Sufinancirano sredstvima programa Europske unije Erasmus+

Improving Skills in Vocational Education and Training

# Joint Vocational Curriculum

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# INTRODUCTION

This deliverable consists of the description of general learning modules together with knowledge and skills areas and key tasks for VET programme for engineering technician as well as the assessment methods.

The curriculum was created to foresee mobility periods and work-based learning perio at the employers as well as ways to enhance students' language skill.

Four modules with assesment criteria were produced .

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# ADDITIVE MANUFACTURING

April 2021

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| Relation to the European and national qualifications framework - EQF/NQF | **SL**: NQF 4.2/EQF 4<br>**HR**: NQF 4.2/EQF 4 |

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| Relation to the existing educational programmes | **SL**:<br>• Mechanical engineering technician, vocational secondary education<br>• Mechanical engineering technician, vocational-technical education<br>• Metal designer / toolmaker, vocational education<br>• Mechanical installation fitter, vocational education<br>**HR**<br>• Mechanical engineering computer technician<br>• Mechanical engineering technician<br>• Computer technician for mechanical engineering |

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| Volume of the learning outcomes | **SL**: 1 ECVET<br>**HR**: 1 ECVET |

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| Justification for implementation | Present-day markets are becoming increasingly more demanding when it comes to the processes of development and production. In addition to the ever-increasing demand for higher quality and higher level of flexibility in development and production, there are simultaneous demands for decrease in costs, and, in particular, for decrease in the time to market. Additional trend, which is more visible in specific market segments, is the abandonment of mass production in favour of small series, and quite often individual (personalized) production. Contemporary additive production processes are being employed in order to meet the demands of such markets. Their fundamental feature is adding the material, most commonly layer-by-layer, until the finished product is completed. Such production principles allow the creation of highly complex product geometry, which could in other, classical production processes, be very difficult or impossible to achieve. |

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| Enrolment requirements / year of education / grade | **SL**: Enrolled in accordance with the above mentioned programmes, with learning contents being organized in the 1st and 2nd years of the education programmes. Recommendation: 1st year of vocational secondary education<br>**HR**: Completed second grade of one of the programmes listed under "Relation to the existing educational programmes" |

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| Educational objectives | Enable the students to learn about the advantages and disadvantages of application of additive technologies in development and production. Provide them with insight into operating principles and equipment used in the most important additive processes. |

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| Learning outcomes | **1. Compare different processes of additive technologies**<br>1.1. List and analyse the processes of additive technologies<br>1.2. Compare the advantages and disadvantages of specific additive technologies<br>1.3. List the basic features of equipment and materials<br>1.4. Describe the phases in creating models using additive technologies<br>1.5. Analyse the environmental aspects of using additive technologies<br>**2. Create a 3D computational model**<br>2.1. Apply the rules of 3D modelling pertaining to the selected additive technology<br>2.2. Create a 3D computational model<br>**3. Prepare a 3D model for additive processing**<br>3.1. Identify and remove the errors in computational models<br>3.2. Analyse the .stl file for the selected additive processes<br>3.3. Correct the .stl file and prepare the 3D model for print<br>**5. Create a product using an additive procedure**<br>5.1. Adjust the printer for 3D print<br>5.2. Compare the impact of different parameters on print quality<br>5.3. Match changeable parameters to the final product<br>5.4. Initiate simulation and the process of model creation<br>5.5. Perform subsequent processing<br>5.6. Assemble the parts of the product |

| Teaching and learning units | Elaboration – Teaching and learning units |
|---|---|
| Fundamentals of additive technologies / Introduction to additive technologies | Possibilities of the application of additive production processes<br>Division of additive processes<br>Materials for additive processes<br>Phases of production using additive technologies |
| Additive production processes | Stereolithography – SLA, PolyJet process<br>Selective Laser Sintering – SLS, 3D Printing – 3DP<br>Fused Deposition Modelling – FDM<br>Laminated Object Manufacturing – LOM<br>Digital Light Processing – DLP<br>Laser Engineering Net Shaping - LENS<br>Direct Metal Deposition - DMD<br>Electron Beam Melting – EBM<br>Selective Laser Melting - SLM |
| Computational modelling for additive technologies | Specifics of computational modelling for additive technologies<br>Errors in modelling and<br>Rules and guidelines for modelling products suitable for 3D printing |
| Product creation using additive processes | Becoming acquainted with the possibilities and features of 3D printers and their tuning<br>Calibrating a 3D printer bed surface, adjusting the parameters of a 3D printer<br>Input of a .stl file into the computer programme of a 3D printer (orientation, calculation of material costs and production time, price)<br>Model creation<br>Removing the model from the bed surface<br>Subsequent processing depending on the requirements and purpose of the model<br>Assembling the individual parts of the product (model) |

