Mechanical Engineering 478: Intermediate Control Systems

Designation: Elective course

Course Description: 3 CR. U/G. State space and frequency domain methods of modeling, analysis and design of multivariate control systems with emphasis on mechanical systems, applications and case studies. Prereq: sr st; MechEng 474 (P).

Textbook: Control System Design: An Introduction to State Space Methods, by Bernard Friedland, McGraw Hill, 1983.

Prerequisites by Topics:

- Modeling of systems
- Root locus method
- Bode diagram

Course Objectives:

- Students will learn the fundamental concepts of state space and multivariable control.
- Students will learn the fundamentals of digital control.
- Students will learn the fundamentals of model reference adaptive (MRA) control.
- Students will learn the fundamentals of linear quadratic regulators (LQR).
- Students will learn the fundamentals of quantitative feedback theory (QFT).

Topics Covered:

- Shaping the dynamic response,
- pole placement techniques,
- model reference adaptive (MRA) control,
- controllability and observability,
- linear observers, kalman filters: Optimum observers,
- quadratic optimal control,
- frequency domain control techniques,
- effect of sampling, digital controllers and
- Quantitative feedback theory (QFT).

Written Communications

The students turn in a laboratory report for an extensive project that they work in teams. The project revolves around the design and implementation of a controller (LQR, MRA, or QFT) on one of three platforms: inverted pendulum, ball and beam or a master/slave apparatus.

Class/Laboratory Schedule:
Three hours lecture per week

Contribution of Course to Meeting the Professional Component:

<u>Category:</u> Engineering topics with design, 3 credits.

- Students understand the fundamental concepts of multivariable control.

- Students understand the fundamental concepts of designing and implementing digital controllers.

- Students can design LQR, MRA and QFT controllers to enhance the performance of systems in both the frequency domain and the time domain.

- Students understand how to implement controllers and are aware of standard industrial practices.

Relationship of Course to Program Outcomes:

i, iii Students design and implement controllers to enhance the performance of dynamical systems.

v The students use MATLAB extensively to validate controllers and expected system performance.

vi The students use data acquisition systems and AD/DA boards to gather, analyze and transform experimental data.

vii The students design and implement controllers to enhance the performance of systems. Often times, the performance guidelines are ill defined.

ix The students use knowledge from introduction to control systems to analyze dynamical systems.

xi The students hone their written communication skills by writing a project report.

xii The students work as a team on a project.

xiii The students synthesize information that they gather to solve open ended problems and to design controllers with ill defined performance guidelines.

Prepared by: Ronald A. Perez, September 23, 2001

Methods of Assessment:

- Prerequisite exam
- Course evaluations by students
- Graded homework assignments
- Graded examinations
- Graded project
- Instructor judgment

Resources Commonly Available:

- Instructor
- Internet
- Professional software on CAE computers
- Laboratory and associated hardware in room PHY-B47

Desirable Student Competencies:

- Ability to use personal computers
- Ability to use the internet
- Good analytical skills
- Good writing skills