BIOE 322/533: FUNDAMENTALS OF SYSTEMS PHYSIOLOGY

INSTRUCTOR:
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LECTURE TIME: MWF 11:00-12:00 (*recitation will also be held some days during class time)
OFFICE HOURS: *TBD*

COURSE DESCRIPTION: This course will cover aspects of medical physiology from an engineering viewpoint. Physiological systems will be analyzed at the molecular, cellular, tissue, and organism levels.

TEXTBOOK: Quantitative Human Physiology, Feher. This book is available at the Rice bookstore. You may find it beneficial to purchase a medical dictionary.

SUPPLEMENTARY MATERIAL: I may post additional text that will supplement the Feher textbook. Reading and review of this text is not required but will aid in understanding of physiological concepts. This material will include educational websites, readings from other textbooks.

The following books are not required for the course (you will do fine without them) but are very good references:
Physiology. Linda S. Costanzo. (Any edition)
Rapid Interpretation of EKG's. Dale Dubin. 6th edition

CANVAS WEBSITE: There is a website associated with the course through Canvas. All handouts (homework, lecture etc) will be posted on the website by the early AM. It is the student's responsibility to review for class. Please check this site regularly for announcements. I will use the class and the site as my major methods of communication. Grades will also be posted to site for individual students.

PREREQUISITES: This course is designed for sophomore bioengineering students. **Enrollment in the course without the accompanying lab is strongly discouraged as all students taking BIOE 322 are**

responsible for the lab material. A strong background in general first year STEM courses including chemistry and calculus-based physics is assumed. BIOE 252 is required. Math through differential equations (Math 211) is required and concurrent or prior enrollment in multi-variable calculus (Math 212) is very strongly recommended. Concurrent enrollment in ELEC 243 is also very strongly recommended. Students should feel comfortable solving problems using differential equations and calculus-based physics without outside references in order to be able to successfully complete the course examinations. ***Graduate students taking the class should meet with me prior to enrollment to discuss familiarity with math and electrical engineering prerequisites.***

COURSE OBJECTIVES: The primary course objective is to apply physical principles to solve problems involving the nervous, cardiovascular, respiratory and urinary systems. Furthermore, the course will apply the concepts of negative feedback control and their application to the maintenance of homeostasis. Students will also be expected to apply the concepts of positive feedback control and their application to rapid responses and certain pathologic responses. The course is designed to meet ABET engineering accreditation requirements.

COURSE OUTCOMES:
Students completing the course should be able to:

1. Describe the components and function of the nervous, cardiovascular, respiratory and urinary systems.
2. Compute diffusive fluxes of small molecules down a chemical or electrical gradient and quantitatively describe the resting potential and action potential in excitable cell types.
3. Interpret electrocardiograms and pathophysiology associated with conductive tissue.
4. Interpret effect of preload, afterload and contractility on pressure-volume loop graphs of the cardiac cycle, specifically end systolic and end diastolic volumes.
5. Determine effect of blood volume, contractility, changes in arteriolar pressure on cardiac and vascular function curves.
6. Compute relationships of pressure, flow and resistance and apply these to physiologic conditions in both the cardiovascular and respiratory systems.
7. Apply computations of gas diffusion to quantitatively describe ventilation and perfusion in the respiratory system.
8. Provide physiologic examples of positive and negative feedback control and relate these control systems to homeostasis and physiological function.
9. Use concentrations of urine and creatinine to calculate renal clearance, renal plasma flow and glomerular filtration rate.

GRADING: Your final grade will be calculated as follows:

Exams	45% (3 x 15%)
PBL Report*	20%
In Class Quizzes	15%
Out of Class Problems	19%
Participation (Surveys)	1%

Graduate students will have an extra submission in their PBL report – 3-5 page Pitfalls and Alternatives Section detailing how the proposed design can fail and the alternative strategies that will be employed to achieve success.

EXAMS: There will be three pledged exams through the semester. It is a violation of the Rice Honor Code to obtain copies of any previous year exams. Written documentation will be required for personal emergencies (medical, death in family, etc) necessitating missing an exam. Prior approval is required and will only be given in very extreme circumstances. Exam re-grade requests will be accepted up to 3 days after the exams are handed back in class/grades are released. If the re-grade is not well-founded, 10% of the grade will be deducted. Please note that with the regrade, the final grade may go up or down. Equations (as listed in the course book appendix) will be provided for exams.

PBL REPORT: A written PBL report will be assigned to groups of four where teams will be evaluating a potential therapy for CV applications and propose improvements to advance the therapy to the clinical stage. More details will be provided further along in the course.

