Control Systems II - ENGR4390
School of Engineering and Computing Sciences
Fall 2019

A. COURSE INFORMATION

Course number/section: ENGR4390 /001
Class meeting time: MWF 11:00-11:50 am
Class location: EN-220
Course Website: Blackboard

B. INSTRUCTOR INFORMATION

Instructor: Jose Baca
Office location: Engineering Building 222B
Office hours: T,W,TR 1-3 pm
e-mail: jose.baca@tamucc.edu
Appointments: Email to make an appointment

C. COURSE DESCRIPTION

Catalog Course Description
Model identification and parameter estimation (least-square identification of a auto-regressive model; nonparametric identification in the time domain; and nonparametric identification in the frequency domain); Robust Control (Nyquist-plots, small-gain, and passivity); Optimal control (LQR/LQG for state-space systems and time-optimal controller for the positioning of a mass using force actuation); Nonlinear control (Lyapunov's stability method; feedback linearization controller for a fully actuated 2nd order mechanical system; backstepping for triangular nonlinear systems; actuator limitations); writing and presenting reports and analysis.

Extended Course Description
The objective of this course is to provide students with the necessary knowledge to design, implement, and document a control engineering project. The course has three components: lectures, prepared laboratories (in the form of a project that is the same for all students), and a design project (specific to each group of students). The lectures and laboratories cover a range of special topics related to the practical implementation of control systems that are not covered in introductory control courses but that are likely to arise in the professional career of controls engineers.

D. PREREQUISITES AND COREQUISITES

Prerequisites
- Control Systems I (EEEN 3330 - ENTC 4446), or Approval of instructor.

Corequisites
None

E. REQUIRED TEXTBOOK(S), READINGS AND SUPPLIES

Required Textbook(s)
No required text - all necessary notes and lab manuals are provided on the course Blackboard website

Optional Textbook(s) or Other References
None

Supplies
None

F. STUDENT LEARNING OUTCOMES AND ASSESSMENT

Assessment is a process used by instructors to help improve learning. Assessment is essential for effective learning because it provides feedback to both students and instructors. A critical step in this process is making clear the course’s student learning outcomes that describe what students are expected to learn to be successful in the course. The student learning outcomes for this course are listed below. By collecting data and sharing it with students on how well they are accomplishing these learning outcomes students can more efficiently and effectively focus their learning efforts. This information can also help instructors identify challenging areas for students and adjust their teaching approach to facilitate learning.

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

- Perform control oriented modeling of dynamic systems
- Implement, commission, and test control systems
- Perform integrated system and control design
- Demonstrate professionalism when working in teams
- Demonstrate effective technical writing and presentation skills

G. INSTRUCTIONAL METHODS AND ACTIVITIES

Programming in Matlab (or Octave) and Simulink, as well as LabView

H. MAJOR COURSE REQUIREMENTS AND GRADING

- Exams (24%) – There will be three in-class exams worth 8% of the final grade each. Please note the dates of the exams on the course schedule below and plan accordingly. Exams may only be made up with an approved University excuse and will be different from the in-class version of the exam. If you have a conflict with an exam date, please let me know as soon as you know about the conflict.
- Quizzes (10%) – Regular quizzes (on-line and in-class) will be given.
- Homework (24%) - Approximately one per week – expect 16 total at 1.5% each
- Participation, and Attendance (18%) – You are expected to attend all scheduled lectures and labs. Your participation will count for class attendance, and your answers will count for a portion of the class participation grade. Either in hardcopy, e-mail, or on the course
Blackboard page, you are encouraged to submit newspaper, magazine, Internet articles, or videos that relate to the topics discussed in class.

- **Laboratory Reports (24%)** - As part of this class, you will have to work on weekly laboratory project assignments. These projects are group effort. Approximately one per week, expect 12 total at 2% each

- Grade Scale: A (90-100%) B (80-89%) C (70-79%) D (60-69%) F (<60%)

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<th>ACTIVITY</th>
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**I. COURSE CONTENT/SCHEDULE**

