SVEUČILIŠTE U ZAGREBU
METALURŠKI FAKULTET

UNIVERSITY OF ZAGREB
FACULTY OF METALLURGY

UNDERGRADUATE UNIVERSITY VOCATIONAL PART-TIME STUDY PROGRAMME IN FOUNDING

- PROGRAM OF THE COURSES -

Sisak, 2017

CONTENT

Name of the course: ANALYSIS OF CASTING DEFECTS

ISVU code: 157493

Status of the course: compulsory

Year of study: 3

Semester: 5

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+0+0+1

Expected enrolment in the course: 15

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: ability to recognize and analyze defects on castings, ability to find out possible causes of casting defects, ability to define measures to prevent casting defects.

Enrolment requirements and required entry competences for the course: the knowledge acquired in the courses of "Fundamentals of solidification and microstructure development", "Technology of making molds and cores", "Melting technology and quality control of the melt", "Casting technology of ferrous metals", "Casting technology of non-ferrous metals", and "Designing of gating and feeding systems"

Learning outcomes at the level of the study programme to which the course contributes: recognize type of casting defect, explain the mechanism of defect formation on the casting and propose methods to avoid the formation of defects on the castings.

Expected learning outcomes at the level of the course: recognize type of casting defect, explain the mechanism of formation of a defect on the casting, analyze the causes of defect formation, suggest methods to avoid defect formation, evaluate the success of the applied method for eliminating the defect.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Classification of defects on the castings (2); Impact of defects on casting properties (3); Defects on the castings that may be associated with the pouring and the flow of the melt, surface irregularity, reaction with molding material and solidification (6); In situ detection and observation of defects on the castings (1); The most significant casting technologies and associated characteristic defects (4); Analysis of the mechanisms of defect formation on the castings (5); The reaction of the melt with the environment (2); Gases in ferrous and non-ferrous casting alloys (2); Types, reactions and controls of the formation of inclusions in ferrous and non-ferrous casting alloys (3); Measures for production of castings without defects (2).

Type of instruction: lectures.

Student responsibilities: students must attend lectures (> 70.0 %).

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (0.5 ECTS) and colloquiums (4.5 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students in the classes and the results of the colloquiums are evaluated. The performance plan of teaching specifies in detail the evaluation of student activities during classes, grading of colloquiums and determining the final grade.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Recognize type of casting defect	1st colloquium, 2nd colloquium
2.	Explain the mechanism of formation of a defect on the casting	1st colloquium, 2nd colloquium
3.	Analyze the causes of defect formation	1st colloquium, 2nd colloquium
4.	Suggest methods to avoid defect formation	1st colloquium, 2nd colloquium
5.	Evaluate the success of the applied method for eliminating the defect	1st colloquium, 2nd colloquium

Required literature:

1. Z. Glavaš, Analiza grešaka na odljevcima, text of the lectures placed on website of Faculty of Metallurgy, Faculty of Metallurgy, Sisak, 2010.
2. S. Hasse, Pogrješke na odljevcima, Croatian Foundry Association, Zagreb, 2003.

Optional literature:

1. M. T. Rowley, International Atlas of Casting Defects, AFS, 1990.
2. …, Aluminium Permanent Mold Handbook, AFS, Des Plaines, Illinois, 2001.

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.

Name of the course: APPLICATION OF INFORMATION TECHNOLOGIES IN FOUNDING

ISVU code: 157132

Status of the course: compulsory

Year of study: 2

Semester: 4

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+2+0+1

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: qualification for basic use of modern developed software packages for gating and feeding system design, mold filling simulations and solidification simulations of castings as well as estimation of defect occurrence in castings, the ability to explain the simulation results obtained through software simulation packages, knowledge of modern concepts of casting production and methods for rapid prototyping, qualification for basic use of software packages for casting optimization, knowledge of modern quality control melt systems.

Enrolment requirements and required entry competences for the course: knowledge gained within the subjects "Technology of making molds and cores" and "Fundamentals of solidification and microstructure development".

Learning outcomes at the level of the study programme to which the course contributes: describe the modern concepts of production of castings, apply software for optimization of casting construction, apply casting processes simulation software and interpret results, explain and understand the casting process and solidification of metal castings in expandable and permanent moulds.

Expected learning outcomes at the level of the course: describe the modern concepts of castings production; apply software packages to optimize casting design, apply software packages to simulate mold filling and solidification of castings and explain the results, apply thermal analysis in the melt quality control system, interpret and apply the results of thermal analysis, organize the production data management system.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Modern concepts of casting production (3); Optimization of castings construction (design) using information technologies (IT) (4); Rapid prototyping (2); Mold filling and solidification simulations of castings (6); Optimizing of the melt quality using information technology (3);

Expert Systems (2); Applied methods of artificial intelligence (2); Melt quality control systems based on thermal analysis (4); Computer appliance in control of foundry production processes (2); Computer appliance in planning and quality assurance (1); Product data management system (1);
Exercises: Appliance of software packages for making models and prototypes (3D) (SolidWorks, AutoCAD, CATIA, Pro / ENGINEER) (6); Design of gating and feeding systems using specialized software packages (Foundry Technology) (7); Appliance of specialized software packages to simulate mold filling and solidification of castings (NovaFlow&Solid, ProCast) (11); Appliance of heat quality control system based on thermal analysis and artificial intelligence (ATAS) (6).

Type of instruction: lectures and exercises, teaching with the help of ICT.

Student responsibilities: students must attend lectures and exercises (> 70.0 %).

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 ECTS), colloquium (2.5 ECTS) and oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: attendance and activity on classes and the results of students on the colloquia are evaluated during the courses. The implementation plan of the subject details the evaluation of student activities during the course, on colloquia and oral exam calculated in the final grade of the subject.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Describe the modern concepts of castings production	Colloquium
2.	Apply software packages to optimize casting design	Oral exam (Seminar/project task)
3.	Apply software packages to simulate mold filling and solidification of castings and explain the results	Colloquium
4.	Apply thermal analysis in the melt quality control system	Colloquium
5.	Interpret and apply the results of thermal analysis	Colloquium
6.	Organize the production data management system	Colloquium

Required literature:

1. F. Unkić, Z. Kivač, Z. Glavaš, Primjena suvremenih informatičkih tehnologija u razvoju i proizvodnji odljevaka, poglavlje u knjizi Suvremeni materijali i postupci, urednik T. Filetin, Hrvatsko društvo za materijale i tribologiju, Zagreb, 2005.

2. R. Roller, E. Baschin, V. Buck, M. Pröm, G. Reuter, H. Rödter, K. Trinkner, R. Winkow, Fachkunde Modellbau – Technologie des Modell – und Formenbaus, Verlag Europa-Lehrmittel, 2003.

Optional literature:

1. K. Weiss, C. Honsel, Simulation of Internal Tension, Structure and Mechanic Properties, European Conference on Advanced Materials and Processes, Aachen, 1989.

Methods of monitoring quality that ensures acquisition of exit competences: Employers testing. Graduate students testing (according to the Quality Manual which is an integral part of the Rulebook on Quality Management System of the Faculty of Metallurgy University of Zagreb).

Name of the course: CASTING OF ALUMINUM SEMIPRODUCTS

ISVU code: 157498

Status of the course: elective

Year of study: 3

Semester: 5

Credit value (ECTS): 4

Type of instruction (number of hours L+S+E+e-learning): 2+1+0+1

Expected enrolment in the course: 15

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: conducting technology and processes of semicontinuous casting of aluminium billets/logs and ingots, conducting technology and processes of continuous casting of aluminium slabs and strips

Enrolment requirements and required entry competences for the course: knowledge gained within the courses Fundamentals of solidification and microstructure development and Melting technology and quality control of the melt

Learning outcomes at the level of the study programme to which the course contributes: explain the process of direct chill and continuous casting of aluminium alloys, relate microstructure and properties of castings, explain and understand the casting process and solidification of metal castings in expendable and permanent moulds, use phase diagrams, recognize type of casting defect

Expected learning outcomes at the level of the course: single out wrought aluminium alloys, explain the solidification and formation of structures during semicontinuous and continuous casting of aluminium alloys, analyze casting defects on casted semi-finished products, propose methods for preventing defects on casted semi-finished products, choose the appropriate semi-continuous casting of aluminium billets/logs and ingots and continuous casting of aluminium slabs and strips, recommend the appropriate heat treatment of aluminium semi-finished products

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Wrought aluminium alloys (2); Solidification and formation of structure during semicontinuous and continuous casting of aluminium alloys (8); Defects on casted semi-finished products (4); Technology and processes of semicontinuous casting of aluminium billets/logs and ingots (8); Technology and processes of continuous casting of aluminium slabs and strips (4); Heat treatment and preparation for further processing of cast aluminium semi-finished products (4).

Seminar paper: More detailed knowledge of the characteristics of certain processes and phases in the process of semiontinuous and continuous casting of aluminum semi-finished products (4); Interpretation of semicontinuous and continuous casting of aluminum semi-finished products through the preparation of the seminar paper (11).

Type of instruction: lectures and seminar paper

Student responsibilities: regular attendance (> 70.0 %) and written of seminar papers

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): regular attendance (0.4 ECTS), seminar paper (0.8 ECTS), colloqiums (1.5 ECTS), oral exam (1.3 ECTS)

Grading and evaluation of student work over the course of instruction and at a final exam: during the teaching, the attendance and activity of the students in the teaching, the seminar paper and the results at the tests are evaluated. The performance plan of the course details the evaluation of students' activities during classes, seminars, colloquiums and oral exams. Everything is included in the final grade.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Single out wrought aluminium alloys	1st colloquium, oral exam
2.	Explain the solidification and formation of structures during semicontinuous and continuous casting of aluminium alloys	1st colloquium, oral exam, seminar paper
3.	Analyze casting defects on casted semi-finished products	1st colloquium, oral exam, seminar paper
4.	Propose methods for preventing defects on casted semi-finished products	1st colloquium, oral exam
5.	Choose the appropriate semi-continuous casting of aluminium billets/logs and ingots and continuous casting of aluminium slabs and strips	2nd colloquium, oral exam, seminar paper
6.	Recommend the appropriate heat treatment of aluminium semi-finished products	2nd colloquium, oral exam

Required literature:

1. D. G. Eskin, Physical Metallurgy of Direct Chill Casting of Aluminium Alloys, CRC Press, 2008.
2. …, ASM Handbook, Volume 15, Casting, ASM International, Materials Park, Ohio, 2008.

Optional literature:

1. …, Aluminium Cast House Technology, Proceedings of Seventh Australian Asian Pacific Confernce, ed. P. R. Whiteley, TMS, 23 – 26 September 2001., Hobart, Australia.

2. …, Aluminium Cast House Technology, Proceedings of Eighth Australasian Confernce, ed. P. R. Whiteley, TMS, 14 – 17 September 2003., Brisbane, Australia.

Methods of monitoring quality that ensure acquisition of exit competences:
Examination of students who have finished study. Analysis predicted by systems for insurance of institution quality. Analysis predicted by systems for insurance quality from authorized University office.

Name of the course: CASTING TECHNOLOGY OF FERROUS METALS

ISVU code: 157130

Status of the course: compulsory

Year of study: 2

Semester: 4

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 3+0+1+0

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: understanding of the relationship between structure of metallic charge material, process parameters, melting, metallurgical quality of melt, melt treatment, inoculation, casting and conditions during solidification with the microstructure and properties of cast iron castings, ability to define the technology for the production of castings from unalloyed and alloyed cast irons and cast steels.

Enrolment requirements and required entry competences for the course: the knowledge acquired in the courses of "Fundamentals of physical metallurgy", "Thermodynamics and kinetics of metallurgical processes", "Technology of making molds and cores", "Classification and properties of casting alloys", "Fundamentals of solidification and microstructure development", and "Melting technology and quality control of the melt".

Learning outcomes at the level of the study programme to which the course contributes: explain and understand the casting process and solidification of metal castings in expendable and permanent moulds, relate microstructure and properties of castings, relate the chemical composition, metallurgical quality of melt and conditions during solidification with the obtained microstructure and properties of castings, determine the melt processing conditions based on the analysis of chemical composition and metallurgical quality of the melt, select charge materials for melting aggregate according to the type of casting alloy that would be produced and the prescribed properties of castings.

Expected learning outcomes at the level of the course: relate the chemical composition, conditions during and after solidification with the obtained microstructure and properties of cast irons and cast steels castings, select charge materials and define the conditions of melting and melt treatment in the production of unalloyed and alloyed cast irons in accordance with the requirements for castings, select charge materials and define the conditions of melting and melt treatment in the production of unalloyed and alloyed cast steels in accordance with the requirements for castings.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Classification of the iron based casting alloys (1); Types and designation systems (1); Gray iron (5); Ductile iron (5); Austempered ductile iron (ADI) (1); Compacted graphite cast iron (4); Malleable cast iron (2); High-alloyed white cast irons (5); Special corrosion and temperature resistant high-chromium cast irons (2); High-alloyed graphitic cast irons (3); High-silicon graphitic cast irons (2); Austenitic nickel-alloyed gray and ductile irons (2); Aluminum-alloyed gray and ductile irons (2); Plain carbon steels (2); Low-alloy steels (2); High-alloy steels (3); Austenitic manganese steels (2);
Exercises: Treatment and inoculation of the melt (2); Magnesium treatment methods: flow-through process, in-mould treatment, sandwich open ladle treatment, tundish cover treatment (2); Analysis of the microstructure and mechanical properties (2); Correlation between process parameters and microstructure (2); Visit to foundries of steel, gray and ductile iron (7).

