Syllabus

1. Data about the program of study

1.1 Institution	The Technical University of Cluj-Napoca
1.2 Faculty	Faculty of Automation and Computer Science
1.3 Department	Computer Science
1.4 Field of study	Computer Science and Information Technology
1.5 Cycle of study	Bachelor of Science
1.6 Program of study / Qualification	Computer science / Engineer
1.7 Form of education	Full time

2. Data about the subject

2.1 Name of the subject	***Real Time Systems***			Subject code	**107**
2.2 Course holder	Prof. dr. eng. Letia Tiberiu - Tiberiu.Letia@aut.utcluj.ro				
2.3 Seminar/laboratory/project activities holder	Assist. dr. eng. Al-Janabi Dahlia - dahlia.aljanabi@aut.utcluj.ro				
2.4 Year of study	III	2.5 Semester	6	2.6 Evaluation type	C
2.7 Subject regime	Formative category: DF – fundamental, DS – specialized, DC – complementary				DS
	Optionality: DOB - mandatory, DOP - optional, DFA - facultative				DFA

3. Estimated total time

3.1 Number of hours per week	4	of which:	Course	2	Seminars	-	Laboratory	2	Project	-
3.2 Number of hours per semester	56	of which:	Course	28	Seminars	-	Laboratory	28	Project	-
3.3 Individual study:										
(a) Manual, lecture material and notes, bibliography										10
(b) Supplementary study in the library, online and in the field										10
(c) Preparation for seminars/laboratory works, homework, reports, portfolios, essays										19
(d) Tutoring										2
(e) Exams and tests										3
(f) Other activities:										-

3.4 Total hours of individual study (suma (3.3(a)...3.3(f)))	44
3.5 Total hours per semester (3.2+3.4)	100
3.6 Number of credit points	4

4. **Pre-requisites** (where appropriate)

4.1 Curriculum	Basic programming Software engineering Discrete event systems
4.2 Competence	Computer programming

5. **Requirements** (where appropriate)

5.1. For the course	Presence 50%
5.2. For the applications	Presence 100%

6. Specific competences

6.1 Professional competences	C2 – Fundamental operation concepts from computer science information and communication technologies C5 Application development, algorithm implementations and control structures using project management principles, programming environment and microcontroller based technologies, DSP, PLC and embedded systems

6.2 Cross competences	N/A

7. Expected learning outcomes

Knowledge	Describes, identifies, summarizes elementary concepts and methods regarding the modeling, analysis, design and testing of computing systems, with microcontrollers or processors, operating systems, graphics processing systems and data acquisition systems. Develops applications using quantum computers.
Skills	Analyze systems using the studied theories and planning, implement, diagnose and troubleshoot digital systems. Develop models for different components of computing systems, hardware and software and evaluate functional and non-functional characteristics Design and implement functional systems of complexity Choose and explain own concepts specific to algorithm design, object-oriented programming, logic and functional programming
Responsibility and autonomy:	Performs computer and information technology project management processes, taking on different roles in the team and describing the results clearly and concisely, verbally and in writing. Takes responsibility for the quality, security and correctness of the developed solutions and manifests autonomy in organizing planning and learning activities, collaborating effectively in teams and adapting to new requirements and technologies.

8. Course objectives

8.1 General objective	Conceiving of reactive applications
8.2 Specific objectives	Specification, design, implementation and testing of control applications

9. Contents

9.1 Lecture	No.hours	Teaching methods	Notes
Real-Time Systems (RTS). Introduction to RTS	2	Interactive	
Specification of real-time applications (RTAs)	2		
Modeling of RTAs using Petri nets	2		
Design of RTAs	2		
Real-Time operating systems	2		
Interprocess communication	2		
Concurrent programming implementation	2		
Quantum computing	2		
Quantum task models	2		
Quantum Processing Unit (QPU) and quantum task implementation	2		
Scheduling (tests and verification)	2		
Verification and test of RT implementation	2		
Utilization of Artificial Intelligence in RTS	2		
Reliability of RTAs	2		

