Course title	**Mathematics 1**							
Course instructor(s)	Ivana Marušić, lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics Undergraduate professional programme of study in Computer Science							
Course status	Compulsory							
Year	1st	**Semester**	1st	**ECTS**	7			
Contact hours (L+PS+S)	30+45+0			L	PS		S	
					APS	LPS		
				30	45	0	0	

Course objectives

Familiarising students with terms related to mathematical analysis and linear algebra, as well as the fundamentals of differential calculus that are necessary for attending, understanding and application in general and professional courses.

Expected learning outcomes

Upon completion of the course students will be able to:

- O1: describe sets of natural numbers, integers, rational numbers, irrational numbers, real numbers and complex numbers, and apply arithmetic operations in the aforementioned sets of numbers,
- O2: explain the terms matrix and determinant, name their properties and use them in the matrix and determinant calculus,
- O3: distinguish between the methods of solving linear equation systems and apply a suitable method in solving a concrete system,
- O4: reproduce basic terms of vector algebra and analytical geometry and apply them while solving tasks,
- O5: analyse and solve a task of medium difficulty in the area of mathematical analysis,
- O6: Define and name the properties of arithmetic and geometric sequence and calculate limits of sequences and functions,
- O7: apply the fundamentals of differential calculus in simple tasks.

Course content

1. Sets (Outcome O1)
The notion of set. Subset. Equality of sets. Cardinal number of a set. Operations with sets.

2. Real and complex numbers (Outcome O1)
Set $\mathbb{N}$. Set $\mathbb{Z}$. Properties of sets $\mathbb{N}$ and $\mathbb{Z}$. Binomial theorem. Set $\mathbb{Q}$. Set $\mathbb{I}$. Properties of sets $\mathbb{Q}$ and $\mathbb{I}$. Set $\mathbb{R}$. Properties of set $\mathbb{R}$. Intervals of real numbers. Absolute value of a real number. Set $\mathbb{C}$. Basic operations with complex numbers. Real and imaginary part of complex numbers. Conjugation of complex numbers. Module of complex numbers. Algebraic form of complex numbers. Equality of complex numbers. Trigonometric form of complex numbers. Exponentiation, inverse exponentiation and division of complex numbers. Equations in the set of complex numbers. Complex plane. System of equations in the set of complex numbers.

3. Linear algebra (Outcome O2, O3)
Definition and special forms of matrices. Basic operations with matrices. Matrix polynomial. Multiplication of matrices. Commutative property of matrices. System of linear equations. Rank of a matrix. Determinant of a matrix. Properties of a determinant. Rule of Sarrus. Laplace expansion of the determinant of the n-th order. Invertible matrix. Computing inverse matrices by applying the Gauss-Jordan method. Computing inverse matrices by means of a determinant. Cramer's rule. Matrix equation.

4. Vector algebra and analytical geometry (Outcome O4)
Coordinate system in space. Scalar product. Vector product. Linear combination of vectors. Area and height of triangle. Parallelogram area. Mixed product. Volume and height of parallelepiped. Volume of tetrahedron. Plane equation. Line equation. Intersection of a line and a plane. Intersection of two lines. Orthogonal projection of a point to the line. Orthogonal projection of a line to the plane. Distance between points. Distance between a line and a plane. Distance between a point and a line. Distance between parallel lines. Distance between skew lines.

5. Functions (Outcome O5)
The notion of function. Equality of functions. Manners of specifying a function. Function properties. Elementary functions and their properties. Function composition. Inverse function and domain. Inverse trigonometric functions.
6. Sequences and limit of sequence (Outcome O6)
The notion of sequence. Arithmetic sequence. Geometric sequence. Properties of sequences. Limit of sequence.
7. Limes and continuity of a function (Outcome O6)
Limes of a function. Continuity of a function. Asymptotes.
8. Derivative (Outcome O7)
The issue of speed. The notion of derivative. Derivatives of some elementary functions. Basic rules of derivation.

Required reading

- Tomić, Milorad: Matematika 1, Technical College in Bjelovar, Bjelovar, 2009
- Tomić, Milorad: Matematika 2, Technical College in Bjelovar, Bjelovar, 2009
- Marušić, Ivana: "Presentation for lectures and practical sessions – Mathematics 1", Bjelovar University of Applied Sciences, Bjelovar, 2017, available on: http://vub.hr/1-godina-matematika-predavanja-vjezbe/predavanja/

Further reading

- Pavlovič Demidović, Boris, et al.: "Zadaci i riješeni primjeri iz Matematičke analize za tehničke fakultete", Golden marketing, Tehnička knjiga, Zagreb, 2003

Course title	**Fundamentals of Engineering Calculus**								
Course instructor(s)	Ivana Marušić, lecturer								
Programme(s) of study	Undergraduate professional programme of study in Mechatronics Undergraduate professional programme of study in Computer Science								
Course status	Compulsory								
Year	1st	**Semester**	1st	**ECTS**	2				
Contact hours (L+PS+S)	0+30+0	L	PS		S				
			APS	LPS					
		0	30	0	0				

Course objectives

Familiarising students with the latest concepts of mathematical analysis for the purpose of upgrading the knowledge of concepts from Mathematics 1.

Expected learning outcomes

Upon completion of the course students will be able to:

- O1: apply mathematical methods and physical laws that have application in the engineering profession,
- O2: recognise physical quantities,
- O3: convert base and derived physical units,
- O4: interpret and graph in kinematics.

Course content

1. Power, algebraic expressions, root (Outcome O1)
Power application. Application of algebraic expressions. Equations. Functions. Polynomials and rational functions. Roots. **2. Arrangement in the set of real numbers (Outcome O1)**
Intervals. Inequalities. Absolute value of a real number.
3. Coordinate system in a plane (Outcome O1)
Distance between points in a plane. Midpoint. System of linear equations. Line. Graph of a function.
4. Geometry (Outcome O1, O2,)
Points, lines and planes. Angle. Triangle. Trapezium. Isosceles trapezium. Parallelogram. Rhombus. Rectangle. Square. Circle. Disk. Perimeter and area.
5. Trigonometry (Outcome O1, O2, O3)
Right-angled triangle trigonometry. Definitions of trigonometric functions. Properties of trigonometric functions. Application of trigonometric functions.
6. Physical quantities and units (Outcome O1, O2, O3)
SI base units. SI additional units. SI derived units with a special name. Allowed units outside the SI. Prefixes of SI units.
7. Graphs in physics (Outcome O1, O4)
Interpretations of graphs in kinematics.

Required reading

- Pisačić, Katarina: "Osnove inženjerskog proračuna", University North, Varaždin, 2014, available on: http://unin.hr/~kpisacic/PA1_vjezbe.pdf
- Marušić, Ivana: "Osnove inženjerskih proračuna", Bjelovar University of Applied Sciences, Bjelovar, 2017, available on: http://vtsbj.hr/osnove-inzenjerskog-proracuna/

Further reading

- Bronštejn, Ilja Nikolajevič; Semendjajev, Konstantin Adolfovič: "Matematički priručnik za inženjere i studente", Tehnička knjiga, Zagreb, 1964

Course title	**Fundamentals of Electrical Engineering**						
Course instructor(s)	Robert Herčeki, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	1st	**Semester**	1st	**ECTS**	7		
Contact hours (L+PS+S)	30 + 45 + 0	L	PS		S		
			APS	LPS			
		30	30	15	0		

Course objectives

Familiarising students with the basic knowledge and problem solving in the area of electrical engineering.

Expected learning outcomes

Upon completion of the course students will be able to:

- O1: define the basic terms of electrostatics,
- O2: define the basic terms of electric circuits,
- O3: analyse DC electric circuits using Ohm's law, Kirchoff's laws and the methods of solving linear networks,
- O4: define the basic terms of electromagnetism,
- O5: analyse the connections of resistors, capacitors and inductors in a DC circuit,
- O6: analyse AC circuits using phasor algebra,
- O7: analyse the three-phase system connections.

Course content

1. Electric charge and electric field (Outcome 1)
Force between charges. Coulomb's law. Electric field of the point, line and surface charge. Gauss's law, potential and voltage in electric field. Dielectric polarisation, vector of electric translation.

2. Basic terms related to electric circuits (Outcome 2)
Electric current, current density, resistance and conductance.

3. Electric circuits of direct current (Outcomes 2, 3)
Charge flow. Ohm's law. Static and dynamic resistance. Temperature dependence of resistance. Connecting resistors, connection in series, connection in parallel and mixed connection. Kirchhoff's laws. Current and voltage real sources. Power and energy of electric current, adjustment to the maximum power.

4. Electric capacitance (Outcome 3)
Fundamentals of electric capacitance. Types of capacitors. Connection in series, connection in parallel.

5. Linear electric networks (Outcome 3)
Notion of electric network, methods of solving. The method of Kirchhoff's laws, method of mesh currents, method of superposition. Thevenin's theorem.

6. Magnetism and electromagnetism (Outcome 4)
Magnetic field, magnetic flux, magnetic induction. Force exerted on moving charges, force exerted on a conductor with running electric current. Magnetic induction of a straight conductor, coil and circular coil. The work of the magnetic field, ferromagnetism, magnetization curve, hysteresis loop. Ampere's Flow Law. Electromagnetic induction, Faraday's Law, Lenz's Rule, rotating loop in a homogenous field. Vortical currents, self-induction and mutual induction, inductivity and mutual inductivity. Energy of the magnetic field.

7. Coil and condenser in a serial circuit (Outcome 5)
Network's response to commutation, forced and free response of a serial RLC circuit. Charging and discharging of condensers. Connection of the serial RL circuit to a source of constant EMS. Interruption of current through a coil.

8. Alternating current (Outcome 6)
Fundamental concepts related to alternating current, instantaneous, effective and average value, frequency. The concept of

a phasor and operations with phasors. Ohmic resistance, inductive and capacitive resistance. The concept of impedance and admittance, phase angle. Resonance, power of alternating current, adjusting to maximal power. Reactive energy compensation.

9. Three-phase system (Outcome 7)

The development of the three-phase system, designation, generator and consumer circuits. Symmetrical and asymmetrical consumers. Working out an asymmetrical system, the charge of the star connection.

The power of three-phase current, symmetrical and asymmetrical load.

Required reading

- Kuzmanović, Branislav: Osnove elektrotehnike 1, Zagreb, Element, 2006
- Kuzmanović, Branislav: Osnove elektrotehnike 2, Zagreb, Element, 2006

Further reading

- Robert L. Boylestad: INTRODUCTORY CIRCUIT ANALYSIS, ISBN: 0-13-173044-4

Course title	**Introduction to Informatics**						
Course instructor(s)	Dario Vidić, lecturer Ivan Sekovanić, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics Undergraduate professional programme of study in Computer Science						
Course status	Compulsory						
Year	1st	**Semester**	1st	**ECTS**	4		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15		30			

Course objectives

Familiarising students with information technologies and their application.

Expected learning outcomes

Upon completion of the course students will be able to:

- O1 analyse the historical development and current significance of computer systems,
- O 2 describe and recognise the main components of a computer system, their functions and the role of numeral systems in computer operation,
- O 3 describe the role of computer operating systems,
- O 4 create a simple database,
- O 5 edit and format texts,
- O 6 process data in table calculations,
- O 7 describe adjustment and maintenance techniques related to the *Windows* operating system and its security settings.

Course content

1. The notion of computer literacy (O1)
Innovations that caused the development of information technologies. Numeral systems.
2. Assemblies and architecture of personal computers (O2)
Von Neumman's model of a digital computer. CPU processor. Memory (RAM, ROM-BIOS, CASHE). Input units (hard disk, CD, DVD, modem, USB, keyboard, mouse, touchpad, scanner, web-camera, digital camera). Output units (monitor, projector, printers, plotters).
3. Operating systems (O3)
Early beginnings and development. Operating systems *Windows* and *Linux* – characteristics and installation. Operating environment in operating systems – GUI, Kernel.
4. Maintenance and security of the operating systems *Windows* (O7)
Administration tools. Antivirus protection. Firewall.
5. MS Office tools (O4, O5, O6)
Word. Excel. Access.

Required reading

1. Dario Vidić, Ivan Sekovanić: Presentations for lectures and practical sessions in the course "Introduction to Informatics", Bjelovar University of Applied Sciences
2. Šimović, Maletić, Afrić: Osnove informatike, Zagreb, 2010

Further reading

Course title	**Technical Materials**						
Course instructor(s)	Stjepan Golubić, PhD, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	1st	**Semester**	1st	**ECTS**	5		
Contact hours (L+PS+S)	30 + 30 + 0	L	PS		S		
			APS	LPS			
		30	24	6			

Course objectives

Familiarising students with the types and structure of materials, state diagrams, basic material properties, heat treatment procedures, testing of metal materials, grading and application of basic technical materials.

Expected learning outcomes

Upon completion of the course students will be able to:

O1: explain the connection between the system, structure and properties of technical materials,
O2: recognise and describe basic groups and subgroups of metal materials,
O3: describe the properties of various types of materials,
O4: describe the procedures of testing basic mechanical properties of materials and technological tests,
O5: recognise and describe basic groups and subgroups of other technical materials,
O6: connect the basic properties and areas of application of technical materials.

Course content

1. Metal materials (Outcome O1, O2, O3)
Crystallography and fundamentals of metallography, state diagrams. Ferrous and non-ferrous materials and alloys, sintered materials. Heat treatment of steel.
2. Nonmetals (Outcome O5)
Polymers, ceramic materials, composites, foams, other materials.
3. Testing mechanical and technological properties (Outcome O4)
Testing static strength and fatigue strength, testing technological properties of materials, testing hardness, tensile and compressive testing.
4. Grading and application of materials (Outcome O6)
Grading of ferrous materials and coloured metals according to the HRH and EN norm. Examples of material application.

Required reading

- Inženjerski priručnik IP4, Volume I – Materials, Školska knjiga Zagreb, 1998
- Stupnišek, Mladen; Cajner, Franjo: Osnove toplinske obrade metala, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 2001
- Golubić, Stjepan: Presentations for lectures and practical sessions in the course “Technical Materials”, Bjelovar University of Applied Sciences, available on: http://vub.hr/1-godina-tehnicki-materijali-program/tehnicki-materijali/

Further reading

- Filetin, Tomislav; Kovačiček, Franjo; Indof, Janez: Svojstva i primjena materijala, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 2007
- Filetin, Tomislav: Izbor materijala pri razvoju proizvoda, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 2006
- Ivušić, Vinko: Dijagram stanja metala i legura, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 2003
- Vitez, Ivan: Ispitivanje mehaničkih svojstava metalnih materijala, Faculty of Mechanical Engineering, Slavonski Brod, 2006.

Course title	Technical English 1							
Course instructor(s)	Ivana Jurković, senior lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics							
Course status	Elective							
Year	1st	Semester	1st	ECTS	2			
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S			
			APS	LPS				
		15	30	0	0			

Course objectives

Developing students' ability to use the English language related to specific technical fields.

Expected learning outcomes

Upon completion of the course students will be able to use the English language to:

- O1: describe technical functions and applications of products and the manner in which products function,
- O2: describe the properties and application of materials used in various fields of engineering,
- O3: describe the shape and features of components and assemblies as well as joining and fixing procedures,
- O4: demonstrate mastery of simple grammatical structures.

Course content

1. Technology applications (Outcome O1)
Description of technical functions and applications.
Emphasising technical advantages.
Simplifying technical explanations.
2. Technical materials (Outcome O2)
Describing technical materials.
Naming and describing the properties of technical materials.
Comparing technical materials.
Describing the application of technical materials.
3. Components and assemblies (Outcome O3)
Describing the shape and properties of components.
Describing the procedures of connecting components into assemblies or complex units.
Describing joining and fixing procedures.
Describing the position of elements in assemblies.
4. Grammar (Outcome O4)
Present, past and future tenses.
Adjectives.
Modal verbs.
Types of questions and forming questions.
Prepositions.
Relative clauses.

Required reading

- Ibbotson, Mark: Cambridge English for Engineering, Cambridge University Press, Cambridge, 2008

Further reading

- Murphy, Raymond: English Grammar in Use, Cambridge University Press, Cambridge, 2004

Course title	Technical German 1						
Course instructor(s)	Ivana Jurković, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	1st	Semester	1st	ECTS	2		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	30	0	0		

Course objectives

Developing students' ability to use the German language related to specific technical fields.

