**King Fahd University of Petroleum & Minerals**
**MECHANICAL ENGINEERING DEPARTMENT**
**ME 413: System Dynamics and Control**

**Catalogue Description**: (2-3-3)
Dynamics of mechanical, fluid, electrical and thermal systems. Equations of motion. Dynamic response of elementary systems. Transfer functions and pole-zero diagrams. Simulation of dynamics of complex systems. Dynamic stability of systems. Open and closed-loop systems. Basic control actions. Laboratory sessions involving use of computers for simulation of dynamic systems and analysis of control systems.

**Status in Curriculum (Required or Elective):** Required (offered Fall & Spring)

**Prerequisites:** ME 201, MATH 301

**Co-requisites:** None

**Prerequisites by Topics:**
- Kinetics of rigid body and Newton's second law (ME201)
- Kirchhoff law of electrical circuits (EE 204)
- Fluid dynamics in tanks and pipes (ME 311)
- Laplace Transform and Differential Equations (MATH 301)

**Textbook:** **System Dynamics**, by K. Ogata, 2004, 4th Ed., Prentice Hall.

**References:**
1. Modeling, Analysis, and Control of Dynamic Systems, 2nd Ed., W. J. Palm III, John Wiley & Sons, 2002.
2. System Dynamics, 1st Ed., W. J. Palm III, Mc Graw Hill, 2005.
3. Modern Control Systems, 9th Ed., R.C. Dorf and R. H. Bishop, Addison-Wesley, 2001.

**Coordinator:** **Dr. Ali Alsaeed,** Assistant Professor of Mechanical Engineering

**Course Objectives:**
1. Basic modeling methodologies for dynamic systems.
2. Methods for analyzing dynamic responses.
3. Classical control techniques using basic control actions.
4. Techniques for analyzing systems' stability.
5. Exposure to experimental laboratory applications of control to various dynamic systems.

**Course Outline (Lecture Topics):**
1. Introduction to systems dynamics (1 hour)
2. Laplace transform (4 hours)
3. Mechanical systems (3 hours)
4. Transfer function approach to modeling dynamic systems (2 hours)
5. Electrical and electromechanical systems (3 hours)
6. Fluid systems (2 hours)
7. Time-domain analysis of dynamic systems (3 hours)
8. Frequency-domain analysis of dynamic systems (3 hours)
9. Time-domain analysis and design of control systems (5 hours)
10. Frequency-domain analysis and design of control systems (4 hours)

**Design Activities/Projects:**
Design assignments include the modeling and design of dynamic and control systems.

**Computer Usage:**
Homework and Lab assignments include the using of MATLAB for the analysis and design of dynamic and control systems.

**Laboratory:**
One three-hour laboratory session per week. Lab sessions and projects include the analysis and experimentation of dynamic and control systems such as mechanical, electrical, electromechanical, and fluid

systems.

**Assessment Tools:**

i- Mid-term Examinations
ii- Homework Assignments
iii- Quizzes
iv- Final Exam
v- Projects and Oral Presentations
vi- Lab Reports

**Course Learning Outcomes:**

After taking this course, students will be able to:

1. Demonstrate knowledge of the fundamental assumptions related to the derivation of simple dynamic models.
2. Demonstrate ability to derive simple dynamic models for basic engineering systems.
3. Demonstrate ability to identify dynamic characteristics: natural frequency, damping, time constant, settling time, etc. of simple dynamic systems.
4. Demonstrate ability to analyze systems' dynamic responses, in both time and frequency domains.
5. Demonstrate knowledge of the basic characteristics, representations, and utilization of the P, PI, PD, and PID controllers.
6. Demonstrate ability to characterize systems' stability based on Routh-Hurwitz criterion, Bode plots, and root locus.
7. Demonstrate ability to perform computer simulations of basic control actions as applied to simple dynamic systems, and to show the effect of varying controller's parameters on stability and performance.
8. Demonstrate ability to perform laboratory experiments to demonstrate the basic control actions as applied to simple mechanical, electromechanical, thermal, and fluid systems.
9. Demonstrate knowledge of how control systems are crucial to the functionality and performance of dynamic systems.

**Course Learning Outcomes mapped to Student Outcomes:**

| Student Outcomes | *a* | *b* | *c* | *d* | *e* | *f* | *g* | *h* | *i* | *j* | *k* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Course-to-Student outcome mapping | 1-5, 7 | 1-6 | 3-4, 7, 9 | 2-5, 7-8 | 2-9 | 7-8 | 3, 7 | 6-9 | 7-9 | 9 | 4, 7-8 |
| Emphasis* | M | L | **S** | **S** | L | L | L | L | L | L | **S** |

* **L**:: Little/None **M**: Moderate **S**: Strong

**Status of Continuous Improvement review of this Course:**

**Date reviewed:** ----------
**Prepared by:** Dr. Ali Alsaeed

**Reviewed by:** Design Dynamics Group
**Date prepared:** December 8, 2014