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| Workload | Education process consists of 35 lessons during a school year |

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| Teaching methods and techniques | Teaching techniques<br>• mentor assisted learning<br>• differentiated learning<br>• individualized learning<br>• learning through problem solving<br>• learning through examples<br>• learning through demonstration<br>Teaching methods<br>• method of dialogue<br>• heuristic method<br>• problem solving method<br>• method of demonstration<br>• method of research<br>• evaluation<br>Note: the choice of teaching methods and techniques for each lesson is made by the teacher, depending on the learning contents, students' characteristics and other conditions. |

<table>
<tr><td rowspan="3">Elements and forms of monitoring and assessment criteria</td><td colspan="3">Elements: acquisition of the programme contents, exercises and understanding of the programme contents<br>Project task: the application of knowledge<br>Forms: Project task; printing out a 3D model based on a process sheet</td></tr>
<tr><td>Area for assessment</td><td>Assessment criteria</td><td>Points</td></tr>
<tr><td>1. Planning</td><td>The student uses different sources of information, determines which material to use depending on its features and purpose, determines the</td><td>15</td></tr>
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| | | methods of processing and tools needed to complete the task. He/she is independent and innovative in his/her work and applies the knowledge acquired in this programme. | |
| | 3. Documentation | The student designs a 3D model given in a process sheet, creates a .stl file, adjusts the .stl file for 3D print | 40 |
| | 2. Performance | The student adjusts the settings of the 3D printer, loads the .stl file and prints the model. | 35 |
| | 4. Presentation | The student presents the process of making the model from the process sheet to the final product | 10 |
| | **Total** | | **100** |
| | **Completion criteria** | | **60** |

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| Teaching staff | **SL**: In accordance with the legal framework<br>**HR:** In accordance with the legal framework |

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| Teaching facilities and equipment | Education process takes place in a lab equipped with 3D printers, supplies, computers with appropriate programmes (CAD programme). Groups can have a maximum of 14 participants. Classes which have more than 14 participants have to be split into groups in order to meet the required criteria. |

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| Teaching resources: | **SL:** Sources for the teachers are available on the Internet<br>**HR:** Godec, D., Šercer, M.: Aditivna proizvodnja, Fakultet strojarstva i brodogradnje, Zagreb, 2015. (Additive Production, Faculty of Mechanical Engineering and Naval Architecture)<br>Šantek, D.: Podjela postupaka brze izradbe prototipova, Strojarstvo, 37(1995)5–6, 231–237. (Division of quick prototyping processes, Mechanical Engineering), available online resources |

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| Learning resources: | **SL:** Internal materials<br>**HR:** Internal materials |

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# CAD/CAM PROGRAMMING OF CNC MACHINES

April 2021

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| Connection to the European and national qualifications framework - EQF/NQF | **SL**: NQF 4.2/EQF 4<br>**HR**: NQF 4.2/EQF 4 |

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| Connection to the current educational programmes | **SL**:<br>• Mechanical engineering technician, vocational secondary education<br>• Mechanical engineering technician, vocational-technical education<br>• Metal designer / toolmaker, vocational education<br>• Mechanical installation fitter, vocational education<br>**HR**<br>• Mechanical CAD technician<br>• Mechanical technician<br>• Computer technician in mechanical engineering |

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| Volume of the learning outcomes | **SL**: 1 ECVET<br>**HR**: 1 ECVET |