Expected learning outcomes

Upon completion of the course students will be able to use the German language to:

- O1: describe technical functions and applications of products and the manner in which products function,
- O2: categorise technical materials and describe their properties and application,
- O3: describe the shape and features of components and assemblies as well as manufacturing techniques,
- O4: demonstrate mastery of simple grammatical structures.

Course content

1. Technology in Use

Description of technical functions and applications. Emphasising technical advantages. Simplifying technical advantages. Grammar focus: *Präsens, Präteritum, Perfekt, Futur*.

2. Technical materials

Categorising technical materials. Naming and describing the properties of technical materials. Comparing technical materials. Describing the application of technical materials. Grammar focus: comparison of adjectives, modal verbs, types of questions, forming questions.

3. Components and assemblies

Describing the shape and properties of components. Describing manufacturing techniques. Describing fixing and jointing techniques. Describing the position of elements in assemblies. Grammar focus: prepositions, relative clauses.

Required reading

- Štambuk, Zdenka; Marinić, Davorka: Deutsch und Technik– Materie – Energie – Information, Školska knjiga, Zagreb, 1991

Further reading

- Muljević, Vladimir; Horvatić, Željko: Njemački – hrvatski i hrvatsko – njemački elektrotehnički rječnik, Školska knjiga, Zagreb, 1996
- Marčetić, Tamara: Deutsche Grammatik im Überblick, Školska knjiga, Zagreb, 2003
- Berger, Maria Cristina; Martini, Maddalena: Generation E, Deutschsprachige Landeskunde im Europäischen Kontext, Ernst Klett, Stuttgart, 2005

Course title	Communication Skills							
Course instructor(s)	Tatjana Badrov, MSc, senior lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics Undergraduate professional programme of study in Computer Science							
Course status	Compulsory							
Year	1st	Semester	1st	ECTS	3			
Contact hours (L+PS+S)	15+30+0	L	PS		S			
			APS	LPS				
		15	30					

Course objectives

Improving students' communication skills.

Expected learning outcomes

Upon completion of the course students will be able to:

O1: explain basic concepts, types and difficulties in the field of communication,
O2: distinguish between the techniques of active listening,
O3: apply information collection techniques and a balanced feedback,
O4: identify and compare basic communication styles and apply an assertive I-message,
O5: distinguish between three types of complaints and complaint resolving techniques,
O6: prepare and deliver a presentation on a given topic,
O7: describe and demonstrate the basic elements of the negotiation process,
O8: explain debate principles and participate in a debate on a given topic.

Course content

1. Introduction to communication (Outcome 1)
The notion of communication. Levels of communication phenomena (intrapersonal, interpersonal, group, public and mass communication). Objectives, principles and types of communication.
2. Verbal communication (Outcome 1)
Factors of efficiency and suitability of verbal communication. Prejudices about communication. Aspects of messages. Criteria of successful verbal communication. Connotative and denotative level of importance of verbal communication.
3. Non-verbal and paraverbal communication (Outcome 1)
Types, characteristics and functions of paraverbal communication. Types and functions of non-verbal messages. Communication skills in business communication.
4. Problems in communication (Outcome 1)
The communication process. Noisiness, noise, barriers to communication. Types of noise, external and internal barriers to communication.
5. Techniques and skills of active listening (Outcome 2)
Listening as a physical and mental activity. Types of (not) listening. Principles of active listening.
6. Skills of information gathering (Outcome 3)
Techniques and skills of asking questions. Types of questions according to the objective of communication.
7. Techniques of giving feedback (Outcome 3)
The concept and purpose of feedback. The five main categories of feedback. A balanced feedback. Receiving and giving praise.
8. Communication styles (Outcome 4)
Aggressive, submissive-aggressive, passive, assertive communication style. The link between communication styles and the outcome of communication. Notion and meaning of assertiveness. Principles of assertive communication. Structure and effect of I-messages in relation to the YOU-message.
9. Recognizing and resolving complaints (Outcome 5)
Notion of complaints. Types of complaints. General rules for resolving complaints. Resolving complaints with regard to the type of complaint.
10. Self-introducing and management of impressions (Outcome 6)

Skills of impressions management. Five main strategies of self-introducing.

11. Presentation techniques and skills (Outcome 6)

Preparation and design of presentations. Delivery structure. Verbal and non-verbal elements of delivery in front of an audience. Answering questions.

12. Negotiation (Outcome 7)

Definition of negotiation and negotiation situations. Characteristics of successful negotiators. Preparing for negotiations. Negotiating strategies. Tactics and techniques for the initial, central and final phase of negotiations. Unethical techniques / tactics in negotiations.

13. Debate (Outcome 8)

Notion of debate. Participants in a debate. Debate parts. Debate in the development of critical, logical and creative thinking.

Required reading

- Reardon, K. (1998): Interpersonalna komunikacija – Gdje se misli susreću, Alineja, Zagreb
- Course materials available in the e-learning system Merlin

Further reading

- Fox, R. (2006): Poslovna komunikacija, Hrvatska sveučilišna naklada, Zagreb

<table>
<tr><td>Course title</td><td colspan="7">Physical Education 1</td></tr>
<tr><td>Course instructor(s)</td><td colspan="7">Damir Lauš, lecturer</td></tr>
<tr><td>Programme(s) of study</td><td colspan="7">Undergraduate professional programme of study in Mechatronics
Undergraduate professional programme of study in Computer Science</td></tr>
<tr><td>Course status</td><td colspan="7">Compulsory</td></tr>
<tr><td>Year</td><td>1st</td><td>Semester</td><td>1st</td><td>ECTS</td><td colspan="3">0</td></tr>
<tr><td rowspan="2">Contact hours (L+PS+S)</td><td colspan="3" rowspan="2">0 + 30 + 0</td><td>L</td><td colspan="2">PS</td><td rowspan="2">S</td></tr>
<tr><td>APS</td><td>LPS</td></tr>
<tr><td colspan="4"></td><td>0</td><td></td><td>30</td><td>0</td></tr>
<tr><td colspan="8">Course objectives</td></tr>
<tr><td colspan="8">Promotion of physical exercise and sports, and enhancing the quality of life in youth, adulthood and old age.</td></tr>
<tr><td colspan="8">Expected learning outcomes</td></tr>
<tr><td colspan="8">Upon completion of the course students will be able to:
O1: demonstrate mastery of practical motor skills and exercise independently,
O2: understand the importance of everyday physical exercise for the shaping of anthropological features and achieving success in one's studies and future professional life.</td></tr>
<tr><td colspan="8">Course content</td></tr>
<tr><td colspan="8">The course is based around a set of kinesiological activities and can be divided into the main and special programme. Students opt for these based on their interests, level of proficiency in motor skills, ability levels, health status and the material conditions available.
The main programme includes kinesiological activities such as athletics, basketball, football, volleyball, dance structures, handball, table tennis…, and the special one is focused on activities less present in primary and secondary school curricula (fitness, aerobics, taekwondo, karate, squash). (Outcome O1, O2)</td></tr>
<tr><td colspan="8">Required reading</td></tr>
<tr><td colspan="8">• -</td></tr>
<tr><td colspan="8">Further reading</td></tr>
<tr><td colspan="8">• -</td></tr>
</table>

Course title	Mathematics 2						
Course instructor(s)	Ivana Marušić, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics Undergraduate professional programme of study in Computer Science						
Course status	Compulsory						
Year	1st	Semester	2nd	ECTS	7		
Contact hours (L+PS+S)	30+45+0	L	PS		S		
			APS	LPS			
		30	45	0	0		

Course objectives

Familiarising students with the latest concepts of mathematical analysis for the purpose of upgrading the knowledge of concepts from Mathematics 1.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: apply the rules of differential calculus and analyse the obtained results,
- O2: apply the basics of differential calculus in simple problems tasks,
- O3: apply differential calculus in analysing a function graph and optimisation of the real function of a real variable,
- O4: correctly apply the basic methods for solving indefinite integrals and analyse the results of integration,
- O5: analyse the problems of calculating areas and apply integration in solving such calculations,
- O6: apply the methods of partial derivative of a function of two variables to finding the extremes of a function of two variables.

Course content

1. **Derivative** (Outcome O1, O2, O3)

Deriving function composition. Deriving an inverse function. Logarithmic differentiation. Implicit function derivation. Higher order derivatives. Differential of a function. Parametric function derivation. Continuity and derivability of functions. Equation of tangents and normals. Indefinite forms. Rise and fall of a function. Extreme points. Concavity and convexity. Inflection points. Function flow.

2. **Indefinite integral** (Outcome O4)

Definition and basic features. Table integrals. Substitution method. Partial integration method. Integration of rational functions. Integration of trigonometric functions. Integration of irrational functions.

3. **Definite integral** (Outcome O5)

Definition and features of definite integrals. Newton-Leibnitz formula. Substitution method in a definite integral. Partial integration method in a definite integral. Improper integrals. Area of a plane shape. Arc length of a plane curve. Volume of solids of rotation. Surface area of a solid of rotation.

4. **Functions of several variables** (Outcome O6)

Definition area of a function. Partial derivatives of the first order. Partial derivatives of the second order. Partial differential equations. Total differential of the first order. Local extremes of functions of two variables.

Required reading

- Tomić, Milorad: Matematika 1, Technical College in Bjelovar, Bjelovar, 2009
- Tomić, Milorad: Matematika 2, Technical College in Bjelovar, Bjelovar, 2009
- Marušić, Ivana: "Presentations for lectures and practical sessions – Mathematics 2", Bjelovar University of Applied Sciences, 2017, available on: http://vub.hr/1-godina-matematika-predavanja-vjezbe/predavanja/

Further reading

- Pavlovič Demidović, Boris, et al.: "Zadaci i riješeni primjeri iz Matematičke analize za tehnička fakultete", Golden marketing, Tehnička knjiga, Zagreb, 2003

Course title	**Application of Mathematical Software Tools**						
Course instructor(s)	Alan Mutka, PhD, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics Undergraduate professional programme of study in Computer Science						
Course status	Compulsory						
Year	1st	**Semester**	2nd	**ECTS**	2		
Contact hours (L+PS+S)	0+30+0	L	PS		S		
			APS	LPS			
		0	0	30	0		

Course objectives

Acquiring basic knowledge and skills in working with the mathematical tool Matlab and Simulink.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: initialise various types of variables in Matlab and execute basic relation and logical operations on them,
- O2: use programming loops and flow control in Matlab,
- O3: use basic mathematical functions, functions for processing sign sequences and functions for working with polynomials in Matlab,
- O4: draw a graph of a given mathematical function using graphical functions in Matlab,
- O5: use basic functions of the symbol package,
- O6: use Simulink to simulate system response.

Course content

1. Introduction to Matlab (Outcome O1)
About *Matlab*. Starting *Matlab*. Organisation of *Matlab* and data structures.
2. Variables (Outcome O1)
Internal variables. External variables. Vectors. Matrices. Complex numbers. Structures. Erasing variables.
3. Operations in Matlab (Outcome O1, O2)
Arithmetic operators. Relational operators. Logical operators. Conditional statements. Loops.
4. Functions (Outcome O3)
Elementary mathematical functions. Functions for vectors and matrices. Functions for working with polynomials. M-functions. M-scripts.
5. Graphical functions of Matlab (Outcome O4)
Functions for drawing 2D graphs. Functions for drawing 3D graphs. Functions for drawing surfaces.
6. Symbolic mathematical expressions (Outcome O5)
Basic functions of Symbolic Toolbox. Conversion of variables. Simplifying symbolic expressions. Functions for solving equations. Functions for solving equation systems. Functions for derivatives and integrals. Drawing graphs.
7. Simulink (Outcome O6)
Basic actions in Simulink. Examples of applying Simulink for the simulation of system behaviour.

Required reading

- Ban, Željko; Matuško, Jadranko; Petrović, Ivan; Primjena programskog sustava MATLAB za rješavanje tehničkih problema, Graphis, Zagreb, 2010

Further reading

- MathWorks: MATLAB ProductHelp, TheMathWorksInc., Natick, 2013

Course title	**Fundamentals of Mechanics**						
Course instructor(s)	Tomislav Pavlic, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	1st	**Semester**	2nd	**ECTS**	7		
Contact hours (L+PS+S)	30 + 45 + 0	L	PS		S		
			APS	LPS			
		30	45	0	0		

Course objectives

Familiarising students with basic knowledge and solving problems in the area of statics, kinematics and dynamics.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: explain the analytical principles of calculating the balance of solids with or without the presence of friction,
- O2: draw diagrams of basic internal quantities of girders,
- O3: use the barycentric calculus of simple and complex solids,
- O4: explain the basic kinematic terms and quantities,
- O5: apply the methods for determining kinematic quantities during rectilinear motion and curvilinear motion,
- O6: apply dynamic analysis on a material particle, system of particles and solids.

Course content

1. Statics of solids (Outcome O1)
Basic notions of the geometry of forces. Reduction of a force system. Osnovni pojmovi iz geometrije sila. Redukcija sustava sila. Releasing solids of bonds. The principle of solidification.
2. Conditions of equilibrium (Outcome O1)
System equilibrium. Analytical conditions of equilibrium. Graphical meaning of the conditions of equilibrium.
3. Conditions of equilibrium with the presence of friction (Outcome O1)
Friction in the contact of solids. Rope friction.
4. Girders (Outcome O2)
Methods of determining internal quantities.
5. Barycentres (Outcome O3)
Barycentres of simple solids. Barycentres of complex solids.
6. Kinematics (Outcomes O4 and O5)
Kinematics of points. Rectilinear motion. Curvilinear motion. Kinematics of solids.
7. Dynamics (Outcome O6)
Fundamental laws of motion. Dynamics of particles, system of particles and solids. Equation of motion. D'Alembert's principle. Work and power. Kinetic energy. Potential energy. Quantity of motion. Kinetic moment. Dynamic inertia moments.

Required reading

- Matejiček, Franjo; Semenski, Damir; Vnučec, Zdravko: "Uvod u statiku sa zbirkom zadataka", Faculty of Mechanical Engineering Slavonski Brod, Slavonski Brod, 2009
- Matejiček, Franjo: Kinetika sa zbirkom zadataka, Faculty of Mechanical Engineering Slavonski Brod, Slavonski Brod, 2010
- Matejiček, Franjo: Kinematika sa zbirkom zadataka, Faculty of Mechanical Engineering Slavonski Brod, Slavonski Brod, 2011

Further reading

- Muftić, Osman: “Mehanika I, Statika“, Tehnička knjiga, Zagreb, 1989
- Group of authors: “Inženjerski priručnik IP1, Volume I - Mechanics“, Školska knjiga, Zagreb, 1996
- Jecić, Stjepan: “Mehanika 2, Kinematika i dinamika“, Tehnička knjiga, Zagreb, 1989
- Kraut, Bojan: „Krautov strojarski priručnik“ 11th edition, Sajema d.o.o., Zagreb, 2009

Course title	**Electronic Components and Assemblies**						
Course instructor(s)	Robert Herčeki, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	1st	**Semester**	2nd	**ECTS**	5		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	16	14			

Course objectives

Familiarising students with basic knowledge about electronic components and assemblies.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: explain the basic properties of semiconductors,
O2: analyse an electronic device with a PN diode,
O3: analyse an electronic device with a bipolar and unipolar transistor,
O4: analyse simple assemblies with an amplifier,
O5: analyse the basic components of power electronics,
O6: explain the operation and application of optoelectronic components.