Type of instruction: lectures and exercises.

Student responsibilities: students must attend lectures and exercises (> 70.0 %).

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (0.5 ECTS), colloquiums (4.5 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students in the classes and the results of the colloquiums are evaluated. The performance plan of teaching specifies in detail the evaluation of student activities during classes, grading of colloquiums and determining the final grade.

Monitoring of the achievement of learning outcomesat the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Relate the chemical composition, conditions during and after solidification with the obtained microstructure and properties of cast irons and cast steels castings	1st colloquium, 2nd colloquium
2.	Select charge materials and define the conditions of melting and melt treatment in the production of unalloyed and alloyed cast irons in accordance with the requirements for castings	1st colloquium
3.	Select charge materials and define the conditions of melting and melt treatment in the production of unalloyed and alloyed cast steels in accordance with the requirements for castings	2nd colloquium

Required literature:

1. Z. Glavaš, F. Unkić, Lijevanje željeznih metala, text of the lectures placed on website of Faculty of Metallurgy, Faculty of Metallurgy, Sisak, 2009.
2. …, Metals Handbook, Volume 15, Casting, ASM International, Metals Park Ohio, 2008.

Optional literature:

1. …, Cast Iron, ASM International, Materials Park, 1999.
2. Metals Handbook, Ninth Edition, Volume 1, Properties and Selection: Irons and Steels, ASM International, Metals Park Ohio, 1978.

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.

Name of the course: CASTING TECHNOLOGY OF NON-FERROUS METALS

ISVU code: 157131

Status of the course: compulsory

Year of study: 2

Semester: 4

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 3+1+0+1

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: understanding the connection process parameters, melting, melt processing, casting and casting conditions with microstructure, the utilization properties of non-ferrous castings (primarily aluminum alloys), the ability to define aluminum alloy casting technology (gravity casting, high pressure casting), understanding the basic principles of squeeze casting and semi-solid casting process.

Enrolment requirements and required entry competences for the course: knowledge gained within the subjects „Fundamentals of physical metallurgy“, „Thermodynamics and kinetics of metallurgical processes“, „Technology of making molds and cores“, „Classification and properties of casting alloys“, „Fundamentals of solidification and microstructure development“ and „Melting technology and quality control of the melt“.

Learning outcomes at the level of the study programme to which the course contributes: explain and understand the process of casting and solidification metal castings in expendable and permanent molds, relate microstructure and usability properties of castings, relate the properties of casting alloys with their structures, define the parameters of high pressure and gravity casting of aluminum alloys, explain casting methods in semi-solid casting process, choose charge materials for the melting aggregate according to the type of casting and the prescribed casting properties.

Expected learning outcomes at the level of the course: select aluminum alloys for gravity and high pressure casting, define melting and melt processing conditions for aluminum castings according to the casting requirements, analyze the aluminum alloy castings microstructure and associate it with the properties, define the parameters of the high-pressure casting technology of aluminum alloys, define the parameters of the gravity casting technology of aluminum alloys, explain the squeeze casting process, explain the semi-solid casting process.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Classification of non-ferrous iron alloys (2); Marking types and systems (1); Aluminum alloys for gravity and high pressure casting (4); Melting and melt treatment (4); Filtration and degassing of aluminum melt (3); Modification and grain refinement of aluminum alloys (3); Dendritic branch spacing and grain size control (2); High-pressure casting technology (5); Gravity casting technology (4); Squeeze casting (2); Aluminum alloys for casting in partially molten state (3); Copper and copper alloys (3); Zinc and zinc alloys (3); Magnesium and magnesium alloys (4); Titanium and titanium alloys (2).
Exercises: Melting and melt treatment of aluminum alloys (1); Modification and inoculation of aluminum alloys (1); Gravity casting of aluminum alloys (1); High-pressure casting aluminum alloys (2); Microstructure analysis of aluminum alloys (2); Testing mechanical properties of gravity and high pressure cast aluminum alloy castings (2); Visits to non-ferrous metal foundries (6).

Type of instruction: lectures and exercises, teaching with the help of ICT.

Student responsibilities: students must attend lectures and exercises (> 70.0 %).

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 ECTS), colloquium (4.5 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: attendance and activity on classes and the results of students on the colloquia are evaluated during the courses. The implementation plan of the subject details the evaluation of student activities during the course, on colloquia calculated in the final grade of the subject.

Monitoring of the achievement of learning outcomesat the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Select aluminum alloys for gravity and high pressure casting	Colloquium
2.	Define melting and melt processing conditions for aluminum castings according to the casting requirements	Colloquium
3.	Analyze the aluminum alloy castings microstructure and associate it with the properties	Colloquium
4.	Define the parameters of the high-pressure casting technology of aluminum alloys	Colloquium
5.	Define the parameters of the gravity casting technology of aluminum alloys	Colloquium
6.	Explain the squeeze casting process	Colloquium
7.	Explain the semi-solid casting process	Colloquium

Required literature:

1. …, Aluminium Casting Technology, AFS, Des Plaines, Illinois, 2001.
2. M. N. Tomović, Livenje obojenih i lakih metala, Tehnološko-metalurški fakultet, Beograd, 1976.
3. H. Kaufmann, P. J. Uggowitzer, Metallurgy and Processing of High-Integrity Light Metal Pressure castings, Schiele & Schön, 2007.

Optional literature:

1. …, Aluminium Permanent Mold Handbook, AFS, Des Plaines, Illinois, 2001.
2. A. C. Street, The Diecasting Book, Second Edition, Portcullis Press LTD, England, 1986.
3. …, Casting Cooper Base Alloys, AFS, Des Plaines, Illinois, 1984.

Methods of monitoring quality that ensures acquisition of exit competences: Employers testing. Graduate students testing (according to the Quality Manual which is an integral part of the Rulebook on Quality Management System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: CHEMICAL ANALYSIS AND MEASUREMENTS IN FOUNDING

ISVU code: 150657

Status of the course: compulsory

Year of study: 1

Semester: 2

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+0+2+1

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: the main object of the course is to introduce students with the basics of chemical analysis, i.e. with principles of particular importance to analytical chemistry and their introduction into a wide range of modern analytical methods and measurement methods in the founding. Working in the lab will enable the acquisition of the skills required to obtain high-quality analytical data.

Enrolment requirements and required entry competences for the course: the knowledge acquired in the courses of „General and inorganic chemistry".

Learning outcomes at the level of the study programme to which the course contributes: determine the temperature and oxygen activity in the melt, determine the chemical composition of casting alloys by analytical techniques, examine the chemical composition and metallurgical quality of the melt.

Expected learning outcomes at the level of the course: prepare an analytical sample, perform qualitative and quantitative chemical analysis of the sample, determine the chemical composition of casting alloy by analytical techniques, determine the temperature of the melt, determine oxygen activity in the melt.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Chemical Analysis, Sample, (2); Sampling of solid sample, Sampling of liquids, Sampling of gases (2); Preparation of analytical sample, Dissolution, Precipitation, Separation and isolation of the analyte (2); Conductivity (in general, methods, metallurgical waste), pH value (in general, methods, metallurgical waste) (2); Radioactivity (in general, methods, metallurgical materials) (2); Testing of foundry sand (4); Temperature of the melt, Oxygen activity in the melt (4); Analysis of gases in metallurgical processes (3); Overview of physicochemical analysis methods, optical methods, electrochemical methods (3);

Thermometric methods, (2); Radioactive methods, Other Methods, (2); Instruments at the Faculty of Metallurgy (2).
Exercises: Determination of cations (4); Determination of alloys (4); Acid demand value (2); Loss on ignition of chromite (4); Determination of chromite in silica sand (4); Measurement of pH and conductivity of eluates (2); Thermal analysis (4); Application of metallurgical waste for the purification of wastewaters (4); Visit to the foundry (2).

Type of instruction: lectures and laboratory exercises.

Student responsibilities: students must attend lectures (> 70.0 %). All laboratory exercises must be performed. All accurate reports must be submitted.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (0.3 ECTS), exercises (1 ECTS), colloquiums (1.5 ECTS) and oral exam (2.2 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students in the classes and the results of the exercises and colloquiums are evaluated. The performance plan of teaching specifies in detail the evaluation of student activities during classes and laboratory exercises, grading of colloquiums and oral exam, and determining the final grade.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Prepare an analytical sample	1st colloquium, laboratory exercises, oral exam
2.	Perform qualitative and quantitative chemical analysis of the sample	1st colloquium, laboratory exercises, oral exam
3.	Determine the chemical composition of casting alloy by analytical techniques	2nd colloquium, laboratory exercises, oral exam
4.	Determine the temperature of the melt	2nd colloquium, oral exam
5.	Determine oxygen activity in the melt	2nd colloquium, oral exam

Required literature:

1. D. A. Skoog, D. M. West, F. J. Holler, Osnove analitičke kemije, Školska knjiga, Zagreb, 1999.
2. M. Kaštelan-Macan, Kemijska analiza u sustavu kvalitete, Školska knjiga, Zagreb, 2003.
3. A. S. Morris, Principles of Measurment and Instrumentation, Prentice Hall, London, 1988.

Optional literature:

1. G. D. Christian, Analytical Chemistry, John Wiley and Sons, New York, 1986.
2. Selected papers in journals and conference proceedings.

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.

Name of the course: CLASSIFICATION AND PROPERTIES OF CASTING ALLOYS

ISVU code: 157124

Status of the course: compulsory

Year of study: 2

Semester: 3

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+1+0+1

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: knowledge of the basic properties of ferrous casting alloys, knowledge of the basic properties of non-ferrous casting alloys, the ability to define the area of application of certain casting alloy.

Enrolment requirements and required entry competences for the course: the knowledge acquired in the courses of "General and Inorganic Chemistry", and "Fundamentals of physical metallurgy ".

Learning outcomes at the level of the study programme to which the course contributes: describe ferrous and non-ferrous casting alloys according to their properties, relate the properties of casting alloys with their structures, select adequate casting alloy depending on the conditions of the castings application, distinguish microstructural constituents in ferrous and non-ferrous alloys.

Expected learning outcomes at the level of the course: separate casting alloys, describe ferrous and non-ferrous casting alloys depending on their properties, relate the properties of casting alloys with their structures, select adequate casting alloy depending on the conditions of the castings application, compare the properties of casting alloys, evaluate the efficacy of using certain casting alloy.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Classification of casting alloys (3); Basic characteristic of ferrous casting alloys: gray cast irons, white cast irons, cast steels (8); Basic characteristic of non-ferrous casting alloys: aluminum casting alloys, magnesium casting alloys, copper casting alloys, zinc casting alloys, nickel casting alloys, titanium casting alloys (12); Alloys for semisolid casting (2); Areas of application of casting alloys (5).
Seminar: More detailed introduction of students with certain casting alloys, their properties, advantages and disadvantages and areas of application (5). Creating of seminar paper from the mentioned areas (10).

Type of instruction: lectures and seminars.

Student responsibilities: students must attend lectures (> 70.0 %) and create a seminar paper.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (0.5 ECTS), seminar paper (1.2 ECTS) and colloquiums (3.3 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students in the classes, seminar paper, and the results of the colloquiums are evaluated. The performance plan of teaching specifies in detail the evaluation of student activities during classes and seminars, grading of colloquiums, and determining the final grade.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Separate casting alloys	1st colloquium, 2nd colloquium
2.	Describe ferrous and non-ferrous casting alloys depending on their properties	1st colloquium, 2nd colloquium, seminar paper
3.	Relate the properties of casting alloys with their structures	1st colloquium, 2nd colloquium, seminar paper
4.	Select adequate casting alloy depending on the conditions of the castings application	1st colloquium, 2nd colloquium, seminar paper
5.	Compare the properties of casting alloys	1st colloquium, 2nd colloquium
6.	Evaluate the efficacy of using certain casting alloy	1st colloquium, 2nd colloquium

Required literature:

1. …, Metals Handbook, Volume 15, Casting, ASM International, Metals Park Ohio, 2, 2008.
2. T. Filetin, F. Kovačiček, J. Indof, Svojstva i primjena materijala, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 2002.
3. J. G. Kaufman, E. L. Rooy, Aluminium Alloy Castings, Properties, Processes and Applications, ASM International, Materials Park, 2005.

Optional literature:

1. I. J. Polmear, Light Alloys, Metallurgy of the Light Metals, Third Edition, Arnold, Great Britain, 1995.
2. H. Kaufmann, P. J. Uggowitzer, Metallurgy and Processing of High-Integrity Light Metal Pressure Castings, Schiele & Schön, Berlin, 2007.

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.

