WEST VIRGINIA UNIVERSITY COLLEGE OF ENGINEERING AND MINERAL RESOURCES
DEPARTMENT OF COMPUTER SCIENCE AND ELECTRICAL ENGINEERING

EE 411 FUNDAMENTALS OF CONTROL SYSTEMS SPRING 2015
9:00-9:50 am. MWF Room 401 ESB 3 credit hours

Prerequisite: EE 327 **Textbook (required):**
K. Ogata, *Modern Control Engineering,* 5th Edition, 2009, Prentice-Hall, ISBN-13:978-0136156734

Other Good References:
- Signals and Systems, Haykin and VanVeen, Wiley and Sons, 1999, ISBN 0-471-13820-7
- Automatic Control Systems, Seventh Edition, by B.C. Kuo, Prentice-Hall, 1995,
- Modern Control Theory, Third Edition, Brogan, W.L., Prentice-Hall, C 1991

Catalog Description:
Representation of dynamic systems. Design of classical and modern control systems in both time and frequency domains. Application of control system design tools such as Root-Locus and Bode Plots to achieve stable feedback control systems meeting pre-specified closed loop performance requirements.

Course Outcomes:
- Representation of Signals and Linear Systems
  - **o** Write input-output differential equations to represent linear systems **o** Find transfer function representation of linear systems
  - **o** Use state space representation of linear systems and transformations to and from the other representations
  - **o** Use block diagram form of system representation with all other representation forms

- Linear Dynamic System structure
  - **o** Relate second order system frequency response to time domain parameters **o** Develop and apply (in the design process), the time domain design parameters: rise time, overshoot, peak time, settling time, and others with frequency domain design parameters: damping factor, natural frequency, damped natural frequency and others.

- System analysis and solution:
  - **o** Find system responses using analytic methods and computational tools **o** Solve linear systems for response ("output") signals resulting from given excitation ("input") signals

- Control System Design
  - **o** Understand and apply in design, the frequency domain design tools: root locus, Routh-Hurwitz method and test, and frequency response (Bode) characteristics
  - **o** Clearly understand and be able to contrast open loop system and closed loop systems.
  - **o** Be able to cite contrasting characteristics and give advantages and disadvantages of each.
  - **o** Be able to list advantages and disadvantages of the use and application of feedback in closed loop control systems design

- Dynamic System Stability
  - **o** Understand fundamentals of system stability and apply the tests to open and closed loop systems to ensure absolute stability **o** Evaluate and design closed loop control systems to meet specifications on relative stability: gain and phase margins and others

- Be able to Effectively Apply modern system tools
  - o Be able to effectively apply software computational tools such as Matlab to analyze and design and simulate controllers for open and closed loop control systems

Topics to be Covered

INTRODUCTION TO AUTOMATIC CONTROL
Definitions
Examples
Closed Loop versus Open Loop

LAPLACE TRANSFORM

Complex Variables and Functions Laplace Transform Definition, Theorems
Inverse Laplace Transform, Partial Fraction Expansions, Use of Matlab Solving Linear Time Invariant Differential Equations/Systems

SYSTEM REPRESENTATION: MATH MODELS

Transfer Functions and Impulse Response
Block Diagrams
State Space Models
Mechanical Systems
Electrical Systems
Linearization of Nonlinear Systems

TRANSIENT RESPONSE
First Order Systems
Second Order Systems
Higher Order Systems
Transient Response Using Matlab
Effects of Integral and Derivative Actions on Performance
Routh's Stability (Criterion
Electronic Controllers
Phase Lead, Phase Lag Controllers
Steady State Errors in Unity Feedback Control Systems

ROOT LOCUS ANALYSIS
Concept of Root Locus
Root Locus Plots
Root Locus Rules
Root Locus Using Matlab
Introduction to Design of Control Systems Using Root Locus

ROOT LOCUS DESIGN METHODS
Lead - Compensators (Controllers)
Lag - Compensators (Controllers)
Lead-Lag - Compensators (Controllers)

FREQUENCY RESPONSE ANALYSIS
Bode Frequency Response Diagrams Bode Response by Matlab Stability Analysis Relative Stability
Closed Loop Frequency Response

COURSE ADMINISTRATION

Instructor: Dr. Muhammad A. Choudhry, email: machoudhry@mail.wvu.edu
Office: 931 ESB Phone:304-293-9685
Office Hours: 4:00-5:00 MWF (or by appointment)

Homeworks: There will be approximately one homework assignment per week. Students are encouraged to discuss homework problems with their colleagues, but the final solutions turned-in should be your own work. No late homeworks will be accepted.

Exam: The exams will be closed book, but you may bring a calculator and a two-sided pages of notes. You will be asked to sign the honor pledge: "I have neither given nor received unauthorized aid on this examination."

GRADING:

Homework	15%
Unannounced Quizzes	10%
Two Exams	50%
Final (comprehensive)	25%

Honor Code:
You may confer with your colleagues on interpretation and approach to homework problems, but the *solutions* must be your own. Turning in a handwritten copy or a photocopy of someone else's solution (another student, author's solution manual, instructor's solution from a previous year) is considered an honor code violation. Using someone else's computer code or plots is considered an honor code violation. **Failure to comply with these guidelines will be interpreted as an honor code violation and dealt with following University procedures.**

Social Justice Statement:
West Virginia University is committed to social justice. I concur with that commitment and expect to foster a nurturing learning environment, based upon open communication, mutual respect, and non-discrimination. Our University does not discriminate on the basis of race, sex, age, disability, veteran status, religion, sexual orientation, color or national origin. Any suggestions as to how to further such a positive and open environment in this class will be appreciated and given serious consideration. If you are a person with a disability and anticipate needing any type of accommodation in order to participate in this class, please advise me and make appropriate arrangements with Disability Services (2936700). If you feel that you are being treated inappropriately or unfairly in any way, please feel free to bring your concerns to my attention. Please be assured that doing so will not prejudice the grading process. In return, I expect you to behave professionally and ethically.