COURSE DESCRIPTION

1. **Course title:** ADVANCED PROGRAMMING OF INDUSTRIAL CONTROLLERS

2. **Course code:** APIC

3. **Validity of course description:** 2019/2020

4. **Level of studies:** 2nd cycle of higher education

5. **Mode of studies:** intramural studies

6. **Field of study:** INFORMATICS

7. **Profile of studies:** COMPUTER SCIENCE

8. **Specialty:** INDUSTRIAL INFORMATICS SYSTEMS

9. **Semester:** 2 and 3

10. **Faculty teaching the course:** Institute of Informatics (RAu2)

11. **Course instructor:** Piotr Gaj PhD, DSc Eng.

12. **Course classification:** common courses

13. **Course status:** obligatory

14. **Language of instruction:** English

15. **Pre-requisite qualifications:**
   - Fundamentals of Computer Science
   - Fundamentals of Computer Networks
   - Fundamentals of Programming

16. **Course objectives:**
The aim of the course is to introduce students into advanced topics of industrial programmable controllers used in control and industrial IT systems as well as to highlight the theoretical and practical issues of their programming. We discuss many advanced issues and specificity of industrial controllers programming and application. Students after this course should be able to configure programmable logic controllers (PLC), to design and create their software as well as to design distributed systems where the main nodes are programmable industrial controllers.

17. **Description of learning outcomes:**

<table>
<thead>
<tr>
<th>Nr</th>
<th>Learning outcomes description</th>
<th>Method of assessment</th>
<th>Teaching methods</th>
<th>Learning outcomes reference code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Student possesses knowledge on programming tools, methods, languages, functional analysis and design of algorithms that can be used with programmable controllers in industrial facilities.</td>
<td>Written exam, Laboratory reports</td>
<td>Lectures, Laboratory classes, online stuffs</td>
<td>K2A_W09 K2A_W11</td>
</tr>
<tr>
<td>2</td>
<td>Student possesses knowledge on physical phenomena related to the interaction between information systems and the industrial environment.</td>
<td>Written exam, Laboratory reports</td>
<td>Lectures, Laboratory classes, online stuffs</td>
<td>K2A_W10</td>
</tr>
<tr>
<td>3</td>
<td>Student possesses knowledge on methods for evaluating the correctness, security and reliability of industrial controllers software.</td>
<td>Written exam, Laboratory reports</td>
<td>Lectures, Laboratory classes, online stuffs</td>
<td>K2A_W06</td>
</tr>
</tbody>
</table>
4. **Student is able to accomplish the engineering and science challenges and propose improvements or alternatives to existing solutions in industrial computer systems.**

| Written exam, Laboratory reports | Laboratory classes, online stuffs | K2A_U01, K2A_U08, K2A_U09 |

5. **Student is able, in accordance to the given specification, taking into account technical and non-technical aspects to design a complex system or IT process for industrial applications, and implement this project, at least in part, using appropriate methods, techniques, technologies and tools, by either adapting an existing or developing the new ones.**

| Written exam, Discussion, Laboratory reports | Laboratory classes, online stuffs | K2A_U10, K2A_U12, K2A_U13 |

6. **Student is able to assess the usefulness of methods and tools for solving the engineering and science tasks in the field of computer science within the industrial systems domain, including the limitations of these methods and tools.**

| Written exam, Discussion, Laboratory reports | Laboratory classes | K2A_U11 |

7. **Student is able to make an interaction and work in interdisciplinary group as a PLC system designer and programmer.**

| Discussion, Laboratory reports | Laboratory classes | K2A_U02 |

8. **Student is aware of the social and educational role of an engineer and scientist.**

| Discussion, Laboratory reports | Lectures, Laboratory classes | K2A_K06 |

18. **Teaching modes and hours**

- **Lecture / BA / MA Seminar / Class / Project / Laboratory**
- **30/0/0/0/0/45**

