COURSE SYLLABUS

ELEN 323: Feedback Control Systems

Fall 2026 | 4 Credits

Course code and title	ELEN 323 - Feedback Control Systems
Credit hours	4 credits
Weekly meetings	Two 75-minute lectures each week; one 150-minute laboratory when scheduled
Prerequisite	ECCE 302
Instructor	Dr. Muhammad Bakr Abdelghany
Email	Muhammad.babdelghany@ku.ac.ae
Office hours	Monday and Wednesday, 3:00–4:00 p.m.
Office	Room 3215
Laboratory instructor	To be announced

1. Course Description

Feedback control connects physical modeling, system analysis, controller design, and experimental evidence. The course develops these ideas across electrical, mechanical, electromechanical, and fluid systems, then applies root-locus, frequency-response, PID, and introductory state-space methods.

Catalog description. Systems modeling using ordinary differential equations and transfer functions; modeling of electrical, mechanical, electromechanical, and fluid systems; system performance and error analysis; stability analysis; root-locus and frequency-response methods; lead, lag, lag-lead, and PID controller design; and an introduction to state-space controller design.

2. Course Content

- System modeling and transfer functions of linear time-invariant systems
- Transient and steady-state performance analysis
- Stability analysis using Routh–Hurwitz methods and root locus
- Frequency-response analysis using Bode and Nyquist methods
- Lead, lag, lag-lead, and PID controller design
- Introductory state-space modeling, stability analysis, and state-feedback design

3. Teaching and Learning Format

Two 75-minute lectures are scheduled each week. One 150-minute laboratory session is scheduled in the designated weeks. Tutorials, problem solving, coursework, simulation, and experimental activities reinforce the theoretical material.

4. Learning Resources

Primary textbook. R. C. Dorf and R. H. Bishop, *Modern Control Systems*, 14th ed., Pearson, 2021. ISBN-13: 978-1292422374.

Software	MATLAB with Control System Toolbox; Simulink; MATLAB Real-Time Simulation (64-bit); QUARC data-acquisition software
Laboratory platforms	DC servo motor; Quanser ball-and-beam system; Quanser double inverted pendulum; MIMO helicopter system; Quanser data-acquisition cards

5. Assessment and Grading

Assessment component	Weight	Purpose
Coursework (quizzes and homework)	**12.5%**	Recall, guided practice, problem solving, and formative feedback
Assignment	**7.5%**	Independent analysis or design task; scope and date to be announced
Semester examination	**25%**	Mid-semester assessment scheduled in Week 8
Laboratory	**20%**	Prediction, implementation, testing, interpretation, and engineering judgment
Final examination	**35%**	Cumulative examination after the teaching weeks
Total	**100%**	**20% continuous work + 20% laboratory + 60% examinations**

Note. Exact quiz, homework, assignment, laboratory, and examination dates will be announced by the instructor and must follow the official academic calendar.

6. Course Learning Outcomes

By the end of the course, students should be able to:

CLO	Course learning outcome	Student outcomes
1	Model different types of linear time-invariant systems.	1
2	Design lead/lag and PID controllers.	1, 2, 6
3	Analyze the stability and performance of LTI systems.	1
4	Design compensators using the root-locus method.	1, 2, 6
5	Apply MATLAB and Simulink to analyze system stability and controller designs.	2, 5, 7

Contribution to Engineering Student Outcomes

SO 1	SO 2	SO 3	SO 4	SO 5	SO 6	SO 7
High	Medium	–	–	High	High	Medium

7. Grade Scale

The following percentage bands are indicative of typical ranges for College of Engineering undergraduate courses.

Letter grade	Grade point	Percentage range	Description
A	4.00	92.5–100%	Excellent
A-	3.70	89.5–<92.5%	Very Good
B+	3.30	86.5–<89.5%	Very Good
B	3.00	82.5–<86.5%	Good
B-	2.70	79.5–<82.5%	Good
C+	2.30	76.5–<79.5%	Satisfactory
C	2.00	72.5–<76.5%	Satisfactory
C-	1.70	69.5–<72.5%	Less Than Satisfactory
D	1.00	59.5–<69.5%	Poor
F	0.00	Below 59.5%	Fail
WF	0.00	Not specified	Withdrew Failing

8. Learning and Laboratory Expectations

Students are expected to follow a consistent engineering workflow throughout the semester:

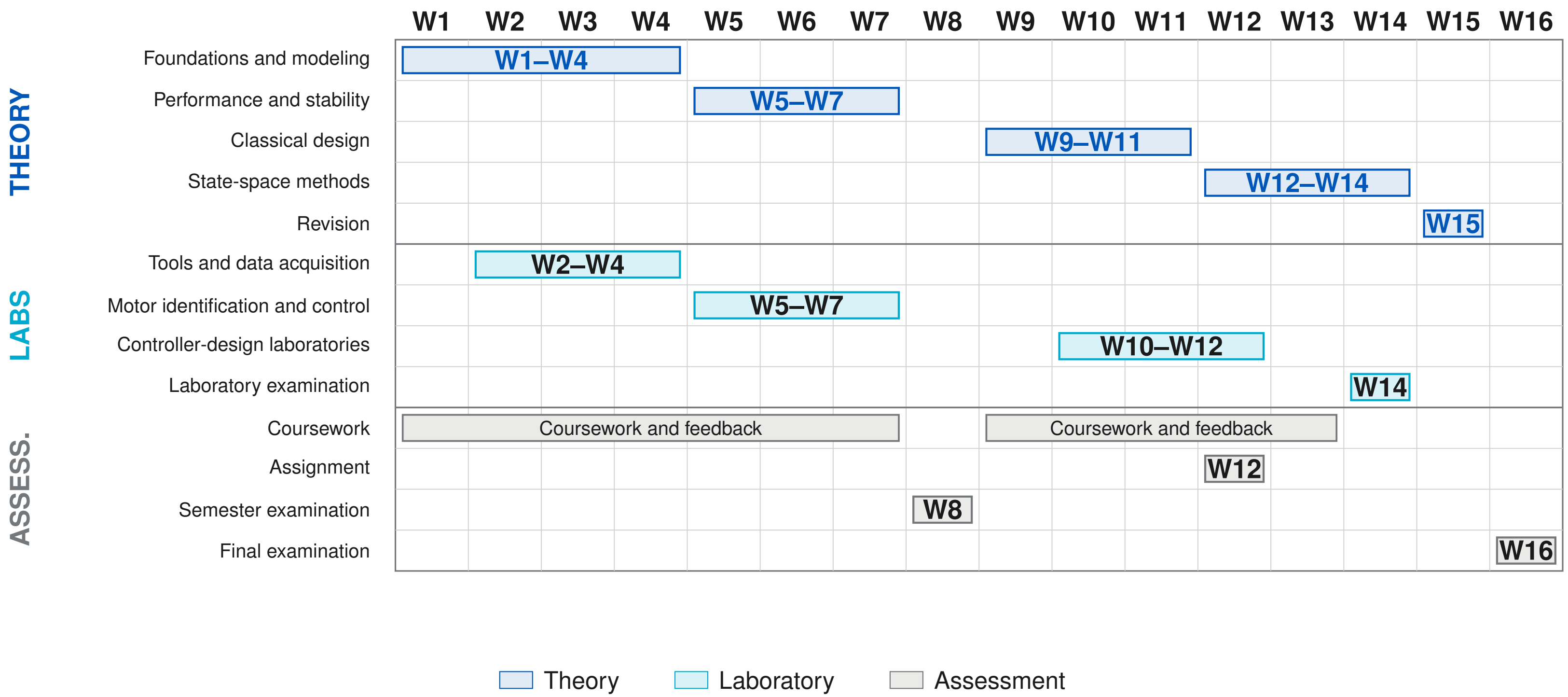
1. **Prepare.** Review the relevant material and identify the physical boundary, inputs, outputs, states, and assumptions.
2. **Derive and predict.** Build the model from physical laws and predict the response before running software or hardware.
3. **Implement and test.** Reproduce the analysis in MATLAB/Simulink, follow safe laboratory procedures, and collect evidence.
4. **Explain.** Compare prediction with evidence and account for discrepancies, limitations, uncertainty, and engineering consequences.

9. Administrative Notes

- Detailed assessment instructions will be communicated through the course e-learning platform.
- Students should consult the official university syllabus supplement and student handbook for institution-wide policies and procedures.
- If this syllabus and the official academic calendar differ, the official calendar and instructor announcements take precedence.

