A New Course Advertisement for the Spring 2024 Semester

MECH 7901/8901 **ST: Design Optimization** (3 Credit Hours)

(intended course title is: Multidisciplinary Design Optimization, MDO)

Date/Time: TBD (I will try to fit in preferred (earlier-than-evening) time slots, once students enroll in the course)
Target Audiences: **Graduate students in All Fields of Engineering and Science**.
Instructor: Dr. Yong Hoon Lee (yhlee@memphis.edu , https://yonghoonlee.com)

- The course will offer ***balanced blend*** of (1) theories/methodologies and (2) hands-on problem-solving techniques.
- Please rest assured, this course does ***NOT*** primarily emphasize computer programming. Proficiency in programming is **not a strict requirement** for success in this course. However, students will need to self-learn some coding skills if they do not have any experience in programming.
- Students from all areas of Engineering and Science fields (including MECH, EECE, CIVL, BIOM, TECH, PHYS, COMP, etc) can bring their own disciplinary domain knowledge and apply MDO topics to their own problems.

Tentative topics to be covered (some topics can be adjusted later):

1. Design Problem Identification (Fundamentals of Optimization Topics)
    - Problem Formulation: Objectives, Constraints, Design Variables
    - Problem Formulation Framework: Predictive Modeling, Comparison Metric, and Design Representation
    - Problem Characteristics: Model Construction, Model Boundedness, Monotonicity Analysis, Design Coupling Analysis

2. Gradient-based Methods (Fundamentals of Optimization Topics)
    - First-order Optimality Conditions: Gradient, Karush-Kuhn-Tucker (KKT) Condition
    - Second-order Optimality Conditions: Hessian, Positive Definiteness
    - Interior Optima: Gradient Descent, Newton's Method, Broyden-Fletcher-Goldfarb-Shanno (BFGS) Method
    - Boundary Optima: Feasible Direction, Constraints, Penalty Method, Sequential Quadratic Programming (SQP) Method

3. Multidisciplinary Modeling Basics
    - Extended Design Structure Matrix (XDSM)
    - Explicit and Implicit Disciplinary Models
    - Problem Decomposition Strategies
    - Total and Partial Derivatives
    - Algorithmic Differentiations (AD)

4. Multidisciplinary Design Analysis and Optimization (MDAO) Fundamentals
    - Linear and Nonlinear Problems, Block Gauss-Seidel, Block Jacobi, and Newton's Methods
    - MultiDisciplinary Feasible (MDF), Individual-Disciplinary Feasible (IDF), All-At-Once (AAO)
    - Monolithic and Distributed, Single-level and Multi-level MDO Approaches
    - Iterative Sequential, Nested, and Simultaneous Formulations

5. Multidisciplinary Design Optimization (MDO) Advanced Topics
    - Sparsity in Problem Formulation
    - Modular Analysis and Unified Derivatives (MAUD) Architecture
    - Adjoint Method in MDO
    - Control Co-Design (CCD) in MDO Perspective

Evaluation:

- Traditional exams will NOT be given.
- Traditional textbook-style practice assignments will NOT be assigned.
- Student performance will be solely assessed based on the outcomes of their projects.

Software Tools to be Used (for projects):

- MATLAB (Optimization Toolbox, included in the UofM MATLAB license)
- Python (SciPy and OpenMDAO packages, miniforge3 installation recommended)