

Overview of Practical Computational Methods for Continuum Mechanics/Biomechanics

Problems in mechanics, generally speaking, take the form of differential equations over 'fields' including stress, strain, velocity, concentration, etc. Sometimes these equations can be solved by hand, with pen and paper, but more often than not some use must be made of numerical or computational methods. Computational results, at the very least, can help develop an intuition into complicated distributions of stress, strain, and other fields.

The present overview is composed of: (1) selected notes and readings dealing with the methodological basis for numerical solution of various equations in mechanics, and (2) a modular, *freeware* experience in computational approaches to solid, fluid, and interfacial film mechanics problems. The readings and notes start by first presenting discretization ideas of grids and meshes followed by elaboration of minimization approaches, eg. energy minimization, and finite elements. The computational exercises are, however, mechanics-oriented, not numerical methods oriented, and have a primary intention of establishing several basic points for practical use of any given computational mechanics package. These key points, *which apply regardless of whether the user of a package is the package developer or not*, are:

- (1) always compare one computer solution to a known, analytic solution of the analogous problem,
- (2) check if possible that a solution obtained through a numerical iteration scheme has converged, and
- (3) refine a mesh or step-size until the solution between two different meshes shows convergence.

Disclaimer - The following set of notes have been compiled from various notes, texts, and internet sources.

Any failure in due acknowledgement is an oversight.

Table of contents & Assignments

Internet Resources for Computational Mechanics

1 - Methods

I. Discretization of Ordinary Differential Eqns. **NumPS#1 due 9/14**

II. Partial Differential Equations & Finite Differences

III. Minimization Principles and rudiments of the Calculus of Variation

A. Work-energy and serial springs

B. Interfacial energy minimization: the soap film

C. Additional readings on FEM

2 - Modules

I. Two-dimensional linear elasticity

A. Tension test of a slab **NumPS#2 due 9/28**

B. Deformation in model peeling of a cell **NumPS#5 due 11/21**

II. Two-dimensional fluid flow

A. Parallel plate channel flow **NumPS#3 due 10/19**

B. Forces on a cell in channel flow **NumPS#6 due 11/28**

III. Interfacial Films in three dimensions

A. Free film between two rings **NumPS#4 due 11/28**

B. Spreading Cells or Drops **NumPS#7 due 12/5**

Internet Resources for Computational Mechanics

http://www.engr.usask.ca/~macphed/finite/fe_resources/fe_resources.html

This website describes and provides access to computational, especially finite element (FE), software via the Internet. We list all public domain and shareware programs which have come to our notice, and a selection of pointers to commercial packages. We also include references to useful URL's, ftp sites, newsgroups, listservers, bulletin boards etc, and to some books which contain source code. - *compiled by: Roger Young and Ian MacPhedran*

Internet Finite Element Resources

Conferences and Courses

Conferences

Courses

Newsgroups

Particular Newsgroup Items

Listservers and Bulletin Board Systems

FE Homepages and FTP Sites

FE Links

CFD Links

Mesh Generation Links

Public Domain FE Programs

FREEWARE with source code

Programs for the PC

SHAREWARE or no source code

Mesh Generators

FE Visualisation

Public Domain Mathematical Software and Miscellaneous Items

Books

FE Code from Books

Online Books/Reviews/Journals

Commercial FE Programs

Companies with an Internet Presence

Other commercial packages

Miscellaneous

Comparisons

Other

Alternative Methods

Boundary Element Method

Computation Fluid Dynamics (CFD)

Discrete Element Method

Finite Difference Method

Finite Volume Method

Volume Element Method

Miscellaneous