Course content

1. Basic properties of semiconductors (Outcome 1)
Electrical properties of semiconductors. Types of carriers. Types of semiconductors. Current conduction in semiconductors. Generation and recombination. Concentrations of carriers in semiconductors.
2. P-N junction and P-N diode (Outcome 2)
P-N junction in equilibrium. P-N junction under voltage. Static characteristics of diodes. Breaking the P-N barrier. Classification of diodes. Semiconductor diode as a switch. Diode circuits in analogue and pulse electronics.
4. Bipolar transistors (Outcome 3)
Operation principles. Areas of operation. Static characteristics. Choosing a location of a static operating point. Transistor parameters in the small signal regime. Transistor as a switch. Amplifier in the common emitter connection. Stability characteristics. Amplifier in the common base connection. Amplifier in the common collector connection. Transistor as a switch. Pulse circuits.
5. Unipolar transistors (Outcome 3)
Operation principles and classification. Analysis of basic characteristics and static characteristics of JFET and MOSFET. Amplifiers with unipolar transistors. MOSFET transistor as a switch. Transistor bridge connection. Comparison between unipolar and bipolar transistors.
7. Amplifiers (Outcome 4)
Cascade amplifiers. Darlington pair. Circuits with feedback. Differential amplifier. Power amplifier. Stabilisers. Operational amplifier; basic terms and characteristics, typical application.
8. Power transistors (Outcome 5)
IGBT. DIAC. Thyristor: operating principle, static characteristics. Switching thyristors on. Switching thyristors off.
9. Optoelectronic components (Outcome 6)
Photoresistors. Photodiodes. LED. Laser diodes. Phototransistors. Solar cells. Application of photoelectric semiconductor elements.

Required reading

- Butković, Željko; Divković-Pukšec, Julijana; Barić, Adrijan: Elektronika 1 – course material, Faculty of Electrical Engineering and Computing, Zagreb, 2010

Further reading
• Biljanović, Petar: Poluvodički elektronički elementi, Školska knjiga, Zagreb 1996 • Biljanović, Petar: Elektronički sklopovi, Školska knjiga, Zagreb, 2001 • Zulim,Ivan; Biljanović, Petar: Elektronički sklopovi – problem book, Školska knjiga, Zagreb, 1994 • Šribar,Julijan; Divković-Pukšec, Julijana: Elektronički elementi, problem book – Parts I and II, Element, Zagreb, 1996

Course title	**Fundamentals of Programming**						
Course instructor(s)	Krunoslav Husak, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	1st	**Semester**	2nd	**ECTS**	4		
Contact hours (L+PS+S)	20 + 30 + 0	L	PS		S		
			APS	LPS			
		20	0	30	0		

Course objectives

Learning how to use the development environment for the development of computer programs using the structured and procedural programming language C.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: use basic and logical types of data,
O2: control the program flow,
O3: use fields in programming solutions,
O4: use strings in programming solutions,
O5: use the existing and define own functions,
O6: code according to a given specification in the programming language C.

Course content

1. Programming languages and programming (Outcome O1)
History of programming languages. Potential application of programming. Code development.
2. Programming language C (Outcome O1)
Writing a code in C. Development environment Visual Studio. Pre-processor commands. Input-output flow commands.
3. Types of data and arithmetic operators (Outcome O1, Outcome O6)
Types of data. Declaration of variables. Arithmetic operations. Assignment operators.
4. Logical types of data and operators (Outcome O1, Outcome O6)
Logical types of data. Comparison operators. Bitwise operators.
5. Command blocks and conditional code execution (Outcome O2, Outcome O6)
Code execution order. Command blocks. If command block. Switch-case command block.
6. Programming loops (Outcome O2, Outcome O6)
For loop. While loop. Do-while loop. Commands break and continue.
7. Fields (Outcome O3, Outcome O6)
One-dimensional fields. Two-dimensional and multi-dimensional fields.
8. Strings (Outcome O4, Outcome O6)
Characters. Strings. Functions for working with strings.
9. Functions (Outcome O5, Outcome O6)
Declaration of a function. Definition of a function. Standard headers. Header. Calling a function.

Required reading

- Domagoj Kusalić: Napredno programiranje i algoritmi u C-u i C++-u, 5th edition, Element, Zagreb, 2014
- Krunoslav Husak: "Presentations for lectures and practical sessions – Fundamentals of Programming", Bjelovar University of Applied Sciences

Further reading

- D. M. Ritchie, B. W. Kernighan (translated by: Ante Denić): Programski jezik C, 2nd edition (https://www.scribd.com/doc/47734390/Programski-jezik-C)
- J. Šribar, B. Motik: Demistificirani C++, 3rd edition, Element, Zagreb, 2010
- Learn C programming, http://www.tutorialspoint.com/cprogramming/ (available on: 21.2.2016)
- C Tutorials, http://www.codingunit.com/category/c-tutorials (available on: 21.2.2016)

Course title	Technical Documentation							
Course instructor(s)	Tomislav Pavlic, senior lecturer Stjepan Golubić, PhD, senior lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics							
Course status	Compulsory							
Year	1st	Semester	2nd	ECTS	3			
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S			
			APS	LPS				
		15	0	30				

Course objectives

Acquiring knowledge required for understanding and development of technical documentation as well as knowledge required for performing professional activities in the area of expertise.

Expected learning outcomes

Upon completion of this course students will be able to:
O1: acquire basic terms related to technical drawings and development of technical documentation,
O2: use the acquired knowledge for developing and reading technical documentation,
O3: develop 2D drawings of simple positions and assemblies,
O4: develop simple documentation in the area of electrical engineering.

Course content

1. Introduction to technical documentation (Outcome O1)
Standardisation and norms: lines, technical lettering, paper formats for technical documentation, scales, title block, designating the documentation.
2. Documentation in mechanical engineering (Outcome O1, O2)
Description of machine parts by orthogonal and isometric projection. Use of cross-sections and recommendations when designing shapes in technical documentation. Simplifying the presentation of machine elements. Spatial presentation. Dimension lines drawing. Surface roughness and designating it in the documentation. Dimension tolerances. Shape and position tolerances. Fits.
3. Documentation in electrical engineering (Outcome O4)
Element designation system. Graphic symbols in drawings and schematics. Electrical schematics (single pole, current, relay, electropneumatic, electrohydraulic, schematics of electronic modules). Connection plans. Material lists. Position drawings. Technical description. Technical specifications of a device and equipment. Instructions for operation and maintenance. Documentation of the functional version. Reading electrical schematics.
4. Use of computers in technical documentation (Outcome O3, O4)
Introduction to working with software tools for designing technical documentation.
5. Types of technical documentation (Outcome O3, O4)
Project documentation, construction documentation, technological documentation, manufacturing documentation. Design flow and application.

Required reading

- Kukec, Đuro: Tehnička dokumentacija, Technical College in Bjelovar, Bjelovar, 2011

Further reading

- Padovan, Lukša: "Inženjerska grafika i dokumentiranje", Graphis d.o.o. Zagreb, Zagreb, 2004
- Švigir, Nikola; Sumina, Damir; Padovan, Lukša: "Tehničko crtanje uporabom CAD programa", Graphis d.o.o. Zagreb, Zagreb, 2007
- Žunar, Milan:"Tehničko Crtanje", Profil Mozaik d.o.o. Zagreb, Zagreb, 2008.

Course title	**Technical English 2**						
Course instructor(s)	Ivana Jurković, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	1st	**Semester**	2nd	**ECTS**	2		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	30	0	0		

Course objectives

Developing students' ability to use the English language related to specific technical fields.

Expected learning outcomes

Upon completion of the course students will be able to use the English language to:

- O1: describe the procedure of developing an engineering project,
- O2: describe technical problems and malfunctions as well as their causes and possible solutions,
- O3: discuss about technical requirements and describe project feasibility, improvements and redesigns,
- O4: demonstrate mastery of simple grammatical structures.

Course content

1. Developing an engineering project (Outcome O1)
Describing project design.
Defining a project, precision and tolerance.
Mathematical expressions.
Describing development procedures in an engineering project.
2. Repair and maintenance (Outcome O2)
Describing technical malfunctions.
Assessment of faults.
Describing the causes of malfunctions.
Discussing repair and maintenance.
3. Technical development (Outcome O3)
Describing technical requirements.
Suggesting ideas and solutions.
Feasibility study.
Describing improvements and redesigns.
4. Grammar (Outcome O4)
Numbers.
Conjunctions.
Pronouns.
Present, past and future tenses.

Required reading

- Ibbotson, Mark: Cambridge English for Engineering, Cambridge University Press, Cambridge, 2008

Further reading

- Murphy, Raymond: English Grammar in Use, Cambridge University Press, Cambridge, 2004

Course title	**Technical German 2**						
Course instructor(s)	Ivana Jurković, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	1st	**Semester**	2nd	**ECTS**	2		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	30	0	0		

Course objectives

Developing students' ability to use the German language related to specific technical fields.

Expected learning outcomes

Upon completion of the course students will be able to use the English language to:

- O1: describe the position of components in assemblies, technical drawings, design procedure and dimensions, precision and tolerances in the preparation of technical documentation,
- O2: describe technical problems and malfunctions as well as their causes and possible solutions,
- O3: discuss about technical requirements and describe project feasibility, improvements and redesigns,
- O4: demonstrate mastery of simple grammatical structures.

Course content

1. Technical drawings

Describing the procedure of making drawings. Dimensioning, precision, tolerances. Design process. Grammar focus: numbers, conjunctions, pronouns.

2. Repair and maintenance

Describing technical malfunctions. Assessment of faults. Describing the causes of malfunctions. Discussing repair and maintenance. Grammar focus: declension of adjectives and nouns.

3. Technical development

Describing technical requirements. Suggesting ideas and solutions. Feasibility study. Describing improvements and redesigns. Grammar focus: subjunctive.

Required reading

- Štambuk, Zdenka;Marinić, Davorka: Deutsch und Technik– Materie – Energie – Information, Školska knjiga, Zagreb, 1991

Further reading

- Muljević, Vladimir; Horvatić, Željko: Njemačko – hrvatski i hrvatsko – njemački elektrotehnički rječnik, Školska knjiga, Zagreb, 1996
- Marčetić, Tamara: Deutsche Grammatik im Überblick, Školska knjiga, Zagreb, 2003
- Berger, Maria Cristina; Martini, Maddalena: Generation E, Deutschsprachige Landeskunde im Europäischen Kontext, Ernst Klett, Stuttgart 2005

<table>
<tr><td colspan="2">Course title</td><td colspan="6">Physical Education 2</td></tr>
<tr><td colspan="2">Course instructor(s)</td><td colspan="6">Damir Lauš, lecturer</td></tr>
<tr><td colspan="2">Programme(s) of study</td><td colspan="6">Undergraduate professional programme of study in Mechatronics
Undergraduate professional programme of study in Computer Science</td></tr>
<tr><td colspan="2">Course status</td><td colspan="6">Compulsory</td></tr>
<tr><td>Year</td><td>1st</td><td>Semester</td><td>2nd</td><td>ECTS</td><td colspan="3">0</td></tr>
<tr><td colspan="2" rowspan="2">Contact hours (L+PS+S)</td><td colspan="2" rowspan="2">0 + 30 + 0</td><td>L</td><td colspan="2">PS</td><td rowspan="2">S</td></tr>
<tr><td>APS</td><td>LPS</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td>0</td><td></td><td>30</td><td>0</td></tr>
<tr><td colspan="8">Course objectives</td></tr>
<tr><td colspan="8">Promotion of physical exercise and sports, and enhancing the quality of life in youth, adulthood and old age.</td></tr>
<tr><td colspan="8">Expected learning outcomes</td></tr>
<tr><td colspan="8">Upon completion of this course students will be able to:
O1: demonstrate mastery of practical motor skills and exercise independently,
O2: understand the importance of everyday physical exercise for the shaping of anthropological features and achieving success in one's studies and future professional life.</td></tr>
<tr><td colspan="8">Course content</td></tr>
<tr><td colspan="8">The course is based around a set of kinesiological activities and can be divided into the main and special programme. Students opt for these based on their interests, level of proficiency in motor skills, ability levels, health status and the material conditions available.
The main programme includes kinesiological activities such as athletics, basketball, football, volleyball, dance structures, handball, table tennis…, and the special one is focused on activities less present in primary and secondary school curricula (fitness, aerobics, taekwondo, karate, squash). (Outcome O1, O2)</td></tr>
<tr><td colspan="8">Required reading</td></tr>
<tr><td colspan="8">• -</td></tr>
<tr><td colspan="8">Further reading</td></tr>
<tr><td colspan="8">• -</td></tr>
</table>

Course title	Sensors						
Course instructor(s)	Marko Miletić, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	2nd	Semester	3rd	ECTS	6		
Contact hours (L+PS+S)	30+30+0	L	PS		S		
			APS	LPS			
		30	12	18			

Course objectives

Acquiring basic knowledge about sensors that are used in mechatronics.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: interpret the characteristics of sensors,
O2: describe measurement methods and procedures of non-electrical and electrical quantities,
O3: describe signal processing in a sensor,
O4: choose an optimal sensor for a specific mechatronic system,
O5: connect a sensor with electronic devices.

Course content

1. Basic terms and definitions, sensor characteristics (Outcome O1)
Definition of measurements, sensors and transducers.
Classification of sensors.
Measurement quantities and units.
Measurement errors.
Statistical analysis of measurement results.
Statistical distributions.
Confidence interval.
Measurable uncertainty.
Error limits and grades of accuracy.
Indication of measurement results.
Mathematical model of a sensor.
Measurement range.
Sensor calibration.
Accuracy.
Sensor nonlinearness.
Hysteresis.
Saturation.
Repeatability.
Reliability.
Uncertainty.
Dead zone.
Resolution.
Output impedance of a sensor.
Sensor output signal.
Collection of sensor data.

2. Methods and procedures of measuring nonelectrical quantities (Outcome O2)
Measurement of length.
Measuring the angle.
Measurement of displacement and rotation.
Measurement of speed and speed of rotation.
Flow measurement.
Temperature measurement.
Measurement of humidity.
Pressure measurement.
Vibration measurements.
Measurement of mass and force.
Level measurement.
3. Methods and procedures of measuring electrical quantities (Outcome O3)
Measurement of current, voltage and power.
U-I procedures.
Bridge procedures.
Wheatstone Bridge.
4. Signal processing in a sensor (Outcome O4)
Signal amplification.
Filtering the signal.
Analogue-to-digital conversion.
Digital-to-analogue conversion.
5. Sensors in mechatronics (Outcome O4)
Voltage and current sensors.
Distance sensors.
Speed sensors.
Shift and rotation speed sensors.
Mechanical presence sensors.
Inductive presence sensors.
Capacitive presence sensors.
Ultrasonic presence sensors.
Magnetic presence sensors.
Analogue and digital temperature sensors.
Moisture sensors.
Pressure sensors.
Flow sensors.
Mass and force sensors.
Level sensors.
Optimal sensor selection.
6. Types of sensor outputs (Outcome O5)
Continuous sensors.
Discrete sensors.
Voltage output.
Current output.
Sensor communication interface.
RS232.
RS485.
CAN.
I2C.
SPI.
AS-i.

Required reading
• Presentations for lectures and practical sessions – Sensors, Bjelovar University of Applied Sciences.
Further reading
• Fraden, Jacob: Handbook of Modern Sensors, Springer, 2010 • Webster, John G.: Measurement, Instrumentation, and Sensors Handbook, CRC Press LLC, 1999

Course title	**Digital Techniques**						
Course instructor(s)	Dario Vidić, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics Undergraduate professional programme of study in Computer Science						
Course status	Compulsory						
Year	2nd	**Semester**	3rd	**ECTS**	6		
Contact hours (L+PS+S)	30 + 30 + 0	L	PS		S		
			APS	LPS			
		30	16	14			

Course objectives

To acquire basic knowledge of digital techniques.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: use different number systems and codes,
- O2: design units for detecting and correcting data transfer errors,
- O3: minimise and realise complex logical functions using basic logic circuits,
- O4: explain the operation of combinational and arithmetic units,
- O5: explain the operation of basic types of bistables and counters,
- O6: design sequential circuits,
- O7: explain the operation of AD and DA conversion circuits.