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| Justification for implementation | With the emergence of CAD/CAM software systems for NC programming, manual programming has steadily been abandoned. Simplicity and the abundance of useful tools and functions make CAM systems indispensable when programming and simulating production by using machine tools. Gaining knowledge about CAM technology will enable students to, on one hand, integrate into the labour market more easily, and on the other, to lay a firm foundation to continue education and improvement in the field of CAD/CAM technologies. |

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| Enrolment requirements / year of education / grade | **SL**: Enrolled in accordance with the above mentioned programmes, with learning contents being organized in the 1st and 2nd years of the education programmes. Recommendation: 1st year of vocational secondary education and vocational-technical education, and 2nd year of vocational education programme (open curriculum)<br>**HR**: completed third grade of any of the educational programmes listed under *Connection to the current educational programmes* |

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| Educational objectives | To enable course participants to acquire knowledge about CAD/CAM programming systems used in manufacturing of metal parts with both simple and complex geometry. |

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| Learning outcomes | **1. Explanation of the technological manufacturing process**<br>1.1. Defining the sequence of operations and processes<br>1.2. Selecting the optimal working regimes according to the theory and the working regimes tables available for the machine tool<br>1.3. Selecting the machines to produce a metal part by using tool catalogues<br>**2. Generating a G-code in CAD/CAM software**<br>2.1. Generating a NC code to set CNC machine tool<br>2.2. Simulating a production process and inputting the corrections<br>2.3. Generating technical documentation<br>2.4. Postprocessing the code<br>**3. Producing a metal part by using a CNC machine tool**<br>3.1. Inputting a programme into a control unit<br>3.2. Initiating the production simulation<br>3.3. Setting the machine tool<br>3.4. Producing a part |

| **Teaching and learning units** | **Description of the theme** |
|---|---|
| Explanation of the technological manufacturing process | • Technological process, operation, procedure<br>• CNC technical documentation<br>• Working regimes<br>• Machines and machines catalogues |
| Generating a G-code in CAD/CAM software | • Defining the machine tool and the raw part<br>• Defining the coordinate system and characteristic points |

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| | • Defining the trajectory of the tool<br>• Selecting the working regime<br>• Defining the tool and the point of changing the tool<br>• Initiating the simulation and correction<br>• Generating G code<br>• Selecting postprocessor and postprocessing<br>• Generating documentation |
| Producing a metal part by using a CNC machine tool | • Inputting a programme into a control unit<br>• Initiating a production simulation<br>• Setting a machine<br>• Producing a part<br>• Measuring and controlling the product |
| Workload | The learning and teaching process is completed during 35 lessons in a school year. |

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| Teaching methods and learning techniques | Learning techniques:<br>• tutor supported learning<br>• differentiated learning<br>• individualised learning<br>• example-based learning<br>• demonstration-based learning<br>Teaching methods:<br>• dialogue<br>• heuristics<br>• problem-solving approach<br>• demonstration - based teaching<br>• assessment<br>Remark: the choice of teaching methods and learning techniques is made by the teacher in accordance with the teaching content, specific needs of the course participants, facilities, equipment, and other conditions. |

<table>
<tr><td rowspan="6">Elements and forms of monitoring and assessment criteria</td><td colspan="3">Elements:<br>• Programme content/ subject matter attainment, practical exercises, and assessment of the subject matter acquisition<br>• Knowledge implementation (project assignment).<br>Forms:<br>Project assignment - to produce a metal part assigned in a manufacturing drawing:<br>1. Generating a NC code in a CAM software<br>2. Generating technical documentation<br>3. Producing a part on a CNC machine</td></tr>
<tr><td>Assessment scope</td><td>Assessment criteria</td><td>Points</td></tr>
<tr><td>1. Planning</td><td>Student uses different sources of information, describes the material according to its characteristics and purpose, selects the material processing methods and tools needed to complete the task. S/he does the work individually and innovatively using the knowledge and skills acquired during the course.</td><td>15</td></tr>
<tr><td>2. Documentation</td><td>Student reads manufacturing drawings and creates CNC technical documentation.</td><td>20</td></tr>
<tr><td>3. Performance</td><td>Student designs a 3D model according to the manufacturing drawings, and explains the technological procedure for its production, defines the machine tool and a raw part, tool trajectory, working regimes and tools. Student generates NC code for the chosen machine tool and postprocesses it. Student inputs the code into the CNC machine and produces a metal part on it.</td><td>55</td></tr>
<tr><td>4. Presentation</td><td>Student presents the assignment completion procedure from the manufacturing drawing to the final product and discusses about it presenting valid arguments.</td><td>10</td></tr>
<tr><td colspan="2">Total</td><td>100</td></tr>
<tr><td colspan="2">Passing criterion</td><td>60</td></tr>
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| Teaching staff | **SL**: In accordance with the legal framework<br>**HR:** In accordance with the legal framework |

