GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160312
Semester –VI
Computational fluid dynamics in Biomedical Systems

Type of course: Professional Elective course - I

Prerequisite: Signal and Image processing, Human Anatomy & Physiology, Fundamental of mechanics.

Rationale: The purpose of learning this course on computational fluid dynamics in biomedical systems for biomedical engineering students is to acquire knowledge about computational fluid dynamics which is useful in analysis & design of various fluid flow medical devices

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Fundamentals of Computational Fluid Dynamics:** Definition & properties of fluids and classification of fluids, Introduction to fluid statics & kinematics, Governing Equations of fluid motion: Lagrangian and Eulerian description, Reynolds transport theorem, Integral & differential forms of governing equations: mass, momentum & energy conservation equations, Euler's equation, Bernoulli's equation, Navier-Stokes equations	**10**	**22%**
2	**Biofluid Mechanics**: Viscoelastic fluids, viscoelastic models, Bio viscoelastic fluids: Protoplasm, Mucus, Saliva, Synovial fluids, Blood rheology, Blood vessel mechanics, Fahraeus - Lindquist effect.	**08**	**18%**
3	**Discretization Fundamentals & CFD Introduction:** Discretization principles: pre-processing, solution, post processing, Structured mesh systems and its properties, Unstructured mesh Systems and its properties, Computational Fluid Dynamics: what, when & why, CFD applications	**10**	**22%**
4	**Introduction to FEM, FDM and FVM:** Finite Element Method (FEM) – principle and application, Finite Difference method (FDM) – principle and application, Finite Volume method (FVM) – principle and application	**08**	**18%**
5	**Computational Approaches in Fluid Dynamics:** Biomedical CFD applications: CFD analysis of the human circulation, CFD analysis of blood pump, CFD analysis in the human respiratory system, Bio-Microfluidic device application and simulations.	**09**	**20%**
	Total	**45**	**100%**

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160312

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
25%	**20%**	**15%**	**15%**	**15%**	**10%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Philip J Pritchard and John W Mitchell, "Fox and McDonald's Introduction to fluid Mechanics", John Wiley, 9thedition, 2012.
2. Goldstein J. Richard, "Fluid Mechanics Measurements", Taylor & Francis Publication, 2nd edition, 1996.
3. T.J. Chung, "Computational Fluid Dynamics", Cambridge University Press, 2nd edition,2010.
4. J.Blazek, "Computational Fluid Dynamics: Principles & Applications", Elsevier, 1st edition, 2001.
5. JiyuanTu, KiaoInthavong & Goodarz Ahmadi, "Computational Fluid and Particle Dynamics in the Human Respiratory System", Springer, 1st edition, 2013.
6. JiyuanTu, KiaoInthavong and Kelvin KianLoong Wong, "Computational Hemodynamics- Theory, Modelling and Applications", 1st edition, Springer, 2015.
7. David A Rubenstein, Wei Yin and Mary D Frame, "Biofluid Mechanics: An Introduction to Fluid Mechanics, Macrocirculation and Microcirculation", Academic Press, 2nd edition, 2015.
8. Y.C Fung, "Biomechanics: Mechanical properties of living tissues", Springer, 2nd edition, 1993.

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Explain the fundamentals of fluid dynamics	22%
CO-2	Describe the mechanics of Bio-fluid	18%
CO-3	Analyze the discretization principles and explain the importance of CFD in general	22%
CO-4	Differentiate the FEM, FDM & FVM	18%
CO-5	Illustrate the application of CFD in biomedical domain	20%

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160312

List of Experiments:

1. Introduction to computational fluid dynamics and applications in biomedical systems.
2. Study of CFD-based analysis for understanding of airflow characteristic incorporated with fluids dynamics in nasal cavity to obtain functional and anatomical data.
3. To study basic steps involved to construct CFD model.
4. To study risk assessments of corona virus pandemic outbreak for Cough droplet dispersion inside user defined area.
5. To study uniform and Non-uniform structured mesh in 2D and 3D for a simple rectangular geometry.
6. Modelling of Inhalation and Heat Transfer in the Nasal Cavity.
7. Computational hemodynamics simulation of blood flow through atherosclerotic arteries and structural analysis of calcified plaques.
8. To study Finite element method.
9. To study Finite difference methods.
10. To study Finite volume methods.
11. To study and design CFD for velocity and flow profile in simplified microfluidic channels.

List of Open Source Software/learning website: List of Computational Software

1. OpenFOAM — Open source CFD software package built using C++ and compiled under UNIX. The code is open and therefore allows full customization and extensions to its standard capability (www.openfoam.com)
2. ANSYS post — Includes ICEM meshing, CFX and Fluent CFD solvers, and CFD Post for processing. Also includes multi-physics for structural and FSI (www.ansys.com)
3. CD-Adapco flow of fluids — Includes STAR-CD and STAR-CCM for simulations involving and solids, heat transfer and stress analysis (www.cd-adapco.co)
4. CFDesign — Part of the Autodesk Simulation portfolio, it provides fluid flow simulation and thermal simulation (www.cfdesign.com)
5. Flow 3D — Modelling for liquids and gases in a wide range of industrial applications and physical processes (www.flow3d.com)
6. Numeca — Provides for fluid dynamics simulations for industrial applications (www.numeca.be)
7. Phoenics — Handles CFD simulations for fluid flow, heat or mass transfer, chemical reaction and combustion in engineering equipment and the environment (www.cham.co.uk)
8. COMSOL — COMSOL Multiphysics is a cross-platform finite element analysis, solver and multiphysics simulation software. It allows conventional physics based user interfaces and coupled systems of partial differential equations.