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<tr>
<th>DATE (BY DAY OR WEEK)</th>
<th>TOPIC</th>
<th>HOMEWORK</th>
<th>LABORATORY ASSIGNMENTS</th>
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| Week 01               | **Course overview**  
Computer-controlled systems  
- Continuous-time systems  
- Discrete-time systems  
- Discrete-time vs. continuous-time transfer functions | TBD      | 1                      |
| Week 02               | **Part I — Model identification and parameter estimation**  
Nonparametric identification  
- Time-domain identification  
- Frequency response identification | TBD      | 2–3                    |
| Week 03               | Parametric identification using least-squares  
- Least-squares line fitting  
- Vector least-squares | TBD      | 2–3                    |
| Week 04               | **Parametric Identification of an ARX Model**  
- ARX model  
- Identification of an ARX model  
- Dealing with known parameters | TBD      | 4                      |
| Week 05 | Practical consideration in parametric identification  
|        | • Choice of inputs  
|        | • Scaling  
|        | • Choice of the sampling frequency  
|        | • Choice of the model order  
|        | • Combination of multiple experiments  
|        | • Closed-loop identification | TBD | 4 |
| Week 06 | **Part II — Robust Control**  
|        | Robust stability  
|        | • Model uncertainty  
|        | • Nyquist stability criterion  
|        | • Small gain condition | TBD | 5 |
| Week 07 | Control design by loop-shaping  
|        | • Open-loop vs. closed-loop specifications  
|        | • Open-loop gain shaping | TBD | TBD |
| Week 08 | **Part III — LQG/LQR Controller Design**  
|        | Review of state-space models  
|        | • Input-output relations  
|        | • Realizations  
|        | • Controllability and observability  
|        | • Stability | TBD | 6 |
| Week 09 | Linear Quadratic Regulation (LQR)  
|        | • Feedback configuration  
|        | • Optimal regulation  
|        | • state-feedback LQR  
|        | • Stability and robustness  
|        | • Loop-shaping control using LQR | TBD | 7-9 |
| Week 10 | LQG/LQR output feedback  
|        | • output feedback  
|        | • full-order observers  
|        | • LQG estimation  
|        | • LQG/LQR output feedback  
|        | • Separation principle | TBD | 7–9 |
| Week 11 | Set-point control  
|        | • Nonzero equilibrium state and input | TBD | 7–9 |
### Week 12
**Part IV — Nonlinear Control**
- Feedback linearization controllers
  - Feedback linearization
  - Generalized model for mechanical systems
  - Feedback linearization of mechanical systems

### Week 13
Lyapunov stability
- Lyapunov stability theorem
- LaSalle's invariance principle
- Lienard equation and generalizations

### Week 14
Lyapunov-based designs
- Lyapunov-based controllers
- Application to mechanical systems

TBD  
TBD

Note: Changes in this course schedule may be necessary and will be announced to the class by the Instructor. The assignments and exams shown are directly related to the Student Learning Outcomes described in Section F.

### J. COURSE POLICIES

#### Attendance/Tardiness
- Students are expected to be in attendance, punctual, and **prepared** for class.

#### Late Work and Make-up Exams
- Late work is not going to be accepted. Make-up Exams are only arranged with 1 week prior notice. No make-up exam will be arranged after each exam.

#### Extra Credit
- Extra Credit questions/problems will be given in some of the tests and homework.

#### Cell Phone Use
- Please refrain from the use of electronic devices during class, as it is distracting to not only you, but also to your instructor and peers. Silence your phones and put them away so you are not tempted to stray off task.

#### Laptop Use
- Laptops will be permitted for particular activities as deemed appropriate.

**Food in Class**
- No food or drinks are allowed during class.

**Missed Exam**
- If you have a conflict with an exam date, please let me know as soon as you know about the conflict.

**Participation**
- In-group and individual activities on a regular basis will count towards final grade

**Others**
- All work submitted for grading must be the student's own work. Plagiarism will result in a score of 0 (zero) for the work or dismissal from the course and the Dean of Students office will be notified. No copying from another student's work of any type is allowed. It is the student's duty to allow no one to copy his or her work.

**K. COLLEGE AND UNIVERSITY POLICIES**

- **Academic Integrity (University)**
  University students are expected to conduct themselves in accordance with the highest standards of academic honesty. Academic misconduct for which a student is subject to penalty includes all forms of cheating, such as illicit possession of examinations or examination materials, falsification, forgery, complicity or plagiarism. (Plagiarism is the presentation of the work of another as one’s own work.) In this class, academic misconduct or complicity in an act of academic misconduct on an assignment or test will result in a failing grade.

