ME 481: Control Systems

This is a cooperative course taught jointly by WSU and the University of Idaho.

Course description:	Analysis and design of feedback control systems.
Number of credits:	3
Course Coordinator:	C. Mo
Prerequisites by course:	ME 348
Prerequisites by topic:	1. Ordinary differential equations and their solutions. 2. Eigenvalues and Eigenvectors. 3. Modeling and analysis of linear systems.
Postrequisites:	None
Textbooks/other required materials:	Gene F. Franklin, J. David Powell and Abbas Emami-Naeini, *Feedback Control of Dynamic Systems*, Pearson, 2015, 7th edition
Course objectives:	1. Concepts, advantages and drawbacks of open-loop, feedback, and feed-forward control. 2. Laplace transformation and Inverse Laplace Transformation, and decomposition of higher order systems into a set of first and second order systems working in parallel. 3. Input-Output, state-space, and transfer function representations. 4. Graphical representation of information flow in time and frequency domains by block diagrams. 5. Relation between actual physical components, their dynamic models, and their graphical representation in block diagrams. 6. Equilibrium, stability, and relative stability in terms of poles/eigenvalues. 7. Impulse, step, and ramp response of first and second order systems. 8. Performance specifications for second order systems. 9. Regulator and PID controllers, their applications and limitations. 10. Root locus analysis. 11. Bode diagram. 12. Controllable, observable, diagonal, and Jordan canonical forms. 13. State transition matrix and convolution integral. 14. Controller design by pole placement.
Topics covered:	1. Control systems, advantages and disadvantages of open loop, feed-forward and feedback controls. 2. Review of Laplace Transformations, Inverse Laplace transformations. 3. Mechanical modeling of dynamics systems in terms of input-output and state-space models.

4. Transfer functions, Block diagram representations in Laplace and time domains.
5. Transient response of first and second order systems.
6. Proportional, integral, and derivative control actions.
7. Stability of feedback systems, Routh stability analysis.
8. Root Locus Analysis.
9. Series and parallel compensation.
10. Bode diagrams.
11. State space representations, and conversions from one representation to another.
12. State transition matrix and its properties.
13. Controller design by pole placement.

Expected learning outcomes:

1. Model simple mechanical, electrical, hydraulic and other systems with ordinary differential equations.
2. Graphically represent these models by block diagrams in time and frequency domain.
3. Represent these models in input-output, transfer function or transfer matrix and various state-space forms.
4. Transform or convert given model representations into a different canonical form.
5. Determine system parameters from given performance specifications for a second order system.
6. Determine impulse, step, and ramp response and infer system performance from these.
7. Perform Routh stability and relative stability analysis.
8. Plot root-locus diagram and infer system behavior from it.
9. Design PID controller.
10. Design lead, lag, or lead-lag compensator using root-locus or Bode plots.
11. Determine state transition matrix.
12. Determine controllability and observability of a given system.
13. Design a controller by pole placement.

Class schedule: Three 50-minute lecture sessions per week, for one semester.

Laboratory schedule: None.

Contribution to meeting the professional component: Engineering Topics

Relationship of course to student outcomes: Meets:

1. School of MME ME educational objectives: 1, 2, 3
2. School of MME ME program outcomes: 1, 2
3. ABET EC2019, Criterion 3 program outcomes: 1, 2, 7

Prepared by: Amy Johnson and C. Mo *Date:* January 29, 2019

POLICIES

A. **Reasonable Accommodation** (the nature of the particular course determines which one applies):

- Pullman Campus. Reasonable accommodations are available for students with a documented disability. If you have a disability and need accommodations to fully participate in this class, please either visit or call the Access Center (Washington Building 217; 509-335-3417) to schedule an appointment with an Access Advisor. All accommodations MUST be approved through the Access Center.
- WSU Online Course. Reasonable accommodations are available in online classes for students with a documented disability. All accommodations must be approved through your WSU Disability Services office. If you have a disability and need accommodations, we recommend you begin the process as soon as possible. For more information contact a Disability Specialist on your home campus: Pullman or WSU Online (http://accesscenter.wsu.edu), Spokane (http://spokane.wsu.edu/students/current/studentaffairs/disability/), Tri-Cities (http://www.tricity.wsu.edu/disability), Vancouver (http://studentaffairs.vancouver.wsu.edu/student-resource-center/disability-services).

B. **Academic Integrity**

WSU expects all students to behave in a manner consistent with its high standards of scholarship and conduct. Students are expected to uphold these standards both on and off campus and acknowledge the university's authority to take disciplinary action. The Standards of Conduct for Students can be found at http://conduct.wsu.edu.

C. **WSU Safety**

WSU is committed to maintaining a safe environment for its faculty, staff, and students. Safety is the responsibility of every member of the campus community and individuals should know the appropriate actions to take when an emergency arises. In support of our commitment to the safety of the campus community the University has developed a Campus Safety Plan, http://safetyplan.wsu.edu. It is highly recommended that you visit this web site as well as the University emergency management web site at http://oem.wsu.edu/ to become familiar with the information provided.