Course content

1. Number systems and codes (Outcome O1, O2)
Number systems (decimal, binary, hexadecimal etc.). (Outcome O1)
Conversion of numbers between number systems. (Outcome O1)
Operations with binary numbers. (Outcome O1)
Characteristic binary codes. (Outcome O1)
Binary encoding. (Outcome O2)
2. Logic circuits (Outcome O3)
Propositional logic. The basic principles of Boolean algebra. AND, OR, NOT, NAND, NOR gates. Complex logical operations. Minterms and maxterms. Methods of minimisation (K-map, the Quine-McCluskey method).
Design of logic circuits in semiconductor technology: TTL technology. CMOS technology.
3. Complex combinational modules (Outcome O4)
Adders. Digital comparator. Parity circuit. Encoder and decoder. Multiplexer and demultiplexer.
4. Bistables (Outcome O5)
Operation and types of bistables. Bistable design using logic integrated circuits.
5. Registers and sequential circuits (Outcome O5 and O6)
Design and implementation of registers. Design of counters. Asynchronous and synchronous counters. Decade counters. Sequential machines.
6. D/A and A/D conversion (Outcome O7)

Required reading

- Vrhovski, Zoran; Šumiga Ivan: Digitalna tehnika – problem book, Technical College in Bjelovar, Bjelovar, 2015
- Dario Vidić: "Presentations for lectures and practical sessions – Digital Techniques", Bjelovar University of Applied Sciences.

Further reading

- Peruško, Uroš: Digitalna elektronika, Školska knjiga, Zagreb, 1996
- Čupić, Marko: Digitalna elektronika i digitalna logika, problem book, Kigen d.o.o., Zagreb, 2006

Course title	**Elements of Precise Mechanics**						
Course instructor(s)	Stjepan Golubić, PhD, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	2nd	**Semester**	3rd	**ECTS**	6		
Contact hours (L+PS+S)	30 + 45 + 0	L	PS		S		
			APS	LPS			
		30	35	10			

Course objectives

1. Familiarising students with standardised elements of precise mechanics, calculation of elements of precise mechanics and materials used for making them.
2. Familiarising students with power and motion transmissions as well as the basic calculation involving the aforementioned transmissions.

Expected learning outcomes

Upon completion of this course students will be able to:
O1: draw standard elements of precise mechanics (machine elements),
O2: recognise and describe elements of precise mechanics,
O3: calculate the stress and dimensions of standard elements of precise mechanics,
O4: recognise and describe motion elements and transmissions,
O5: calculate motion elements and basic relations and dimensions of transmissions.

Course content

1. Basic terms (Outcome O1)
Standardisation. Allowed stress. Classification of elements of precise mechanics (machine elements). Drawing machine elements.
2. Permanent and non-permanent joints (Outcome O2, O3)
Screws, nuts, washers. Hub joints. Pin and bolt connections. Welded, soldered, riveted, interference, glued joints. Other fixing methods.
3. Energy containers and resistors (Outcome O2, O3)
Springs, weights, flywheels, jigs, gyroscopes, adjusters, stopcocks, brakes, chokes.
4. Seals and sealing (Outcome O2, O3)
Static sealing. Dynamic sealing.
5. Motion transmission elements (Outcome O4, O5)
Axles, shafts and sleeves. Lubricants. Sliding bearings. Roller bearings. Clutches.
6. Transmissions (Outcome O4, O5)
Friction drives, belt drives, chain drives, gear drives.

Required reading

- Karl-Heinz Decker: Elementi strojeva, Tehnička knjiga, Zagreb, 2006
- Golubić, Stjepan: Presentations in the course Elements of Precise Mechanics, Bjelovar University of Applied Sciences, http://vub.hr/elementi-porecizne-mehanike-program/kolegij/

Further reading

- Kraut, Bojan: Strojarski priručnik, Tehnička knjiga, Zagreb
- Group of authors: Krautov strojarski priručnik, Sajema, Zagreb, 2009

Course title	**Signals and Systems**						
Course instructor(s)	Zoran Vrhovski, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	2nd	**Semester**	3rd	**ECTS**	5		
Contact hours (L+PS+S)	30 + 30 + 0	L	PS		S		
			APS	LPS			
		30	24	6	0		

Course objectives

Familiarising students with the application of the theory of signals and systems.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: mathematically describe signals, draw signals and determine signal properties,
- O2: determine the response of a continuous system by solving a difference equation with constant coefficients,
- O3: apply the Laplace transform in continuous signals and systems,
- O4: apply the Fourier analysis in signals and systems,
- O5: determine the response of a discrete system by solving a difference equation with constant coefficients,
- O6: apply the Z-transform in discrete signals and systems.

Course content

1. Fundamental terms (Outcome O1)
Types of signals and systems.
Continuous signals and systems.
Discrete signals and systems.
Basic signals.
Basic properties of signals and systems.
Basic signal operations.
Analogue-to-digital signal conversion.
2. Continuous systems (Outcome O2, O3, O4)
System description by means of a linear differential equation with constant coefficients. (Outcome O2)
Solving linear differential equations with constant coefficients. (Outcome O2)
Block presentation of a system. (Outcome O2)
The concept of the convolution integral. (Outcome O2)
Laplace transform. (Outcome O3)
Basic characteristics of Laplace transform. (Outcome O3)
Application of Laplace transform. (Outcome O3)
Transfer function of a continuous system. (Outcome O3)
Presentation of a periodical signal by a trigonometric and exponential Fourier series. (Outcome O4)
Fourier transform. (Outcome O4)
3. Discrete systems (Outcome O5, O6)
Describing a system using the difference equation with constant coefficients. (Outcome O5)
Solving linear difference equations with constant coefficients. (Outcome O5)

The Z-transform. (Outcome O6)
Basic characteristics of the Z-transform. (Outcome O6)
Application of the Z transform.
The transfer function of a discrete system. (Outcome O6)
4.Application of the software tool Matlab and Simulink in signals and systems (Outcome O1, O2, O3, O5, O6)

Required reading

- Vrhovski, Zoran; Purković, Dalibor: Signali i sustavi – problem book, Technical College in Bjelovar, Bjelovar, 2016
- Vrhovski, Zoran: Presentations in Signals and Systems, Bjelovar University of Applied Sciences, 2018, https://vub.hr/signali-i-sustavi/ (available on: 5.7.2018)

Further reading

- Vrankić, Miroslav: Signali i sustavi – problem book, Graphis, Zagreb, 2007

Course title	Technical English 3						
Course instructor(s)	Ivana Jurković, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	2nd	Semester	3rd	ECTS	2		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	30	0	0		

Course objectives

To develop students' ability to use the English language related to specific technical fields.

Expected learning outcomes

Upon completion of the course students will be able to use the English language to:

- O1: describe regulations, standards procedures and measures related to occupational health and safety
- O2: describe automated systems, measurable parameters, readings and approximate values
- O3: explain testing procedures, conduction of experiments and describe the predicted outcomes of testing
- O4: demonstrate mastery of more complex grammatical structures

Course content

1. Occupational health and safety (Outcome O1)
Description of occupational health and safety measures.
Protective equipment.
Regulations and standards.
Written instructions.
2. Automatic control (Outcome O2)
Describing automated systems.
Describing measurable parameters.
Giving approximate values.
Describing graphs.
3. Tests and experiments (Outcome O3)
Describing tests and experiments.
Comparison of results and expectations.
Assumptions.
4. Grammar (Outcome O4)
Imperative.
Conditional clauses.
Passive Voice.
Nouns.
Compounds.
Articles.

Required reading

- Ibbotson, Mark: Cambridge English for Engineering, Cambridge University Press, Cambridge, 2008

Further reading

- Murphy, Raymond: English Grammar in Use, Cambridge University Press, Cambridge, 2004

Course title	**Technical German 3**						
Course instructor(s)	Ivana Jurković, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	2nd	**Semester**	3rd	**ECTS**	2		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	30	0	0		

Course objectives

To develop students' ability to use the German language related to specific technical fields.

Expected learning outcomes

Upon completion of the course students will be able to use the German language to:

O1: describe procedures and requirements related to occupational health and safety,
O2: describe the differences between regulations and standards and give examples,
O3: describe automated systems, measurable parameters, readings and approximate values,
O4: explain testing procedures, conduction of experiments and describe the predicted outcomes of testing,

Course content

1. Occupational health and safety

Description of occupational health and safety measures. Protective equipment. Regulations and standards. Written instructions. Grammar focus: differences between colloquial and written style, imperative, conditional sentences.

2. Automatic control

Describing automated systems. Describing measurable parameters. Giving approximate values. Describing graphs. Grammar focus: passive structures.

3. Tests and experiments

Describing tests and experiments. Comparison of results and expectations. Assumptions. Grammar focus: types of nouns, plural of nouns, compounds, articles.

Required reading

- Štambuk, Zdenka; Marinić, Davorka: Deutsch und Technik– Materie – Energie – Information, Školska knjiga, Zagreb, 1991

Further reading

- Muljević, Vladimir; Horvatić, Željko: Njemačko – hrvatski i hrvatsko – njemački elektrotehnički rječnik, Školska knjiga, Zagreb, 1996
- Marčetić, Tamara: Deutsche Grammatik im Überblick, Školska knjiga, Zagreb, 2003
- Berger, Maria Cristina; Martini, Maddalena: Generation E, Deutschsprachige Landeskunde im Europäischen Kontext, Ernst Klett, Stuttgart 2005

Course title	**Fundamentals of Mechanical Operations**						
Course instructor(s)	Božidar Hršak, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	2nd	**Semester**	3rd	**ECTS**	5		
Contact hours (L+PS+S)	30 + 15 + 0	L	PS		S		
			APS	LPS			
		30	15	0	0		

Course objectives

1. Acquiring basic knowledge in mechanical operations and processes oriented on directly applicable laws and contents.
2. Understanding individual laws and processes implemented in mechanical operations with coarsely dispersed materials via machines, assemblies and systems.
3. Developing assessment skills, fundamentals of dimensioning and selection of appropriate elements and machines applicable in professional work.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: recognise and name key devices, assemblies, mechanisms and machines in the process of mechanical operations and transport of ground solid materials,
- O2: describe individual operation processes and laws that represent a part or a whole of a process,
- O3: use practical examples to interpret individual processes of mechanical operations and apply them in practice,
- O4: apply their insights in solving practical tasks on examples of mechanisms, devices, installation assemblies,
- O5: differentiate between the types and methods of mechanical operations and suggest more efficient procedures in certain practical cases,
- O6: calculate the basic quantities of power and motion, and select devices and assemblies applicable in mechanical operations or transport of ground particles by means of gaseous and/or liquid media,
- O7: control the devices during the transport of ground particles by means of gaseous and liquid media.

Course content

1. Basic terms (Outcome O1)
Purpose and application.
Presentation of the application of machines, devices, equipment, systems and plants.
2. Dispersed systems, mixtures (Outcomes O1-O4)
Basic terms and definitions (dispersed system, specific names of dispersed systems, ...). (Outcome O2)
Mixing of elements, porosity, fluid influence, hygroscopicity. (Outcomes O3-O4)
3. Distribution and separation of particles and particle separation efficiency (Outcomes O2-O4)
Dispersion parameters, measurable properties, particle sphericity, grinding degree, separation of solid particles in processes
4. Particle sedimentation (Outcomes O2-O4)
Free sedimentation, resistance forces (spherical and non-spherical particles). (Outcomes O2-O3)
Particle sedimentation speed. (Outcomes O2-O3)
Sedimentation tanks. (Outcomes O2-O3)
Vertical and horizontal sedimentation tank. (Outcomes O2-O4)
Other types of sedimentation tanks. (Outcomes O2-O3)

Coagulation. (Outcomes O2-O3)
Flocculation. (Outcomes O2-O3)
Practical examples. (Outcomes O3-O4)
5. Classification and sorting (Outcomes O2-O4)
Hydraulic and pneumatic classification. (Outcomes O2-O4)
Classification by sieving, sieving machines. (Outcomes O2-O3)
Sorting. (Outcomes O2-O3)
Filtering, filters, types and application of filters, basic parameters and dimensioning. (Outcomes O2-O4)
Centrifugation, removal of dust (wet, dry). (Outcomes O2-O3)
Practical examples. (Outcomes O3-O4)
6. Centrifugation. Cyclones. (Outcomes O2-O6)
Centrifugation, types of centrifuges and their operation, application. (Outcomes O2-O6)
Cyclones. (Outcomes O2-O5)
Multicyclones. (Outcomes O2-O5)
Flow. (Outcomes O2-O4)
Piping. (Outcomes O2-O4)
Pressure drop calculation. (Outcomes O2-O5)
Practical examples. (Outcomes O3-O6)
7. Pneumatic transport (Outcomes O2-O7)
Elements, assemblies and devices, impact parameters, flow speed, piping, pressure drop calculation, application. (Outcomes O2-O7)
Practical examples. (Outcomes O3-O7)
8. Hydraulic transport (Outcomes O2-O7)
Purpose and basic parts, mixture flow speed, pressure drop. (Outcomes O2-O7)
Pump aggregate. (Outcomes O2-O5)
Cost-effectiveness (technical parameters, investment costs, exploitation costs,...) (Outcomes O2-O4)
Practical examples. (Outcomes O3-O7)
9. Grinding solid materials (Outcomes O2-O5)
Defining the purpose, method and procedures of grinding. (Outcomes O2-O3)
Grinding application. (Outcomes O2-O4)
Crushing and milling. (Outcomes O2-O5)
Energy consumption estimation. (Outcomes O2-O4)
Practical examples. (Outcomes O3-O5)
10. Machines for grinding solid materials (Outcomes O2-O6)
Crushing (crushing machines – coarse, medium, fine). (Outcomes O2-O3)
Milling (milling machines – fine, very fine). (Outcomes O2-O3)
Determining the capacity and power of machine and devices. (Outcomes O4-O6)
Practical examples. (Outcomes O3-O6)
11. Equipment in mechanical operations systems (Outcomes O2-O7)
Transport ventilators. (Outcomes O2-O7)
Dosing feeders. (Outcomes O2-O5)
Gear transporters (purpose and transport materials, coils, capacity, impact parameters, bevel, drive devices, calculations and dimensioning,...). (Outcomes O2-O7)
Storing solid particles. (Outcomes O2-O3)
Practical examples. (Outcomes O3-O7)

Required reading

- Čikić, Ante; Kondić, Živko: Osnove mehaničkih operacija, Technical College in Bjelovar, Bjelovar, 2012
- Čikić, Ante; Kondić, Živko: Osnove mehaničkih operacija – practical examples, Technical College in Bjelovar, Bjelovar, 2014
- Čikić, Ante: Authorised presentations in lectures and practical sessions in Fundamentals of Mechanical Operations, Technical College in Bjelovar, Bjelovar, 2017, https://moodle.srce.hr/2017-2018/course/view.php?id=26743

Further reading

- Hornby, N.; Edwards, M.F.; Nienow, A.W.: Mixing in the process industries, Butterworths, London, 1985
- Oldslue, J.Y.: Fluid Mixing Technology, McGrew – Hill, New York, 1983
- Kipke, K.:Problems in MixingTechnology, McGrew – Hill, New York, 1983
- Loffler, F.: Staubabscheiden, Georg Thieme Verlag, Stuttgart, 1988
- Hraste, M.: Filtriranje – tehnička enciklopedija 5, Leksikografski zavod, Zagreb,1976
- Hraste, M.: Mehaničke operacije, Sveučilišna naklada, Zagreb, 1990
- Zglav, M.: Miješanje – tehnička enciklopedija 8, Leksikografski zavod, Zagreb, 1982
- Koharić, V.: Mehaničke operacije, Faculty of Mechanical Engineering and Naval Arcitecture, Zagreb, 1996
- Bogner, M.; Vuković, D.: Tehnika pročišćavanja, Smeits, Beograd, 1996
- Beer, E.: Priručnik za dimenzioniranje uređaja kemijske industrije, Zagreb, 1980
- Bogner, M.: Termotehničar 2, 3rd edition, Smeits, Beograd, 2004
- Materials written by of equipment and device manufacturers, various online sources.