Semester Gantt Chart

Two 75-minute lectures per week, with laboratory and assessment activity in designated weeks.



Key milestones: Week 8 - semester examination; Week 12 - assignment; Week 14 - final laboratory examination; Week 15 - revision; Week 16 - final examination period.

Note. The laboratory sequence places PID motor control before the formal PID theory block and pole placement before the state-space theory block. These sessions should be introduced as guided previews unless the instructor elects to resequence them.

10. Detailed Weekly Teaching Plan: Weeks 1–8

Week	Theory content	Laboratory	Milestone
1	Introduction: the control problem, terminology, and motivation for feedback.	No laboratory.	Orientation
2	Dynamics of translational and rotational mechanical systems.	Experiment 1: MATLAB Control System Toolbox.	–
3	Transfer functions of electrical and electronic circuits.	Experiment 2: Simulink tutorial.	–
4	Modeling electromechanical systems.	Experiment 3: MATLAB real-time workshop and Quanser DAQ.	–
5	Performance analysis of linear time-invariant systems.	Experiment 4: DC servo bump-test system identification.	–
6	Routh–Hurwitz stability; root-locus construction and MATLAB.	Experiment 5: proportional speed and position control.	–
7	Root-locus construction techniques and design method.	Experiment 6: PID speed control.	Guided preview
8	Semester examination.	No numbered experiment.	Semester exam

Teaching Emphasis

- Weeks 1–4 establish the modeling vocabulary and connect physical laws to transfer functions.
- Weeks 5–7 introduce performance, stability, and the root-locus method.
- The Week 7 PID laboratory is treated as a guided implementation preview.

Note. The official academic calendar and instructor announcements determine exact meeting dates, holidays, and examination times.

11. Detailed Weekly Teaching Plan: Weeks 9–16

Week	Theory content	Laboratory	Milestone
9	Root-locus controller design; Bode plots and LTI stability analysis.	No laboratory.	–
10	Lead and lag compensator design.	Experiment 7: controller design using root locus.	–
11	Lag-lead compensation; PID controller design and tuning.	Experiment 8: state feedback by pole placement.	Guided preview
12	State-variable models; transfer-function conversions; controllable and observable canonical forms.	Experiment 9 / assignment: frequency-response system identification.	Assignment
13	Stability analysis of state-space models.	No laboratory.	–
14	State-space controller design.	Final laboratory examination.	Lab final
15	Revision and cumulative synthesis.	No activity specified.	Revision
16	Final examination period.	No laboratory.	Final exam

Teaching Emphasis

- Weeks 9–11 develop classical controller design using root locus and frequency-response tools.
- Weeks 12–14 introduce state-variable models, stability, and state-feedback design.
- Weeks 15–16 consolidate the course and complete the final examination.

Key Schedule Events

Week 12 Frequency-response system-identification assignment.

Week 14 Final laboratory examination.

Week 15 Revision and cumulative synthesis.

Week 16 Final examination period.

12. Laboratory Schedule

Experiment	Week	Laboratory focus
1	W2	Introduction to MATLAB Control System Toolbox
2	W3	Simulink tutorial
3	W4	MATLAB real-time workshop and introduction to the Quanser data-acquisition card
4	W5	DC servo motor transfer-function identification by step response (bump test)
5	W6	Speed and position control of a DC motor using proportional control
6	W7	Speed control of a DC motor using PID control
7	W10	Feedback-controller design using the root-locus method
8	W11	State-feedback controller design using pole placement
9	W12	Design of experiment: system identification using frequency response (listed as an assignment in the source schedule)
Final	W14	Final laboratory examination

13. Laboratory Submission Standard

Each laboratory submission should present a concise engineering narrative containing:

1. **Problem and model:** objective, physical boundary, variables, and assumptions.
2. **Prediction:** expected response before simulation or hardware testing.
3. **Implementation:** software settings, controller parameters, and calibration.
4. **Results:** readable plots or tables with labels, units, and operating conditions.
5. **Comparison:** agreement, discrepancy, uncertainty, saturation, noise, or delay.
6. **Conclusion:** evidence-supported finding and any remaining limitation.

Note. A plot without interpretation is incomplete evidence. Laboratory work should compare prediction with measurement and present a defensible engineering conclusion.

MODEL → PREDICT → TEST → INTERPRET