Course 116027
Continuum Physics (Fluid and Solid Mechanics)

General information:

Semester: Spring 2024 (תשפ"ד)

Course language: Hebrew

Grade composition: 80% Final exam, 20% Homework (mandatory)

Homework: Given every other week, 5-6 problem set (the last set may be split into two short ones). Required to submit at least 75% of the problem sets to attend the final exam.

Syllabus:

Part I – fluid mechanics

Fundamentals: The continuum description of matter and the fluid state, Eulerian and Lagrangian descriptions, forces on a fluid element – the stress tensor: pressure and hydrostatics, the strain tensor and viscosity.

Equations of motion: The Navier-Stokes equations, Continuity equation, Incompressible flow, Unidirectional flows.

Conservation laws: Momentum and mass conservation, Fluxes and out-of-equilibrium fluxes, Heat diffusion, Conservation of total energy, Entropy equation, Eulerian vs Lagrangian conservation laws.

Flow regimes, Ideal flow and Vorticity: Reynolds number and similarity, Ideal flow – Bernoulli, potential flow, Vorticity: Kelvins circulation theorem, equation of motion.

Effects of viscosity on the flow: Generation of vorticity and laminar boundary layer, low Reynolds number flow.

Part II – solid mechanics

Fundamentals: Definition of strain and stress tensors, Free energy and generalized Hook's law, homogeneous deformation (examples)

The equations of equilibrium for isotropic bodies : Reduction to 2D, Compatibility relations, Airy stress function, in-plane and out-of-plane deformation.

Elastic waves: Dilatational and shear waves in an infinite medium, Snell Law, Rayleigh waves, Waves in rods and plates

Viscosity of solids: Maxwell model, Kelvin-Voiget model, viscoelastic waves, Kramers-Kronig Relation

Microscopic origin of elasticity and viscoelasticity: Crystal elasticity, entropic (rubber) elasticity

Book list:

Part I – fluid mechanics

- An introduction to fluid dynamics / *G.K. Batchelor*.
- Physical hydrodynamics /*Etienne Guyon et.al.*
- Fluid mechanics : a short course for physicists / *Gregory Falkovich*
- Elementary fluid dynamics /*D.J Acheson*

Part II – solid mechanics

- Theory of Elasticit*/ L.D.Landau and E.M.Lifshitz*
- Theory of Elasticity*/ S.P.Timoshenko and J.N.Goodier*
- Introduction to the Mechanics of a Continuous Medium*/ Lawrence E. Malvern*
- The Feynman Lectures on Physics, Vol. II, Ch. 31, 38, 39 *(always a nice read)*