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| Teaching facilities and equipment | Teaching is taking place in a specialised classroom which is providing working space for 14 students at most and which is equipped with software and hardware necessary for CAD/CAM programming, as well as machines for producing a part. Classes in which there are more than 14 students, have to be split into groups to meet the required criterion. |

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| Teaching resources | **SL:** Sources for the teachers are available on the Internet<br>**HR:** Bošnjaković, Mladen; Stojić, Antun: *Programming CNC Machines,* Slavonski Brod, University of Slavonski Brod, 2011, available online resources |

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| Learning resources | **SL:** Internal materials<br>**HR:** Internal materials |

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# MACHINE VISION

April 2021

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| Relation to the European and national qualifications framework – EQF/NQF | **SL**: NQF 4.2/EQF 4<br>**HR**: NQF 4.2/EQF 4 |

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| Relation to the existing educational programmes | **SL**:<br>• Mechanical engineering technician, vocational secondary education<br>• Mechanical engineering technician, vocational-technical education<br>• Metal designer / toolmaker, vocational education<br>• Mechanical installation fitter, vocational education<br>**HR**<br>• Mechatronics technician<br>• Mechanical engineering computing technician<br>• Mechanical engineering technician<br>• Computing technician for mechanical engineering |

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| Volume of the learning outcomes | **SL**: 1ECVET<br>**HR**: 1 ECVET |

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| Justification for implementation | Machine vision has become essential in mass production. Machine vision is crucial in product quality control, in managing processes and in identification of the product. The usage of machine vision and network cameras can speed up the production, increase the quality of the product and reduce the costs. |

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| Enrolment requirements / year of education / grade | **SL**: Enrolled in accordance with the above mentioned programmes, with learning contents being organized in the 1st and 2nd years of the education programmes. Recommendation: 1st year of vocational secondary education and vocational-technical education, and 2nd year of vocational education programme (open curriculum)<br>**HR**: completed second grade of one of the programmes listed under "Relation to the existing educational programmes" |

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| Educational objectives | Facilitate acquisition of knowledge needed to apply vision systems in automatic production, including techniques for obtaining digital images, methods of image processing, detection of edges and contours, and object recognition and the application of images in metrology and sensorics. |

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| Learning outcomes | **1. Explain the choice of the vision system components depending on the purpose**<br>1.1. Describe the purpose of a vision system<br>1.2. List the components of a vision system<br>1.3. Apply the norms and recommendations for vision systems usage<br>**2. Prepare the recording environment and set the lights**<br>2.1. Explain the relationship and impact of parameters on digital image<br>2.2. Set the lights and scenography<br>2.3. Record the images using different settings for lights and different angles<br>2.4. Use image processing tools<br>**3. Choose the camera, the lens and other hardware components**<br>3.1. Choose the appropriate camera and lens<br>3.2. Connect a management programme with the camera<br>**4. Measuring and testing of the machine**<br>4.1. Adjust and calibrate the system<br>4.2. Compare the impact of different parameters on the results of the measuring process<br>4.3. Match changeable parameters with the results of the measuring process. |

| **Teaching and learning units** | **Elaboration – Teaching and learning units** |
|---|---|
| Concept of creation of a vision system | Definition of a vision system<br>Application of a vision system<br>Components of a vision system |

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| | Norms and recommendations in the application of vision systems |
| Fundamentals of image processing | Parameters of image creation<br>Tools for digital image processing<br>Image analysis |
| Technical features of the system | Camera<br>Processor unit of a vision system<br>I/O Module<br>Other hardware components |
| Vision process | Adjustment and calibration of a vision system<br>VBAI interface<br>PLC timer<br>Results of the measuring process |
| Workload | Education process consists of 35 lessons during a school year. |

