# Process Automation (Fall 2024-2025)

## Brief course description

In today's global economy, process automation plays an increasingly crucial role. Engineers strive to automate various devices and integrate them into complex computer systems to facilitate a wide range of activities for people.

The Process Automation course will explore the fundamental components necessary for the implementation and management of automated systems. This includes an in-depth look at different sensors, actuators, and industrial computers. The course covers learning how to program these computers and connect them into reliable industrial networks. Additionally, the course covers the creation of user-friendly control systems and the integration of industrial computers with higher-level enterprise management systems. To ensure that the automation of devices is safe and error-free, the course includes preparing for real-world challenges in the computer lab using models of industrial robots and production lines. This hands-on approach allows students to gain practical experience and confidence in managing automated systems.

The course involves mandatory and graded practical exercises. A significant portion of the course grade is derived from a project developed during the semester. This project accounts for half of the final grade, while the other half is based on the student performance in the final exam demonstrating theoretical knowledge.

**Content Highlights:**

- **Systems and System Theory:** Introduction to systems and processes, management theory (definitions, methods, and quality of management), and management systems (purpose, functions, and components).
- **Control Function Tools:** Focus on programmable logic controllers (PLCs) including structure and programming models. Students will learn standard programming languages per IEC 61131, such as flow diagrams, functional programming, ladder diagrams, and command lists.
- **Communication Protocols in Production:** Study communication protocols between PLCs and other devices (e.g., RS422, RS485, Profibus, Modbus, AS-interface). Explore how PLCs connect with higher-level systems using protocols like Profibus and industrial Ethernet.
- **Higher-Level Management Systems:** Understand the purpose and development of SCADA (Supervisory Control and Data Acquisition) systems for production control, and the role of MES (Manufacturing Execution Systems) in connecting production management with ERP (Enterprise Resource Planning) systems.

## Learning Outcomes

After successfully completing the course, students should be able to:

- Gain a comprehensive understanding of the principles and practices of process automation.
- Acquire the skills necessary to design, program, and manage automated systems in various industrial contexts.
- Understand the fundamental principles and elements of computer-aided process control.
- Implement process automation techniques.
- Comprehend and analyze the connection between theoretical concepts and their practical application in process control.
- Develop competencies in system integration and aspects of computer-aided manufacturing.

## Expected level of expertise

- **Basic programming skills** (recommended). While not mandatory, knowledge of programming concepts will be advantageous, especially when working with programmable logic controllers (PLCs) and other automation software tools.

- **Basic knowledge of communication protocols and computer networks** (recommended). Understanding these concepts will help in grasping the communication aspects covered in the course.

## Instructor

name: Octavian Machidon
email: octavian.machidon@fri.uni-lj.si (put “63737C” in the subject line; please use the course webpage from ucilnica for any questions that may be of general interest to people in the class)

## Teaching assistant

name: Octavian Machidon
email: Octavian.Machidon@fri.uni-lj.si (put “63737C” in the subject line; please use the course webpage from ucilnica for any questions that may be of general interest for people in the class)

## Course meetings

| | **Lectures** | **Lab sessions** | **Office hours Octavian** |
|---|---|---|---|
| **Time** | Tuesday 12-15 | Thursday 13-15 | Schedule via email |
| **Location** | PR17 | PR17 | Schedule via email |

## Resources

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| **Course website** | https://ucilnica.fri.uni-lj.si/course/view.php?id=41 |

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| | NOTE: The course website is the main point for all the time-sensitive course information, for all class-related discussions, lecture and lab session materials, and for additional assigned readings. It is your responsibility to ensure that you are following updates from ucilnica.fri.uni-lj.si. |
| **Communication** | A Slack workspace **pafri2024.slack.com** is the main forum for discussing course-related issues. Please sign up with your full name and, ideally, add your picture to the profile! https://join.slack.com/t/fri-yyr2611/shared_invite/zt-2pqp712h2-vncL5V10XjLiFDNrNu7Hxg |
| **Software and Hardware Requirements** | Individual work will be mandatory when working on your projects. For that, you will need either to install locally, on your Windows 10/11 machine, the following tools:<br>● TwinCAT 3.1 build 4024.6<br>● TwinCAT 3 HMI TE 2000 version 1.12.762.42<br>● Visual Studio 2019 16.11.34 Community edition + ASP.NET and Web development component<br>● TwinCAT 3 OPC UA Server 5.1.119.0<br>● TwinCAT 3 OPC UA Client 4.4.43<br>● TwinCAT 3 OPC UA Client 4.4.188.0<br>Alternatively, you can use a virtual machine that will provide you with the development environment installed and configured. You will need VMware Player 17 or later to run the VM. Size of the VM: 20 GB (compressed) \| 32 GB (extended). |

