CE 620: Introduction to the Finite Element Method

Instructor: Mandar M. Inamdar
Office: 136 Civil
Course-Website: http://www.civil.iitb.ac.in/~minamdar/ce620/

Tentative Syllabus:

Sr.	Topic	Number of lectures
1	Motivation for the course	1
2	Non-dimensionalisation of differential equations	2
3	Introduction to Rayleigh-Ritz, Weighted-Residual, Galerkin Methods	3
4	Finite Element Method in 1D: weak form, boundary conditions, finite elements, assembly	3
5	Introduction to Python + FENiCS + pre-post processing	3
6	Solving simple PDEs (Poisson equation, Heat equation) in FENiCS in 1D and 2D, types of elements, convergence	6
7	Finite Element Method for Linear Elasticity: Statics + Dynamics	6
8	Other topics: porous flows, stokes flows	3
9	Non-linear problems in finite element method using FENiCS	6
10	Special topics: iso-parametric formulation, ALE methods	3
	Total Lectures	36

Tentative grading scheme (total 100 marks):

The course will involve programming using elementary python and FENiCS environment
1. Five short quizzes: 5 marks each (total 25 marks)
2. Mid-sem exam: 20 marks
3. Final Exam: 30 marks
4. Assignments + Project: 25 marks

Recommended texts:

There is no required text-book for this course. There are many, many texts and online lectures/ notes available. I will also add additional resources on the course website. Following texts are what I will refer to.

Main References:

1. Langtangen, Hans Petter, Anders Logg, and Aslak Tveito. *Solving PDEs in Python: The FEniCS Tutorial I*. Springer International Publishing, 2016. free pdf
2. Logg, Anders, Kent-Andre Mardal, and Garth Wells, eds. Automated solution of differential equations by the finite element method: The FEniCS book. Vol. 84. Springer Science & Business Media, 2012. free pdf

3. Langtangen, Hans Petter, and Kent-Andre Mardal. "Variational Methods for Linear Systems." *Introduction to Numerical Methods for Variational Problems*. Springer, Cham, 2019. 365-376.
4. Bathe, Klaus-Jürgen. Finite element procedures. Klaus-Jurgen Bathe, 2006.
5. Jacob, Fish, and Belytschko Ted. *A first course in finite elements*. Wiley, 2007.
6. Barber, James R. *Intermediate mechanics of materials*. Vol. 175. Springer Science & Business Media, 2010.
7. Scott, L. Introduction to Automated Modeling with Fenics. Computational Modeling Initiative LLC, 2018. Older version of pdf

Additional References:

5. Hughes, Thomas JR. The finite element method: linear static and dynamic finite element analysis. Courier Corporation, 2012.
6. Seshu, P. Textbook of finite element analysis. PHI Learning Pvt. Ltd., 2003.
7. Brenner, Susanne, and Ridgway Scott. *The mathematical theory of finite element methods*. Vol. 15. Springer Science & Business Media, 2007.
8. Desai, Yogesh M., TI Eldho, and Arvind H. Shah. Finite element method with applications in engineering. Pearson Education India, 2011.