ECE4570 Course Syllabus

ECE4570

System Theory for Communication and Control (3-0-3-4)

CMPE Degree
This course is Elective for the CMPE degree.

EE Degree
This course is Elective for the EE degree.

Lab Hours
0 supervised lab hours and 3 unsupervised lab hours

Course Coordinator
Verriest,Erik I

Prerequisites
ECE 3550

Corequisites
None

Catalog Description
Study of the basic concepts in linear system theory and numerical linear algebra with applications to communication, compution, control and signal processing. A unified treatment.

Textbook(s)
Brian Hall, *Lie Groups, Lie Algebras, and Representations-An Elementary Introduction* (2nd edition), Springer-Verlag, 2016. ISBN 9783319134666(optional)

Fuhrmann, *A Polynomial Approach to Linear Algebra*, 2010.(optional)

Course Outcomes
Upon successful completion of this course, students should be able to:

1. Detect and exploit mathematical structure to solve complex problems (exact and approximation) in systems theory.
2. Apply common proof techniques to verify the validity of (simple) conjectures.
3. Apply basic principles (such as feedback) in a broad context of engineering.
4. Exploit geometric structure and symmetries in system and signal models to reduce hard problems to simpler ones.
5. Synthesize complex processes with elementary building blocks.
6. Solve engineering problems through teamwork.

Student Outcomes
In the parentheses for each Student Outcome:
"P" for primary indicates the outcome is a major focus of the entire course.
“M” for moderate indicates the outcome is the focus of at least one component of the course, but not majority of course material.

"LN" for "little to none" indicates that the course does not contribute significantly to this outcome.

1. (P) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. (LN) 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. (LN) An ability to communicate effectively with a range of audiences
4. (LN) 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. (M) 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. (M) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. (P) An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

Topical Outline

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Introduction
     Matrix algebra and algebraic structures
     State equations for multi-variable linear systems
Reachability and Observability Properties
     Range space, reachability, and minimum norm solution
     Null space, observability, and last squared error solution
     Finite state systems and linear modular systems: cyclic codes
Solutions of State Equations
     Eigen problem
     Stability
     Quadratic forms
     Adjoints
Elements of Polynomial System Theory (Algebraic System Theory)
     Rings and modules of polynomials
     Functional Models and Shift Spaces
     Linear Systems Analysis and Design
Systems on Lie Groups (Applications to Control and Computation)
     Matrix Lie Groups
     Lie algebras and exponential mapping, BCH-formula
     Basic Representation Theory
     Applications in attitude control, switched systems and ODE-sol
Linear Systems in Disguise
     Carleman Linearization
     Perspective systems (Applications in computer vision)
     Quaternions (Applications in Robotics, Control and Signal Proc
Design in Control and Communication
     State feedback design
     State observer design
     Stabilization and convergence of numerical algorithms
     Motion planning and steering
     Synchronization in communication systems
Simulation and Modelling
     Shift-register synthesis
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Subspace identification algorithm
Parametrization and sensitivity
Elementary notions of optimization