GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Master of Engineering
Level: PG
Branch: Bio Medical Engineering
Subject Code: ME02031031
Subject Name: Cardiovascular System & Dynamics

w. e. f. Academic Year:	2024-25
Semester:	2
Category of the Course:	Professional Elective Course

Prerequisite:	Human Anatomy & Physiology, Biomechanics, Cardiovascular mechanics
Rationale:	To attain comprehensive knowledge and understanding of the vascular system, the heart and the blood system in terms of function and basic structure. This will enable the students to understand the types of blood flow that occurs into the blood vessel and how blood interacts with the walls of the blood vessel. The reason for emphasizing on the fundamental aspects is that it will provide a detailed understanding of the properties associated with the system, at a level which students and teachers at this age range can feel comfortable with.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Understand the physiology and anatomy of the heart and circulatory system	R,U
02	Influence of pressure in maintaining the blood pressure and heart rate	R,U,N
03	To analyze the Fluid characteristics and viscosity	R,U,N,E,A
04	Integrate fluid dynamics engineering concepts to examine and to model the biological flow in human body	R,U,A,N,E
05	Development of mathematical models of the cardiovascular system	R,U,A,N,E,C

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA / CA (M)	PA/CA (I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	Cardiovascular system of human body, Electrical system of the heart, Mechanical events in cardiac cycle, correlation between mechanical and electrical events in the heart, coronary circulation, Microcirculation	6	15
2.	Kinetic energy, pressure-volume relations in ventricles, cardiac valve dysfunction, blood pressure regulation and controlling factors, heart failure, Blood hematology and blood Rheology, Blood characteristics, Abnormalities of blood, Blood types, Plasma viscosity, blood pH	9	20
3.	Introduction to fluid mechanics, fluid properties, basic laws of conservation of mass, energy and momentum, Stress, Strain, Elasticity, Hook's law, Newton's laws of viscosity, Power law constitutive model for blood, Fluid characteristics and viscosity, calculation of yield stress for blood	9	20

4.	Types of fluid flow, Laminar blood flow, Turbulent blood flow, Importance of turbulence, Newtonian fluids, Non Newtonian fluids, Laminar Flow of Non Newtonian Fluids, Flow of Newtonian and non-Newtonian fluid in rigid, flexible and collapsible tubes, blood flow through arteries and veins, methods for measuring viscosity, forces that drive or resist blood flow, Vascular resistance to blood flow, Reynolds number, Poiseuille's law, Application of Poiseuille's law, Bernoulli equation, Pulsatile Flow.	12	25
5.	Anatomy and physiology of blood vessels, Wave phenomena in blood vessels, Types of vessels, Mechanics of arterial walls, Compliance, Windkessel model, vascular pathologies, coronary artery bypass grafting (CABG), Intra-Aortic Balloon Pump (IABP).	9	20
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
20	**25**	**20**	**15**	**15**	**5**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. Biomechanics: Circulation By Y.C.Fung. Pub. Springer Verlay. New York.
2. Biofluid Dynamics, P. Nithiarasu, School of Engineering, Swansea University, SWansea SA2 8PP
3. Biofluid Mechanics: By Jagan. N. Mazumdar Pub. World scientific

4. Biofluid Mechanics: The Human Circulation 2nd Edition, Krishna B. Chandran, Stanley E. Rittgers, Ajit P. Yoganathan, CRC Press
5. Biofluid mechanics in cardiovascular system: By Lee Waite Pub. Mc Grawhill
6. Snapshots of Hemodynamzics: By Nico Westerof Pub. Springer
7. Cardiovascular Fluid Mechanics - lecture notes - F.N. van de Vosse and M.E.H. van Dongen, Eindhoven University of Technology
8. The Cardiovascular System: Mathematical Modeling, Numerical Algorithms, Clinical Applications Quarteroni, A.; Manzoni, A.; Vergara, C., Politecnico di Milano, Milano (Italy)

(b) Open source software and website:

1. SimVascular : https://simvascular.github.io/
2. Lifex-cfd : https://lifex.gitlab.io/cfd.html
3. https://www.ansys.com/academic - ANSYS free student software
4. http://virtualrat.org/research-projects/cardiovascular-systems-dynamics-etiology-hypertension
5. https://www.bartleby.com/essay/The-Circulatory-System-and-Fluid-Dynamics-FKUMJ6SVC
6. https://web.stanford.edu/group/biodesign/cgi-bin/bmesource/sample-page/engineering/biomechanics/
7. http://www.mathworks.com.au/academia/student_center/tutorials/index.html

Suggested Course Practical List: If any

1. To study a Web based interactive cardiovascular model
2. To use the Web based cardiovascular model to study the various cardiac malfunctions
3. To perform Blood flow simulation in ANSYS Fluent
4. To study the evaluation of compliance of artificial blood vessel graft
5. Multiscale modeling of cardiovascular function
6. Dynamics of a cardiovascular model obtaining measurable pulsatile pressure output

List of Laboratory/Learning Resources Required: Computer system with advanced simulation software for computational fluid dynamics (blood flow)

Suggested Project List: Create a flow simulation model with different arteries.

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