Name of the course: CORROSION AND PROTECTION OF CASTINGS

ISVU code: 157500

Status of the course: elective

Year of study: 3

Semester: 5

Credit value (ECTS): 4

Type of instruction (number of hours L+S+E+e-learning): 2+1+0+1

Expected enrolment in the course: 15

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: understanding of corrosion mechanisms of ferrous and non - ferrous alloys in different application conditions, the ability to select the appropriate cast protection procedure depending on the application conditions.

Enrolment requirements and required entry competences for the course: basic knowledge of general and inorganic chemistry, knowledge of the type of ferrous and non-ferrous castings and the application of ferrous and non-ferrous castings.

Learning outcomes at the level of the study programme to which the course contributes: select the appropriate method of protecting castings from corrosion.

Expected learning outcomes at the level of the course: explain the mechanisms of chemical, electrochemical and atmospheric corrosion and corrosion in soil and seawater, identify the appropriate corrosion test method depending on casting conditions, select the appropriate corrosion protection method of the castings, evaluate the effectiveness of the applied corrosion protection method.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Corrosion mechanisms (3); Chemical corrosion (2); Electrochemical corrosion (2); Corrosion of castings in special working conditions (1); Atmospheric corrosion (1); Corrosion in soil (1); Corrosion in sea water (1); Corrosion testing methods (1); Optical testings (1); Chemical testings (1); Electrochemical testings (1); Mechanical testings (1); Special forms of corrosion damages (1); Corrosion of iron and steel castings (2); Corrosion of aluminium alloys (2); Corrosion protection by external current source (1); Anode and cathode protection (1); Protection by inhibitors (1); Protection by metal coatings: nickel plating, copper plating and zinc-plating (2); Protection by non-metallic coatings: phosphating, browning, enamelling (2); Protection by coatings: paints, varnishes and polymer masses (2).

Seminar paper: More detailed information on specific corrosion protection processes of castings (4); Creation of a seminar paper on a theme of specific corrosion protection procedure for ferrous or non-ferrous castings (11).

Type of instruction: lectures and seminar paper, teaching with the help of ICT.

Student responsibilities: students must attend lectures (> 70.0 %) and create a seminar paper.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): attendance (0.3 ECTS), seminar paper (1.0 ECTS), colloquia (1.5 ECTS), oral exam (1.2 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: during the course the attendance and activity of the students at the classes, the seminar paper and the results at the colloquia are evaluated. By the performance plan of the course the evaluation of students' activities during classes, seminars, colloquia and oral exams and the calculation in the final grade of the course were described in details.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Explain the mechanisms of chemical, electrochemical and atmospheric corrosion and corrosion in soil and seawater	Colloquium, oral exam
2.	Identify the appropriate corrosion test method depending on casting conditions	Colloquium, oral exam
3.	Select the appropriate corrosion protection method of the castings	Seminar paper
4.	Evaluate the effectiveness of the applied corrosion protection method	Seminar paper

Required literature:

1. E. Stupnišek-Lisac, Korozija i zaštita konstrukcijskih materijala, Fakultet kemijskog inženjerstva i tehnologije, 2007.
2. I. Esih, Z. Dugi, Tehnologija zaštite od korozije I dio, Školska knjiga, Zagreb, 1990.
3. I. Esih, Z. Dugi, Tehnologija zaštite od korozije II dio, Sveučilište u Zagrebu, Zagreb 1992.

Optional literature:

1. I. Esih, Osnove površinske zaštite, Sveučilište u Zagrebu, FSB, Zagreb, 2003.
2. K. Jarić, A. Rešetić, Korozija, Korexpert, d.o.o., Zagreb, 2003.

Methods of monitoring quality that ensure acquisition of exit competences: employee surveys, surveys of completed students (according to the Quality Manual which is the integral part of the Rule Book on Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: DESIGNING OF GATING AND FEEDING SYSTEMS

ISVU code: 157129

Status of the course: compulsory

Year of study: 2

Semester: 4

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+0+2+1

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: understanding of the basic laws of dimensioning and construction of the gating and feeding system, ability to construct and dimension gating and feeding system for casting ferrous and non-ferrous castings.

Enrolment requirements and required entry competences for the course: the knowledge acquired in the courses of „Technology of making molds and cores ", and „Fundamentals of solidification and microstructure development ".

Learning outcomes at the level of the study programme to which the course contributes: construct and calculate the horizontal and vertical gating system for the casting of ferrous and non-ferrous alloys, construct and calculate feeding system for ferrous and non-ferrous casting alloys, explain and understand the casting process and solidification of metal castings in expendable and permanent moulds.

Expected learning outcomes at the level of the course: construct and calculate the horizontal and vertical gating system for the casting of ferrous and non-ferrous alloys, construct and calculate feeding system for ferrous and non-ferrous casting alloys, apply exothermic and insulating sleeves around the feeder, apply chills in order to optimize the feeding system.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Requirements that the gating system must meet (1); Types of gating systems (1); Components of the gating system (3); Basic principles of fluid dynamics (2); Casting speed (1); Laws of dimensioning and construction of the gating and feeding system for casting ferrous and non-ferrous castings (3); Filters (1); Volume changes during the cooling and solidification of castings (2); Casting modulus (1); Dimensioning of feeders (3); Feeding of gray cast irons (4); Feeding of white cast irons (2); Feeding of cast steels (2); Feeding of Al-Si casting alloys (2); Application of exothermic and insulating sleeves (1); Application of chills (1).

Exercises: Calculation of gating systems for casting of gray cast irons (3); Calculation of gating systems for casting of steels (3); Calculation of gating systems for casting of aluminum alloys (3); Calculation of casting modulus (5); Calculation of feeding system for gray cast irons castings (7); Calculation of feeding system for steels castings (3); Calculation of feeding system for aluminum castings (4); Calculation of chills (2).

Type of instruction: lectures and exercises.

Student responsibilities: students must attend lectures and exercises (> 70.0 %).

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (0.5 ECTS), colloquiums (2.5 ECTS), and oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students in the classes and the results of the colloquiums are evaluated. The performance plan of teaching specifies in detail the evaluation of student activities during classes, grading of colloquiums and oral exam, and determining the final grade.

Monitoring of the achievement of learning outcomesat the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Construct and calculate the horizontal and vertical gating system for the casting of ferrous and non-ferrous alloys	1st colloquium, oral exam
2.	Construct and calculate feeding system for ferrous and non-ferrous casting alloys	2nd colloquium, oral exam
3.	Apply exothermic and insulating sleeves around the feeder	2nd colloquium, oral exam
4.	Apply chills in order to optimize the feeding system	2nd colloquium, oral exam

Required literature:

1. F. Unkić, Z. Glavaš, Osnove lijevanja metala - Zbirka riješenih zadataka, text of the exercises placed on website of Faculty of Metallurgy, Faculty of Metallurgy, Sisak, 2009.
2. …, The Basic Principles of Fluid Dynamics Applied to Running Systems of Castings, National Metalforming Centre, Institute of Cast Metals Engineers, England, 2007.
3. S. I. Karsay, The Practical Foundryman's Guide to Feeding and Running Grey-, CG – and SG Iron Castings, Ferrous Casting Centre Ltd., Republic of South Africa, 1985.

Optional literature:

1. J. Campbell, Castings Practice – The 10 Rules of Castings, Elsevier Butterworth-Heinemann, England, 2004.

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.

Name of the course: DISPOSAL AND RECYCLING OF THE CASTING MATERIALS

ISVU code: 157128

Status of the course: compulsory

Year of study: 2

Semester: 3

Credit value (ECTS): 4

Type of instruction (number of hours L+S+E+e-learning): 2+1+0+1

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: understanding the environmental impact of the foundry, the ability to define methods and procedures for waste disposal and recovery of foundry waste, the ability to analyze the environmental pollution measurement results, the ability to define methods for reducing environmental impacts.

Enrolment requirements and required entry competences for the course: high school education in the field of ecology and understanding the casting process.

Learning outcomes at the level of the study programme to which the course contributes: recognize sources of environmental contamination in the foundry, recognize environmentally harmful substances in foundries, describe the procedures for disposal and waste management of hazardous and non-hazardous waste.

Expected learning outcomes at the level of the course: recognize sources of environmental contamination in the foundry, define environmentally harmful substances in foundries, describe the procedures for disposal of hazardous and non-hazardous foundry waste, recognize the possibilities of recovery of certain types of foundry waste (foundry sand), describe procedures for reducing the amount of hazardous and non-hazardous waste in the foundry and reducing the harmful effects on the environment.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Influence of Foundry on the Environment (3); Legal regulations and regulations in the field of environmental protection (3); Foundry waste (3); Disposal of solid metal waste (3); Recycling of solid metal waste (3); Waste management of slag (2); Recycling of slag (2); Waste management of dust (1); Recycling of dust (1); Waste management of Wasted Foundry Sand (2); Recycling of Wasted Foundry Sand (2); Environmental pollution measurements (2); Possibilities of Reduction of Harmful Effects on the Environment (3).

Seminar work: More detailed knowledge of the effects of foundry scraps, techniques and equipment for reducing emissions of pollutants into the environment, recycling and recovery of certain types of casting waste (5). Preparation of seminar work (10).

Type of instruction: lectures, seminar work and learning with help of ICT.

Student responsibilities: regular attendance of lectures (> 70.0 %) and seminar work.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (0.2 ECTS), seminar essay (1.0 ECTS), colloquiums (2.8 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: attendance on classes, research, continuous monitoring – 2 colloquiums or written and oral exam.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Explain the impact of the foundry on the environment	1st colloquium, seminar, written and oral exam
2.	Recognize sources of environmental contamination in the foundry	1st colloquium, seminar, written and oral exam
3.	Define environmentally harmful substances in foundries	1st colloquium, 2nd colloquium, seminar, written and oral exam
4.	Describe the procedures for disposal of hazardous and non-hazardous foundry waste	2nd colloquium, seminar, written and oral exam
5.	Recognize the possibilities of recovery of certain types of foundry waste (foundry sand)	2nd colloquium, seminar, written and oral exam
6.	Describe procedures for reducing the amount of hazardous and non-hazardous waste in the foundry and reducing the harmful effects on the environment	2nd colloquium, seminar, written and oral exam

Required literature:

1. V. Glavač, Uvod u globalnu ekologiju, Hrvatska sveučilišna naklada, Zagreb, 2001.
2. N. Injac, Okoliš i njegova zaštita, OSKAR, Zagreb, 2004.
3. M. Omerović, Problemi zaštite okoline u proizvodnji i preradi metala, I dio, Dom štampe, Zenica, 1991.

Optional literature:

1. T. E. Graedel, B. R. Allenby, Industrial Ecology, Pearson Education, Inc., New Jersey, 2003.
2. A-M. Bašnec, V. Kopun, Priručnik– Procjena stanja okoliša u gospodarskim subjektima, Kopun, Zagreb, 2004.

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.

Name of the course: ENGLISH LANGUAGE I AND II

ISVU code: 150651; 150659

Status of the course: compulsory

Year of study: 1

Semester: 1 and 2

Credit value (ECTS): 3

Type of instruction (number of hours L+S+E+e-learning): 1+0+1+1

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: ability of spoken communication using professional language, ability of written communication using professional language, understanding professional language, ability to apply grammatical structures and principles typical for the professional language

Enrolment requirements and required entry competences for the course: second language, teamwork, ability to communicate with non-experts, ability to work in an international environment.

Learning outcomes at the level of the study programme to which the course contributes: knowledge of general and professional English.

Expected learning outcomes at the level of the course: compare and contrast general and professional English based on selected texts and topical units, recognize and explain grammatical structures and principles typical for professional language in examples (verb tenses, definite and indefinite articles, comparison of adjectives, relative clauses), apply grammatical structures and aspects in writing exercises, formulate a text summary, arguments and definitions in writing.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: The contents of the course are designed so as for the four language learning skills to be equally represented: reading, writing, listening, speaking. Linguistic text analysis through questions and answers (6); critical reading of different texts and passages (6); text analysis (2); taking notes and writing summaries (5); writing short essays (3); differentiating between formal and informal writing styles (1); proofreading (1); oral presentation (6).
Exercises: translating professional texts from the field of casting (20); communication (10).

Type of instruction: lectures and exercises; ICT assisted teaching

Student responsibilities: attendance (over 80 % of lectures and exercises), written and oral exam

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance and participation (0.4 ECTS), written exam (1.3 ECTS), oral exam (1.3 ECTS)

Grading and evaluation of student work over the course of instruction and at a final exam: during classes, students' attendance and participation is evaluated. Operative course plan details student evaluation at classes, in written and oral exams and calculating the final grade.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Compare and contrast general and professional English based on selected texts and topical units	Practising on examples, communication in foreign language in class
2.	Recognize and explain grammatical structures and principles typical for professional language in examples (verb tenses, definite and indefinite articles, comparison of adjectives, relative clauses)	Practising on examples, communication in foreign language in class
3.	Apply grammatical structures and aspects in writing exercises	Practising on examples, communication in foreign language in class
4.	Formulate a text summary, arguments and definitions in writing	Practising on examples, communication in foreign language in class

Required literature:

1. L. Šestić, English for Metallurgists, Zenica, 1985.
2. E.D. Zemach, A.L. Rumisek, Academic Writing from Paragraph to Essay, Macmillan, 2003.
3. J. van Emden, Effective Communication for Science and Technology, Palgrave Publishers Ltd, 2001.

