I. **COURSE TITLE**: SYSTEM IDENTIFICATION AND DIAGNOSTICS

II. **ACADEMIC TERM**: Second Semester (spring)of Academic Year

III. **PROFESSOR:** Prof: Dionisio Bernal (Northeastern University): d.bernal@neu.edu

IV. **COURSE DESCRIPTION:** Methods for identifying the fundamental characteristics of structures. Includes topics in linear algebra (singular value and QR decomposition, pseudo inversion, and so on); input-output relationships for linear time-invariant systems; frequency response functions; signal processing fundamentals; realization theory; the eigensystem realization algorithm; use of observers in identification; and introduction to out-only system identification.

V. **TOPICS TO BE COVERED IN THE COURSE:**

1. **Mathematical Background** - Total Least Squares, Regularized Least Squares, Singular Value Decomposition, QR and other factorizations, Pseudo-inversion, Eigenvalues and Eigenvectors, the Jordan Canonical Form, Cayley-Hamilton, Derivative of Traces, Projection matrices, etc.
2. **State-Space Formulation -** State-Space equations, solution of the State-Space equations, connection between discrete and continuous time representations.
3. **Realization Theory -** Observability and Controllability, Grammians, the Eigensystem Realization Algorithm.
4. **An Introduction to the Kalman Filter -** Formulation, the steady state gain, connection to the identification problem..
5. **Deterministic Identification -** Direct deconvolution, observer Markov Parameters (MP), system MP, balanced realizations. Discriminating system modes from noise modes, difficulties from closely spaced eigenvalues, normalization, combining realizations obtained with different sampling.
6. **Stochastic Identification** - Extraction of MP from output covariance, extraction of modal parameters, limitations associated with the lack of deterministic input measurements.
7. **From Identification to Diagnosis -** Detection, localization and quantification, model updating strategies, conditioning difficulties, localization of damage using null space techniques.

VI. **INSTRUCTIONAL STRATEGIES**: Conferences, guest speakers, literature reviews, Group exercises and extra curricular activities deemed congruente and complementary to the objectives of this course. Substantial independent and Group study will be undertaken. **The course is taught at NEU with Web Streaming Capabilities to UPRM.**

VII. **TEXTBOOKS**

1. **Recommended**
   . - Jer-Nan Juang (1994) *System Identification*

2. **Other References:**
   - Golub and van Loan (1989) *Matrix Computations*
   - Friswell and Mottershead (1996) *Finite Element Model Updating in Structural Dynamics*
   - Scherbaum F., (2001) *Of Poles and Zeros.*