## Tentative course outline

| Week | Lectures | Labs |
|---|---|---|
| 30.9 - 4.10 | Introduction. Course outline | No labs |
| 7.9 - 11.10 | PLC - Hardware | Getting to know the software tools and equipment |
| 14.10 - 18.10 | PLC Programming, part I<br><br>Ladder diagram (LD) | Introduction to PLC programming. Ladder diagrams. Manual control of devices. |
| 21.10 - 25.10 | PLC Programming, part II<br><br>LD (cont.), Function Block Diagram (FBD), Sequential Function Chart (SFC), Instruction List (IL), Structured Text (ST) | Manual control |
| 28.10 - 1.11 | PLC programming, part III | No labs - Holiday! |

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| | ST (cont.), programming techniques, project-related tips | |
| 4.11. - 8.11. | Sensing and Actuation Components, part I | Checkpoint 1: Manual control |
| 11.11. - 15.11. | Sensing and Actuation Components, part II | Automatic control |
| 18.11. - 22.11. | Human-machine interface (HMI) | Automatic control |
| 25.11. - 29.11. | Guest lecture from the industry | Checkpoint 2: Automatic control |
| 2.12.- 6.12. | Industrial buses | SCADA |
| 9.12. - 13.12. | Company visit | SCADA |
| 16.12. - 20.12. | OPC | OPC-UA |
| 23.12. - 27.12. | No class - work on your projects | No labs - work on your projects |
| 30.12. - 3.1. | No class - work on your projects | No labs - work on your projects |
| 6.1. - 10.1. | Higher-Level Control Systems – MES (Manufacturing Execution System) Smart factory | OPC-UA |
| 13.1. - 17.1. | Documentation and Safety, Regulations | Final project presentations! |

Blue - Lectures

Yellow - Labs

Green - You present!

Red - No class

## Course components

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| **Lectures** | Attendance is **highly recommended**, as lectures introduce key concepts and principles essential for laboratory exercises. Students attending the labs are assumed to be familiar with the necessary material covered in lectures.<br>Two events will be held during the semester as part of the lectures: a guest lecture (from an industry expert) and a company tour. Attendance at these events is strongly encouraged. |
| **Lab Sessions** | The laboratory exercises focus on developing a project in pairs, covering everything from manual and automatic device control to creating a SCADA system with OPC UA or ADS communication. |
| **Project work** | Project progress will be evaluated three times throughout the semester. The dates will be announced in advance and will also be indicated in the course syllabus (which might get updated on the fly, so make sure you check it out periodically). The first two evaluations will each contribute 10% to the final grade, and the third (final presentation at the end of the semester), will count for 15%. The project report (documentation) will contribute an additional 15% and is a prerequisite for the oral exam. The project report must include a description of the system, its operation, and user instructions. The deadline for submitting the final report will be announced in class, typically a few days before the oral exam. In total, the lab exercises account for 50% of the final grade. The remaining 50% is from the oral exam. |
| **Oral Exam** | You will have an oral exam in the end. The exam questions will be very related to what has been taught in lectures and lab sessions. You will be given a set of practice questions near the end of the semester. The exam is a closed book one - no textbooks or notes of any kind are allowed. The oral exam deadline usually aligns with the official exam dates in Studis. |

## Marking

## Final grade is composed as follows:

- 50% project work and lab exercises
    - 10% first checkpoint (manual control)
    - 10% second checkpoint (automatic control)
    - 15% final presentation
    - 15% written report
- 50% Final oral exam

**if you don’t do well on the project -- you cannot pass the course!** To pass the course you need to collect at least half of the project points and half of the oral exam points.

## Policies

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| **Plagiarism and cheating** | Cooperative work is an important part of learning; you are encouraged to study together, discuss the lectures, and discuss the software solutions. However,<br>DO NOT:<br>● turn in duplicate work (no matter how small the shared part is)<br>● copy work (even one line) from another team's project or from a published source without citing the original material;<br>● have anyone else but the team members contribute to your project<br>In addition:<br>● Clearly state the contributions of each team member in the final report<br><br>Finally, anyone caught breaching the above guidelines will fail the course. The University of Ljubljana policy on academic honesty can be found here: http://www.uni-lj.si/o_univerzi_v_ljubljani/organizacija__pravilniki_in_porocila/predpisi_statut_ul_in_pravilniki/2013071214420651/ (in Slovenian, but Google translate does a good job in translating it to English). Cheating is considered a major breach of policy and can result in a suspension from the University.<br><br>Finally, if you are struggling with the course and need help, contact the instructor or the TA and we will do all that we can to help, including meeting outside of regular office hours if need be, just DO NOT CHEAT. |
| **Project work** | The project is to be done in teams. However, that doesn't mean you should not discuss issues with your class peers. Feel free to use Slack for that. |
| **Attendance** | All team members must attend and present at all checkpoints and final the presentation. |

## Students with Disabilities

If you are a student with a disability and would like to discuss special academic accommodations, please contact the instructor. In addition, the University of Ljubljana has adopted special guidelines regarding university procedures and the study process itself to ensure special needs students have equal rights and access to public information. Please contact Helena Zupan (phone: 014768180, e-mail: helena.zupan@fri.uni-lj.si ) who is in charge of handling such needs at FRI.

## Disclaimer

The lecturer reserves the right to modify course content within the boundaries of the accredited programme.