Course title	Microcomputers							
Course instructor(s)	Zoran Vrhovski, senior lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics Undergraduate professional programme of study in Computer Science							
Course status	Compulsory							
Year	2nd	Semester	4th	ECTS	4			
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S			
			APS	LPS				
		15		30				

Course objectives

To familiarise students with the application of microcomputers and their programming and usage in the design and production of more complex electronic devices.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: choose a microcomputer that is optimal for a given purpose from the aspect of price, features and availability
- O2: configure microcomputer operation using registers in the development software environment
- O3: create a microcontroller control program for a given purpose in the development software environment
- O4: use microcontroller interrupts when it is required by the functionality of an electronic device
- O5: connect electronic devices to a microcontroller taking into account the purpose of an individual pin of a microcontroller

Course content

1. Fundamental concepts and microcomputer architecture (Outcome O1)
Application of microcomputers. Historical development of microcomputers. Differences between microcomputers, microcontrollers and microprocessors. Microcomputer structure: CPU, buses. Microcomputer architecture: (CISC, RISC). Execution of microcomputer instructions.
2. Microcontrollers (Outcome O1, O2, O4)
Features. Architecture. CPU. Clock rate. Instruction execution. Set of instructions. Memory. Input/output registers. Reset. Watchdog. Interrupts. Digital inputs and outputs. Counters and timers. PWM. Digital-to-analogue converter. Analogue-to-digital converter and analogue inputs. USART (serial communication). I2C communication. SPI communication. External interrupts. Power supply. Producers of microcontrollers. Features of the Atmel ATMega16 microcontroller.
3. Programming a microcontroller (Outcome O2, O3, O4)
Programming a microcontroller. Instruction set of the Atmel AVR microcontroller family. Machine code. Main program and infinite loops. Interrupt routines. Functions. Microcontroller programming environments. Fuse bits. Lock bits. In-System Programming.
4. Connecting electronic devices to a microcontroller (Outcome O4, O5)
Connecting the following devices to a microcontroller: push buttons, LED diodes, LCD display, potentiometer, NTC resistor, numeric display, optocoupler, transistor as a switch, relay, buzzer, analogue and digital temperature sensors, Bluetooth module, graphic display, GSM module, matrix keyboard, servo motor, ultrasound sensor, real time clock module, H bridge, communication modules. Microcomputer system management using a computer or smartphone application.

Required reading

- Vrhovski, Zoran; Miletić, Marko: Mikroračunala - Programiranje mikrokontrolera porodice Atmel u programskom okruženju Atmel Studio 6, Technical College in Bjelovar, Bjelovar, 2014
- Vrhovski, Zoran: Presentations of lectures in Microcomputors, Bjelovar University of Applied Sciences, available on: https://vub.hr/mikroracunala/
- ATMEL: 8-bit AVR Microcontroller with 16K Bytes In-System Programmable Flash – ATMEGA16,

http://ww1.microchip.com/downloads/en/DeviceDoc/doc2466.pdf (available on: 19.7.2018)

Further reading

- F. Barrett, Steven; Pack, Daniel; Thornton, Mitchell: Atmel AVR microcontroller primer: programming and interfacing, Morgan &Claypool Publishers, Thornton, 2007

Course title	Mechanisms						
Course instructor(s)	Tomislav Pavlic, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	2nd	Semester	4th	ECTS	4		
Contact hours (L+PS+S)	(15 + 30 + 0)	L	PS		S		
			APS	LPS			
		15	20	10	0		

Course objectives

Acquiring and being able to use the knowledge necessary for understanding, selection, modification, adjustment and usage of various types of mechanisms within mechatronic systems.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: acquire the characteristics of basic types of mechanisms,
O2: use the acquired knowledge in designing and dimensioning various types of mechanisms,
O3: analyse the kinematics and dynamics of basic types of mechanisms,
O4: construct mechanisms according to specified requirements and needs.

Course content

1. Introduction to the theory of mechanisms (Outcome O1)
Structure and classification of mechanisms. Mechanism members. Kinematic pairs. Kinematic chains. Motion freedom degrees.
2. Structure and classification of mechanisms (Outcome O1)
Methods of shaping mechanisms.
3. Basic types of mechanisms (Outcome O1 and O2)
Four-bar mechanisms, reciprocating mechanisms, ridge cam mechanisms, coulisse mechanisms, gear mechanisms etc. Mechanisms driven by electric motors, pneumatic and hydraulic.
4. Kinematic analysis of mechanisms (Outcome O1, O2, O3)
Kinematic characteristics of motion laws. Kinematics of drive and working elements of mechanisms. Current speed pole. Velocity and acceleration plan method. Determing the position, velocity and acceleration of mechanisms.
5. Mechanism dimensioning (Outcome O3)
Selection and adjustment of mechanical and electrical components for the construction of various types of mechanisms.
6. Construction of mechanisms (Outcome O4)
Construction of mechanisms of different kinematics, driven by various drives used in mechatronic systems.

Required reading

- Husnjak, M.: Teorija mehanizama, Faculty of Mechanical Engineering and Naval Arcitecture in Zagreb, 2003
- Pavlic, Tomislav: Lectures in the course Mechanisms, Bjelovar University of Applied Sciences, Bjelovar, 2018

Further reading

- Hagedorn, L., Thonfeld, W. and Rankers A.: Konstruktive Getriebelehre, Springer-Verlag, Berlin Heidelberg, 2009
- Bazjanac, D.: Osnovi teorije mehanizama, Zagreb, 1966
- Muftić, O.,Drača, K.: Uvod u teoriju mehanizama, Sveučilišna naklada Liber, Zagreb, 1974

Course title	**Automated Control**						
Course instructor(s)	Zoran Vrhovski, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	2nd	**Semester**	4th	**ECTS**	6		
Contact hours (L+PS+S)	30 + 30 + 0		L	PS		S	
				APS	LPS		
			30	24	6	0	

Course objectives

Enabling students to analyse and synthesise a continuous automated control system.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: test the linearity and time invariance of systems
- O2: determine transfer functions, poles, zeros and amplification of time dynamic members in an open and closed automated control system
- O3: parametrise a first-order or second-order system according to defined time response requirements
- O4: analyse an automated control system response within the time and frequency domain
- O5: apply the stability analysis procedures to linear continuos automated control systems
- O6: determine the structure and parameters of a regulator according to the defined time response requirements of a closed automated control circle
- O7: determine the structure and parameters of the Ziegler-Nichols method

Course content

1. Basic terms and definitions (Outcome O1)
System classification
Linear time-invariant continuous systems
Basic structures of control systems
2. Mathematical models of linear continuous systems (Outcome O2)
Description of linear systems using linear differential equations
Description of systems by the transfer function in the Laplace domain
Description of systems using state variables
3. Block algebra in an automated control system (Outcome O2)
Block diagram of a system – basic elements
Serial and parallel blocks
Feedback
Open and closed automated control circle
Control system structure
4. Time response of the system of basic dynamic members (Outcomes O3, O4)
System response according to the position of system poles (Outcome O4)
Time characteristics of basic dynamic members: P, PT1, PT2, PT2S I, D, DT1, member with transport delay (Outcomes O3, O4)
System quality indicators (Outcomes O3, O4)
5. Frequency response of basic dynamic members (Outcome O4)

Nyquist and Bode diagram
Frequency characteristics of basic dynamic members: P, PT1, PT2, PT2S I, D, DT1, member with transport delay
6. Stability analysis of an automated control system (Outcome O5)
Algebraic stability criteria: Hurwitz stability criterion and Routh stability criterion
Frequency criterion of stability: Nyquist stability criterion and determining stability using the Bode diagram
7. Synthesis of the regulation circle of an automated control system (Outcomes O6, O7)
Synthesis requirements of an automated control system (Outcomes O6, O7)
Basic structure of an automated control system: control system, regulator, actuator, sensor (Outcomes O6, O7)
Parametrisation of basic regulator versions using the Ziegler-Nichols method (Outcome 7)
Parametrisation of PI regulators using the technical optimum method (Outcome 6)
Parametrisation of basic regulator versions according to the defined requirements of time response (Outcome 6)
Cascade control systems (Outcome 6)
8.Application of the Matlab and Simulink software for the analysis and synthesis of linear continuos automated control systems (Outcomes O2, O3, O4, O5, O6, O7)

Required reading

- Vrhovski, Zoran: Automatsko upravljanje – Analiza i sinteza linearnih kontinuiranih sustava, Technical College in Bjelovar, Bjelovar, 2013
- Vrhovski, Zoran; Glumac, Slaven: Automatsko upravljanje – problem book, Bjelovar University of Applied Sciences, 2018, available on: https://vub.hr/images/uploads/1341/automatsko-upravljanje-zbirka-01.pdf

Further reading

- Crnošija, Petar; Bjažić, Toni: Osnove automatike I. dio, Analiza i sinteza kontinuiranih sustava - teorija i primjena, Element, Zagreb, 2011

Course title	**Thermodynamics and Fluid Mechanics**						
Course instructor(s)	Božidar Hršak, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	2nd	**Semester**	4th	**ECTS**	5		
Contact hours (L+PS+S)	30 + 30 + 0		L	PS		S	
				APS	LPS		
			30	30	0	0	

Course objectives

1. Acquiring basic knowledge of thermodynamics and fluid mechanics directed towards directly applicable laws and contents.
2. Understanding the individual thermodynamic and hydraulic principles and processes implemented in thermotechnical devices, assemblies and systems.
3. Developing the sense of estimation about the fundamentals of thermodynamic and hydrodynamic calculations (dimensioning), and the selection of certain elements and devices applicable in the area of expertise.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: identify key thermodynamic and fluid processes in individual plant and installation segments,
- O2: describe individual thermodynamic and fluid principles that form a part or a whole of a process,
- O3: use practical examples to interpret the basic principles in thermodynamics and fluid mechanics,
- O4: apply their knowledge in solving practical tasks on examples of specific thermotechnical and hydraulic devices and assemblies,
- O5: differentiate between the modes of heat exchange, distribution of media and the efficiency of individual thermotechnical devices,
- O6: calculate basic power and motion quantities and select individual thermotechnical and hydraulic elements, devices and assemblies,
- O7: control devices in the distribution of gaseous and liquid media.

Course content

1. Fundamental terms in thermodynamics (Outcome O1 – O4)
Technical thermodynamics, basic state quantities, balance, heat, temperature, temperature scale, pressure, volume, mass, quantity of matter, speed, level, energy, mechanical work, power. (Outcome O1)
Practical examples. (Outcome O2 – O4)
2. The first law of thermodynamics. The ideal gas equation. (Outcome O2 – O4)
The first law of thermodynamics, internal energy, work. (Outcome O2)
The ideal gas equation. (Outcome O2 – O3)
Quantity of matter. (Outcome O2 – O3)
Specific heat. (Outcome O2 – O3)
Practical examples. (Outcome O3 - O4)
3. Changes in the state of ideal gases (Outcome O2 - O4)
Mixtures of ideal gases. (Outcome O2 – O3)
Changes in the state: isochoric, isobaric, isothermal, adiabats, polytropic. (Outcome O2 – O3)
Practical examples. (Outcome O3 - O4)
4. Cycle processes. The second law of thermodynamics (Outcome O2 – O4)

Closed and open cycle processes. (Outcome O2 - O3)
The Carnot process. (Outcome O2 - O3)
The Joule process. (Outcome O2 - O3)
Diesel and Otto process. (Outcome O2 - O3)
The second law of thermodynamics. (Outcome O2 - O3)
Reversible and irreversible processes. (Outcome O2 - O3)
Practical examples. (Outcome O3 - O4)

5. Heat exchange (Outcome O2 – O5)

Heat exchange (purpose, mode, and application). (Outcome O2 - O3)
Conduction, convection, radiation. (Outcome O2, O3, O5)
Heat conduction through single-layer and multilayer flat walls and tubes. (Outcome O2, O3, O5)
Practical examples. (Outcome O3 - O4)

6. Convection. Heat exchangers (Outcome O2 - O5)

Natural and forced convection, features, coefficient of heat transfer. (Outcome O2 - O3)
Examples of calculations for different application cases. (Outcome O3 - O5)
Heat exchangers (recuperators, regenerators, direct), counterflow, parallel flow, cross flow. (Outcome O3 - O5)
Practical examples. (Outcome O3 - O4)

7. Moist air (Outcome O2 - O4)

Air composition, aggregate states of air humidity, "h - x" diagram, enthalpy of moist air. (Outcome O2 - O3)
Practical examples. (Outcome O3 - O4)

8. Processes of thermodynamic treatment of moist air (Outcome O2 - O5)

Purpose and application. (Outcome O2 - O3)
Heating, cooling, mixing two and more airflows, humidifying (water and steam), dehumidifying. (Outcome O2, O3, O5)
Practical examples. (Outcome O3 - O4)

9. Introduction to fluid mechanics (Outcome O2, O3, O5)

Basic concepts and definitions, characteristics of applicable fluids in technical practice.

10. Hydrostatics (Outcome O2 - O5)

Static pressure, dynamic pressure, stagnation pressure, connected vessels, bottom pressure, buoyancy, floating of the bodies. (Outcome O2, O3, O5)
Practical examples. (Outcome O3 - O6)

11. Kinematics and fluid dynamics (Outcome O2 - O5)

Fundamentals of kinematics and fluid dynamics. (Outcome O2 - O3)
Liquid energy. (Outcome O2 - O3)
The amount of motion. (Outcome O2 - O3)
Practical examples. (Outcome O3-O6)

12. Equation of continuity and Bernoulli's equation (Outcome O2 - O6)

Equation of continuity (piping, channels). (Outcome O2, O3, O5)
Bernoulli's equation and modified Bernoulli's equation. (Outcome O2, O3, O5)
Practical examples. (Outcome O3 - O6)

13. Piping flow and hydrodynamic piping calculation (Outcome O2 - O7)

Laminar and turbulent flow. (Outcome O2, O3, O7)
Roughness of pipes and coefficient of frictional resistance, the Moody diagram, hydraulic smooth and hydraulic rough pipes, linear and individual resistance, piping calculation. (Outcome O2, O3, O5, O7)
Practical examples. (Outcome O3 - O6)

14. Flowing out and tank draining. Open channel flow (Outcome O2 - O7)

Laminar and turbulent flow. (Outcome O2, O3, O7)
Flowing out through small openings. (Outcome O2, O3, O5, O7)
Flowing out from the tank under overpressure. (Outcome O2, O3, O5, O7)
Flowing out below the liquid level. (Outcome O2, O3, O5, O7)
Flowing out through large openings. (Outcome O2, O3, O5, O7)
Tank shapes and design. (Outcome O2, O3, O5)
Tank discharge time. (Outcome O2, O3, O5, O7)

Level equalisation time. (Outcome O2, O3, O5, O7)
Open channel flow. (Outcome O2, O3, O5, O7)
Practical examples. (Outcome O3 - O7)

Required reading

- Mađerić, Damir; Čikić, Ante: Problem book in Thermodynamics, University North, Varaždin, 2015
- Čikić, Ante: Presentations of lectures and practical sessions in the course Thermodynamics and Fluid Mechanics, Bjelovar University of Applied Sciences, 2018, https://moodle.srce.hr/2017-2018/course/view.php?id=26745

Further reading

- Turk, I.: Nauka o toplini I, Sveučilišna naklada, Zagreb 1989
- Hnatko, Emil; Jukić, Josip: Toplina, College of Slavonski Brod, Slavonski Brod, 2012
- White, F.M.: Fluid Mechanics, McGraw-Hilkl, Singapore, 1987
- Alfirević, Ivo; Virag, Zdravko: Mehanika fluida, article, Engineering Manual 1,Školska knjiga, 1997
- Shaughnessy Jr., Edward J.; Katz, Ira M.; Schaffer, James P.: Introduction to Fluid Mechanics, OxfordUniversity, New York - Oxford, 2005.
- Galović, Antun: Termodinamika I, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 2011
- Galović, Antun: Termodinamika II, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 2010

Course title	**Electromechanical and Electronic Converters**						
Course instructor(s)	Marko Miletić, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	2nd	**Semester**	4th	**ECTS**	4		
Contact hours (L+PS+S)	30+15+0	L	PS		S		
			APS	LPS			
		30	10	5			

Course objectives

Familiarising students with the fundamentals of working with electromechanical and electronic converters.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: calculate the magnetic state and load of a metal object,
- O2: select an electric machine with respect to electrical and mechanical loads,
- O3: determine the operating mode of an electric machine and the methods of regulating the machine's operating point,
- O4: classify electronic converters according to the source and consumer type,
- O5: calculate electric parameters of electronic converters according to the specifications.

