NATIONAL UNIVERSITY OF ENGINEERING
COLLEGE OF MECHANICAL ENGINEERING

MECHATRONICS ENGINEERING PROGRAM

MT227 MODERN AND OPTIMAL CONTROL

I. GENERAL INFORMATION

CODE	:	MT227 Modern and Optimal Control
SEMESTER	:	7
CREDITS	:	3
HOURS PER WEEK	:	4 (Theory – Practice - Lab)
PREREQUISITES	:	MT235 Classic Control
CONDITION	:	Compulsory

II. COURSE DESCRIPTION

The course trains the student in applying automatic control concepts, methods and techniques so that he or she is capable of synthesizing a plant model or a continuous or discrete process meant to be analogically or digitally controlled, analyzing its stability and compensating the system according to design requirements, using state space theory.

III. COURSE OUTCOMES

1. Learn basic concepts of modern open and closed loop control systems, and the foundation of its analysis and design, understanding it is the necessary basis for the course.
2. Formulate mathematical models for components and physical systems based on the state space concept, understanding it is necessary for the insight into modern control.
3. Analyze and simulate the transient and steady response, as well as to establish conditions for control systems stability, assessing results according to the solved physical problem. Understand modern control system operation principles with its applications in analog compensation.
4. Learn and apply digital control concepts and applications of digital controllers design.

IV. LEARNING UNITS

1. CONCEPTS REVIEW OF CLASSIC AUTOMATIC CONTROL SYSTEMS / 5 HOURS

Introduction to classic automatic control concept, through a global review of all tools provided by control system theory.

2. CLOSED LOOP SYSTEMS STABILITY ANALYSIS / 5 HOURS

Critical gain analysis, from which, the system becomes unsteady/ Gain analysis for an error in steady state given for several entrance signal forms/ Discussion about closed loop system stability using several methods such as Nyquist, Bode, Evans and Nichols.

3. PROCESS OR PLANT COMPENSATION / 5 HOURS

PID compensators/ Phase compensation/ Leading phase compensators design/ Lagging phase compensators design.

4. MODERN AUTOMATIC CONTROL. STATE VARIABLES. MODELS ANALYSIS ACCORDING TO STATE SPACES / 10 HOURS

State space concepts and its usage/ Equilibrium equations deduction for electromechanical models and its relation with models according to state space theory/ State variables choice according to the model/

State equations formulation indicating A and B matrices/ System (or outlet) equations formulation indicating C and D matrices.

5. OBSERVABILITY AND CONTROLLABILITY ANALYSIS. STATE FEEDBACK AND COMPENSATION / 20 HOURS
Observability and controllability analysis/ Use of state graph in an open loop system/ System controllability analysis/ Plant analysis through state variable theory/ Plant transfer function for state variables based models/ Characteristic equation and open loop system roots/ State variables feedback compensation in control systems/ Compensators design using state variable feedback and any theory with this aim. (ITEA and dead beat)/ Closed loop control scheme understanding state feedbacks and the relevant compensator. / Performance simulation of state variables feedback compensation using MATLAB / Compensation cases analysis with useful examples/Computer-aided simulation.

V. LABORATORY EXPERIENCES

Lab 1: System modeling and a plant or process transfer function synthesizing.
Lab 2: Critical gain, from which, the system becomes unsteady. Gain for a steady-state error. Closed loop system stability analysis using NYQUIST, BODE and NICHOLS plots, and root locus or EVANS.
Lab 3: Phase compensators design, Making of close loop control system understanding the located compensator and its performance simulation with any simulation tool. (SYMULINK or MATLAB's TOOLBOX) Expected specifications checking.
Lab 4: Open-loop problem analysis according to state space theory.
Lab 5: Controllability and observability analysis.
Lab 6: State system feedback compensation. Simulation of its performance with any simulation tool. (SYMULINK or MATLAB TOOLBOX) Expected specifications checking.

VI. METHODOLOGY

The course is carried out in computing lab, theory and practice sessions. In theory sessions, the instructor introduces concepts, theorems and applications. In practice sessions, several problems are solved and their solutions are analyzed. In lab sessions, Matlab simulation software is used to solve problems and analyze their solutions. In all sessions student's active participation is encouraged.

VII. EVALUATION FORMULA

The average grade PF is calculated as follows:

PF = (EP+EF+((P1+P2)/2+(L1+L2+L3+L4+L5+L6)/6)/2)/3

EP: Mid-Term Exam	EF: Final Exam
P#: Quizzes	L#: Labs

VIII. BIBLIOGRAPHY

1. **DORF, R. - BISHOP, R.**
   Modern Control Systems, 2005, 10th edition (Spanish)
   Prentice Hall International, Madrid, Spain.

2. **OGATA, K.**
   Modern Engineering of Control, 2005, 4th edition (Spanish)
   Prentice Hall International, Madrid, Spain.