Course title	Computer Control Systems
Course number	0917433
Credit hours (lecture and lab)	3 (3 + 0)
ECTS (weekly contact and self-study load)	5 (2 + 3) The course will be offered as a blended course where there are two weekly inperson contact hours, and one credit hour for activities, projects, guided exercises, etc. (worth 3 hour of practical each week).
Prerequisites/co-requisites	Embedded Systems Lab (0907334) + Signals Analysis and Systems (0953221)
Prerequisites by topic	Students are required to have good understanding of embedded systems design concepts and programming, as well as good knowledge of linear continuous and discrete time systems. Basic knowledge in MATLAB is preferable.
Level and type (compulsory, elective)	BSc compulsory course
Year of study and semester	Fourth Year – First Semester
Description	The undergraduate course introduces students to the basic concepts of continuous/digital open-loop and closed-loop feedback systems, and system modelling using Laplace and Z-transforms. Students will learn about a system's transfer function, block diagram model reduction, and the transfer's function zeros, poles, and stability analysis. The course will cover the unit and impulse transient response of first and second order control systems as well as computing the static steady state errors. A brief introduction to PID controllers will be given and how to design and tune them in MATLAB/Simulink . The course will use Simulink to allow students to build and analyze a simple control system. The course will also introduce practical considerations in control systems design: ADCs and DACs, control timeliness (hard/soft), sampling frequency (Nyquist/Shannon/Aliasing/jittering and its effects), choosing suitable sensors per application, actuators, advanced interfacing, signal conditioning and filtering (FIR, IIR, 1D Kalman), sources of error (quantization, fixed-point vs. floating point tradeoffs, controller architecture), choosing the correct controller, control system safety, fault-tolerance, and scalability. Finally, the course introduces DSP libraries and control blocks as well as the basics of real-time control systems programming based on ARM Cortex-M and Cortex-R as a case-study.

Objectives	1. Introduce students to the fundamentals of open-loop and closed-loop feedback control systems. 2. Introduce the students to the basic concepts of system modelling, Laplace and Z-transforms, and transfer functions. 3. Introduce students to the techniques that analyze system stability, and its transient response to impulse and unit functions and system steady-state errors.

	4. Enable students to understand and analyze the functional, temporal, and non-functional requirements of a control system and enable them to make sound decisions regarding practical considerations in designing and implementing control systems. 5. Introduce students to the basics of control system programming and the use of specialized DSP and control libraries. 6. Introduce students to the design and tuning of PID controllers.
Intended learning outcomes	Upon successful completion of this course, students will be able to:

No	Intended learning Outcome (ILO)	Program learning outcome (PLO)*
1	Demonstrate sound understanding of the basic principles of computer-controlled systems and be able to design and analyze practical systems	1
2	Use MATLAB and Simulink to model, analyze and test control systems	2
4	The ability to conduct proper analysis and experimentation in the hardware and software design of a computer-controlled system through simulation	6

(*) The PLOs are listed in the appendix

Teaching and learning methods	Development of ILOs is promoted through the following teaching and learning methods: • The School of Engineering and the computer engineering department labs are open for the students to practice the practical aspects and solve the Simulink and programming homework / project assignments. • The student attends the class presentations and participates in the discussions. • The student joins the related online team/group and participates in its discussions. • The student studies the reference material, including books, APIs, and videos. • The student studies and understands the designated self-study material and solves relevant exercises to check their understanding. • The student solves the assignments related to control system design and analysis. • The student carries out a term project or complete and online course on programming a control system or designing one using MATLAB Simulink or both • The student develops a professional report about recent advances and topics related to control systems for the term report.
Learning material	Textbook, class handouts, some instructor keynotes, selected YouTube videos, online short courses and access to a personal computer and the internet.

<table>
<tr><td>Resources and references</td><td>Required book(s), assigned reading and audio-visuals:
1. Control Systems Engineering, Norman S. Nise, 8thEdition (2021), John Wiley And Sons
2. Mathworks Online Courses
3. MATLAB and Simulink help and documentation