Optional literature:

1. Recent news in metallurgy from the internet (student-selected texts).

Methods of monitoring quality that ensure acquisition of exit competences: employer questionnaires, graduates' questionnaire (according to Quality Regulations as a section of the Quality System Regulations of the Faculty of Metallurgy of the University of Zagreb).

Name of the course: FUNDAMENTALS OF MODELING IN FOUNDING

ISVU code: 157499

Status of the course: elective

Year of study: 3

Semester: 5

Credit value (ECTS): 4

Type of instruction (number of hours L+S+E+e-learning): 2+0+1+1

Expected enrolment in the course: 15

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 3.0 %

Course objectives: introduction to fundamental ideas and methods from the area of solidification modelling of castings.

Enrolment requirements and required entry competences for the course: the knowledges from the courses: Fundamentals of solidification and microstructure development, Heating technology, Technology of making molds and cores, Melting technology and quality control of the melt, Casting technology of ferrous metals, Casting technology of nonferrous metals, Designing of gating and feeding systems, Application of information technologies in founding.

Learning outcomes at the level of the study programme to which the course contributes: compare the success of mathematical models of solidification of castings with concrete results from practice, explain and understand the casting process and solidification of metal castings in expendable and permanent moulds, construct and calculate the horizontal and vertical gating system for the casting of ferrous and non-ferrous alloys, construct and calculate feeding system for ferrous and non-ferrous casting alloys.

Expected learning outcomes at the level of the course: show knowledge about fundamental principles of mathematical methods for modelling of solidification and microstructures of castings, develop mathematical model of solidification of casting of simple geometrical shape, comparison of mathematical models of solidification of casting with real results in practice.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Introduction in mathematical modelling and presentation of computer programs for solidification of castings (2); Methods of modelling: method of analog modelling, method of finite difference, method of finite element, method of pseudostationary state (10); Examination of explicit and implicit methods of finite difference (4); Implicit alternation direction method and Saulyev explicit method (4); Method of prediction of shrinkage in

castings (3); Semiquantative model of hot tears (2), Modelling of microstructure of castings (3); Computer optimization of casting construction (2).
Exercises: Mathematical models of solidification of real castings of steel, gray iron and nonferrous metals (6); Mathematical models of solidification of castings of L, T and H shape, blank gear, flange, valve, railway wheel, cylinder, sphere (9).

Type of instruction: lectures, exercises, ICT.

Student responsibilities: attendance to lectures and exercises (> 70.0 %).

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): attendance (0.5 ECTS), colloquiums (2.0 ECTS), oral exam (1.5 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: attendance and activity of students to class and results of colloquiums. By the plan of subject in detail is prescribed evaluation of student activity through class, colloquium and oral exam and incorporated in final grade.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Show knowledge about fundamental principles of mathematical methods for modelling of solidification and microstructures of castings	Colloqium, oral exam
2.	Develop mathematical model of solidification of casting of simple geometrical shape	Auditory exercises, colloquium
3.	Comparison of mathematical models of solidification of casting with real results in practice	Auditory exercises, oral exam

Required literature:

1. B. Carnahan, H. A. Luther, J. O. Wilkes, Applied Numerical Methods, John Wiley, New York, 1969.
2. P. R. Sahm, P. N. Hansen, Numerical Simulation and Modeling of Casting and Solidification Processes for Foundry and Cast-Jouse, CIATF, 1984.

Optional literature:

1. G. D. Smith, Numerical Solution of Partial Differential Equations, University Press, Oxford, 1974.

Methods of monitoring quality that ensure acquisition of exit competences: employer questionnaires, graduates' questionnaire (according to Quality Regulations as a section of the Quality System Regulations of the Faculty of Metallurgy of the University of Zagreb).

Name of the course: FUNDAMENTALS OF PHYSICAL METALLURGY

ISVU code: 150652

Status of the course: compulsory

Year of study: 1

Semester: 2

Credit value (ECTS): 6

Type of instruction (number of hours L+S+E+e-learning): 3+1+0+1

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 3.0 %

Course objectives: knowledge of a crystal structure, ability to use phase diagrams, understanding the conversion process in metal materials, knowledge of a microstructure constituents in cast metallic materials, ability to analyze microstructure of cast metallic materials and its impact on properties

Enrolment requirements and required entry competences for the course: the subject matter of General and Inorganic Chemistry

Learning outcomes at the level of the study programme to which the course contributes: use phase diagrams, explain the mechanism of eutectic, peritectic and eutectoid reaction, explain phase transformations in ferrous and non-ferrous casting alloys, explain and understand the casting process and solidification of metal castings in expendable and permanent moulds.

Expected learning outcomes at the level of the course: distinguish and explain the crystal structures metals, explain solid solutions and intermetallic compounds, explain defects in the crystal lattice, distinguish the aggregate states of metals, use the equilibrium phase diagrams, use the phase diagrams, apply the phases rule, explain the eutectic, peritectic and eutectoid reaction, distinguish the microstructural constituents in ferrous and aluminium alloys, describe the mechanical and physical properties of metals.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: The structure of the atom and the bonding of metal atoms (1); Crystal structures of metals and alloys (2); Basic structural types of metals and alloys (1); Solid solutions (2); Intermetallic compounds (2); Deffects in the crystal lattice (2); Aggregate metal states and their transformations (2); Equilibrium phase diagrams (2); Phase transformations (3); Phase Rule (1); Diffusion in metals (1); Interfaces (2); Eutectic and peritectic binary system (3); Reactions in solid state (3); Solvents from solid solutions (2); Eutectoid transformation (2); Phase diagram of iron-carbon (4); Phase diagram of aluminium-silicon (4); Microstructural

constituents (4); Physical properties of metals (1); Mechanical properties of metals (1). Seminar work: Learn in detail about phase transformation in ferrous and aluminium alloys, mechanisms of eutectic, peritectic and eutectoid reactions (5). Making a seminar paper about above themes (10).

Type of instruction: lectures and seminar work, teaching by ICT.

Student responsibilities: students have to attend lectures (> 70.0 %) and work out a seminar paper.

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 ECTS), seminar paper (1.0 ECTS), colloquiums (2.5 ECTS), oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: during the course, the attendance and activity of the students in the teaching, the seminar paper and the results at the colloquia are evaluated. The performance plan of the subject explains in details the evaluation of students' activities during lectures, seminars, colloquia and oral exams and the calculation in the final grade of the subject as well.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Distinguish and explain the crystal structures metals	1st colloqium, seminar paper
2.	Explain solid solutions and intermetallic compounds	1st colloqium, seminar paper
3.	Explain defects in the crystal lattice	1st colloqium, seminar paper
4.	Distinguish the aggregate states of metals	2nd colloquium, seminar paper
5.	Use the equilibrium phase diagrams	2nd colloquium, seminar paper
6.	Use the phase diagrams	2nd colloquium, seminar paper
7.	Apply the phases rule	2nd colloquium, seminar paper
8.	Explain the eutectic, peritectic and eutectoid reaction	3rd colloqium, seminar paper
9.	Distinguish the microstructural constituents in ferrous and aluminium alloys	3rd colloqium, seminar paper
10.	Describe the mechanical and physical properties of metals	3rd colloqium, seminar paper

Required literature:

1. T. Matković, P. Matković, Fizikalna metalurgija I, nastavni tekst postavljen na internet stranicu Metalurškog fakulteta, Sisak, 2005.
2. J. D. Verhoeven, Fundamentals of Physical Metallurgy, John Wiley & Sons, New York, 1975.

Optional literature:

1. R. W. Cahn, P, Haasen, Physical Metallurgy, North-Holland, Amsterdam, 1996.

Methods of monitoring quality that ensure acquisition of exit competences: Employee questionnaire, questionnaire of completed students (according to the Quality Manual, which is an integral part of the Rule Book on Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: FUNDAMENTALS OD SOLIDIFICATION AND MICROSTRUCTURE DEVELOPMENT

ISVU code: 157125

Status of the course: compulsory

Year of study: 2

Semester: 3

Credit value (ECTS): 6

Type of instruction (number of hours L+S+E+e-learning): 3+0+1+1

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: understanding the solidification process of iron and steel, understanding the solidification process of Al-SI alloys, understanding the effect of inoculation and modification on the casting microstructure, the ability to analyze the influence of the chemical composition and solidification conditions on the microstructure and properties of the castings.

Enrolment requirements and required entry competences for the course: knowledge gained within the subjects of Fundamentals of physical metallurgy and Thermodynamics and kinetics of metallurgical processes.

Learning outcomes at the level of the study programme to which the course contributes: explain and understand process of casting and solidification of metal castings in expendable and permanent moulds, relate microstructure and properties of castings, relate the chemical composition, metallurgical quality of melt and conditions during solidification with the obtained microstructure and properties of castings, use phase diagrams.

Expected learning outcomes at the level of the course: explain the mass and heat transfer as well as phenomena associated with the solidification process of the casting, describe solidification of iron, steel and aluminium alloy solidification, relate the microstructural and usability properties of castings, relate the chemical composition and solidification conditions with resulting microstructure and utilization properties of the castings.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Liquid and solid state (1); Atomic mobility (1); Heat release (1); Heat transfer during solidification (2); Mass and energy transmission (2); Boundary surface solid/liquid (2); Solubility reduction (1); Nucleation (2); Crystal growth (2); Micro and macro segregation (3); Fe-C eutectics (4); Al-Si eutectics (3); Effects of inoculation and modification (3); Solidification of Cast Iron (4); Solidification of white iron castings (3); Solidification of steel (3); Solidification of Al-Si alloy (4); Quantification of primary microstructure parameters (2);

Impact of melt composition and conditions on solidification microstructural features and utilization properties of castings (2).

Type of instruction: lectures and exercises, teaching with the help of ICT.

Student responsibilities: students must attend lectures and exercises (> 70.0 %).

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 ECTS), colloquium (3.0 ECTS), oral exam (2.5 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students at the lectures and the results on the colloquia are evaluated during the course. The performance plans of the subject details the evaluation of students' activities during classes, on colloquia and oral exams, and is calculated in the final grade of the subject.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Explain the mass and heat transfer as well as phenomena associated with the solidification process of the casting	Colloquium
2.	Describe solidification of iron, steel and aluminium alloy solidification	Colloquium
3.	Relate the microstructural and usability properties of castings	Colloquium
4.	Relate the chemical composition and solidification conditions with resulting microstructure and utilization properties of the castings	Colloquium

Required literature:

1. …, Metals Handbook, Volume 15, Casting, ASM International, Metals Park Ohio, 2008.
2. J. E. Gruzleski, Microstructure Development During Metalcasting, AFS, Des Plaines, Illinois, 2000

Optional literature:

1. J. E. Gruzleski, B. M. Closset, The Treatment of Liquid Aluminium-Silicon Alloys, AFS, Des Plaines, Illinois, 1990.
2. G. Krauss, Steels – Processing, Structure and Performance, ASM International, Materials park, Ohio, 2005.

Methods of monitoring quality that ensure acquisition of exit competences: Employee Testing, Graduated Students testing (according to the Quality Manual that forms an integral part of the Rule Book on Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: FURNACES IN FOUNDING AND REFRACTORY MATERIALS

ISVU code: 157126

Status of the course: compulsory

Year of study: 2

Semester: 3

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 3+0+1+1

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 1.5 %

Course objectives: understand the principle of work of cupola, induction, flame, electric arc and electric resistance furnaces, the ability to select the appropriate refractory material for smelting aggregates and heating aggregates used in casting

Enrolment requirements and required entry competences for the course: knowledge gained within the framework of courses General and inorganic chemistry and Heating technology.

Learning outcomes at the level of the study programme to which the course contributes: explain heat transfer during melting and heating in foundry aggregates, explain the principle of operation of cupola, induction, electric arc and reverberatory furnace, analyse melting aggregate performance and optimize the melting process, distinguish types of refractory materials, use refractory materials depending on their properties.

Expected learning outcomes at the level of the course: explain the principle of work of cupola, induction, flame, electric arc and electric resistance furnace, analyze the technological parameters of a melting process and optimize the melting process, distinguish the types of refractory materials, propose an adequate type of refractory materials depending on the application conditions.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Division of foundry furnaces depending on the purpose, the place of use, and the heating mode (2); Cupola furnaces (3), Induction furnaces (4), Open flame furnaces (3), Electric arc furnaces (3); Electric resistance furnaces (1); Furnace for maintaining the melt temperature (holding furnaces) (2); Burners (2); Optimization of heating and melting process (3); Definition and meaning of refractory material (2);Oxide and non-oxide materials, shaped and unshaped refractory materials (9); Properties, methods of testing the properties of refractory materials (3); Application of refractory materials in cast iron (8).

Exercises: Calculation examples of the dimensioning of furnace walls, design of the furnace operating space and process control in furnaces (4); Project tasks (2); Determination of properties of refractory materials (3); Operating exercises (6).

Type of instruction: lectures and exercises, teaching with the help of ICT.