Course content

1. Conversion of mechanical and electrical energy (Outcome O1)
Electromagnetic induction.
Generating voltage.
Energy conversion laws.
Torque and angular velocity.
Energy balance.
Law of flow.
Air gap.
Energy status of a machine and signs of voltage, current and power.
2. Synchronous machine (Outcome O2, O3)
Operation principle and basic construction parts.
Wind-up methods and mechanical characteristics of the machine.
Operation modes.
Substitute electric model.
3. Asynchronous machine (Outcome O2, O3)
Operation principle and basic construction parts**.**
Voltage equations and equivalent schemes.
Measurement of torque and speed of rotation.
Idling, short circuit and load curves.
Single-phase motors.
4. DC machine (Outcome O2, O3)
Operation principle and performance of a DC machine.
Motor equations and schematic representation.
Electromechanical characteristic.
Operation modes.
5. Fundamentals of conversion techniques (Outcome O4)

The physical principle of disconnecting in the energy circuit.
The notion of commutation.
Power converters. Direct converters.
Conversion process.
Conversion components and u-i characteristics.
Semiconductor valves.

6. DC converters (Outcome O5)

DC consumers. DC sources.
Direct DC converters.
Indirect DC converters.
Multidirectional DC converters.

7. Rectifiers (Outcome O5)

Classification.
Basic properties.
Inductive and capacitive load.
Uncontrolled rectifiers.
Phase-controlled rectifiers.
Single-phase and three-phase bridge.
Impact on AC network.

8. Autonomous inverters (Outcome O5)

Types of AC consumers.
Single-phase inverters.
Uncontrolled and phase-controlled inverters.
Pulse-width modulation.

Required reading

- Presentations of lectures and practical sessions in the course Electromechanical and Electronic Converters, Bjelovar University of Applied Sciences
- Petrović, Igor: Elektromehanički i elektronički pretvarači – problem book, Technical College in Bjelovar, Bjelovar, 2015

Further reading

- I. Flegar, Elektronički energetski pretvarači, Kigen, Zagreb, 2010

Course title	**Manufacturing Techniques**							
Course instructor(s)	Ivan Samardžić, PhD, Full Professor Antun Stoić, PhD, Full Professor							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics							
Course status	Compulsory							
Year	2nd	**Semester**	4th	**ECTS**	5			
Contact hours (L+PS+S)	30 + 30 + 0			L	PS		S	
					APS	LPS		
				30	20	10	0	

Course objectives

Familiarising students with the fundamentals of manufacturing techniques with an emphasis on the needs in the field of mechatronics.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: describe basic manufacturing techniques,
O2: select a suitable manufacturing technique or a combination of manufacturing techniques as well as tools in manufacturing simple products,
O3: determine the significant variables in manufacturing techniques for the purpose of achieving technological manufacturing of products,
O4: analyse the advantages and disadvantages of various manufacturing techniques.

Course content

1. Introduction to manufacturing techniques. (Outcome O1)
2. The difference between a technological and manufacturing process. (Outcome O1)
3. Fundamentals of manufacturing techniques: (Outcome O1)
Casting. Metal forming. Welding and techniques similar to welding. Material processing by particle separation. Treatment of polymers and material surface protection.
4. Application of manufacturing techniques in manufacturing products for the treatment of various materials. (Outcome O2)
5. Correct selection of a manufacturing technique and tools. (Outcome O2)
6. Parameters of manufacturing techniques. (Outcome O3)
7. Advantages and disadvantages of manufacturing techniques. (Outcome O4)

Required reading

- Šavar Šime: Obrada odvajanjem čestica, Sveučilišna naklada Liber, Zagreb, 1991
- Povrzanović, Aleksandar: Odabrana poglavlja iz obrade deformiranjem, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 1996
- Bošnjaković, Mladen; Stoić, Antun: Programiranje CNC strojeva, College of Slavonski Brod, Slavonski Brod, 2011

Further reading

- Samrdžić, Ivan: Analiza tehnologičnosti zavarenih konstrukcija, Faculty of Mechanical Engineering in Slavonski Brod, Slavonski Brod, available on: http://www.sfsb.unios.hr/kth/zavar/ (2.3.2016)
- Esih, Ivan; Dugi, Zvonimir: Tehnologija zaštite od korozije, Školska knjiga, Zagreb, 1990

Course title	**Technical English 4**						
Course instructor(s)	Ivana Jurković, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	2nd	**Semester**	4th	**ECTS**	2		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	30	0	0		

Course objectives

To develop students' ability to use the English language related to specific technical fields.

Expected learning outcomes

Upon completion of the course students will be able to use the English language to:

O1: describe examples of advanced technologies and innovative solutions,
O2: communicate in via e-mail,
O3: draft a curriculum vitae and job application in standard international formats,
O4: prepare and give a 10-minute presentation in English on one of the given topics in the technical area.

Course content

1. Advanced technologies (Outcome 1)
Renewable energy sources. Describing possibility and restrictions. Advanced technology and innovations.
2. Writing formal and informal e-mails (Outcome 2)
Levels of formality. Enquiries. Offers. Exchanging information. Deadlines. Confirming deadlines and arrangements.
3. Curriculum vitae and job application (Outcome 3)
Writing a curriculum vitae and job application in the English language.
4. Presentation skills in the English language (Outcome 4)
Preparing a structured presentation in English on a given topic related to the technical field.

Required reading

- Ibbotson, Mark: Cambridge English for Engineering, Cambridge University Press, Cambridge, 2008

Further reading

- Murphy, Raymond: English Grammar in Use, Cambridge University Press, Cambridge, 2004

Course title	Technical German 4						
Course instructor(s)	Ivana Jurković, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	2nd	Semester	4th	ECTS	2		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	30	0	0		

Course objectives

To develop students' ability to use the German language related to specific technical fields.

Expected learning outcomes

Upon completion of the course students will be able to use the German language to:

O1: describe differences between fossil fuels and renewable energy sources,
O2: communicate via e-mail,
O3: draft a curriculum vitae and job application in standard international formats,
O4: prepare and give a 10-minute presentation on one of the given topics.

Course content

1. Energy

Energy. Fossil fuels and renewable energy sources. Describing forces. Describing possibility and restrictions. Grammar focus: reported speech.

2. Writing formal and informal e-mails

Levels of formality. Enquiries. Exchanging information. Deadlines. Confirming deadlines and arrangements.

3. Curriculum vitae and job application

Writing a curriculum vitae and job application in the German language.

4. Presentation skills in the German language

Preparing a short, structured presentation in English on a given topic related to the technical field.

Required reading

- Štambuk, Zdenka; Marinić, Davorka: Deutsch und Technik– Materie – Energie – Information, Školska knjiga, Zagreb, 1991

Further reading

- Muljević, Vladimir; Horvatić, Željko: Njemačko – hrvatski i hrvatsko – njemački elektrotehnički rječnik, Školska knjiga, Zagreb, 1996
- Marčetić, Tamara: Deutsche Grammatik im Überblick, Školska knjiga, Zagreb, 2003
- Berger, Maria Cristina; Martini, Maddalena: Generation E, Deutschsprachige Landeskunde im Europäischen Kontext, Ernst Klett, Stuttgart 2005

Course title	**Computer-Aided Process Management and Control**						
Course instructor(s)	Zoran Vrhovski, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	3rd	**Semester**	5th	**ECTS**	5		
Contact hours (L+PS+S)	30 + 30 + 0	L	PS		S		
			APS	LPS			
		30	9	21	0		

Course objectives

Familiarising students with the automatisation of industrial processes via PLC devices that are programmed using the CoDeSys platform and SCADA system.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: select sensors and actuators and connect them with a PLC device for the purpose of automatisation of simple processes
- O2: program PLC devices using the standard IEC 61131-3
- O3: design a control programme of a PLC device for simple processes using the CODESYS platform
- O4: connect a PLC device and the SCADA system using industrial protocols for the purpose of collecting data, performing measurements and displaying data on a computer
- O5 design a SCADA system for simple processes

Course content

1. Basic terms and definitions (Outcome O1)
Basic terms.
Historical development of PLC devices.
The role and significance of PLCs in industry.
2. Programmable Logic Controllers (Outcome O1)
Operating principle of PLCs.
PLC architecture (CPU, digital inputs and outputs, analogue inputs and outputs).
PLC devices Schneider Electric.
Modules for expanding digital/analogue inputs and outputs.
3. Sensors and actuators in industrial automatisation (Outcome O1)
Connecting digital and analogue sensors to a PLC device.
Connecting actuators to a PLC device.
4. The CODESYS platform for industrial automatisation and standard IEC 61131-3 (Outcome O2, O3)
Standard IEC 61131-3: Programme structure. Variables, Identifiers. Key words. Comments. Types of data. Addressing. (Outcome O2)
Programming languages in the standard IEC 61131-3: Ladder diagram (LD). Function block diagram (FBD). Structured text (ST). Instruction list (IL). Sequential function chart (SFC). (Outcome O2)
CODESYS platform: programming language Continuous Function Chart (CFC). (Outcome O3)
Functions/operators: Logical functions/operators. Arithmetic functions/operators. Conversion of data type. Bit shifting operators. Selection functions/operators. Comparison functions/operators. Numerical functions. (Outcome O2)
Function blocks: Edge detection. Latches. Timers (TON, TOF, TP). Counters. (Outcome O2)
Software development environment for programming PLCs. (Outcome O3)

Other functions and function blocks. (Outcome O3)

5. Industrial communication networks and protocols (Outcome O4)

Communication network hierarchy in industry.

Industrial protocols.

6. SCADA systems (Outcome O4, O5)

Fundamentals of the system for collecting, processing and displaying data in industrial automatisation (SCADA). (Outcome O5)

Tags. (Outcome O4)

Visualisation. Trends. Alarms. (Outcome O5)

Software development environment for designing the SCADA system. (Outcome O5)

7. Introduction to Industry 4.0 and industrial Internet of things (IIOT) (Outcome O4, O5)

Required reading

- Vrhovski, Zoran: Presentations of lectures and practical sessions in the course Computer-Aided Process Management and Control, Bjelovar University of Applied Sciences, Bjelovar, 2018, https://vub.hr/racunalno-upravljanje-procesima/ (available: 24.7.2018)
- Schnider Electric: Modicon M241 LogicController, Hardware Guide, Schneider Electric, 2015, http://www.schneider-electric.com/download/ww/en/products/current/ (available: 21.2.2016)
- Schnider Electric: Modicon M241 LogicController, ProgrammingGuide, Schneider Electric, 2015, http://www.schneider-electric.com/download/ww/en/products/current/ (available: 21.2.2016)
- Howlett, Bruce: Getting Started With SoMachine Self Study Manual - SoMachineVer 4.1.1, Schneider Electric, 2015

Further reading

- Hanssen, Dag Hâkon: Programmable Logic Controllers: A Practical Approach to IEC 61131-3 using CODESYS, John Wiley&Sons, Ltd, United Kingdom, 2015

Course title	**Pneumatics and Hydraulics**						
Course instructor(s)	Neven Maleš, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	3rd	**Semester**	5th	**ECTS**	5		
Contact hours (L+PS+S)	30 + 30 + 0	L	PS		S		
			APS	LPS			
		30	10	20	0		

Course objectives

Familiarising students with the application of pneumatics and hydraulics.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: analyse pneumatic and electropneumatic components and systems
- O2: select pneumatic and electropneumatic components for a particular purpose
- O3: solve tasks in the area of automatisation using the methods of pneumatic and electropneumatic control
- O4: analyse hydraulic and electrohydraulic components and systems
- O5: draw hydraulic and electrohydraulic system schematics
- O6: solve tasks in the area of automatisation by means of proportional and servohydraulics

Course content

1. **PNEUMATICS** (Outcome O1, O2, O3)
   Basic terms of pneumatics. (Outcome O1)
   System for the supply and distribution of pressurised air. (Outcome O2)
   Pressurised air preparation. (Outcome O2)
   Pneumatic executive elements. (Outcome O2, O3)
   Pneumatic control elements. (Outcome O2, O3)
   Pneumatic control methods (Outcome O3)
   Special pneumatic elements. (Outcome O2)
   Pneumatic control. (Outcome O3)
   Electropneumatics. (Outcome O3)
   Maintenance of pneumatic systems. (Outcome O1)
   .
2. **HYDRAULICS** (Outcome O4, O5, O6)
   Basic terms of hydraulics. (Outcome O4)
   Hydraulic elements. (Outcome O4)
   Hydraulic executive elements. (Outcome O4)
   Hydraulic control elements. (Outcome O5)
   Electrohydraulics. (Outcome O5)
   Proportional hydraulics. (Outcome O6)
   Servohydraulics (Outcome O6)
   Maintenance of hydraulic systems. (Outcome O4)

Required reading

- Nikolić, Gojko: Pneumatika i hidraulika, Part I, PNEUMATIKA, Školske novine, Zagreb, 2005

- Nikolić, Gojko; Novaković, Jakša.: Pneumatika i hidraulika, Part II, HIDRAULIKA, Školske novine, Zagreb, 2003
- Maleš, N.: Handouts in Pneumatics and Hydraulics, Centre of New Technologies, Zagreb, 2014

Further reading

- Koroman, V., Mirković, R.: Hidraulika i pneumatika, Školska knjiga, Zagreb, 1991
- Maleš, Neven: Elektropneumatika, Festo, Zagreb, 2008
- Maleš, Neven: Proporcionalna hidraulika, Festo, Zagreb, 2011
- Catalogues and flyers: Festo, Linde, Danfos, Bosch-Rexroth, Parker etc.

Course title	Applied Robotics						
Course instructor(s)	Tomislav Pavlic, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	3rd	Semester	5th	ECTS	5		
Contact hours (L+PS+S)	(30 + 30 + 0)	L	PS		S		
			APS	LPS			
		30	10	20	0		

Course objectives

Familiarising students with basic knowledge and problem solving in the area of modern robotics.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: acquire and use basic terms related to the architecture and kinematic structures of robotic systems
O2: acquire and use basic terms related to robot and machine control types
O3: use the acquired knowledge in designing a model of flexible manufacturing systems and robotic cells
O4: carry out virtual simulations of the motion and behaviour of real robotic systems
O5: program and control real robots and robotic systems of various structures

Course content

1. General facts about robotisation (Outcome O1)
Definition of a robot. Historical development of robotics. Classification, characteristics, application of robots. Introducing robots into production. Programming tools for modelling and programming a robot and its environment.

2. Kinematics of robots and machines (Outcome O1, O2)
Coordinate systems. Standards. Translation. Rotation. Basic concepts of mechanism theory, kinematic pairs, kinematic chains, degrees of movement freedom. Connection between internal and external coordinates. Basic terms related to direct and inverse kinematics. Representation and comparison of kinematics of manipulators / robots and CNC machines with the same number of degrees of movement freedom.

3. Robotised manufacturing systems (Outcome O1, O2)
Elements and basic structures of robotised production systems. Industrial and mobile robots in modern production. Examples of production processes where manipulators, robots and robotised systems are most commonly used.

4. Planning of trajectories and pathlines of movement of robots and similar machines (Outcome O1, O2)
The notion of trajectory and pathline. The notion of G-code. Description of G and M functions while programming robots and CNC machines. Point-to-point movement of robots and machines - PTP. Continuous movement along a pathline - CP. Interpolated motion. Overview of robotic and machine languages. Levels of robot and machine programming.

5. Mechanical, energy, measuring and control systems in robots and machines (Outcome O1, O2, O3)
Mechanical system design in robots and machines. Energy support of robots and machines. Types of measuring systems. Types of control systems.

6. Drives in robotised systems (Outcome O1, O2) (Outcome O1, O2, O3)
Electric drives. Hydraulic drives. Pneumatic drives. Overview of the operation of robots and machines with various types of drives. Standards in electropneumatic and electrohydraulic drives.

7. Types of manipulators, robots and machines in robotised production systems (Outcome O1, O2, O3)
Industrial robots. Manipulators. CNC machines. Service robots. Technological robots. Assembly robots. Measurement robots. Mobile robots.