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| Teaching methods and techniques: | Teaching techniques:<br>• mentor assisted learning<br>• differentiated learning<br>• individualized learning<br>• learning through problem solving<br>• learning based on examples<br>• learning based on demonstration<br><br>Teaching methods: |

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| | • method of dialogue<br>• heuristic method<br>• problem solving method<br>• method of demonstration<br>• method of research<br>• evaluation.<br>Note: the choice of teaching methods and techniques for each lesson is made by the teacher, depending on the learning contents, students' characteristics and other conditions. |

<table>
<tr><td rowspan="4">Elements and forms of monitoring and assessment criteria</td><td colspan="3">Elements: acquisition of the programme contents, exercises and understanding of the programme contents. Application of knowledge (project task).<br>Forms: Project task: Create and use a vision system as a tool for recognition of distinctive features of an object (forms, dimensions, engravings etc.) Each student should define a basic feature of an object, camera settings, lens and recognition of an irregular object (e.g. damages, incorrect dimensions etc.).</td></tr>
<tr><td>Assessment area</td><td>Assessment criteria</td><td>Points</td></tr>
<tr><td>1. Planning</td><td>The student uses different sources of information, he/she plans the work process using technical information, drawings, tables, graphs and standards needed to complete the task. He/she is independent and innovative in his/her work and uses the knowledge acquired in this programme.</td><td>15</td></tr>
<tr><td>2. Documentation</td><td>The student uses technical documentation when choosing the components of the vision system, he/she creates the scheme of the vision system and takes notes on the results of the system setting.</td><td>20</td></tr>
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| | 3. Performance | The student chooses the appropriate lens, sets the camera to the optimal distance from the object, correctly sets the scene and the parameters of lighting, establishes the connection between the PLC and the camera. The student correctly defines the features for recognition of the chosen object, analyses the impact of different parameters on the results of the measuring process. | 55 |
| | 4. Presentation | The student presents the process of performing the task and participates in an informed discussion (explains the choice of lens and camera, explains why the system recognized certain object as appropriate / inappropriate) | 10 |
| | **Total** | | **100** |
| | **Completion criteria** | | **60** |

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| Teaching staff | **SL**: In accordance with the legal framework<br>**HR:** In accordance with the legal framework |

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| Teaching facilities and equipment | Teaching process is conducted in a lab equipped with software, hardware and ancillary resources required for creation of vision systems. Groups can be of up to 14 participants, larger classes have to be split into groups in order to meet the required criteria. |

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| Teaching resources: | **SL:** Sources for the teachers are available on the Internet<br>**HR:** Sources for the teachers are available on the Internet |

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| Learning resources: | **SL:** Internal materials<br>**HR:** Internal materials |

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# BUSINESS COMMUNICATION

April 2021

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| Relation to the European and national qualifications framework /educational system - EQF/NQF | **SL**: NQF 4.2/EQF 4<br>**HR**: NQF 4.2/EQF 4 |

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| Relation to the existing educational programmes | **SL**:<br>• Mechanical engineering technician, vocational secondary education<br>• Mechanical engineering technician, vocational-technical education<br>• Metal designer / toolmaker, vocational education<br>• Mechanical installation fitter, vocational education<br>• Economic technician, vocational secondary education<br>• Technician for gastronomy and tourism, vocational secondary education<br>**HR**<br>• Mechanical engineering computer technician<br>• Mechanical engineering technician<br>• Computer technician for mechanical engineering |

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| Volume of the learning outcomes | **SL**: 1 ECVET<br>**HR:** 1 ECVET |

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| Justification for implementation | Communication is very important part of doing business, of organizing and managing systems. Transferring messages, maintaining the correspondence, exchanging and processing information, giving and receiving requests among professional organizations, contacts with business partners etc. - these are the constituent parts of a communication system, indispensable for any organization. |

