**ENPH 443 Linear Control Systems**

**Department: Mathematics, Physics and Engineering**
**Credit Hours: 4**

**Current Catalog Description:**
Application of state variable and frequency domain techniques to modeling and analysis of single input, single output linear control systems; physical implementation of control systems by integrating sensors, actuators and other control system components; use of software design tools.

**Course Schedule:**
3 lecture hr/wk, 3 lab hr/wk

**Coordinator:**
Dr. Denise Martinez

**Prerequisites by Topic:**
ENPH 314 – Signals and Systems
MATH 306 – Differential Equations

**Program Outcome and Course Learning Goals Map:**
The Program Outcomes for Engineering Physics are:

A. an ability to apply knowledge of math, engineering & science
B. an ability to design and conduct experiments, as well as to analyze and interpret data
C. an ability to design system, component or process to meet needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
D. an ability to function on multi-disciplinary teams
E. an ability to identify, formulate, and solve engineering problems
F. an understanding of professional and ethical responsibility
G. an ability to communicate effectively
H. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
I. a recognition of need for, and ability to engage in life-long learning
J. a knowledge of contemporary issues
K. an ability to use techniques, skills, and modern engineering tools necessary for engineering practice.
L. a depth and breadth of knowledge in engineering and physics necessary to work in a multidisciplinary environment

| **Course Goals**<br>Upon completion of this course with a C or better, students will | **Program Outcome(s):** |
|---|---|
| 1. Understand the role of control systems in engineering and science as well as its application to other fields such as business and society. | F,H,I,J,L |
| 2. Understand and be able to obtain the time response of a system to step, ramp, impulse and sinusoidal signals by hand and using Matlab. | A,E,K |
| 3. Explain and determine the following control systems terminology: Characteristic equation, poles and zeros, and initial and Final Value Theorems, delay time, rise time, peak time, max overshoot, settling time, and steady state error, transient and steady state responses, stability, Bode plot, Nyquist plot | A,E |
| 4. Be able to translate between differential equation, state space and transfer function representations of system models by hand and using Matlab. | A,E,K |
| 5. Understand the effects of P, I, and D in PID control and be able to design and implement P, PI, PD, and PID controllers using op-amps. | A,B,C,D,E,G,K |
| 6. Be able to use the Routh Stability criterion to determine stability and parameter | A,E |

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|---|---|
| ranges. | |
| 7. Understand and be able to apply the Root Locus Method (by hand and in Matlab) to investigate parameter variation in a closed loop system. | A,B,E,K |
| 8. Understand and be able to apply the Nyquist Stability Criterion. | A,E |
| 9. Be able to determine the controllability and observability of a state space system. | A,E |
| 10. Be able to design controllers using pole placement. | A,B,C,D,E,G,K |

**Topics Covered:**

- Introduction to Control Systems
- Review Laplace transform methods
- Modeling system dynamics
- Linearization of nonlinear systems
- State space system representation
- Transfer functions
- Transient and steady-state analyses
- Root Locus Methods
- Frequency analysis – Bode
- Frequency analysis - Nyquist
- Lag/lead design using frequency response
- PID design
- Controllability and observability
- Pole placement design
- Servo design
- Design with state observers

**Academic Honesty:**

Cheating, plagiarism (submitting another person's materials or ideas as one's own), or doing work for another person who will receive academic credit are all-impermissible. This includes the use of unauthorized books, notebooks, or other sources in order to secure of give help during an examination, the unauthorized copying of examinations, assignments, reports, or term papers, or the presentation of unacknowledged material as if it were the student's own work. Disciplinary action may be taken beyond the academic discipline administered by the faculty member who teaches the course in which the cheating took place.

**Students with Disabilities Policy:**

It is the policy of Tarleton State University to comply with the Americans with Disabilities Act (ADA) and other federal, state, and local laws relative to the provision of disability services. Students with disabilities attending Tarleton State University may contact the Office of Disability Services at (254) 968-9478 to request appropriate accommodation. Furthermore, formal accommodation requests cannot be made until the student has been officially admitted to Tarleton State University.

**Contribution of Course to Meeting the Professional Requirement:**
Engineering Topics: 100%

**Status of Continuous Improvement Review of this Course:**
**Prepared by:** *Denise Martinez*
**Date:** *Jan 7, 2005*

**Reviewed by:** *Denise Martinez*
**Date:** *May 9, 2005*
**Review notes:**
05/09/05: Servo design and Design with State Observers could be omitted or covered as survey.

**Reviewed by:** *Denise Martinez and Falih Ahmad*
**Date:** *March 15, 2009*
**Review notes:**
03/15/09: updated prereqs to include DE; removed lead/lag compensation and nonlinear system linearization due to time constraints