IN CLASS QUIZZES: In class quizzes will cover review problems assigned as part of the course reading. Quizzes will be closed book. All review problems assigned until an exam is held are fair game for quizzes (not only the current day's reading). All quizzes will be conducted on Canvas – a subset will be graded.

OUT OF CLASS PROBLEMS: Homework (HW) assignments will be assigned throughout the semester. Students may use the course textbook, along with other textbooks, to complete the assignments. Any attempt to obtain solutions via the internet, prior students, homework banks, or any other means is a violation of the Honor Code. Students in no cases may possess or access prior year homework assignments for any sections of BIOE 322 or cross-listed courses (Honor Code). However, collaboration with other students to complete homework is acceptable and highly encouraged. Homework must include name in the upper left-hand corner of each page with answers boxed. Homework should be uploaded onto Canvas by deadline. No late homework will be accepted under any circumstance. Questions on HW should be posted to the online HW forum so that all students are able to see the response (HW questions will be answered through Canvas, not through email.) All HW will be collected – a subset will be graded.

PARTICIPATION: Surveys will be posted throughout the duration of the course. Completion of the surveys by the deadline will count towards participation credit. No late work will be accepted.

ATTENDANCE: If you must miss a class for any reason, you are responsible for talking to another student in the class and obtaining any course material missed. Attendance will be taken via Zoom User Reports. Although attendance is not a formal part of your grade, I will consider attendance and class participation when determining final grade.

CLASS PREPARATION: This class will use a combination of lectures, case studies, and problem solving based approaches. In order to get the most out of each class, students should come to class having carefully read and studied the assigned material. To keep up with the pace of the course, students should devote time each day to studying the material to be covered. Please have your course textbook, a scientific calculator, a cell phone or laptop if you have one, and other materials handy during class for problem solving. Any handouts needed will be available by 7 AM each class day.

SYLLABUS CHANGES: The syllabus is subject to change including changes in grading procedures and changes in schedule. Notice will be given in advance of any changes in grading procedures.

HONOR CODE: Under no circumstances may students possess or consult *any* material from previous year BIOE 322/533 (or cross-listed) courses. This includes, but is not limited to homework, case studies, in class problems, exams, and solutions to any of these materials. All students are expected to abide by the Rice Honor Code at all times. Exams will be pledged.

REGRADING POLICY: Written assignment re-grade requests (email is sufficient) will be accepted up to 3 days after the assignments are handed back in class/grades are released. If the re-grade is not well-founded, 10% of the grade will be deducted. Please note that with the regrade, the final grade may go up or down.

DISABILITIES: Any student with a documented disability needing academic adjustments is requested to speak with me during the first two weeks of class. All discussions will remain confidential.

STUDENT LEARNING RESEARCH: During this course, I will be conducting student learning-related research. The purpose of the research is to demonstrate the effectiveness of different pedagogical strategies such as creation, observation of videos as a teaching tool. These activities will be no different from normal class activities with the exception effectiveness data from students on these innovations will be collected. No identifying information will be collected. Participation in this study is voluntary and students may refuse to participate and withdraw at any point in time. Lack of participation will have no impact on student grade or academic standing.

<u>Attendance</u>

While attendance is required in this course, these are different times that we live in with the COVID pandemic underway. All instructional material will be made available via Canvas, Zoom or Google Drive for all students, those learning in person or remotely. For both in class and remote students, if you cannot attend class due to health, please let the instructor team know at your earliest convenience via email.

