CONTINUUM MECHANICS AND TRANSPORT PHENOMENA

PROF. T. RENGANATHAN
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IIT Madras

TYPE OF COURSE : New I Core I UG
COURSE DURATION : 12 weeks (29 Jul'19 - 18 Oct'19)
EXAM DATE : 17 Nov 2019

PRE-REQUISITES : Engineering Physics, Engineering Mathematics, Chemical Process Principles, Engineering Thermodynamics

INTENDED AUDIENCE : Undergraduate students in Chemical Engineerig, Mechanical Engineering, Biotechnology

INDUSTRIES APPLICABLE TO : Any process industry

COURSE OUTLINE :
This course relates the laws of Physics to the conservation equations of transport phenomena. Continuum mechanics brings out the analogy between solid and fluid mechanics. Transport phenomena brings out the analogy between the transport of momentum, energy and mass.

ABOUT INSTRUCTOR :
Prof. T. Renganathan is a faculty in the Department of Chemical Engineering at IIT Madras. Prior to joining IIT Madras, he worked as a faculty at Anna University, Chennai. He has taught many of the core courses in Chemical Engineering and established two undergraduate laboratories. His areas of research includes multiphase flows, microfluidics, gasification and capture of $C0_2$. He has carried out many sponsored and consultancy projects mainly in the area of energy and environment.

COURSE PLAN :

Week 1: Fluid kinematics : Eulerian vs. Lagrangian; Material Derivative; Flow visualization; System vs. Control volume; Reynolds Transport Theorem

Week 2: Total mass balance : integral balance and applications; differential balance and applications

Week 3: Linear Momentum balance : Integral balance; Calculation of force

Week 4: Stress : Traction Vector, Stress at a point, Stress element, stress tensor; Cauchy's formula; Equality of cross shears; Fluids at rest; Stress in fluids

Week 5: Strain : Types and measures of deformation; Displacement Field, Displacement Gradient – 1D, 3D; relationship between strain and Displacement Field; displacement Gradient Tensor, Strain tensor, Rotation tensor; Fluids vs. Solids; Strain rate tensor

Week 6: Hooke's Law; Lame's equation; Relationship between material properties; Newton's law of viscosity; Navier-Stokes equation

Week 7: Pascals's law and applications; Bernoulli equation and applications; Applications of Navier-Stokes equation - Couette flow and Poiseuille flow

Week 8: Momentum transport : Shear stress as momentum flux; Navier Stokes equation; Integral energy balance and applications

Week 9: Differential balance for total energy, Potential energy, Kinetic energy, Internal energy, Enthalpy, Temperature; Fourier's law; Applications of differential energy balance - Composite walls, Couette Flow

Week 10: Integral component mass balance and applications (batch reactor and CSTR); Fick's law; total flux, diffusion flux, convection flux, different average velocities; differential component mass balance

Week 11: Applications of differential component mass balance : Diffusion through stagnant film; diffusion with homogeneous reaction

Week 12: Shell balance in Cylindrical and Spherical Coordinates : Liquid flow through pipe; Current Flow through wire; Sublimation of solid; Concluding remarks