- **Classroom/Professional Behavior**
  Texas A&M University-Corpus Christi, as an academic community, requires that each individual respect the needs of others to study and learn in a peaceful atmosphere. Under Article III of the Student Code of Conduct, classroom behavior that interferes with either (a) the instructor’s ability to conduct the class or (b) the ability of other students to profit from the instructional program may be considered a breach of the peace and is subject to disciplinary sanction outlined in article VII of the Student Code of Conduct. Students engaging in unacceptable behavior may be instructed to leave the classroom. This prohibition applies to all instructional forums, including classrooms, electronic classrooms, labs, discussion groups, field trips, etc.

- **Statement of Civility**
  Texas A&M University-Corpus Christi has a diverse student population that represents the population of the state. Our goal is to provide you with a high quality educational experience that is free from repression. You are responsible for following the rules of the University, city, state and federal government. We expect that you will behave in a manner that is dignified, respectful and courteous to all people, regardless of sex,
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ethnic/racial origin, religious background, sexual orientation or disability. Behaviors that infringe on the rights of another individual will not be tolerated.

- **Deadline for Dropping a Course with a Grade of W (University)**
  I hope that you never find it necessary to drop this or any other class. However, events can sometimes occur that make dropping a course necessary or wise. **Please consult with your academic advisor, the Financial Aid Office, and me, before you decide to drop this course.** Should dropping the course be the best course of action, you must initiate the process to drop the course by going to the Student Services Center and filling out a course drop form. Just stopping attendance and participation WILL NOT automatically result in your being dropped from the class. Please consult the Academic Calendar ([http://www.tamucc.edu/academics/calendar/](http://www.tamucc.edu/academics/calendar/)) for the last day to drop a course.

- **Grade Appeals (College of Science and Engineering)**
  As stated in University Procedure 13.02.99.C2.01, Student Grade Appeal Procedures, a student who believes that he or she has not been held to appropriate academic standards as outlined in the class syllabus, equitable evaluation procedures, or appropriate grading, may appeal the final grade given in the course. The burden of proof is upon the student to demonstrate the appropriateness of the appeal. A student with a complaint about a grade is encouraged to first discuss the matter with the instructor. For complete details, including the responsibilities of the parties involved in the process and the number of days allowed for completing the steps in the process, see University Procedure 13.02.99.C2.01, Student Grade Appeal Procedures. These documents are accessible through the University Rules website at [http://www.tamucc.edu/provost/university_rules/index.html](http://www.tamucc.edu/provost/university_rules/index.html), and the College of Science and Engineering Grade Appeals webpage at [http://sci.tamucc.edu/students/GradeAppeal.html](http://sci.tamucc.edu/students/GradeAppeal.html). For assistance and/or guidance in the grade appeal process, students may contact the chair or director of the appropriate department or school, the Office of the College of Science and Engineering Dean, or the Office of the Provost.

- **Disability Services**
  The Americans with Disabilities Act (ADA) is a federal anti-discrimination statute that provides comprehensive civil rights protection for persons with disabilities. Among other things, this legislation requires that all students with disabilities be guaranteed a learning environment that provides for reasonable accommodation of their disabilities. If you believe you have a disability requiring an accommodation, please call (361) 825-5816 or visit Disability Services in Corpus Christi Hall 116.

  If you are a returning veteran and are experiencing cognitive and/or physical access issues in the classroom or on campus, please contact the Disability Services office for assistance at (361) 825-5816.
• **Statement of Academic Continuity**

In the event of an unforeseen adverse event, such as a major hurricane and classes could not be held on the campus of Texas A&M University–Corpus Christi; this course would continue through the use of Blackboard and/or email. In addition, the syllabus and class activities may be modified to allow continuation of the course. Ideally, University facilities (i.e., emails, web sites, and Blackboard) will be operational within two days of the closing of the physical campus. However, students need to make certain that the course instructor has a primary and a secondary means of contacting each student.

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**L. OTHER INFORMATION**

• **Academic Advising**

The College of Science & Engineering requires that students meet with an Academic Advisor as soon as they are ready to declare a major. The Academic Advisor will set up a degree plan, which must be signed by the student, a faculty mentor, and the department chair. Meetings are by appointment only; advisors do not take walk-ins. Please call or stop by the Advising Center to check availability and schedule an appointment. The College’s Academic Advising Center is located in Center for Instruction 350 or can be reached at (361) 825-3928.

**GENERAL DISCLAIMER**

I reserve the right to modify the information, schedule, assignments, deadlines, and course policies in this syllabus if and when necessary. I will announce such changes in a timely manner during regularly scheduled lecture periods.