Jordan University of Science and Technology
Faculty of Engineering
Biomedical Engineering Department

BME 552 Physiological Fluid Mechanics

Course Description

3 Credit hours (3 h lectures). Basic concepts and problems of fluid and solid mechanics are introduced and applied to the analysis of blood flow in the macro and microcirculation, and to other physiological flows. Analysis of mathematical models is combined with discussions of physiological mechanisms.

Text Book(s)

Title	Applied Biofluid Mechanics
Author(s)	Waite L & Fine J
Publisher	McGraw-Hill
Year	2007
Edition	New Ed

References

Books	Mazumdar, J (1992) “Biofluid Mechanics.” World Scientific Fung, Y.C. (1996) “Biomechanics of Circulation”, 2nd Ed., Springer-Verlag Crowe, R. (2004). “Engineering Fluid Mechanics.” 8th Ed. John Wiley and Sons. Lighthill, J. “Physiological Fluid Mechanics.” Springer-Verlag. Hellums, J. and Brown, C. “Cardiovascular Fluid Dynamics.” University Press Fung, Y.C. (1996). “Biomechanics: Properties of Living Tissues.” Springer-Verlag Fung, Y.C. (1993). “First Course in Continuum Mechanics of Physical and Biological Engineers and Scientists.” 3rd Ed. Prentice-Hall. Caro, C.G., Pedley, R.C., Schroter, R.C., and Seed, W.A. (1978) “The Mechanics of Circulation.” Oxford University Press. Peterson D.R., Bronzino J.D (EDs) (2008) “Biomechanics; Principles & Applications” CRC Press Ethier C.R. & Simmons C.A.(2007)“Introductory Biomechanics, From Cells to Organisms” Cambridge University Press Waite L (2006)”Biofluid Mechanics in Cardiovascular Systems” McGraw-Hill Oomens C, Brekelmans M, Baajians F (2009) “Biomechanics, Concepts and Computation” Cambridge University Press
Journals	- Biofluid Dynamics and Biofluidics - American Journal of Physiology: Renal, Fluid, and Electrolyte Physiology - Journal of Biomechanical Engineering - Journal of Fluid Mechanics

	- International Journal of Multidisciplinary Fluid Sciences
Internet links	- http://www.bmecentral.com/publications/ - http://www.sciencedirect.com - http://www.elsevier.com - http://www.springer.com

Prerequisites	
Prerequisites by topic	Biomedical Instrumentation I, Fluid Mechanics
Prerequisites by course	BME 411, ME 343
Co-requisites by course	N/A
Prerequisite for	N/A

Objectives and Outcomes[1]

Objectives	**Outcomes**
1. Appreciate the role of physiological fluid mechanics in Biomedical Engineering	1.1. Appreciate the role of physiological fluid mechanics in Biomedical Engineering and build an appreciation for the applications of engineering in biology and medicine
2. Introduce fluid concepts essential to the understanding of biofluid mechanics and physiological fluid mechanics	2.1. Revisit Basic Concepts in Fluid Mechanics 2.2. Study the kinematics of Fluid Flow 2.3. Apply hydrostatics equations to clinical applications 2.4. Apply conservation relations to fluid flow 2.5. Differentiate between viscid and in-viscid flow
3. Apply basic concepts in fluid mechanics to clinical fluid dynamic measurements	3.1. Learn the applications of hydrostatics and hydrodynamics to clinical fluid measurements 3.2. Evaluate different methods of Cardiac output measurement (Fick, Dilution, …) 3.3. Derive equations for flow rate measurement using Doppler ultrasound and electromagnetic flow transducers
4. Analyze problems involving circulatory biofluid mechanics and blood rheology	4.1. Analysis of Total Peripheral Flow 4.2. The study of Circulatory Biofluid Mechanics as it pertains to Blood Rheology - Blood Composition and Structure 4.3. Analyze the flow properties of blood, and blood vessel structure
5. Study the flow properties of blood and their relation to blood vessel structure	5.1. E Explain the different models of Biofluid and blood flow 5.2. Apply Poiseuilli's Law to the study of Blood Flow 5.3. Introduce the different classes of Non-Newtonian fluids
6. Apply different mathematical models to describe the behavior of non-Newtonian viscous fluids such as blood	6.1. Derive the Power Law model of Non-Newtonian fluid flow 6.2. Derive the Herschel-Bulkley model of Non-Newtonian fluid flow 6.3. Derive the Casson Modelof Non-Newtonian fluid flow 6.4. Analyze the flow of a Non-Newtonian fluid in an elastic tube 6.5. Apply the Casson model using linear elastic theory to blood flow
7. Correlate the different mechanical, electrical, and	7.1. Explain the underlying physiology of heart mechanics 7.2. Differentiate between the different events taking place during the