Student responsibilities: students must attend lectures and exercises (> 70.0 %).

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): teaching attendance (0.5 ECTS), colloquium (2.5 ECTS), oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students in the teaching and the results on the colloquia are valued during the course. Detailed evaluation of student activities during classes, in colloquia and oral exams and in the final calculation grade of the course by the expected learning outcomes at the level of the course were prescribed.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Explain the principle of work of cupola, induction, flame, electric arc and electric resistance furnace	colloquium, oral exam
2.	Analyze the technological parameters of a melting process and optimize the melting process	colloquium, oral exam
3.	Distinguish the types of refractory materials	colloquium, oral exam
4.	Propose an adequate type of refractory materials depending on the application conditions	colloquium, oral exam

Required literature:

1. …, Metals Handbook, Volume 15, Casting, ASM International, Metals Park, Ohio, 2008.
2. A. Rađenović, Vatrostalni materijali, Metalurški fakultet Sveučilišta u Zagrebu, Sisak, 2010.

Optional literature:

1. D. Jovanović, Z. Popović, Peći u metalurgiji gvožđa i čelika, Univerzitet u Beogradu, 1970.
2. J. H. Chasters, Refractories – Production and Properties, Edward Arnold, London 1973.

Methods of monitoring quality that ensure acquisition of exit competences: Employee Examination, Examination of completed students (according to the Quality Manual that is a

component Part of the Rulebook on Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: GENERAL AND INORGANIC CHEMISTRY

ISVU code: 150647

Status of the course: compulsory

Year of study: 1

Semester: 1

Credit value (ECTS): 7

Type of instruction (number of hours L+S+E+e-learning): 3+0+2+0

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: course objective is acquiring of basic knowledge and understanding of basic principles in the field of general and inorganic chemistry. Focus is on the ensembles that are the basis for the understanding of specialized subjects in the field of casting metal materials.

Enrolment requirements and required entry competences for the course: chemistry subject matter from secondary school.

Learning outcomes at the level of the study programme to which the course contributes: analyse the chemical reactions that take place during melting and casting, explain the properties of chemical elements based on their position in the periodic system, explain and understand the casting process and solidification of metal castings in expendable and permanent moulds.

Expected learning outcomes at the level of the course: interpret atom structure, identify the type of chemical bond, define state of aggregation, distinguish and describe the types of chemical reactions, distinguish types of solutions, explain the influence of various factors on kinetics of chemical reactions, explain the chemical equilibrium, classify elements in periodic table of elements.

Course content broken down in detail by weekly class schedule (syllabus): Lectures (45): substances (2); structure of pure substances (2); aggregate states (2); structure of atom (1); type of chemical bonds (2); complex compounds (2); solutions (2); chemical reactions (3); chemical kinetics (2); chemical equilibrium (2); chemical reactions energy changes (2); periodic table of elements - properties of elements and their compounds (12); properties of metals and nonmetals (11).
Exercises (30): stoichiometry (2); separation of components in heterogeneous and homogeneous mixture (4); determination of relative atomic mass (3); preparation of complex

compound (4); neutralization titrations (2); solutions (4); types of chemical reactions (3); kinetics of chemical reactions (3); different properties of metals and nonmetals (5).

Type of instruction: lectures and exercises.

Student responsibilities: attendance a minimum of 70.0 % lectures. Successfully finished laboratory exercises.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (1 ECTS), experimental work and colloquium (3 ECTS), oral exam (3 ECTS).

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, colloquiums and oral exam.

Monitoring of the achievement of learning outcomes at the level of the course

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	interpret atom structure	1st colloquium, oral exam
2.	identify the type of chemical bond	1st colloquium, laboratory exercises, oral exam
3.	define state of aggregation	1st colloquium, oral exam
4.	distinguish and describe the types of chemical reactions	1st colloquium, oral exam
5.	distinguish types of solutions	1st colloquium, oral exam
6.	explain the influence of various factors on kinetics of chemical reactions	2nd colloquium, laboratory exercises, oral exam
7.	explain the chemical equilibrium	2nd colloquium, laboratory exercises, oral exam
8.	classify elements in periodic table of elements	2nd colloquium, laboratory exercises, oral exam

Required literature:

1. D. Hršak, Opća kemija, Teaching material posted on the website of the Faculty of Metallurgy, 2009.
2. A. Rađenović, Anorganska kemija, Teaching material posted on the website of the Faculty of Metallurgy, 2009.
3. A. Rađenović, A. Štrkalj, Vježbe iz anorganske kemije, Teaching material posted on the website of the Faculty of Metallurgy, Sisak, 2009.

Optional literature:

1. I. Filipović, S. Lipanović, Opća i anorganska kemija, I i II dio, Školska knjiga, Zagreb, 1995.

Methods of monitoring quality that ensure acquisition of exit competences: employer poll, graduate students poll.

Name of the course: HEAT TREATMENT

ISVU code: 157133

Status of the course: compulsory

Year of study: 2

Semester: 4

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+0+0+1

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: understanding of the effect of alloying elements on the parameters and results of heat treatment, ability define parameters of annealing, normalization, quenching, tempering and decreased stresses of steel casting and gray iron casting, define of parameters heat treatment white iron casting, define parameters of heat treatment aluminium casting.

Enrolment requirements and required entry competences for the course: knowledge obtained into colegium Basic phisical metallurgy, Thermodinamic and konetics of metallurgical processes, Heat technique, Fundament of solidifaction, Technology casting iron metals, Technology casting of non-ferous metals

Learning outcomes at the level of the study programme to which the course contributes: define the parameters of heat treatment of ferrous and aluminium casting alloys, distinguish microstructural constituents in ferrous and non-ferrous alloys, use phase diagrams, relate microstructure and properties of castings.

Expected learning outcomes at the level of the course: recognize of phase and structures into ferrous and non-ferrous alloys, explain the effect of alloying elements on the microstructure and properties of ferrous and non-ferrous alloys, define parameters of annealing, normalization, quenching and tempering of steel castings as well as elimination of stresses depending from chemical composition structure and requirements properties, define parameters of annealing, normalization, quenching and tempering of iron castings with graphite as well as elimination of stresses depending from chemical composition structure and requirements properties, define heat treatment parameters of white iron casting depending from chemical composition, structure and requirements properties, define heat treatment parameters of aluminium casting depending from chemical composition, structure and requirements properties.

Course content broken down in detail by weekly class schedule (syllabus): Phase and structure (4); Decomposition of austenite (2); Effect of alloying elements (3); Heat treatment

steel castings: annealing, normalization, hardenability, quenching, tempering, elimination of stresses (6); Heat treatment of ferrous casting with graphite: elimination of stresses, annealing, normalization, quenching, tempering (5); Heat treatment of temper castings (1), Heat treatment of white iron castings (3), Heat treatment of aluminium castings (6).

Type of instruction: lectures and teaching using ICT.

Student responsibilities: students must attend over 70.0 % of lectures.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): attendance (0.5 ECTS), colloquiums (2.5 ECTS), oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: during the course the attendance and activity of students in the teaching and results of colloquiums. The performance plan of the subject details the evaluation of students' activities during classes, colloquiums and oral exams and the calculation of the final grade of the subject.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Recognize of phase and structures into ferrous and non-ferrous alloys	Colloquiums and oral exam
2.	Explain the effect of alloying elements on the microstructure and properties of ferrous and non-ferrous alloys	Colloquiums and oral exam
3.	Define parameters of annealing, normalization, quenching and tempering of steel castings as well as elimination of stresses depending from chemical composition structure and requirements properties	Colloquiums and oral exam
4.	Define parameters annealing, normalization, quenching and tempering of iron castings with graphite as well as elimination of stresses depending from chemical composition structure and requirements properties	Colloquiums and oral exam
5.	Define heat treatment parameters of white iron casting depending from chemical composition, structure and requirements properties	Colloquiums and oral exam
6.	Define heat treatment parameters of aluminium casting depending from chemical composition, structure and requirements properties	Colloquiums and oral exam

Required literature:

1. …, Metals Handbook, Volume 15, Casting, ASM International, Metals Park Ohio, 2008.
2. D. Krumes, Toplinska obradba, Strojarski fakultet, Slavonski Brod, 2000.

Optional literature:

1. G. Krauss, Principles of Heat Treatment of Steel, ASM, Metals Park, Ohio, 1980.
2. R. Elliott, Cast Iron Technology, Butterwort & Co, London, 1988.
3. …, Aluminium Casting Technology, AFS, Des Plaines, Illinois, 2001.

Methods of monitoring quality that ensure acquisition of exit competences: Employee examination, Examination of students (according to the Quality Manual that forms an integral part of the Rulebook of Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: HEATING TECHNOLOGY

ISVU code: 150656

Status of the course: compulsory

Year of study: 1

Semester: 2

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+0+2+1

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 1.5 %

Course objectives: understand the basic physical and chemical laws that govern the process of combustion and heat transfer, the ability to optimize the heating and melting processes.

Enrolment requirements and required entry competences for the course: knowledge gained in the courses General and inorganic chemistry and Physics.

Learning outcomes at the level of the study programme to which the course contributes: explain heat transfer during melting and heating in foundry aggregates, analyse melting aggregate performance and optimize the melting process.

Expected learning outcomes at the level of the course: explain the combustion processes of solid and gaseous fuels in foundry aggregates, explain the heat transfer at heating and melting in foundry aggregates, describe the process of melting of solid input materials in induction and electric arc furnaces using electricity, analyze energy utilization during heating and melting, optimize the heating and melting process.

Course content broken down in detail by weekly class schedule (syllabus): General considerations concerning the requirements and heating technology processes in furnaces applicable in casting (3); Heat and temperature (2); Fuel (2); Combustion (2); Combustion thermodynamics (3); Burners (2); Gas analysis (2); Heating process (3); Electric energy as heat source for heating and melting (2); Heat Transfer (3); Useful heat and heat losses (1); Optimization of heating and melting process (3); Use of flue gas heat (2).
Exercises: Calculation examples from industrial practice related to heat transfer processes during melting (15); Calculation examples from industrial practice related to heat transfer processes during heating (15).

Type of instruction: lectures and exercises, teaching with the help of ICT.

Student responsibilities: students must attend lectures and exercises (> 70.0 %).

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): teaching attendance (0.5 ECTS), colloquiums (2.5 ECTS), oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students in the teaching and the results on the colloquia are valued during the course. Detailed evaluation of student activities during classes, in colloquia and oral exams and in the final calculation grade of the course by the expected learning outcomes at the level of the course were prescribed.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Explain the combustion processes of solid and gaseous fuels in foundry aggregates	colloquium, oral exam
2.	Explain the heat transfer at heating and melting in foundry aggregates	colloquium, oral exam
3.	Describe the process of melting of solid input materials in induction and electric arc furnaces using electricity	colloquium, oral exam
4.	Analyze energy utilization during heating and melting	colloquium, oral exam
5.	Optimize the heating and melting process	colloquium, oral exam

Required literature:

1. W. Lehnert, Toplotehničke osnove za industrijske peći, Metalurški fakultet, Sisak, 2001
2. …, Foundry Energy Management, AFS, Des Plaines, Illinois, 1982.

Optional literature:

1. J. Ward, R. Collin, Industrial Furnace Technology, University of Glamorgan, 2003.
2. …, Ljevački priručnik, Savez Ljevača Hrvatske, Zagreb, 1985.

Methods of monitoring quality that ensure acquisition of exit competences: Employee Examination, Examination of completed students (according to the Quality Manual that is a component Part of the Rulebook on Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: INTRODUCTION TO ENTREPRENEURSHIP

ISVU code: 150649

Status of the course: compulsory

Year of study: 1

Semester: 1

Credit value (ECTS): 3

Type of instruction (number of hours L+S+E+e-learning): 2+1+0+1

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 1.5 %

Course objectives: to introduce the students in the basic concepts of entrepreneurship.

Enrolment requirements and required entry competences for the course: high school education in the field of economy and enterprise organization and entrepreneurship.

Learning outcomes at the level of the study programme to which the course contributes: analyse company business results.

Expected learning outcomes at the level of the course: define the basic elements for the establishment and organization of companies (market analysis, idea, location, financing, business plan), design marketing companies, analyze company business results (income and expense, cost price, profit / loss, financial flow, profitability of enterprises).

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Advantages and disadvantages of legal forms of entrepreneurship (2); Business results of the company: income and expense, cost price, profit / loss account, balance sheet, financial flow, profitability of enterprises, reproduction ability of enterprises (8); Entrepreneurial venture: types of entrepreneurial venture (buying an existing job, launching a new job), marketing of entrepreneurship (exploration of business opportunities, market analysis, location), financing (calculation and planning, working capital, sources of funding and financial environment of the enterprise); Investment program (Business Plan): Concept of business plan, Business plan content, Business plan design methodology (6); Creating a business plan (Exemplary examples) (3); Enterprise management (3).
Seminar paper: More detailed introduction to entrepreneurship in developed countries, planning, investment programs, business plan, pricing, performance benchmarking (5). Seminar work from the mentioned areas (10).

Type of instruction: Lectures and seminar work, ICT.