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| Enrolment requirements / year of education / grade | **SL**: Enrolled in accordance with the above mentioned programmes, with learning contents being organized in the 1st and 2nd years of the education programmes. Recommendation: 1st year of vocational secondary education and vocational-technical education, and 2nd year of vocational education programme (open curriculum)<br>**HR**: completed second grade of one of the programmes listed under "Relation to the existing educational programmes" |

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| Educational objectives | Acquiring competences for successful interpersonal communication within the framework of different business activities in present-day business organizations, and their appropriate application within the context of individual and cultural differences. |

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| Learning outcomes | **1. Acknowledge the importance of successful communication in present-day society and business**<br>1.1. Explain the basic concepts of business communication<br>1.2. Understand the forms and models of business communication<br>1.3. Choose processing tools using tool catalogues<br><br>**2. Communication using various media**<br>2.1. Coordinate verbal communication with non-verbal cues<br>2.2. Apply information-communication technologies in communication<br>2.3. Understand the importance of public speaking and presentation<br>**3. Apply communication skills**<br>3.1. Be familiar with the advantages of teamwork<br>3.2. Develop and apply successful listening skills and knowledge<br>3.3. Apply business etiquette with peers and managers<br>3.4. Apply business etiquette in communication with all participants and in all forms of communication, and act in compliance with good business practices<br>3.5. Develop professional responsibility and organizational culture in work environment<br>3.6. Plan and lead a business interview, meeting<br>3.7. Demonstrate appropriate reactions to issues and conflicts |

| **Teaching and learning units** | **Elaboration – teaching and learning topics** |
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| Introduction to business communication | Importance of communication in present-day society and business<br>Conceptual definitions<br>Communication<br>Business communication |

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| Forms and models of business communication | Forms of business communication<br>Spoken communication<br>Written communication, information-communication technologies<br>Non-verbal communication<br>Using information-communication technologies for on-line communication |
| Communication skills | Assertive communication<br>Barriers in communication and ways to overcome them, strategies for conflict resolution<br>Interpersonal communication and types of personality according to disposition<br>Communication with colleagues, clients and relationships with clients<br>Teamwork<br>Business etiquette in different forms of communication<br>Preparing and moderating a business meeting |
| Workload | Education process consists of 35 lessons during a school year. |

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| Teaching methods and techniques | Teaching techniques<br>• mentor assisted learning<br>• differentiated learning<br>• individualized learning<br>• learning through examples<br>• learning through demonstration<br><br>Teaching methods<br>• method of a dialogue<br>• heuristic method<br>• problem solving method<br>• method of demonstration<br>• individual work |

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| | • work in pairs, groups<br>• role-play<br>• evaluation<br>Note: the choice of teaching methods and techniques for each lesson is made by the teacher, depending on the learning contents, students' characteristics and other conditions. |

<table>
<tr><td rowspan="6">Elements and forms of monitoring and assessment criteria</td><td colspan="3">Elements: The acquisitions of the programme contents, exercises and understanding of the programme contents.<br>The application of knowledge (project task).<br>Forms:<br>Project task 1: »Employment« - comment a job advertisement using a real case, prepare a job application, add a motivational letter and curriculum vitae created with Europass digital template which can be updated. Each participant prepares a job application in his/her mother tongue and in a foreign language, applying the knowledge of communication theory and business etiquette, he/she describes the flow of the job interview.</td></tr>
<tr><td>Area of assessment</td><td>Assessment criteria</td><td>Points</td></tr>
<tr><td>1. Planning</td><td>The student independently uses various sources of information and analyses the available information needed to perform the task. He/she is independent and innovative in his/her work and applies the knowledge acquired in this programme.</td><td>15</td></tr>
<tr><td>2. Documentation</td><td>The students examines various documents which can help him/her complete the tasks by learning from high quality examples.</td><td>15</td></tr>
<tr><td>3. Performance</td><td>The student writes a job application and a motivational letter for a specific job advertisement. Using ICT, he/she creates a resume (CV) in Europass template.</td><td>60</td></tr>
<tr><td>4. Presentation</td><td>The student presents the processes used to complete the tasks and participates in an informed discussion.</td><td>10</td></tr>
<tr><td colspan="2">Total</td><td>100</td></tr>
<tr><td colspan="2">Completion criteria</td><td></td></tr>
</table>