19. **Syllabus description:**

**Lecture:**

- **Industrial Programmable Controller:**
  - classification, operation principles, hardware definition, review of contemporary solutions,
  - idea of operation, purpose of existence, and examples.
- **Hardware description of devices:**
  - modern hardware constructions, processors, memories, central units, racks and cassettes, io circuits, coprocessors, modules, power supply.
- **Controller in work:**
  - program execution, cycle definition, elements of the cycle, types of cycles, discussion of individual stages of the cycle, duration of the cycle, restart modes, persistence & retentiveness, interrupts, and examples.
  - discussion about PLC vs. DCS stations and other types of controllers.
- **Hardware and software configuration of controllers:**
  - concept of configuration, preparing a configuration according to the system requirements.
  - memory organization, data types, variables, system zones, variable allocation, block instances, types of addressing and types of memory access, retentive memory.
- **Discussion of programming languages:**
  - discussion of text and graphic languages including: STL, IL, LD, FBD, ST, SFC, GRAPH, CFC, C,
  - discussion about automatic code generation,
  - language conversion.
- **Discussion of the standardization:**
  - discussion of IEC 61499.
- **Programming elements:**
  - common elements shared between different languages,
  - addressing and inter-module communication.
- **Overview of the commands list:**
- discussion of the advanced instructions for the Simatic/GE IP PACSystems, and other platforms with examples.

- Discussing examples of programs for various platforms:
  - examples of code that performs specific tasks, discussion of a practical problem being solved, discussion of the method of the presented solution and alternative solutions.

- Description of phenomena occurring in each of the controller elements:
  - discussion of phenomena at the interface between the central unit and the coprocessor,
  - cooperation with the computer network, cooperation and other drivers.

- Good practices while programming

**Laboratory:**

- Discussion of advanced functions of programming tools
  - presentation of contemporary development environments for various hardware platforms together with a discussion of the most important functions and showing examples of the real projects,
  - block interfaces, instances, global and local variables,
  - work with time oriented tasks,
  - programming sequential machines.

- Implementation of practical tasks in real devices including:
  - configuring the devices and projects,
  - the students work in the groups and with laboratory systems,
  - PLC cooperation in many logical subsystems and one physical system.

- Practical comparison:
  - Dedicated programming languages with the universal ones.
  - Logic languages with the sequential description languages.
  - Programming the models of real machines.

- The tasks being made during the classes are usually a part of the real solutions. To highlight the important problems of programming industrial controllers the tasks might be either elements of real applications or specially prepared ones.

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**20. Examination:** yes

**21. Primary sources:**

- [6]. William Bolton, Programmable Logic Controllers, Newnes, 2006
- [8]. Wilamowski, B.M. and Irwin, J.D. Fundamentals of Industrial Electronics, CRC Press 2011, USA
- [9]. Wilamowski, B.M. and Irwin, J.D. Industrial Communication Systems, CRC Press 2011, USA
- [11]. Online: Relevant papers published by IEEE Transactions on Industrial Informatics (ieeexplore.ieee.org)
- [12]. Online: Relevant papers published by LNCS, CCIS (link.springer.com)
- [13]. Online Wikibooks: Introductory PLC Programming
- [14]. Online: Nebojsa Matic, Introduction to PLC controllers, microE
23. Total workload required to achieve learning outcomes

<table>
<thead>
<tr>
<th>No.</th>
<th>Teaching mode:</th>
<th>Contact hours / Student workload hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lecture</td>
<td>30/30</td>
</tr>
<tr>
<td>2</td>
<td>Classes</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Laboratory</td>
<td>45/45</td>
</tr>
<tr>
<td>4</td>
<td>Project</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>BA/ MA Seminar</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Other (exam)</td>
<td>0/30</td>
</tr>
<tr>
<td></td>
<td>Total number of hours</td>
<td>75/105</td>
</tr>
</tbody>
</table>

24. Total hours: 180

25. Number of ECTS credits: 5

26. Number of ECTS credits allocated for contact hours: 2

27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects): 3

28. Comments:
…………………..
(date, Instructor’s signature)
…………………..
(date, the Director of the Faculty Unit signature)