Student responsibilities: students must attend over 70 % of lectures and are required to complete a seminar in writing form and orally present.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): attendance (0.3 ECTS), seminar work (0.7 ECTS), oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: during the course the attendance and activity of students in the teaching and seminar work is evaluated. The performance plan of the subject details the evaluation of students activities during classes, seminars and oral exams and the calculation of the final grade of the subject.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Define the basic elements for the establishment and organization of companies (market analysis, idea, location, financing, business plan)	1st colloquium
2.	Design marketing companies	1st colloquium
3.	Analyze company business results (income and expense, cost price, profit / loss, financial flow, profitability of enterprises)	1st colloquium, 2nd colloquium, seminar work

Required literature:

1. I. Vajić, Management i poduzetništvo, Centar za poduzetništvo Zagreb, 1994.
2. F. Ruža, V. Veselica, Ekonomika poduzeća, Varaždin 2002.

Optional literature:

1. P. Sikavica, M. Novak, Poslovna organizacija, Informator, Zagreb, 1999.
2. V. Žanić, Vodič za poduzetnike, Ministarstvo gospodarstva RH, Zagreb, 1999.
3. V. Brkanić i sur., Računovodstvo poduzetnika, Zagreb 2008.

Methods of monitoring quality that ensure acquisition of exit competences: Employee examination, Examination of students (according to the Quality Manual that forms an integral part of the Rulebook of Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: MATERIALS TESTING

ISVU code: 157134

Status of the course: compulsory

Year of study: 2

Semester: 4

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+0+2+1

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 3.0 %

Course objectives: mastering the basic methods of technical, technological and non-destructive testing of castings, ability to analyse the results of test of casting properties and connection with chemical composition and microstructural properties, ability to analyse defects in castings on the basis of test results.

Enrolment requirements and required entry competences for the course: knowledge of the type and properties of ferrous and non-ferrous castings and the place of application.

Learning outcomes at the level of the study programme to which the course contributes: analyse the results of the examination of the mechanical properties of metallic materials, analyse the results of non-destructive methods of testing metallic materials, relate microstructure and properties of castings.

Expected learning outcomes at the level of the course: define the mechanical and physical properties of metal materials, define the methodology for sampling, choose the appropriate method for testing the properties of metal materials and detecting errors in the castings, analyse the test results of the examination of the mechanical propreties of metallic materials, analyse the test results of non-destructive methods of testing of metallic materials, recommend corrective actions in the production process in order to achieve the prescribed properties of castings.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Physical and physicochemical properties of materials on which the instrumental methods of analysis are based (2); Sampling (1); Mechanical testing: short-term static tests (tensile, compressive, flexural and torsional testing), long-term static tests (creep testing), short-term dynamic testing (impact toughness), long-term tests (material fatigue), testing hardness of materials (10); Technological testing (2); Non-destructive testing (2); Defects in metal materials (2); Optical testing (endoscopy and boroscopy) (1); Radiographic testing (2);

Ultrasonic testing (2); Magnetic testing (1); Dye penetration testing (1); Standards for testing materials properties (4).
Exercises: Static tensile testing (4); Determination of impact toughness (3); Hardness testing (3); Technological testing (2); Optical (endoscopic and boroscopic) testing (1); Magnetic testing (2); Ultrasonic testing (3); Dye penetration testing (2); Visit to industrial plants and introduction to the applied test methods (10).

Type of instruction: lectures and exercises, ICT teaching.

Student responsibilities: attendance at lectures (> 70.0 %) and complete exercises.

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 ECTS), colloquiums (2.5 ECTS), oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: during the course it is evaluated the presence and activity of students in class and the results of the colloquiums. With implementation plan of course it is prescribed in details the evaluation of student activities during class, at colloquiums and oral exam and impute in the final assessment of the course.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Define the mechanical and physical properties of metallic materials	1st colloquium, written exam, oral exam
2.	Define the methodology for sampling	1st colloquium, written exam, oral exam
3.	Choose the appropriate method for testing the properties of metal materials and detecting errors in the castings	2nd and 3rd colloquium, written exam, oral exam
4.	Analyse the test results of the examination of the mechanical properties of metallic materials	Exercises 2-6
5.	Analyse the results of non-destructive methods of testing metallic materials	Exercises 7-10
6.	Recommend corrective actions in the production process in order to achieve the prescribed properties of castings	3rd colloquium, written exam, oral exam

Required literature:

1. S. Rešković, Ispitivanje materijala, website of the Faculty of Metallurgy, Sisak, 2009.
2. I. Vitez, Ispitivanje mehaničkih svojstava metalnih materijala, Josip Juraj Strossmayer, University of Osijek, SFSB, Slavonski Brod, 2006.

Optional literature:

1. M. Franz, Mehanička svojstva materijala, FSB, Zagreb, 1998.

2. V. Krstelj, Ultrazvučna kontrola, FSB, Zagreb, 2003.

Methods of monitoring quality that ensure acquisition of exit competences: employer's examination, examination of graduate students (according to the Quality manual that forms an integral part of the Rulebook on quality assurance and improvement at the Faculty of Metallurgy, University of Zagreb).

Name of the course: MATHEMATICS

ISVU code: 150645

Status of the course: compulsory

Year of study: 1

Semester: 1

Credit value (ECTS): 6

Type of instruction (number of hours L+S+E+e-learning): 3+0+2+2

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 2

Percentage of instruction in the course on line: 10.0 %

Course objectives: acquiring basic knowledge and techniques from mathematical analysis necessary in other professional courses and practical application

Enrolment requirements and required entry competences for the course: high school knowledge

Learning outcomes at the level of the study programme to which the course contributes: developing the ability to perform logical conclusion and precision in research

Expected learning outcomes at the level of the course: define a mathematical problem, understand some mathematical theorems, translate into mathematical language simple problems and solve them, solve simple mathematical problems, solve the system of linear equations, statistically analyze the data from the practice

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Functions: numbers, real functions of real variables, sequences, series (15); Linear algebra: matrix, determinant, systems of linear equations, line and plane in the rectangular coordinate system (15); Statistics: Basic set and pattern, empirical distribution, correlation (15).
Exercises: Exercises are used to solve the tasks from the above mentioned material (30).

Type of instruction: lectures and exercises, mixed classes.

Student responsibilities: students must attend lectures and exercises (> 70.0 %).

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): colloquiums (2 ECTS), written exam (2 ECTS), oral exam (2 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the performance plan of the subject details the evaluation of the students on the colloquia, oral and written exams and the calculation of the final grade of the subject.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Define a mathematical problem	Oral exam
2.	Understand some mathematical theorems	Oral exam
3.	Translate into mathematical language simple problems and solve them	Colloquiums, written exam
4.	Solve simple mathematical problems	Colloquiums, written exam
5.	Solve the system of linear equations	Colloquiums, written exam
6.	Statistically analyze the data from the practice	Colloquiums, written exam

Required literature:

1. T. Bradić, J. Pečarić, R. Roki, M. Strunje, Matematika za tehnološke fakultete, Element, Zagreb, 1998.
2. S. Kurepa, Matematička analiza 1, Tehnička knjiga, Zagreb, 1990.
3. S. Kurepa, Matematička analiza 2, Tehnička knjiga, Zagreb, 1990.
4. I. Šošić, V. Serdar, Uvod u statistiku, Školska knjiga, Zagreb, 2002.

Optional literature:

1. S. Kurepa, Uvod u matematiku, Tehnička knjiga, Zagreb, 1984.
2. V. P. Minorski, Zbirka zadataka iz više matematike, Tehnička knjiga, Zagreb, 1971.
3. N. Elezović, A. Aglić, Linearna algebra, Zbirka zadataka, Zagreb, 1999.
4. B. P. Demidovič, Zadaci i riješeni primjeri iz više matematike s primjenom na tehničke nauke, Tehnička knjiga, Zagreb, 1986.

Methods of monitoring quality that ensure acquisition of exit competences: Examination of employers, Examination of graduated students (according to the Quality manual that is integral part of the Rulebook on quality system of the Faculty of Metallurgy, University of Zagreb).

Name of the course: **MELTING TECHNOLOGY AND QUALITY CONTROL OF THE MELT**

ISVU code: 157127

Status of the course: compulsory

Year of study: 2

Semester: 3

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 3+0+2+0

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: ability to define melting technology in cupola, induction, reverberatory and electric arc furnaces, the ability to calculate the composition and structure of charge for melting furnaces in foundries, ability to determine the chemical composition and melt quality (thermal analysis, wedge test piece, oxygen content).

Enrolment requirements and required entry competences for the course: the knowledge acquired in the courses of Fundamentals of physical metallurgy, Thermodynamics and kinetics of metallurgical processes and Heating technology.

Learning outcomes at the level of the study programme to which the course contributes: explain the principle of operation of cupola, induction, electric arc and reverberatory furnace, select charge materials for melting aggregate according to the type of casting alloy that would be produced and the prescribed properties of castings, define the melting technology in cupola, induction, electric arc and reverberatory furnaces, examine the chemical composition and metallurgical quality of the melt, apply thermal analysis in melt quality control system.

Expected learning outcomes at the level of the course: select charge materials for melting aggregate according to the type of casting alloy that would be produced and the prescribed properties of castings, define the melting technology in cupola, induction, electric arc and reverberatory furnaces, select the appropriate inoculant and treatment alloy, examine the chemical composition and metallurgical quality of the melt, determine the melt processing conditions based on chemical composition and metallurgical quality of the melt.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Charge materials (3); Processes during melting (3); Melting technology in cupola (4); Desulphurization of the melt (2); Melting technology in induction furnaces (5); Inoculation of the melt (4); Melting technology in electric arc furnaces (4); Melting technology in reverberatory furnaces (4); Chemical composition analysis (2); Metallurgical quality of the

(3); Thermal analysis (3); Determination of the oxygen content in the melt (2); Systems for quality control of the melt (3); Control of chilling tendency of cast irons (2); Testing of the castability of the melt (1).
Exercises: Thermal analysis of gray cast irons (4); Thermal analysis of Al-Si casting alloys (4); Interpretation of the cooling curves (3); Connection of thermal parameters, microstructural features and properties of casting (3); Determination of oxygen content in gray cast irons melts (3); Analysis of chemical composition (2); Calculation of the charge for the melting furnaces (4); Visit to foundries of ferrous and non-ferrous castings (7).

Type of instruction: lectures and exercises, ICT teaching.

Student responsibilities: students must attend lectures and exercises (> 70.0 %).

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (0.5 ECTS), colloquiums (2.5 ECTS), and oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students in the classes and the results of the colloquiums are evaluated. The performance plan of teaching specifies in detail the evaluation of student activities during classes, grading of colloquiums and oral exam, and determining the final grade.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Select charge materials for melting aggregate according to the type of casting alloy that would be produced and the prescribed properties of castings	1st colloquium, 2nd colloquium, oral exam
2.	Define the melting technology in cupola, induction, electric arc and reverberatory furnaces	1st colloquium, 2nd colloquium, oral exam
3.	Select the appropriate inoculant and treatment alloy	1st colloquium, 2nd colloquium, oral exam
4.	Examine the chemical composition and metallurgical quality of the melt	1st colloquium, 2nd colloquium, oral exam
5.	Determine the melt processing conditions based on chemical composition and metallurgical quality of the melt	1st colloquium, 2nd colloquium, oral exam

Required literature:

1. …, Metals Handbook, Volume 15, Casting, ASM International, Metals Park Ohio, 2008.
2. …, Aluminium Casting Technology, AFS, Des Plaines, Illinois, 2001.
3. W. J. Jackson, M. W. Hubbard, Steelmaking for Steelfounders, Steel Castings Research and Trade Association, Great Britain, 1979.

Optional literature:

1. …, Cast Iron, ASM International, Materials Park, 1999.
2. …, Aluminium Permanent Mold Handbook, AFS, Des Plaines, Illinois, 2001.

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.

Name of the course: METALLOGRAPHIC ANALYSIS

ISVU code: 157492

Status of the course: compulsory

Year of study: 3

Semester: 5

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+0+2+1

Expected enrolment in the course: 15

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: knowledge and mastering of sample preparation techniques for metallographic analysis, ability to conduct metallographic analysis of cast metal materials, ability to analyse the results of metallographic analysis of cast metal materials, ability to work on a metallographic microscope with a software package for automatic image processing.

Enrolment requirements and required entry competences for the course: knowledge gained within the framework of subjects: Fundamentals of solidification and microstructure development, Designing of gating and feeding systems, Casting technology of ferrous metals, Casting technology of non-ferrous metals, Materials testing and Heat treatment.

Learning outcomes at the level of the study programme to which the course contributes: prepare samples for metallographic analysis, use equipment for metallographic analysis and interpret the results of analysis, relate microstructure and properties of castings, distinguish microstructural constituents in ferrous and non-ferrous alloys.