[1] Lower-case letters in brackets refer to the Program outcomes

functional aspects of the circulatory system	heart cycle (mechanical, electrical, physiological) 7.3. Analyze the mechanical cycle events in relation to ventricular function 7.4. Study the operation of heart valves and its relation to blood flow in arteries
8. Apply specialized mathematical and optimization models to explain biological behavior in the cardiovascular system	8.1. Study the Shear Stress on vessel walls and its contribution to the development of uniform shear hypothesis 8.2. Derive models and equations to explain bifurcation patterns
9. Encourage life long learning, foster teamwork and enhance students' communication skills	9.1. Write technical report and give oral presentation on team work projects

Topics Covered		
Week	**Topics**	**References**
1	- Discuss Syllabus and Course Structure - Introduction to Physiological Fluid Mechanics - Basic Concepts in Fluid Mechanics	 Chapter 1.1 Chapter 1.2
2	- Viscosity and Reynold's Number - Poiseuille's law and Bernoulli's equation - Conservation Relations	1.3 1.4, 1.5 1.6
3	- Hydrostatics - Womersly Numbers - Review Problems	1.7 1.8
4	- The Cardiac Cycle - Coronary Circulation - Microcirculation and lymphatic circulation	2.8 2.10 2.11-2.12
First Exam (See Dept. Schedule)		
6	- Mechanics of Breathing - Pulmonary system fluid mechanics	3.4 3.5-3.7
7	- Pulmonary pathophysiology and extreme environmental respiration - Blood Rheology and components	3.8-3.9 4.1- 4.2
8	- Blood characteristics - Structure of blood vessels	4.3 5.1-5 .2
9	- Blood vessel mechanics - Pulse wave velocity	5.3-5.4 5.6
10	- Mechanics of heart valves - Fluid kinematics	6.4 7.2-7.5
11	- Models of blood flow in vessels	7.6-7.8
Second Exam (See Dept. Schedule)		
12	- Answer & Solve Problems - Modeling principles	Hand Out Chapter 9
13	- Modeling Examples	Chapter 9, 10
14	- Clinical Fluid Dynamic Measurements	Chapter 8
Final Exam		

Evaluation		
Assessment Tool	**Expected Due Date**	**Weight**
Quizzes & HW's	End of the Semester	10%
First Exam	See Dept. Schedule	25 %
Second Exam	See Dept. Schedule	25 %
Final Exam	According to the University final examination schedule	40 %

Teaching & Learning Methods
- Different active learning methods/approaches such as: Engaged Learning, Problem-based Learning, Structured Problem-solving, will be used. - The teaching method that will be used in this course will be discussing and extrapolating mechanical relationships and applying them directly to different physiological systems. PowerPoint presentations will be prepared for the course materials. - A typical lecture would start with a short review (~ 5 minutes) using both PowerPoint presentations and the blackboard. the students would have a lecture on new materials using PowerPoint presentations and blackboard. The lecture presentation will involve extrapolating mathematical relationships for biofluid flow in the body and understanding the parameters involves in the mathematical equations and their relationships to physiological parameters and pathology . Then, some example problems will be presented and discussed with the students to illustrate the appropriate problem solving skills that the students should learn. After the end of each section a homework will be assigned and the students will be quizzed on the material.

Policy	
Attendance	Attendance will be checked at the beginning of each class. University regulations will be strictly followed for students exceeding the maximum number of absences.
Homework	Working homework problems is an essential part of this course and they represent a key opportunity to learn the subjects discussed. For each homework a quiz will be given that covers the questions of the homework. Late homework will not be accepted. 25% of the HW grade will be deducted for each late day.
Student Conduct	It is the responsibility of each student to adhere to the principles of academic integrity. Academic integrity means that a student is honest with him/herself, fellow students, instructors, and the University in matters concerning his or her educational endeavors. Cheating will not be tolerated in this course. University regulations will be pursued and enforced on any cheating student.

Contribution of Course to Meeting the Professional Component
The course contributes to building the fundamental basic concepts and applications of physiological fluid mechanics in Biomedical Engineering.

ABET Category Content	
Engineering Science	3.0 Credits
Engineering Design	

Applied Biofluid Mechanic has been added to your Cart. Add to Cart. Turn on 1-Click ordering.Â He is also the author of Biofluid Mechanics in Cardiovascular Systems, published by McGraw-Hill. Jerry Fine, Ph.D., is Associate Professor of Mechanical Engineering. Before he joined the faculty at Rose, Dr. Fine served as a patrol plane pilot in the U.S. Navy and taught at the U.S. Naval Academy.Â I always had an unfulfilled interest in fluid mechanics and being a physician this filled the bill. Read more. Helpful.