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| | Project task 2: Planning and moderating a business meeting. Group work.<br>Students recognize one challenging situation which can potentially be solved by teamwork. Based on a real-life situation, participants plan conducting a business meeting in physical and online format. They define the purpose and objectives of the meeting, organize the venue, schedule and logistics for the meeting, they conduct the meeting, and do the follow-up activities. For example, the task includes business etiquette, the roles of the individuals in a team, recommendations for conducting a meeting where both the host and the participants are online. Possible topics: joint design of a product in mechanical engineering, conducting polls and suggestions for provision of non-refundable grants; implementation of changes to the education system and similar. | | |
| | **Area of assessment** | **Assessment criteria** | **Points** |
| | 1. Planning | The student independently uses various sources of information and analyses the available information needed to perform the task. He/she is independent and innovative in his/her work and applies the knowledge acquired in this programme. | **15** |
| | 2. Documentation | The students examines various documents which can help him/her complete the tasks by learning from high quality examples. | **15** |
| | 3. Performance | Students plan and conduct a business meeting. Students recognize the problem and prepare a list of required team members, their roles, and scope and mode of their work. During the process, they produce documents related to business calls, mail, invitations for videoconferences, minutes of the meeting … and define them in terms of contents, having in mind business etiquette in physical and online environment of a business meeting. | **60** |
| | 4. Presentation | The group presents their work, other participants provide feedback on the work done and on the documentation prepared. | **10** |
| | | | **100** |

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| Teaching staff | **SL**: Teachers who hold university degrees in psychology, pedagogy, sociology, communications, journalism, tourism, hospitality, economy or organization. ICT contents require high level of IT education.<br><br>**HR:** In accordance with the legal framework |

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| Teaching facilities and equipment | Education process takes place in a computer equipped classroom. |

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| Teaching resources: | **SL:** Sources for the teachers are available on the Internet<br>**HR:** Sources for the teachers are available on the Internet |

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|---|---|
| Learning resources: | **SL:** Internal materials<br>**HR:** Internal materials |

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# CAD/CAM PROGRAMMING OF CNC MACHINES

April 2021

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| Connection to the European and national qualifications framework - EQF/NQF | **SL**: NQF 4.2/EQF 4<br>**HR**: NQF 4.2/EQF 4 |

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| Connection to the current educational programmes | **SL**:<br>• Mechanical engineering technician, vocational secondary education<br>• Mechanical engineering technician, vocational-technical education<br>• Metal designer / toolmaker, vocational education<br>• Mechanical installation fitter, vocational education<br>**HR**<br>• Mechanical CAD technician<br>• Mechanical technician<br>• Computer technician in mechanical engineering |

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| Volume of the learning outcomes | **SL**: 1 ECVET<br>**HR**: 1 ECVET |

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| Justification for implementation | With the emergence of CAD/CAM software systems for NC programming, manual programming has steadily been abandoned. Simplicity and the abundance of useful tools and functions make CAM systems indispensable when programming and simulating production by using machine tools. Gaining knowledge about CAM technology will enable students to, on one hand, integrate into the labour market more easily, and on the other, to lay a firm foundation to continue education and improvement in the field of CAD/CAM technologies. |

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| Enrolment requirements / year of education / grade | **SL**: Enrolled in accordance with the above mentioned programmes, with learning contents being organized in the 1st and 2nd years of the education programmes. Recommendation: 1st year of vocational secondary education and vocational-technical education, and 2nd year of vocational education programme (open curriculum)<br>**HR**: completed third grade of any of the educational programmes listed under *Connection to the current educational programmes* |

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| Educational objectives | To enable course participants to acquire knowledge about CAD/CAM programming systems used in manufacturing of metal parts with both simple and complex geometry. |