Recommended book(s), material and media:
4. Computer Controlled Systems: Theory and Applications. G. Perdikaris, Springer.
5. K. Ogata, “Modern Control Engineering”, 5th Edition, 2010, Pearson Hall
6. Harder et al. “A practical Introduction to Real-Time Systems for Undergraduate Engineering”, University of Waterloo, 2018 Available for free on authors’ website.
7. Qing Li and Caroline Yao, “Real-Time Concepts for Embedded Systems”, 2003
8. Cottet et al, “Scheduling in Real-Time Systems”, 2002, Wiley and Sons.
9. Digital Control Engineering – Analysis and Design, 2nd Edition, Fadali and Visiolo, Elsevier, 2013
10. Modern Control Systems, Dorf and Bishop, 13th Edition, 2017, Pearson Hall
11. Embedded Control System Design – A model based approach, Alexandru Forrai, Springer, 2013</td></tr>
<tr><td>Topic outline and schedule</td><td><table><tr><th>Week</th><th>Topic</th><th>ILO</th><th>Resources</th></tr><tr><td>1</td><td>Introduction to control systems, functional, temporal, and non-functional requirements of computer control systems Self-Learning (MATLAB REVIEW)</td><td>1</td><td>1, 3, 4</td></tr><tr><td>2</td><td>Introduction to control systems, functional, temporal, and non-functional requirements of computer control systems
Self-Learning (Review of Signals, Sampling, ADCs)</td><td>1</td><td>1, 3, 4</td></tr></table></td></tr>
</table>

	3	Review of linear continuous invariant systems and the Laplace transform. System modeling. Self-Learning (System Modeling in MATLAB)	1	1, 3,
	4	Model reduction using mathematical and blockreduction methods Self-Learning (System Modeling in MATLAB)	1	1, 3

	5	Model reduction using mathematical and blockreduction methods Self-Learning (System Modeling in MATLAB)	1	1, 3
	6	Transfer Functions and analysis of system's poles, zeros, and basics of control system stability Self-Learning (Exercises)	1	1, 3
	7	Transfer Functions and analysis of system's poles, zeros, and basics of control system stability (System Modeling in MATLAB)	1	1, 3
	8	Unit response of first and second order control systems	1	1, 3
	9	Unit response of first and second order control systems Self-Learning (Exercises)	1	1, 3
	10	System Stability Self-Learning (Mathworks Simulink on ramp Course)	1, 2,6	1, 2, 3
	11	Control System Steady State Errors Self-Learning (Mathworks Simulink Course)	1, 2, 6	1, 2, 3
	12	Control System Steady State Errors Self-Learning (Mathworks Simulink Course)	1,2, 6	1, 2, 3
	13	Introduction to PID Controllers Mathworks Simulink Control Systems Course)	1,2, 6	1, 2, 3
	14	Introduction to Digital Control Systems, Zero Order Sample and Hold Circuit, Z-transform, Model Reduction, Stability and Steady State Errors	1,2, 6	1, 2, 3
Evaluation tools	Opportunities to demonstrate achievement of the ILOs are provided through the following assessment tools:			

Assessment tool	Mark	Topic(s)	Time
Quizzes	10%	Control Systems Basic and Block Diagram Reduction	W6 – W12
MATLAB and Simulink Online Courses	12%	Simulink and Control System Design or Analysis	W10 - W14
Design Project or Report	8%	Simulink and Control System Design or Analysis	W10 - W14
Midterm exam	30%	Introduction to Time Response	W8
Final exam	40%	All material	W16
Total	100%		

Student requirements	The student should have a computer and internet connection.

<table>
<tr><td>Course policies</td><td>A-Attendance policies:
• Attendance is required. Class attendance will be taken every class and the university polices will be enforced in this regard.
B- Absences from exams and submitting assignments on time:
• A makeup exam can be arranged for students with acceptable absence causes.
• Assignments submitted late, but before announcing or discussing the solution can be accepted with an incremental penalty of 10% per day capped at 50%.
• The project report / Simulink Course must be handed completed on time.
C- Health and safety procedures:
• All health and safety procedures of the university and the school should be followed.
D-Honesty policy regarding cheating, plagiarism, misbehavior:
• Open-book exams (students can access all necessary mathematical tables, APIs, MATLAB and Simulink Help, and selected course material) All submitted work must be of the submitting student.
• Other text or code or models must be properly quoted with clear source specification.
• Cheating will not be tolerated.
E- Available university services that support achievement in the course:
• Microsoft Teams team and Moodle course page
• The School of Engineering has six labs with licensed MATLAB/Simulink software alongside selected packages</td></tr>
<tr><td>Additional information</td><td>None</td></tr>
</table>

Appendix

Learning Outcomes for the BSc in Computer Engineering

Students who successfully complete the BSc in Computer Engineering will be able to:

[1]	an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
[2]	an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
[3]	an ability to communicate effectively with a range of audiences
[4]	an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
[5]	an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
[6]	an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
[7]	an ability to acquire and apply new knowledge as needed, using appropriate learning strategies