8. Auxiliary tools, devices and machines in robotised production systems (Outcome O1, O2, O3)
Positioners. Vibratory conveyor. Supply lines. Supply devices. Moving lines. Manipulator and robot grippers. Tool, robot and machine receivers. Accept robot tools and machines. Plasma cutting systems, laser cutting, water-jet cutting. Presses.

Robotic welding equipment.

9. Sensor technology and robotic vision (Outcome O3, O4)

Position sensors. Speed sensors. Force sensors. Elements of robotic vision. Image analysis. Object recognition and gripping. Overview of the operation of robots and machines in combination with various types of sensors and robotic vision.

10. Software tools in robotised production systems (Outcome O5)

Software tools for modelling robotic cells. Software tools for offline and online robot programming. The role of the CAD/CAM/CNC chain and the integration of modules for programming robotised systems.

Required reading

- Šurina, Tugomir; Crneković, Mladen: Industrijski roboti, Školska knjiga, Zagreb, 1990
- Pavlic, Tomislav: Lectures in the course Applied Robotics, Bjelovar University of Applied Sciences, Bjelovar, 2018

Further reading

- Nikolić, Gojko; Vranješ, Božo; Kunica, Zoran; Jerbić, Bojan: Projektiranje automatskih montažnih sustava, Kigen, Zagreb, 2009
- Kovačić, Zdenko; Bogdan, Stjepan; Krajči, Vesna: Osnove robotike, Grafis, Zagreb, 2000

Course title	**Quality Management**					
Course instructor(s)	Stjepan Golubić, PhD, senior lecturer					
Programme(s) of study	Undergraduate professional programme of study in Mechatronics					
Course status	Compulsory					
Year	3rd	**Semester**	5th	**ECTS**	3	
Contact hours (L+PS+S)	15 + 15 + 0	L	PS		S	
			APS	LPS		
		15	15			

Course objectives

Acquiring knowledge about the fundamentals of quality, the implementation of quality management in modern production and contemporary perspectives and approaches to quality assurance.

Expected learning outcomes

Upon completion of this course students will be able to:
O1: explain the significance of product and service quality in contemporary production,
O2: explain the types, objectives and methods of quality management,
O3: explain the organisation of a quality management system based on the norm ISO 9001,
O4: calculate basic quality indicators,
O5: explain the principles of quality,
O6: explain the methods of quality improvement.

Course content

1. The notions of quality and quality control (Outcome O1)
2. Contemporary perceptions of quality (Outcome O1)
3. Overview of the quality control function (Outcome O2)
4. Quality improvement policy and objectives (Outcome O2)
5. Fundamentals of quality management (Outcome O3)
6. The role of statistical methods in quality control systems (Outcome O4)
7. Contemporary quality control concept TQC (Outcome O5)
8. Organisational and technical prerequisites of quality control (Outcome O5)
9. Systematisation of quality control methods (Outcome O6)
10. Seven basic statistical methods Ishikawa diagram (Outcome O6)
Check sheet. Pareto principle. Control chart. Flow diagram. Histogram. Scatter diagram.
11. Seven new statistical methods (Outcome O6)
Matrix diagram. Affinity diagram. Tree diagram. Interrelationship diagram. Process decision program chart PDCP. Arrows diagram. Matrix data analysis. Trend. Process capability analysis. Computer-aided control chart analysis. Sampling methods. Sampling plans, terminology. The importance of sampling plans, sampling, types of plans.
12. The Taguchi method. (Outcome O6)
13. FMEA. (Outcome O6)
14. QFD. (Outcome O6)
15. Six Sigma. (Outcome O6)

Required reading

- Kondić, Živko; Čikić, Ante: Upravljanje kvalitetom u mehatronici, Technical College in Bjelovar, Bjelovar, 2012

Further reading

- Kondić Živko: Statistička kontrola kvalitete, Polytechnic of Varaždin, Varaždin, 2012

Course title	**LabVIEW Graphical Programming**						
Course instructor(s)	Alan Mutka, PhD, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics Undergraduate professional programme of study in Computer Science						
Course status	Compulsory						
Year	3rd	**Semester**	5th	**ECTS**	5		
Contact hours (L+PS+S)	30+30+0	L	PS		S		
			APS	LPS			
		30	0	30	0		

Course objectives

Familiarising students with the fundamentals of graphical programming and the use of the LabView software

Expected learning outcomes

Upon completion of this course students will be able to:

O1: explain the principle of graphical programming in the LabView environment,
O2: apply loops and flow control in graphical programming,
O3: use relation data in graphical programming,
O4: apply modularity in graphical programming,
O5: use modules for connection with peripheral devices,
O6: apply advanced approaches in graphical programming.

Course content

1. Introduction to the *LabVIEW* programming environment (Outcome O1)
What is *LabVIEW*? Virtual instruments (VI). Front panel. Block diagram. Browsing through controls, virtual instruments and functions. Techniques of error correction in programming. Error processing. Program execution.
2. Graphical programming in the *LabVIEW* environment (Outcome O2, O3, O4)
Implementation of VI. Controls and displays. Programming loops. Time delay functions. Graphical data display. *Case* structures. Modular applications. Use of subVI. Arrays. Clusters. Polymorphism. Working with files and text.
3. Measuring and signal generating device (Outcome O5)
Measurement and generation of analogue signals. Digital inputs and outputs. Analogue inputs and outputs. Virtual measuring instruments. Virtual oscilloscope. Time-frequency analysis of the measured signal. Connecting a sensor and actuator to LabView.
4. Advanced LabView graphical programming (Outcome O6)
Sequential programming. State machines. Data transfer between parallel loops. Variables. Queues. Events.

Required reading

- National Instruments: LabVIEW Core 1Course Manual, National Instruments, 2015
- National Instruments: LabVIEW Core 1 Excercises, National Instruments, 2015
- National Instruments: LabVIEW Core 2 Course Manual, National Instruments, 2015
- National Instruments: LabVIEW Core 2 Excercises, National Instruments, 2015

Further reading

- National Instruments: LearnLabVIEW, available on: http://www.ni.com/academic/students/learnlabview/ (2.3.2016)

<table>
<tr><td colspan="2">Course title</td><td colspan="6">Field Practice 1</td></tr>
<tr><td colspan="2">Course instructor(s)</td><td colspan="6">Stjepan Golubić, PhD, senior lecturer</td></tr>
<tr><td colspan="2">Programme(s) of study</td><td colspan="6">Undergraduate professional programme of study in Mechatronics</td></tr>
<tr><td colspan="2">Course status</td><td colspan="6">Compulsory</td></tr>
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<tr><td></td><td></td><td></td><td></td><td>80</td><td>10</td></tr>
</table>

Course objectives

1. Familiarising oneself with the company, work environment and colleagues.
2. Gaining an insight into the organisation and work in a real work environment.
3. Learning to take on and carry out specific work tasks.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: describe a company/trade/craft and the fundamentals of company functions (activities, management structure, organisational units,…)
- O2: identify the main parts of a production organisation
- O3: explain the production cycle
- O4: present an overview of a mechatronic system at a company/trade
- O5: describe the functionality and maintenance of the chosen mechatronic system

Course content

Required reading

- Guidelines for Mechatronics students on doing the field practice.
- Field practice journal.

Further reading

Course title	**Automatisation of Machines and Devices 1**							
Course instructor(s)	Zoran Vrhovski, senior lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics							
Course status	Compulsory							
Year	3rd	**Semester**	5th	**ECTS**	4			
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S			
			APS	LPS				
		15	0	30	0			

Course objectives

Familiarising students with the application of PLC devices in the automatisation of machines and devices.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: use active and passive elements as components of a control system and integrate them in a common control system
- O2: select control system elements according to process requirements
- O3: select a configuration of a simple PLC device for the automatisation of machines and devices
- O4: determine the important features of technical documentation of an automated system and create documentation for a real industrial plant
- O5: deasign the control program of a PLC device in the software environment until the commissioning phase

Course content

1. Introduction to automatisation (Outcome O1, O2)
Familiarising students with the notion of automatisation in industry using contemporary technologies.
2. Elements of automatisation (Outcome O1, O2)
The analysis of using active and passive elements as components of a control system.
Integration and synthesis of elements into a common control system.
3. Configuration of control systems (Outcome O3)
Selection of control system elements according to process requirements.
4. Technical documentation of control systems (Outcome O4)
Familiarising students with significant features of technical documentation of an automated system.
Creating documentation for designed models in a laboratory or at a real industrial facility.
5. Designing and production of a control system (Outcome O5)
Selection of the configuration of a simple PLC device without HMI for the drive control and designing a programme in a software environment until the commissioning phase.

Required reading

- Simatic S7-200 Programmable Controller System Manual, Siemens, Nuernberg, 2007

Further reading

Course title	**Virtual Design of Mechatronic Systems**							
Course instructor(s)	Tomislav Pavlic, senior lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics							
Course status	Elective							
Year	3rd	**Semester**	5th	**ECTS**	4			
Contact hours (L+PS+S)	(15 + 30 + 0)	L	PS		S			
			APS	LPS				
		15	0	30	0			

Course objectives

To acquire and learn how to use the acquired knowledge necessary for understanding, modelling and digital production of positions and assemblies of mechatronic systems as well as the supporting documentation.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: acquire basic terms related to the virtual modelling of parts and assemblies
O2: use the acquired knowledge for creating the required documentation
O3: create CAD models according to the rules and needs of digital production
O4: perform simulations of the behaviour of designed mechatronic systems that are identical to the real ones

Course content

- Technical documentation in virtual design of mechatronic systems. (Outcome O1 and O2)
- Standards in mechatronics. (Outcome O2)
- Fundamentals of CAD tools for 2D and 3D design. (Outcome O1 and O2)
- Part design. (Outcome O1)
- Assembly design. (Outcome O1)
- Bases of standard parts. (Outcome O2)
- 2D technical documentation. (Outcome O2)
- 3D sheet metal design. (Outcome O1 and O2)
- Rendering and designing photorealistic images of mechatronic systems from the designed 3D models. (Outcome O3)
- Design of mechatronic system animations. (Outcome O3 and O4)
- Intruduction to simulations. (Outcome O4)
- Surface design. (Outcome O3 and O4)
- Design of welded constructions. (Outcome O2, O3 and O4)
- Piping design. (Outcome O3)
- Distribution cabinet wiring. (Outcome O4)
- Transfer from a 3D model to *.dxf and *.dwg industrial standards. (Outcome O4)
- Preparation of a 3D model for the usage and integration in CAD/CAM/CNC systems, i.e. generally for the needs of digital production. (Outcome O4)

Required reading

- Pavlic, Tomislav: Lectures in the course Virtual Design of Mechatronic Systems, Technical College in Bjelovar, Bjelovar, 2015, http://vtsbj.hr/virtualno-oblikovanje-program/kolegij (17.3.2016)

Further reading

- Lombard, Matt: SolidWorks 2009 do kraja, Kompjuter biblioteka Beograd, 2009
- Shih, Randy; Schilling, Paul: SolidWorks 2008 Parametarsko modelovanje, Kompjuter biblioteka Beograd, 2008

Course title	**Design and Production of Electronic Devices**							
Course instructor(s)	Marko Miletić, lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics							
Course status	Elective							
Year	3rd	**Semester**	5th	**ECTS**	4			
Contact hours (L+PS+S)	15 + 30 + 0			L	PS		S	
					APS	LPS		
				15		30		

Course objectives

Familiarising students with the procedure of designing and producing electronic devices.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: describe the process of developing an electronic device,
O2: make an electric schematic of the device and the library of components,
O3: design a printed circuit board taking into account the requirements of the electronic device,
O4: make the technical documentation of the electronic device,
O5: produce a simple electronic device.

Course content

1. Introduction to designing and production of electronic components (Outcome O1)
Technologies applied in the production of elements, assemblies and devices in electrical engineering.
THT technology.
SMT technology.
Technological trends.
Selection of an optimal technology.
2. Electronic components (Outcome O1)
Resistors for the THT technology.
Resistors for the SMT technology.
Capacitors.
Diodes and transistors.
IC casings for the THT technology.
IC casings for the SMT technology.
Component packaging.
3. Basic processes (Outcome O1)
Photolithography.
Screen printing.
Etching.
Metallisation.
Procedures for achieving mechanical and electrical connections.
Soldering.
Gluing.
4. Technology of printed connections (Outcome O1)
Substrates.
One-sided PCB.
Two-sided PCB with metallised holes.
Production of multi-layer PCB.
New materials for printed circuit boards.

Special printed circuit boards.
Stop mask.
5. Preparation of electronic module production (Outcome O1)
PCB design.
Technological steps in the PCB production.
Application of advanced CAD tools.
Guidelines for quality design.
Guidelines for production design.
Guidelines for robust design.
Printed circuit boards of mixed technologies (THT and SMT).
Aspects that are important in the SMT design.
Dimensions of soldering surfaces.
Test design.
Heat design.
Electromagnetic compatibility EMC.
6. Automatic positioning and soldering of electronic components (Outcome O1)
THT technology.
Solder wave.
Surface mounting.
Reflow soldering.
Solder paste.
Screen printing.
Heat convection soldering.
IR soldering. Positioning of components.
Solder mistakes.
Testing of finalised boards with components.
7. Design and production of electronic devices (Outcome O2, O3, O4, O5)
Creating a drawing of the circle schematic using basic functions. (Outcome O2, O5)
Use of libraries. (Outcome O2, O5)
Adding components. (Outcome O2)
Connecting of components. (Outcome O2, O5)
Electrical rule check (ERC). (Outcome O2, O5)
Creating a PCB schematic based on the schematic drawing. (Outcome O3, O5)
Drawing dimensions and adding holes. (Outcome O3, O5)
Positioning components onto a PCB. (Outcome O3, O5)
Placing copper surfaces (restricted areas, connecting signal wiring, grounding and polygons). (Outcome O3, O5)
Automatic interdependence. (Outcome O3, O5)
Design rule check (DRC). (Outcome O3, O5)
Polygon filling. (Outcome O3, O5)
Libraries. (Outcome O4, O5)
Generating graphical files. (Outcome O4, O5)
Use of CAM models. (Outcome O4, O5)
Generating output files for the production of printed circuit boards. (Outcome O4, O5)

Required reading

- Presentations of lectures and practical sessions in the course Design and Production of Electronic Devices

Further reading

- Duncan, Mitchell: Eagle V6: Getting Started Guide [PCB Design], 2013
- Coombs, Clyde: Printed Circuits Handbook, 2007

- Williams, Tim: The Circuit Designer's Companion, 2013
- Bogatin, Eric: Signal and Power Integrity, 2009

Course title	**Maintenance of Mechatronic Systems**						
Course instructor(s)	Stjepan Golubić, PhD, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	3rd	**Semester**	6th	**ECTS**	4		
Contact hours (L+PS+S)	30 + 15 + 0	L	PS		S		
			APS	LPS			
		30	15				

Course objectives

Acquiring basic knowledge about organisation, technology and concept of the maintenance of mechatronic systems.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: define the main functions and tasks of the maintenance of mechatronic systems,
O2: explain the most common causes of malfunctions and faults,
O3: explain and describe the methods and approaches to the maintenance of mechatronic systems,
O4: calculate the availability of mechatronic systems,
O5: describe the basic technologies in the maintenance of mechatronic systems,
O6: describe various methods of maintenance organisation.

