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:
3 strongly supported; 2 supported; 1 minimally supported

Student Outcomes Pre-Fall 2018 (ABET EC2000)

a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
2		2		3				1		2

Student Outcomes Fall 2018 forward (ABET EC2019)

1	**2**	**3**	**4**	**5**	**6**	**7**
3	2					1

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