauka Univerziteta u Novom sadu, Novi Sad, 2009. Scientific and professional papers in refereed journals and conference proceedings.

2.13. Methods of monitoring quality that ensure acquisition of exit competences	Input and output students survey. Survey at the level of faculty and University. Analyses provided in the system of quality assurance of the institution. Analyses provided in the system of quality assurance and an authorized office of the University.

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Define the terms, types and classification of packaging materials.	1st colloquium, written and oral exam
2	Predict the function of packaging.	1st colloquium, written and oral exam
3	Compare the properties of different packaging materials.	1st colloquium, written and oral exam, seminar paper
4	Predict of packaging for various products.	1st and 2nd colloquium, written and oral exam, seminar paper
5	Analyze the properties of metal packaging.	2nd colloquium, written and oral exam
6	Explain the role of recycling packaging materials.	2nd colloquium, written and oral exam

1. COURSE DECRIPTION – GENERAL INFORMATION			ISVU CODE:
1.1. Course teacher	Assoc.Prof. Ivan Brnardić, PhD Assoc.Prof. Tamara Holjevac Grgurić, PhD	1.6. Year of study	2
1.2. Name of the course	**LIGHT POLLUTION**	1.7. Credit value (ECTS)	4
1.3. Associate teachers	-	1.8. Type of instruction (number of hours L+S+E+e-learning)	30+15+0+0
1.4. Study programme (undergraduate, graduate, integrated)	graduate	1.9. Expected enrolment in the course	10
1.5. Status of the course	elective	1.10. Level of use of e-learning (1, 2, 3 level), percentage of instruction in the course on line (20% maximum)	1., 5%

2. COURSE DESCRIPTION			
2.1. Course objectives	1. To explain the key concepts of light pollution, with particular emphasis on light pollution from industrial entities. 2. To introduce the principles of protection from light pollution and tasks of entities that carry out protection and resource conservation.		
2.2. Enrolment requirements and required entry competences for the course	Knowledge on environment protection and work on computers.		
2.3. Learning outcomes at the level of the study programme to which the course contributes	Analyse the development and application of new technologies. Combine social, ethical and business principles and norms in the professional field. Combine the skills necessary for lifelong learning, including continued professional training.		
2.4. Expected learning outcomes at the level of the course (4-10 learning outcomes)	1. Define the light pollution. 2. Explain the impact of light pollution on wildlife, human health and workers. 3. Explain the principles of protection against contamination by light. 4. Explain the obligations of economic operators according to the legislation. 5. Select procedures to avoid and reduce light pollution.		
2.5. Course content broken down in detail by weekly class schedule (syllabus)	LECTURES (30): Light as a source of environmental pollution, light pollution from urban areas and industry. 3h The impact of light pollution on wildlife and the environment and to human health. 3h The link between light pollution and health of workers in the industry. 3h Principles of light pollution protection. 3h The Law on the light pollution protection. 3h Entities to ensure the implementation of light pollution protection. 3h Standards of illumination and mandatory methods to illuminate. 3h Protection measures, restrictions and prohibitions. 3h Planning, construction, maintenance and reconstruction of lighting, the responsibility of manufacturers of products that serve the clarification. 3h Administrative supervision and inspection. 3 hours SEMINAR (15): Example seminar work and preparation and presentation of seminar paper.		
2.6. Type of instruction	☒ lectures	☐ independent study	2.7. Comments:

	☒ seminars and workshops ☐ exercises ☐ online in entirety ☐ mixed e-learning ☐ field work		☐ multimedia and the internet ☐ laboratory ☐ work with the mentor ☐ (other)			
2.8. Student responsibilities	Regular attendance of lectures, written and orally presented seminar work.					
2.9. Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of CTS credits is equal to the credit value of the course)*:*	Class attendance	0.5	Research		Practical training	
	Experimental work		Report			
	Essay		Seminar essay	1.0	(Other--describe)	
	Tests		Oral exam	1.25	(Other—describe)	
	Written exam	1.25	Project		(Other—describe)	
2.10. Grading and evaluation of student work over the course of instruction and at a final exam	Attendance on classes, preparation and presentation of seminar paper, continuous monitoring – 2 preliminary exams or written and oral exam.					

2.11. Required literature (available at the library and via other media)	**Title**	**Number of copies at the library**	**Availability via other media**
	I. Brnardić, Lectures from Light pollution, Sisak, 2016.		Internet – Merlin system for e-learning
	The Law on the light pollution protection, OG 114/11, RH, 2011.		http://narodne-novine.nn.hr/clanci/sluzbeni/2011_10_114_2221.html
	T. Sofilić, Pravo okoliša, Skripta, Metalurški fakultet, Sisak, 2015.		http://www.simet.unizg.hr/nastava/predavanja/preddiplomski-sveucilisni-studij-metalurgija/3-godina-preddiplomskog-studija/pravo-okolisa/view
	D. Božičević, The influence of light pollution on the envirionment and human, Rad u zborniku sa znanstvenog skupa Lječilišna medicina i turizam, Veli Lošinj, 2010., 56-61.		https://www.google.hr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&uact=8&ved=0ahUKEwiEvv7kyPzNAhVBsBQKHY9XCwoQFggsMAI&url=http%3A%2F%2Fhrcak.srce.hr%2Ffile%2F107383&usg=AFQjCNHfFxpuFedTnyfkzicxkP0i25No7w
	Ž. Andreić, K. Korlević, D. Andreić, A. Bonaca, P. Korlević, M. Kramar, Light pollution in Croatia, Građevinar 63 (2011) 8, 757-764.		https://www.google.hr/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjcgNKCyfzNAhUDXBQKHdsPDQQQFggcMAA&url=http%3A%2F%2Fhrcak.srce.hr%2Ffile%2F107383&usg=AFQjCNHfFxpuFedTnyfkzicxkP0i25No7w
	V. Dubrovečak, City lightning, Znanstveni časopis		https://www.google.hr/search?q=V.+Dubrove%C4%8Dak%2C

	za arhitekturu i urbanizam, 18 (2010) 39, 205-217.		+Osvjetljivanje+gradova%2C+Znanstveni+%C4%8Dasopis+za+arhitekturu+i+urbanizam&ie=utf-8&oe=utf-8&client=firefox-b&gfe_rd=cr&ei=L5CMV4yDA6ao8weI0YyIDg
2.12. Optional literature (at the time of the submission of the study programme proposal)	Available scientific literature on the subject of light pollution.		
2.13. Methods of monitoring quality that ensure acquisition of exit competences	Survey on the faculty and University level. Analysis predicted by systems for insurance of institution quality. Analysis predicted by systems for insurance quality from authorized University office.		

Ordinal number	Expected learning outcomes at the level of the course (4-10)	Methods for monitoring of the achievement of learning outcomes
1	Define the light pollution.	1st colloquium, seminar, written and oral exam
2	Explain the impact of light pollution on wildlife, human health and workers.	1st colloquium, seminar, written and oral exam
3	Explain the principles of protection against contamination by light.	1st colloquium, seminar, written and oral exam
4	Explain the obligations of economic operators according to the legislation.	2nd colloquium, seminar, written and oral exam
5	Select procedures to avoid and reduce light pollution.	2nd colloquium, seminar, written and oral exam