Bibliography
1. T. Leţia. Sisteme de timp-real. Editura Albastră (Microinformatica), ISBN 973-9443-49-4, 2001 (363 pag.).
2. T. Letia, A. Astilean. Sisteme cu evenimente discrete: modelare, analiză şi control. Editura Albastră
3. (Microinformatica), Cluj-Napoca, ISBN. 973-9215-76-9, 1998 (228 pag.).
4. B. Bărbat, F.G. Filip. Informatică industrială. Ingineria programării în timp-real. Ed. Tehnică, Bucureşti, 1997.
5. J.E. Cooling. Software Design for Real-time Systems. International Thomson Computer Press, London, 1991.
6. Alan Burns, A. Wellings. Real-Time Systems and Programming Languages. Addison Wesley, 2001 6. A.M.K. Cheng. Real-Time Systems. Scheduling, Analysis and Verification, JhonWiley ans Sons, 2002
7. G. Buttazzo. Real-Time Systems. Predicatble Scheduling and Applications. Springer, 2005.
8. Bruce Powel Douglass. Real-Time UML. Third Edition. Advances in The UML for Real-Time Systems. Ed. AddisonWesley. 2007.
9. E.J.Brubo şi Greg Bollella. Real_Time Java Programming with Java RTS. Sun Micorsystems, 2009.
10. B.P. Douglass. Real Time UML Third Edition. Advances in the UML for Real-Time Systems. Addison-Wesley, 2007
11. A.M.K. Cheng. Real-Time Systems Scheduling, Analysis, and Verification. Ed. Wiley Interscience, JohnWiley and Sons, 2002.
12. G.C. Buttazzo. Hard Real-Time Computing. predictable Scheduling Algorithms and Application. Second Edition. Ed. Springer. 2005.
13. T. S. Letia, D. Al- Janabi, "Object Enhanced Time Petri Nets", 3rd International Conference on Event-Based
14. Control, Communication and Signal Processing (EBCCSP), DOI: 10.1109/EBCCSP.2017.8022831, 2018.
15. T.S. Letia, C. Avram, D. Al-Janabi, I. Miu and O. Cuibus. Development of Dynamic System Applications Using Distributed Quantum-Centric Computing, Mathematics 2025, 13, 3159. https://doi.org/10.3390/math13193159.
16. T.S. Letia, E.M. Durla-Pasca, E.M.; D. Al-Janabi; O.P. Cuibus. Development of Evolutionary Systems Based on Quantum Petri Nets. Mathematics **2022**, 10, 4404. https://doi.org/10.3390/math10234404Academic

9.2 Aplications (seminar/laboratory/project)	Hours	Teaching methods	Notes
L1. Utilities and the Execution Environment – Tool and development environment	2	Interactive	
L2. Threads of Execution in Java SE – General Notations	2		
L3. Threads of Execution in Java SE – Classic synchronization mechanisms	2		
L4. Threaded applications in Java SE - Testing and implementing Petri nets and Time Petri nets using classic synchronization mechanisms	2		
L5. Threads of execution in Java SE – java.util.concurrent package - Part 1 -	2		
L6. Threads of execution in Java SE – Design using UML and Implementation.	2		
L7. Threads of execution in Java SE – java.util.concurrent package - Part 2	2		
L8. Java SE runtime applications - Testing and implementing Petri nets and Time Petri nets, using synchronization mechanisms from the java.util.concurrent package	2		
L9. Real-Time Java – Object Enhanced Time Petri Nets (OETPN)	2		
L10. Conceiving Applications with OETPN Models	2		
L11. Quantum Petri Nets (QPN) Model - Introduction for the QPNs	2		
L12. Conceiving Application with QPN Models	2		
L13. Compensatory activities	2		
L14. Final test -	2		

Bibliography
1. Radu Miron, M.M Santa, T.S. Letia. Real Time Systems. Laboratory training lessons. TUCN

10. Bridging course contents with the expectations of the representatives of the community, professional associations and employers in the field

11. Evaluation

Activity type	Assessment criteria	Assessment methods	Weight in the final grade
Course	Final exam (E)	Written test	0,66
Seminar			
Laboratory	Test(L)	Written test + source code + implementation	0,33
Project			
Minimum standard of performance: E≥5, M≥ 5, L≥5			

Date of filling in: 29.06.2026	**Responsible**	**Title, First name Last name**	**Signature**
	Course	Prof. dr. eng. Tiberiu LETIA	
	Applications	Assist. dr. eng Dahlia AL-JANABI	

Date of approval in the department	Head of department, Prof.dr.eng. Rodica Potolea
Date of approval in the Faculty Council	Dean, Prof.dr.eng. Vlad Mureșan