Expected learning outcomes at the level of the course: prepare samples for metallographic analysis, select the appropriate etching agent, use the equipment for metallographic analysis, interpret the results of metallographic analysis of metal materials, interpret the results of scanning electron microscopy for metal materials.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Metallography, the basics (1); Preparation of samples for metallographic analysis (2); Means for sample etching (3); Metallographic microscope and associated equipment (3); Metallographic analysis of cast iron samples with graphite and interpretation of results (6); Metallographic analysis of casted steel samples and interpretation of results (4); Metallographic analysis of white iron castings and interpretation of results (3); Metallographic analysis of cast Al-alloy and interpretation of results (6); Search electron microscope and energy dispersive spectrometer (2).

Exercises: Preparation of samples for metallographic analysis (4); Metallographic analysis of iron and non-ferrous metals (7); Metallographic Analysis of Steel Castings (7), Metallographic analysis of aluminum alloys (7); interpreting the results of Metallographic Analysis Results (5).

Type of instruction: lectures and exercises, teaching with the help of ICT.

Student responsibilities: students must attend lectures and exercises (> 70.0 %) and complete the exercises.

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 ECTS), colloquiums (2.5 ECTS credits), oral exam (2.2 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students at the lectures and the results on the colloquia are evaluated during the course. The performance plans of the subject details the evaluation of students' activities during classes, on colloquia and oral exams, and is calculated in the final grade of the subject.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Prepare samples for metallographic analysis	Colloquium, Exercises
2.	Select the appropriate etching agent	Colloquium, Exercises
3.	Use the equipment for metallographic analysis	Colloquium, Exercises
4.	Interpret the results of metallographic analysis of metal materials	Colloquium, Exercises
5.	Interpret the results of scanning electron microscopy for metal materials	Colloquium, Exercises

Required literature:

1. H. Šuman, Metalografija, Tehnološko-metalurški fakultet, Beograd, 1981.
2. G. F. Vander Voort, Metallography – Principles and Practice, ASM, Materials Park, Ohio, 1999.

Optional literature:

1. …, Metallography and Microstructures, ASM Handbook, Volume 9, ASM, Materials Park, Ohio, 2004.
2. S. Hasse, Structure of Cast Iron Alloys, Schiele & Schön, 2008.

Methods of monitoring quality that ensures acquisition of exit competences: Employee Testing, Graduated Students testing (according to the Quality Manual that forms an integral part of the Rule Book on Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: PHYSICS

ISVU code: 150646

Status of the course: compulsory

Year of study: 1

Semester: 1

Credit value (ECTS): 6

Type of instruction (number of hours L+S+E+e-learning): 3+0+2+2

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 2

Percentage of instruction in the course on line: 10.0 %

Course objectives: inform students about basic laws of physics and their practical application in problems related to metal casting.

Enrolment requirements and required entry competences for the course: high school level math and physics

Learning outcomes at the level of the study programme to which the course contributes: explain and understand the casting process and solidification of metal castings in expendable and permanent moulds, knowledge of the physical basis of phenomena in nature and ability to identify physical quantities involved in the process under consideration.

Expected learning outcomes at the level of the course: define the fundamental physical quantities and units of measurement**,** describe the following physical concepts: mass, force, work, energy, pressure and temperature**,** define the basic structure concepts of the substances, examine the dimensions of the component, examine the mass, density and viscosity of the substance, apply learned concepts to solve simple problems.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Physical quantities (2); International System of Units (SI) (2); Kinematics and particle dynamics (3); Mass (2); Force (2); Newtonian laws (3); Mechanical work (2); Energy (3); Conservation Laws (3); Deformation of the body (3); Fluid mechanics (4); Oscillations and Waves (2); Pressure and temperature: thermal processes (4); Thermodynamic Laws (4); Electricity and Magnetism (3); Substance structure (3).
Exercises: Measuring length with a Vernier Caliper and a micrometer screw (2); Verification of Newton's 2nd Law (2); Mass measurement (2); Density measurement (2); Measurement of viscosity (2); Latent heat of fusion (4); Calibration of thermocouples (4); Measurement of electromotive force (4); Numerical exercises (8).

Type of instruction: lectures and exercises, mixed instructions.

Student responsibilities: students have to attend instructions (> 70.0 %) and complete the exercises.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (0.35 ECTS credits), colloquia (3.0 ECTS credits), oral exam (2.65 ECTS credits).

Grading and evaluation of student work over the course of instruction and at a final exam: during the semester, the attendance and activity of the students on the course and the results on the colloquia. The outline plan of the subject details the evaluation of students' activities during semester, on colloquia and oral exams and contribution to the final grade.

Monitoring of the achievement of learning outcomesat the level of the course

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Define the fundamental physical quantities and units of measurement	Colloquium, written and oral exam
2.	Describe the following physical concepts: mass, force, work, energy, pressure and temperature	Colloquium, written and oral exam
3.	Define the basic structure concepts of the substances, examine the dimensions of the component, examine the mass, density and viscosity of the substance	Seminar paper, LAB exercises and oral exam
4.	Apply learned concepts to solve simple problems	Colloquium, written exam

Required literature:

1. P. Kulišić, Mehanika i toplina, Školska knjiga, Zagreb, 1996.
2. N. Cindro, Fizika I, II, Školska knjiga, Zagreb, 1988.

Optional literature:

1. P. Kulišić i sur., Elektomagnetske pojave i struktura tvari, Školska knjiga, Zagreb, 2003.
2. N. Cindro, P. Colić, Fizika, Školska knjiga, Zagreb, 1996.

Methods of monitoring quality that ensure acquisition of exit competences: Employee survey, Completed Students survey (according to the Quality Manual, which is an integral part of the Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: QUALITY MANAGEMENT

ISVU code: 150658

Status of the course: compulsory

Year of study: 1

Semester: 2

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+0+2+1

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: ability to apply a quality management system in foundries.

Enrolment requirements and required entry competences for the course: secondary education in the area of quality management.

Learning outcomes at the level of the study programme to which the course contributes: apply basic quality assurance tools.

Expected learning outcomes at the level of the course: define the basic concepts of quality assurance and quality management (planning, monitoring, improvement), analyse quality features of processes, products and services, explain the quality cost, interpret features of ISO standards, apply basic quality assurance tools, analyse the results of statistical process control, apply and customize documentation in quality management system.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Standards and Quality management systems: definition of quality, quality management principles, general objectives and tasks, ISO standards (6); Construction of a quality management system: quality policy, resources, substrates and documentation, quality costs, accreditation and certification. (8); Quality management in industrial practice: documentation level, quality plans, customer-supplier relationship, entrance control, process control, final control, definition of inconsistent products, process improvement (10); Methods of quality management systems and choice of priorities: Deming`s cycle of quality, Shewhart's approach, Ishikawa diagram, Pareto analysis (6).
Exercises: differences in construction of quality management systems for different processes (15); measurable indexes of process capability (3); use of Shewhart's control charts (4); Pareto analysis (4); Application of SPC (Statistical Process Control) software packages (4).

Type of instruction: lectures and exercises, ICT teaching.

Student responsibilities: attendance at lectures and exercises (> 70.0 %).

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 ECTS), colloquiums (2.5 ECTS), oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: during the course it is evaluated the presence and activity of students in class and the results of the colloquiums**.** With implementation plan of course it is prescribed in details the evaluation of student activities during class, at colloquiums and oral exam and impute in the final assessment of the course.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Define the basic concepts of quality assurance and quality management (planning, monitoring, improvement)	1st colloquium
2.	Analyse quality features of processes, products and services	1st exercise, 1st and 2nd colloquium, written exam, oral exam
3.	Explain the quality cost	2nd colloquium, written exam, oral exam
4.	Interpret features of ISO standards	2nd colloquium, written exam, oral exam
5.	Apply basic quality assurance tools	3rd colloquium, written exam, oral exam
6.	Analyse the results of statistical process control	Exercises 2.-5., 3rd colloquium, written exam, oral exam
7.	Apply and customize documentation in quality management system	3rd colloquium, written exam, oral exam

Required literature:

1. F. Dusman, Osiguranje kvalitete u industrijskoj proizvodnji, FSB, internal script, Zagreb
2. ISO 9000 quality management systems, Croatian Association of Technical Culture, Zagreb 1996.

Optional literature:

1. International standard ISO 9001:2000
2. International standard ISO 14001:2001

Methods of monitoring quality that ensure acquisition of exit competences: Employer's examination, examination of graduate students (according to the Quality manual that forms an integral part of the Rulebook on quality assurance and improvement at the Faculty of Metallurgy, University of Zagreb).

Name of the course: SURFACE ENGINEERING

ISVU code: 157501

Status of the course: elective

Year of study: 3

Semester: 5

Credit value (ECTS): 4

Type of instruction (number of hours L+S+E+e-learning): 2+1+0+1

Expected enrolment in the course: 15

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: understanding of mechanisms of surface engineering of ferrous and non-ferrous alloys, ability to define of procedures surface engineering of casting depending from their application.

Enrolment requirements and required entry competences for the course: knowledge of properties and fields application of ferrous and non-ferrous castings.

Learning outcomes at the level of the study programme to which the course contributes: select the appropriate coating process or modification of the casting surface depending on the conditions of use of the casting.

Expected learning outcomes at the level of the course: explain the mechanisms of particular techniques coating and modification of castings surfaces, analyse results obtained using of particular procedure coating or modification, evaluate efficacy of used procedure of coating or modification.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Clasification of coating and modification of surfaces (1); Basic physic-chemical roles for particular techniques of coating and modification of surfaces (4); Mechanical surface engineering (2); Procedures of surface quenching (flame, induction, laser and electro beam techniques) (3); Thermochemical procedures (cementation, nitriding, carbonitriding etc.) (6); Metal coatings (5); Chemical vapour deposition and physical vapour deposition techniques (3); Non-metallic coatings (3); Organic coatings (3).
Seminar work: Detail knowledge with particular surface engineering techniques of castings, (3); Preparation of seminar work for particular procedure modification or coating of surafce for the ferrous and non-ferrous castings (12).

Type of instruction: lectures, seminar work and teaching using ICT.

Student responsibilities: students must attend over 70.0 % of lectures, preparation of seminar work.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): attendance (0.3 ECTS), seminar work (0.7 ECTS), colloquiums (1.5 ECTS), oral exam (1.5 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: during the course the attendance and activity of students in the teaching, seminar work and results of colloquiums. The performance plan of the subject details the evaluation of students' activities during classes, seminar work, colloquiums and oral exams and the calculation of the final grade of the subject.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Explain the mechanisms of particular techniques coating and modification of castings surfaces	Colloquium and oral exam
2.	Analyse results obtained using of particular procedure coating or modification	Colloquium and oral exam
3.	Evaluate efficacy of used procedure of coating or modification	Colloquium and oral exam

Required literature:

1. M. Gojić, Površinska obradba materijala, Metalurški fakultet Sisak, 2010.
2. I. Esih, Osnove površinske zaštite, Fakultet strojarstva i brodogradnje, Zagreb, 2003.

Optional literature:

1. T. Filetin, K. Grilec, Postupci modificiranja i prevlačenja površina, Hrvatsko društvo za materijale i tribologiju, Zagreb, 2004.
2. D. Krumes, Površinske toplinske obrade i inženjerstvo površine, Strojarski fakultet Slavonski Brod, Sveučilište u Osijeku, Slavonski Brod, 2004.

Methods of monitoring quality that ensure acquisition of exit competences: Employee examination, Examination of students (according to the Quality Manual that forms an integral part of the Rulebook of Quality System of the Faculty of Metallurgy, University of Zagreb).

Name of the course: TECHNICAL DRAWING AND MACHINE ELEMENTS

ISVU code: 150648

Status of the course: compulsory

Year of study: 1

Semester: 1

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 2+0+2+1

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: the ability to make technical drawings of castings in pencils, training for basic use of software packages for making technical drawings of castings, knowledge of basic elements of machines used in casting.

Enrolment requirements and required entry competences for the course: high school knowledge of technical culture and descriptive geometry

Learning outcomes at the level of the study programme to which the course contributes: make a technical drawing of casting, explain the working principle and function of the basic elements of machines in the foundry.

Expected learning outcomes at the level of the course: make a technical drawing of casting with a pencil, make a technical drawing of the casting by using specialized software packages, describe basic machinery elements (screws, springs, axles, shafts, bearings, couplings, transmissions).

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Elements of technical drawings (1); Lines (1); Scales (1); Paper format for technical drawings (1); Technical letter (2); Orthogonal projection rules (2); Cross sections (2); Dimensioning (2); Processing and surface roughness (1); Geometric tolerance (1); Dimension tolerances and fits (1); Creating technical drawings using program packages (2); Screws and screw connections (1); Springs (1); Axles and shafts (2); Bearings (2); Couplings (1); Friction transmission (1); Belt transmission (1); Chain transmission (1); Gear transmission (1); Liquid flow elements (2).
Exercises: Make a technical drawings with a pencil and using specialized software packages (20), Dimensioning of machine elements (10).

Type of instruction: lectures and exercises, teaching with the help of ICT.

