ME 697 Variational Methods and Structural Optimization 3-0-0-6

Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): Regular Letter Grades
Kind of Proposal (New Course / Revision of Existing Course): New course
Offered as (Compulsory / Elective): Elective
Offered to: UG final year and all PG students
Offered in (Odd/ Even / Any): Any
Offered by (Name of Department/ Center):Mechanical Engineering
Pre-Requisite: Familiarity with multivariable calculus and differential equations.

Preamble / Objectives:
Structural optimization rests on the concepts of calculus of variations, mechanics and mathematical programming. With the advent of computers, structural optimization became a powerful tool in complex industrial design problems. Objective of the course is to introduce variational calculus and its applications to the structural optimization (size, shape and topology optimization). The computer based assignments are given so that students appreciate the concepts they learn in the course. At the end of the course, students will be equipped to formulate and solve any new structural optimization problem that they encounter in engineering practice.

Course Content/ Syllabus

Mathematical preliminaries: Vector spaces, normed linear spaces, inner product spaces, functionals, Gâteaux variation, Fréchet differential; Calculus of variations: Motivating examples, first variation and Euler-Lagrange equations, second variation and sufficiency conditions for extremum, isoperimetric problems, global and local constraints, strong form and weak form of governing equations in mechanics, transversality conditions; One dimensional problems: Size optimization of bars and beams, stress constraints, eigenvalue problems for strings, bars and beams; Mathematical programming: Karush-Kuhn-Tucker (KKT) conditions, brief introduction to numerical optimization algorithms, application of mathematical programming to structural optimization problems; Structural optimization: Truss topology optimization, sensitivity analysis, topology optimization with frames and continuum elements, optimality criteria method for stiff structure, design of compliant mechanisms.

References:
1. I. M. Gelfand and S. V. Fomin, *Calculus of Variations*, Dover Publications, 2003.
2. R. Weinstock, *Calculus of Variations with Applications to Physics and Engineering*, Dover Publications, 1975.
3. A. S. Gupta, *Calculus of Variations with Applications*, Prentice-Hall of India Pvt. Ltd., New Delhi, 2008.
4. D. R. Smith, *Variational Methods in Optimization*, Dover Publications, 1998.
5. P. W. Christensen and A. Klarbring, *An Introduction to Structural Optimization*, Springer, 2009.
6. R. T. Haftka, and Z. Gurdal, *Elements of Structural Optimization*, Kluwer Academic Publishers, 1992.
7. M. P. Bendsøe, and O. Sigmund, *Topology Optimization: Theory, Methods, and Applications*, Springer, 2003.
8. P. Y. Papalambros and D. J. Wilde, *Principles of Optimal Design*, Cambridge University Press, 2000.
9. D. G. Luenberger, *Optimization by Vector Space Methods, John-Wiley* & Sons, 1969.