Course content

1. Basic terms in the theory of the maintenance of mechatronic systems. (Outcome O1)
2. User demands while purchasing new equipment. (Outcome O1)
3. Preparation for the exploitation of new equipment. (Outcome O1, O2)
4. Development of approaches and concepts of the maintenance function as related to the development of mechatronic systems. (Outcome O3)
5. Terotechnological approach. (Outcome O3)
CPO. Planned maintenance.
6. Theoretical aspects of maintenance. (Outcome O3)
7. Equipment classification. (Outcome O1, O2)
Quality features of the equipment. Theoretical indicators of equipment status.
8. Standstill and its significance. (Outcome O2)
Collecting and analysing standstill data.
9. Maintenance strategy. (Outcome O3, O4)
Maintenance methods. Planned maintenance. Issues related to spare parts stock for the purpose of maintenance. Maintenance costs. Maintenance IT system. Calculation of effectiveness and reliability of technical systems and the use of results. Maintenance appropriateness.
10. Technologies in equipment maintenance. (Outcome O5)
General approach to the design and application of maintenance technologies. Parameters for determining equipment status and types of diagnostic equipment (instruments and methods). Application of various technologies in machine part repair (positions and assemblies).
11. Lubrication and the fundamentals of technical system conservation. (Outcome O5)
12. Defining maintenance processes and their organisational implementation in various fields of industry. (Outcome O6)
13. Maintenance centralisation and decentralisation. (Outcome O6)

14. Contemporary solutions in the organisation of maintenance and global trends. (Outcome O6)
Required reading
• Kondić, Živko; Čikić, Ante; Kondić, Veljko: Osnove održavanja mehatroničkih sustava 1, Technical College in Bjelovar, Bjelovar, 2014
Further reading
• Blanchard, Benjamin: Logistic, Engineering and Management, Prentince Hall, New Jersey, 1990

Course title	**Field Practice 2**						
Course instructor(s)	Stjepan Golubić, PhD, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	3rd	**Semester**	5th	**ECTS**	3		
Contact hours (L+PS+S)	0 + 80 + 10	L	PS		S		
			APS	LPS			
				80	10		

Course objectives

1. Familiarising oneself with the company, work environment and colleagues.
2. Gaining an insight into the organisation and work in a real work environment.
3. Learning to take on and carry out specific work tasks.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: describe a company/trade/craft and the fundamentals of company functions (activities, management structure, organisational units,…)
- O2: identify the main parts of a production organisation
- O3: explain the production cycle
- O4: analyse the behaviour of a chosen mechatronic system
- O5: evaluate the functionality of the chosen mechatronic system and suggest potential improvements

Course content

Required reading

- Guidelines for Mechatronics students on doing the field practice.
- Field practice journal.

Further reading

Course title	Thesis						
Course instructor(s)	Course instructors in the professional programme of study in Mechatronics						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Compulsory						
Year	3rd	Semester	6th	ECTS	9		
Contact hours (L+PS+S)	0 + 0 + 120	L	PS		S		
			APS	LPS			
					120		

Course objectives

1. To individually research and cover a selected topic, using the theoretical and practical knowledge acquired during studies.
2. To use the achieved competences in solving problems related to the field of study and to successfully use professional and scientific literature in the written coverage of the topic.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: cover topics related to the area of mechatronics using the theoretical and practical knowledge acquired in the course of studies,
- O2: document the researched topic related to the field of mechatronics,
- O3: present the researched topic related to the field of mechatronics.

Course content

Course content is based on the selected thesis topic.

Required reading

- Literature to be used for thesis depends on the topic selected and covered. Literature used in a thesis shall be listed in the printed version thereof.

Further reading

Course title	**Automatisation of Machines and Devices 2**						
Course instructor(s)	Zoran Vrhovski, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	3rd	**Semester**	6th	**ECTS**	4		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	0	30	0		

Course objectives

Familiarising students with the application of HMI devices and the SCADA system in the automatisation of machines and devices.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: implement a HMI device in an automated system
O2: configurate a communication network for an automated system
O3: design and implement system automatisation using a PLC
O4: develop a control programme for a simple automated system
O5: design and implement an automated SCADA system

Course content

1. Familiarising students with HMI devices (Outcome O1)
Familiarising students with the notion of HMI and visualisation in automatisation.
Overview of drive visualisation methods.
2. Communication protocols in industry (Outcome O2)
ASI communication protocol.
Profibus communication protocol.
Profinet communication protocol.
Selection and use of industrial and communication protocols in automatisation.
3. Control systems of medium complexity (Outcome O1, O3, O4)
Connecting HMI devices to simple control systems.
Design of the HMI software support.
Tags and memory in devices.
4. Design and implementation of an automated system (Outcome O5)
Design, implement and carry out the commissioning of a simple SCADA system for an industrial drive.

Required reading

- Simatic S7-1200 Programmable Controller System Manual, Siemens, Nürnberg, 2014
- Simatic Step7 Basic V13 SP1 System Manual, Siemens, Nürnberg, 2014

Further reading

Course title	**Computer Aided Manufacturing**							
Course instructor(s)	Tomislav Pavlic, senior lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics							
Course status	Elective							
Year	3rd	**Semester**	6th	**ECTS**	4			
Contact hours (L+PS+S)	(15 + 30 + 0)	L	PS		S			
			APS	LPS				
		15	0	30	0			

Course objectives

To acquire and learn how to use knowledge necessary for understanding, programming and digital production of components of mechatronic systems using particle removal processes and additive technologies.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: acquire and use basic terms related to the design of technological processes in CNC particle removal processes
O2: acquire and use basic terms related to the design of the CAD/CAM/CNC chain
O3: use the acquired knowledge for manufacturing components using the CNC particle removal processes
O4: manufacture components using various technologies according to the rules and requirements of digital production

Course content

1. Role and position of CNC technologies today. (Outcome O1)
2. Historical development of CNC systems. (Outcome O1)
3. Material forming and material removal processes. (Outcome O1)
4. Characteristics of contemporary robotised manufacturing systems. (Outcome O2)
5. Designing technological processes that involve drilling, milling and turning. (Outcome O1, O2)
6. Drive measurements in production during material removal processes. (Outcome O1, O2, O3)
7. Clamping methods, centering methods, methods of producing devices by material removal processes. (Outcome O1, O3)
8. Manual programming of CNC machines and using the G-code. (Outcome O2)
9. Programming of CNC machines using the CAD/CAM system. (Outcome O2)
10. CIM machining systems (Computer Integrated Manufacturing). (Outcome O3, O4)
11. The role of pre-processor and post-processor in using CAD/CAM tools. (Outcome O3)
12. The role of pre-processor and post-processor in using real control units of processing systems. (Outcome O4)
13. The notion of tool trajectory in machining and additive technologies. (Outcome O4)
14. The advantages and disadvantages of a 3-axis CNC machining in comparison with multi-axis machining. (Outcome O4)
15. Differences in machining in wood industry and metal industry, and comparison with additive technologies etc. (Outcome O1, O2, O3, O4)

Required reading

- Pavlic, Tomislav: Lectures in the course Computer Aided Manufacturing, Technical College in Bjelovar, Bjelovar, 2015

Further reading

- Bošnjaković, Mladen; Stoić, Antun: Programiranje CNC strojeva, College of Slavonski Brod, Slavonski Brod, 2011
- Shih, Randy; Schilling, Paul: SolidWorks 2008 Parametarsko modelovanje, Kompjuter biblioteka Beograd, 2008

Course title	**3D Modelling Design**							
Course instructor(s)	Božidar Hršak, senior lecturer Tomislav Pavlic, senior lecturer							
Programme(s) of study	Undergraduate professional programme of study in Mechatronics							
Course status	Elective							
Year	3rd	**Semester**	6th	**ECTS**	4			
Contact hours (L+PS+S)	15 + 30 + 0			L	PS		S	
					APS	LPS		
				15	0	30	0	

Course objectives

Upoznavanje studenata s metodama 3D sinkronog modeliranja, 3D skeniranja i 3D printanja.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: develop 3D and 2D workshop documentation of parts (ppositions) and assembly,
- O2: carry out the stress analysis of a 3D model of positions and the fluid flow analysis of the 3D model of an assembly,
- O3: develop a photorealistic image and animation of the operating function of a 3D assembly,
- O4: carry out 3D printing of a position and/or assembly using a 3D printer based on the created 3D model of the position and/or assembly,
- O5: scan the existing position using a 3D scanner and upgrade the scanned position.

Course content

1. Types of technical documentation (Outcome O1, O2, O3)
Standards
2. Construction-technological documentation (Solid Edge/NX (traditional – synchronous modelling)) (Outcome O1, O2, O3)
3D modelling of parts
Development of 2D workshop drawings of parts (sections, details, dimension lines drawing, entering other labels)
3. 3D modelling of assemblies (Outcome O1, O2, O3)
Assembling and disassembling of assemblies
Photorealistic assembly representation
Assembly animation
4. Development of 2D workshop drawings of assemblies and parts of assemblies (Outcome O1, O2, O3)
5. 3D modelling of parts and sheet metal assemblies (Outcome O1, O2, O3)
6. Development of 2D workshop drawings of assemblies and parts of assemblies made of sheet metal (Outcome O1, O2, O3)
7. 3D modelling of a welded assembly (Outcome O1, O2, O3)
8. Development of 2D workshop drawings of a welded assembly and parts of a welded assembly (Outcome O1, O2, O3)
9. Additive technologies (Outcome O4, O5)
Classification and application of AM procedures. Product manufacturing phases and the most common AM procedures.
Comparison of Fused Deposition Modelling – FDM and other AM procedures, 3D printers and required software tools.
3D scanner i required software tools.
The connection between a 3D printer and/or scanner and CAD software tools in the process of reverse engineering.

Required reading

- Kukec, Đuro; Hršak, Božidar: "Konstruiranje 3D modeliranjem", Technical College in Bjelovar, Bjelovar, 2012
- Kukec, Đuro: Tehnička dokumentacija, Technical College in Bjelovar, Bjelovar, 2011

Further reading

- Kukec, Đuro; Kukec, Mihael: "3D konstruiranje računalom i projektiranje računalom", Technical College in Bjelovar, Bjelovar, 2009

Course title	**Contemporary Manufacturing Processes**						
Course instructor(s)	Ivan Samardžić, PhD, Full Professor Antun Stoić, PhD, Full Professor						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	3rd	**Semester**	6th	**ECTS**	4		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	30	0	0		

Course objectives

Familiarising students with technological possibilities of contemporary processes.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: define the classification, physical fundamentals, advantages and disadvantages of the application of contemporary manufacturing processes,
- O2: know the fundamental features of machines and equipment used in contemporary manufacturing processes,
- O3: solve a simple numerical task in technology application related to contemporary manufacturing processes,
- O4: critically analyse the conditions of applying a certain contemporary manufacturing process.

Course content

1. Introduction to contemporary manufacturing processes
2. Classification and types of contemporary manufacturing processes
3. The chronology of development of contemporary manufacturing processes
4. Plasma cutting and plasma welding
5. Contemporary processes of joining and gluing
6. Contemporary manufacturing processes using concentrated energy flows
7. Contemporary high-efficiency welding processes
8. Application of automated and robotised welding processes
9. Application of contemporary processes of joining materials by OMD procedures
10. Contemporary material cutting processes
High speed machining. Hard machining. Machining with rotating cutting plates.
11. Energy-based cutting processes
Laser cutting and water jet cutting. ECM. EDM. UZM.
12. Contemporary finishing processes
Expanding. Magnetic abrasive processes. Deburring.
13.Fast manufacturing processes – general facts
14. Prototyping
15.Tool manufacturing processes and fast product manufacturing processes

Required reading

- Lukačević, Z. et al.: Class notes - New technologies and materials, Faculty of Mechanical Engineering in Slavonski Brod, 1998

Further reading

- Bošnjaković, M; Stoić, A.: Programiranje CNC strojeva, College of Slavonski Brod, 2014
- Valiček, J.; Stoić, A.; Kozak, D.; Samardžić, I. Novak-Marcinčin, J; Modrak V.: Rezanje mlazom vode, University of Osijek, Faculty of Mechanical Engineering in Slavonski Brod, 2011
- Krumes, D.; Lukačević, Z.; Raos, P.; Stoić, A.; Stubićar, M.: Nove tehnologije, University of Osijek, Faculty of Mechanical Engineering in Slavonski Brod, 1998

Course title	**Renewable Energy Sources**						
Course instructor(s)	Neven Maleš, lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	3rd	**Semester**	6th	**ECTS**	4		
Contact hours (L+PS+S)	15 + 30 + 0	L	PS		S		
			APS	LPS			
		15	0	30	0		

Course objectives

Familiarising students with renewable energy sources.

Expected learning outcomes

Upon completion of this course students will be able to:

- O1: determine the assessment of potential and limitations of new energy sources in comparison with the conventional sources
- O2: create power assessment as well as the assessment of produced electric energy for all energy sources
- O3: design solar photovoltaic power plants (on-grid and off-grid)
- O4: demonstrate the skill of using software tools for modelling energy sources
- O5: design solar water heating systems for the preparation of warm water and heating
- O6: explain the basic advantages and limitations of biomass, wind energy, geothermal sources, heat pumps, small hydroelectric power plants and hydrogen

Course content

1. Energy sources and environment (Outcome O1)
2. Solar energy and solar geometry (Outcome O1)
3. Photovoltaic power plants (Outcome O2, 03, 04)
4. Solar water heating systems (Outcome O4, O5)
5. Wind energy (Outcome O1, 06)
6. Biomass energy (Outcome O1, 06)
7. Biofuel and biogas (Outcome O1, 06)
8. Geothermal energy and heat pumps (Outcome O1, 04, O6)
9. Small hydroelectric power plants (Outcome O1, 06)
10. Hydrogen and combustible elements (Outcome O1, 06)

Required reading

- Petar Kulišić (1991), Sunčana energija i energija vjetra, Školska knjiga, Zagreb
- Majdandžić, Ljubomir: Obnovljivi izvori energije, Graphis d.o.o., Zagreb, 2009

Further reading

- Petar Kulišić (1991), Sunčana energija i energija vjetra, Školska knjiga, Zagreb
- T. Ćurko: Course book: Hlađenje i dizalice topline, Faculty of Mechanical Engineering and Naval Architecture, Zagreb, 2008
- F. Barbir, PEM Fuel Cells: Theory and Practice, Elsevier/Academic Press, Burlington, 2005
- Majdandžić, Ljubomir: Solarni sustavi, Graphis d.o.o., Zagreb, 2010

Course title	**Additive Technologies**						
Course instructor(s)	Tomislav Pavlic, senior lecturer Stjepan Golubić, PhD, senior lecturer						
Programme(s) of study	Undergraduate professional programme of study in Mechatronics						
Course status	Elective						
Year	3rd	**Semester**	6th	**ECTS**	4		
Contact hours (L+PS+S)	(15 + 30 + 0)	L	PS		S		
			APS	LPS			
		15		30	0		

Course objectives

To acquire and learn how to use knowledge necessary for understanding, selection and usage of additive technologies required for the development of new and modification of existing products within a mechatronic system.

Expected learning outcomes

Upon completion of this course students will be able to:

O1: acquire basic terms related to additive technologies and reverse engineering
O2: acquire basic terms related to materials used in additive technologies
O3: use the acquired knowledge in the application of additive technologies in digital production
O4: design CAD models using the 3D scanning technology, photogrammetry and object visualisation
O5: amend the obtained point clouds and design real models using 3D printing technologies

Course content

- General facts about additive technologies. (Outcome O1, O2)
- Properties and types of materials in additive technologies. (Outcome O1, O2)
- 3D printing. (Outcome O3)
- 3D scanning. (Outcome O3)
- Reverse engineering. (Outcome O3)
- Digital production. (Outcome O3)
- Photogrammetry and object visualisation. (Outcome O4)
- Fundamentals of CAD tools for 2D and 3D modelling as related to additive technologies. (Outcome O4)
- Fundamentals of software tools used in additive technologies. (Outcome O4)
- Using CAD tools for modelling parts. (Outcome O4)
- Conversion of the 3D model into industrial standards of additive technologies in engineering and medicine. (Outcome O5)
- Preparation, use and integration of amended 3D models in CAD/CAM/CNC/AM systems. (Outcome O5)

Required reading

- Pavlic, Tomislav: Lectures in the course Additive Technologies, Bjelovar University of Applied Sciences, Bjelovar, 2018
- Stjepan Golubić: Lectures in the course Additive Technologies, Bjelovar University of Applied Sciences, Bjelovar, 2018

Further reading

- Lombard, Matt: SolidWorks 2009 do kraja, Kompjuter biblioteka Beograd, 2009
- Shih, Randy; Schilling, Paul: SolidWorks 2008 Parametarsko modelovanje, Kompjuter biblioteka Beograd, 2008
- Solidworks – online sources
- Autodesk Meshmixer / Netfabb - online sources
- MakerBot Desktop / MakerWare for Digitizer - online sources
- Makerbot Digitizer - online sources
- Makerbot Replicator 2x - online sources