Student responsibilities: students have to attend lectures (> 70.0 %) and do the exercises.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): teaching attendance (0.5 ECTS), colloquiums (2.5 ECTS), oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: during the course the attendance and activity of the students in the teaching and the results on the colloquium are evaluated. The outline plan of the subject details the evaluation of students' activities during classes, on colloquium and oral exams and the calculation in the final assessment of the exam.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Make a technical drawing of casting with a pencil	colloquium
2.	Make a technical drawing of the casting by using specialized software packages	colloquium
3.	Describe basic machinery elements (screws, springs, axles, shafts, bearings, couplings, transmissions)	oral exam

Required literature:

1. B. Kovač, Tehničko crtanje, Školska knjiga, Zagreb, 1967.
2. M. Opalić, M. Kljajin, S. Sebastijanović, Tehničko crtanje, Sveučilišni udžbenik, Zrinski, Čakovec, 2003.
3. L. Lazić, Elementi strojeva, Metalurški fakultet, Sisak, 2001.

Optional literature:

1. K. H. Decker, Elementi strojeva, Tehnička knjiga, Zagreb, 1986.

Methods of monitoring quality that ensure acquisition of exit competences: Employee examination, Examination of completed students (according to the quality manual, which is an integral part of the rule book on quality system of the Faculty of Metallurgy, University of Zagreb).

Name of the course: TECHNOLOGY OF MAKING MOLDS AND CORES

ISVU code: 157123

Status of the course: compulsory

Year of study: 2

Semester: 3

Credit value (ECTS): 5

Type of instruction (number of hours L+S+E+e-learning): 3+0+2+0

Expected enrolment in the course: 17

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: the ability of elaboration of casting construction and technological process of mold making, the ability to choose the appropriate material for making molds and cores, the ability to make expendable molds and cores.

Enrolment requirements and required entry competences for the course: the knowledge acquired in the courses of "General and Inorganic Chemistry", and "Technical drawing and machine elements".

Learning outcomes at the level of the study programme to which the course contributes: define the elements of the elaboration of the technological process of expendable and permanent moulds making, select the appropriate process and technology for expendable core and mold making depending on the casting requirements that are being produced.

Expected learning outcomes at the level of the course: select patterns, core and mold mixture for casting, select the appropriate process and technology for expendable core and mold making, make a simpler expendable mold and core, define the elements of the elaboration of the technological process of expendable and permanent moulds making, analyze damages on the permanent molds.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Classification of procedures for making expendables molds and cores (2); Elaboration of casting construction and technological process of making expendable mold (3); Patterns and pattern making (4); Molding mixtures for making expendable molds (sands, binders, additives) (6);
Testing properties of molding mixtures (3); Procedures, technology and equipment for manual and machine making of expendable molds (6); Materials and binders for making expendable cores (molds) (4); Sand reclamation (4); Procedures, technology and equipment for making expendable cores (5); Areas of application of permanent molds (2); Advantages and disadvantages of permanent molds compared to expendable molds (1); Elaboration of

technological process of making permanent mold (1); Materials and technology for the production of permanent molds (1); Thermal and mechanical loads of permanent molds during application (2); Damages on the permanent molds formed during the application (1).
Exercises: Technological elaboration of the casting drawing (4); Hand making of molds and cores from green sand and chemically bonded sand (sodium silicate/CO_2) (5); Testing the properties of green sand (3); Visit to foundries of ferrous and non-ferrous castings (5); Technological elaboration of permanent mold (2); Analysis of thermal loads during the application of permanent molds in high-pressure die casting of Al casting alloys (2); Analysis of damages on permanent molds formed during the application in high-pressure die casting of Al casting alloys (2); Visit to the high-pressure die casting plants (5); Visit to permanent mold manufacturers (2).

Type of instruction: lectures and exercises, teaching with ICT.

Student responsibilities: students must attend lectures (> 70.0 %) and perform the exercises.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): class attendance (0.5 ECTS), colloquiums (2.5 ECTS), and oral exam (2.0 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: the attendance and activity of the students in the classes and the results of the colloquiums are evaluated. The performance plan of teaching specifies in detail the evaluation of student activities during classes, grading of colloquiums and oral exam, and determining the final grade.

Monitoring of the achievement of learning outcomesat the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Select patterns, core and mold mixture for casting	1st colloquium, oral exam
2.	Select the appropriate process and technology for expendable core and mold making	1st colloquium, oral exam
3.	Make a simpler expendable mold and core	1st colloquium, oral exam
4.	Define the elements of the elaboration of the technological process of expendable and permanent moulds making	1st colloquium, 2nd colloquium, oral exam
5.	Analyze damages on the permanent molds	2nd colloquium, oral exam

Required literature:

1. …, Metals Handbook, Volume 15, Casting, ASM International, Metals Park Ohio, 2008.
2. Z. Bonačić Mandinić, I. Budić, Osnove tehnologije kalupljenja, jednokratni kalupi I. dio, Mechanical Engineering Faculty in Slavonski Brod, Slavonski Brod, 2001.

3. I. Budić, Z. Bonačić Mandinić, Osnove tehnologije kalupljenja, jednokratni kalupi II.dio, Mechanical Engineering Faculty in Slavonski Brod, Slavonski Brod, 2004.
4. F. Unkić, Z. Glavaš, Osnove lijevanja metala - Zbirka riješenih zadataka, text of the exercises placed on website of Faculty of Metallurgy, Faculty of Metallurgy, Sisak, 2009.

Optional literature:

1. M. Galić, T. Grgasović, L. Karbić, M. Komadina, S. Šetek, F. Tomić, V. Žura, Kalupljenje, I dio, Croatian Foundry Association, Zagreb, 1979.
2. M. Galić, T. Grgasović, L. Karbić, M. Komadina, S. Šetek, F. Tomić, V. Žura, Kalupljenje, II dio, Croatian Foundry Association, Zagreb, 1979.

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.

Name of the course: THERMODYNAMICS AND KINETICS OF METALLURGICAL PROCESSES

ISVU code: 150654

Status of the course: compulsory

Year of study: 1

Semester: 2

Credit value (ECTS): 6

Type of instruction (number of hours L+S+E+e-learning): 3+0+0+1

Expected enrolment in the course: 20

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: knowledge of thermodynamic laws that are needed to foundrymen for understand of physic-chemical processes in material and technology, understanding of laws for technological processes, ability of quantitative analysis of metallurgical processes.

Enrolment requirements and required entry competences for the course: knowledge of the course of General and inorganic chemistry.

Learning outcomes at the level of the study programme to which the course contributes: use phase diagrams, explain and understand the casting process and solidification of metal castings in expendable and permanent moulds, relate the properties of casting alloys with their structure.

Expected learning outcomes at the level of the course: define the equilibrium conditions, apply the thermodynamics laws in real examples, explain and distinguish entalphy, entrophy and free energy, apply the Gibbs rule of phasis, explain the phase transformations in metals and alloys, use of phase diagrams, use of Richardson's diagram, apply the Raoult's and Henry's law, explain the solubility of gases in molten metal.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Equilibrium (2); Gases and Vapours (2); First law of thermodynamics (1); The second law of thermodynamics (1), Auxiliary functions: Helmholtz and Gibbs free energy, thermodynamic potentials, Gibbs-Helmholtz equation (5); Thermodynamics of diffusion (2); Heat capacity (1), Entalphy (2); Entrophy (2); The third law of thermodynamics (1); Phase equilibrium: Gibbs rule of phasis, phase transformations, phase diagrams (6); Theory of solutions: activity (2); Raoult's law (2); Henry's law (2); Richardson's diagram (2); Solubility of gases in metallic melts (4); Kinetics of reactions (3); Kinetics of phase transformations in metals (5).

Type of instruction: lectures, teaching with the help of ICT.

Student responsibilities: attendance to lectures (> 70.0 %).

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): attendance (0.5 ECTS), colloquiums (3.0 ECTS), oral exam (2.5 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: attendance and activity of students to class and results of colloquiums. By the plan of subject in detail is prescribed evaluation of student activity through class, colloquiums and oral exam and incorporated in final grade.

Monitoring of the achievement of learning outcomes at the level of the course

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Define the equilibrium conditions	colloquiums, oral exam
2.	Apply the thermodynamics laws in real examples	colloquiums, oral exam
3.	Explain and distinguish entalphy, entrophy and free energy	colloquiums, oral exam
4	Apply the Gibbs rule of phasis	colloquiums, oral exam
5.	Explain the phase transformations in metals and alloys	colloquiums, oral exam
6.	Use of phase diagrams	colloquiums, oral exam
7.	Use of Richardson's diagram	colloquiums, oral exam
8.	Apply the Raoult's and Henry's law	colloquiums, oral exam
9.	Explain the solubility of gases in molten metal	colloquiums, oral exam

Required literature:

1. V. Gontarev, Termodinamika materialov, Naravoslovnotehniška fakulteta, Univerza v Ljubljani, Ljubljana 2005.
2. M. Spasić, D. Vučurović, Teorija metalurških procesa, I deo, Tehnološko – metalurški fakultet Univerziteta u Beogradu, Beograd, 1978.

Optional literature:

1. D. R. Gaskell, Introduction to the Thermodynamics of Materials, Fourth Edition, Taylor & Francis, London, 2003.
2. J. Burke, The Kinetics of Phase Transformations in Metals, Pergamon Press, 1980.

Methods of monitoring quality that ensure acquisition of exit competences: Employee examination, Examination of completed students (according to the quality manual, which is an integral part of the rule book on quality system of the Faculty of Metallurgy, University of Zagreb).

Name of the course: WELDING

ISVU code: 157494

Status of the course: compulsory

Year of study: 3

Semester: 5

Credit value (ECTS): 4

Type of instruction (number of hours L+S+E+e-learning): 2+0+1+1

Expected enrolment in the course: 15

Level of use of e-learning (1, 2, 3 level): 1

Percentage of instruction in the course on line: 5.0 %

Course objectives: understanding of the effect of chemical composition on weldability of ferrous and non-ferrous castings, ability to define preparation of materials for welding, ability selection of appropriate welding procedures of castings, ability to analyse of defects into weld joints.

Enrolment requirements and required entry competences for the course: knowledge obtained by courses: Basic solidification and development of microstructure, Technology casting of ferrous metals, Technology casting of non-ferrous metals, Heat treatment, Testing of materials.

Learning outcomes at the level of the study programme to which the course contributes: select the appropriate procedure and parameters of repair welding depending on the type of defect and type of material to be welded, recognize type of casting defect.

Expected learning outcomes at the level of the course: describe basic techniques of welding and types of welded joints, define weldability, explain the effect of chemical composition on weldability, determine appropriate type of electrode for welding depending on type materials, classify additional materials for welding, determine additional power for welding and calculation consume of additional materials for electro-arc welding, classify defects during welding and describe control methods of welding, use the flame and electro-arc welding techniques.

Course content broken down in detail by weekly class schedule (syllabus): Lectures: Define of welding and review of welding techniques (11); Types weld joints (1); Effect of chemical composition on weldability (4); Preparation for welding (1); Selection appropriate electrodes for welding (2); Plame welding (2); Electro-arc welding techniques (3); Electro-resistance welding (2); Behaviour ferrous catings, non-ferrous metals and alloys during welding (4); Repair welding (3); Post-weld heat treatment (3); Defects into weld joints (3), Safe and protection at welding (1).

Exercises: Welding of ferrous castings (5); Control of weld joints (5).

Type of instruction: lectures and exercises, teaching using ICT.

Student responsibilities: students must attend over 70.0 % of lectures and have finished exercises.

Screening of student's work (specify the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the credit value of the course): attendance (0.3 ECTS), colloquiums (2.0 ECTS), oral exam (1.7 ECTS).

Grading and evaluation of student work over the course of instruction and at a final exam: during the course the attendance and activity of students in the teaching and results of colloquiums. The performance plan of the subject details the evaluation of students' activities during classes, colloquiums and oral exams and the calculation of the final grade of the subject.

Monitoring of the achievement of learning outcomes at the level of the course:

Ordinal number	Expected learning outcomes at the level of the course	Methods for monitoring of the achievement of learning outcomes
1.	Describe basic techniques of welding and types of welded joints	Colloquiums and oral exam
2.	Define weldability	Colloquiums and oral exam
3.	Explain the effect of chemical composition on the weldability	Colloquiums and oral exam
4.	Determine appropriate type of electrode for welding depending on type materials	Colloquiums and oral exam
5.	Classify additional materials for welding	Colloquiums and oral exam
6.	Determine additional power for welding and calculation consume of additional materials for electro-arc welding	Colloquiums and oral exam
7.	Classify defects during welding and describe control methods of welding	Colloquiums and oral exam
8.	Use of flame and electro-arc welding techniques	Colloquiums and oral exam

Required literature:

1. M. Gojić, Tehnike spajanja i razdvajanja materijala, Metalurški fakultet, Sisak, II. nepromijenjeno izdanje, 2008.
2. …, Metals Handbook, Volume 15, Casting, ASM International, Metals Park Ohio, 2008.

Optional literature:

1. I. Lukačević, Zavarivanje, Strojarski fakultet Slavonski Brod, 1998.
2. I. Juraga, M. Živčić, M. Gracin, Reparaturno zavarivanje, vlastita naklada, Zagreb, 1994.

Methods of monitoring quality that ensure acquisition of exit competences: Employee examination, Examination of students (according to the Quality Manual that forms an integral part of the Rulebook of Quality System of the Faculty of Metallurgy, University of Zagreb).