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| Learning outcomes | **1. Explanation of the technological manufacturing process**<br>1.1. Defining the sequence of operations and processes<br>1.2. Selecting the optimal working regimes according to the theory and the working regimes tables available for the machine tool<br>1.3. Selecting the machines to produce a metal part by using tool catalogues<br>**2. Generating a G-code in CAD/CAM software**<br>2.1. Generating a NC code to set CNC machine tool<br>2.2. Simulating a production process and inputting the corrections<br>2.3. Generating technical documentation<br>2.4. Postprocessing the code<br>**3. Producing a metal part by using a CNC machine tool**<br>3.1. Inputting a programme into a control unit<br>3.2. Initiating the production simulation<br>3.3. Setting the machine tool<br>3.4. Producing a part |

| **Teaching and learning units** | **Description of the theme** |
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| Explanation of the technological manufacturing process | • Technological process, operation, procedure<br>• CNC technical documentation<br>• Working regimes<br>• Machines and machines catalogues |
| Generating a G-code in CAD/CAM software | • Defining the machine tool and the raw part<br>• Defining the coordinate system and characteristic points |

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| | • Defining the trajectory of the tool<br>• Selecting the working regime<br>• Defining the tool and the point of changing the tool<br>• Initiating the simulation and correction<br>• Generating G code<br>• Selecting postprocessor and postprocessing<br>• Generating documentation |
| Producing a metal part by using a CNC machine tool | • Inputting a programme into a control unit<br>• Initiating a production simulation<br>• Setting a machine<br>• Producing a part<br>• Measuring and controlling the product |
| Workload | The learning and teaching process is completed during 35 lessons in a school year. |

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| Teaching methods and learning techniques | Learning techniques:<br>• tutor supported learning<br>• differentiated learning<br>• individualised learning<br>• example-based learning<br>• demonstration-based learning<br>Teaching methods:<br>• dialogue<br>• heuristics<br>• problem-solving approach<br>• demonstration - based teaching<br>• assessment<br>Remark: the choice of teaching methods and learning techniques is made by the teacher in accordance with the teaching content, specific needs of the course participants, facilities, equipment, and other conditions. |

<table>
<tr><td rowspan="6">Elements and forms of monitoring and assessment criteria</td><td colspan="3">Elements:<br>• Programme content/ subject matter attainment, practical exercises, and assessment of the subject matter acquisition<br>• Knowledge implementation (project assignment).<br>Forms:<br>Project assignment - to produce a metal part assigned in a manufacturing drawing:<br>1. Generating a NC code in a CAM software<br>2. Generating technical documentation<br>3. Producing a part on a CNC machine</td></tr>
<tr><td>Assessment scope</td><td>Assessment criteria</td><td>Points</td></tr>
<tr><td>1. Planning</td><td>Student uses different sources of information, describes the material according to its characteristics and purpose, selects the material processing methods and tools needed to complete the task. S/he does the work individually and innovatively using the knowledge and skills acquired during the course.</td><td>15</td></tr>
<tr><td>2. Documentation</td><td>Student reads manufacturing drawings and creates CNC technical documentation.</td><td>20</td></tr>
<tr><td>3. Performance</td><td>Student designs a 3D model according to the manufacturing drawings, and explains the technological procedure for its production, defines the machine tool and a raw part, tool trajectory, working regimes and tools. Student generates NC code for the chosen machine tool and postprocesses it. Student inputs the code into the CNC machine and produces a metal part on it.</td><td>55</td></tr>
<tr><td>4. Presentation</td><td>Student presents the assignment completion procedure from the manufacturing drawing to the final product and discusses about it presenting valid arguments.</td><td>10</td></tr>
<tr><td colspan="2">Total</td><td>100</td></tr>
<tr><td colspan="2">Passing criterion</td><td>60</td></tr>
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| Teaching staff | **SL**: In accordance with the legal framework<br>**HR:** In accordance with the legal framework |

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| Teaching facilities and equipment | Teaching is taking place in a specialised classroom which is providing working space for 14 students at most and which is equipped with software and hardware necessary for CAD/CAM programming, as well as machines for producing a part. Classes in which there are more than 14 students, have to be split into groups to meet the required criterion. |

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| Teaching resources | **SL:** Sources for the teachers are available on the Internet<br>**HR:** Bošnjaković, Mladen; Stojić, Antun: *Programming CNC Machines,* Slavonski Brod, University of Slavonski Brod, 2011, available online resources |

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| Learning resources | **SL:** Internal materials<br>**HR:** Internal materials |