Course Schedule

Week #	Day	Date	Unit	Unit Subtopics	Problem Sets	Quiz	PBL	Other
Week 1	M	January 9	INTRODUCTION/MEMBRANES	Introduction to Course*, Membrane Properties, Transport, Channels				
	W	January 11		Potential: Membrane, Equilibrium				
	F	January 13		Action Potential		Quiz 1 (3.1-3.2)		Introductory Quiz, PBL Group Signup
Week 2	M	January 16	MLK Day - NO CLASS					
	W	January 18		Nerve Conduction, Cable Properties of Axons				
	F	January 20		Cable Properties of Axons, Neuromuscular Junction				
Week 3	M	January 23		Neuromuscular Junction Wrap-up + NEURO REVIEW				
	W	January 25	MUSCLE	Muscle Structure, Energy Types				
	F	January 27		Cross-Bridge Formation		Quiz 2 (3.5-3.6)		
Week 4	M	January 30		RECITATION PS 3.2 Help				
	W	February 1		Passive, Active Tension, Force Velocity Curve	PS 3.2 Due			
	F	February 3		EXAM REVIEW				
Week 5	M	February 6		Exam I				
	W	February 8	CARDIOVASCULAR	Blood, Compliance, Vessel Structure				
	F	February 10	Spring Recess - NO CLASS					
Week 6	M	February 13		Heart Anatomy, Electrophysiology			PBL Check-In with Instructors (outside of class) - times will be posted via Canvas	
	W	February 15		Electrophysiology, Cardiac Cycle (partly)			Tech Memo Due	
	F	February 17		Cardiac Cycle, Action Potential		Quiz 3 (5.1-5.2, 5.4-5.6)		
Week 7	M	February 20		RECITATION: PS 5.1/5.2 Help				
	W	February 22		ECG, Mean Axis Depolarization	PS 5.1, 5.2 Due			
	F	February 24		ECG Case Studies				
Week 8	M	February 27		ECG, Cellular Basis for Contractility			Abstract Due	
	W	March 1		Cardiac Function Curve				
	F	March 3		RECITATION: PS 5.3 Help				
Week 9	M	March 6		Hemodynamics, Cardiac Output	PS 5.3 Due			
	W	March 8		Venous Return Integration				
	F	March 10		Venous Return Integration, EXAM REVIEW				
Week 10	M	March 13	Spring Break - NO CLASS					
	W	March 15	Spring Break - NO CLASS					
	F	March 17	Spring Break - NO CLASS					
Week 11	M	March 20		Exam II				
	W	March 22	RESPIRATORY	Diffusion, Compliance				
	F	March 24		Lung Volumes, Gas Exchange				
Week 12	M	March 27		PBL Day (not required to come to class but I will be present)				
	W	March 29		Lung Volumes, Gas Exchange		Quiz 4 (6.1-6.3)	PBL Check In outside of class	
	F	March 31		Gas Transport				
Week 13	M	April 3		Acid-Base Physiology, Respiratory Compensation				
	W	April 5		RECITATION: PS 6.1/6.2 Help				
	F	April 7	RENAL/URINARY	Body Volume, Osmolarity			Draft, CATME, Self-Reflection Due	
Week 14	M	April 10		Kidney Function, Glomerular Filtration (partly)	PS 6.1/6.2 Due			
	W	April 12		Glomerular Filtration, Reabsorption (partly)				
	F	April 14		Component Reabsorption		Quiz 5 (7.1-7.4)		
Week 15	M	April 17		RECITATION: PS 7.1/7.2 Help				
	W	April 19		Water and Salt Transport , EXAM REVIEW (may be after class hours)	PS 7.1/7.2 Due			
	F	April 21		Exam III				
Week 16	F	April 28					PBL Report, CATME, Self-Reflection Due	

Reading Schedule

Week #	Day	Date	Unit	Unit Subtopics	Required Feher Reading Section (pages)	Ignore these sections in Feher	Supplemental Feher Reading	Supplemental Costanzo Reading, 6th edition (pages)
Week 1	**M**	January 9	**INTRODUCTION/MEMBRANES**	Introduction to Course*, Membrane Properties, Transport, Channels	3.1 (255-257)		2.5 (161-168), 2.6 (170-176)	**(3-18)**
	W	January 11		Potential: Membrane, Equilibrium	3.1-3.2 (257-261), (265-270)	"Strength-Duration Relationship is Hyperbolic" (268), "Patch Clamp Experiments Measure Unitary Conductances" (271)		**(18-26)**
	F	January 13		Action Potential	3.2-3.3 (280-284)			**(23-26)**
Week 2	**M**	January 16	**MLK Day - NO CLASS**					
	W	January 18		Nerve Conduction, Cable Properties of Axons	3.3 (280-287)			**(23-26)**
	F	January 20		Junction	3.3 (280-287)			**(23-26)**
Week 3	**M**	January 23		**REVIEW**	3.6 (318-325)			**(26-30)**
	W	January 25	**MUSCLE**	Muscle Structure, Energy Types	3.5-3.6 (305-310), (318-325)	"a-actinin at the z-disk ...," "Myomesin joins the ...", "Overall structure of the..." (310-312)		**(26-30),(34-37)**
	F	January 27		Cross-Bridge Formation	3.5-3.6 (312-314)	"force is transmitted..." (314-315)		**(34-39)**
Week 4	**M**	January 30		**RECITATION PS 3.2 Help**				
	W	February 1		Passive, Active Tension, Force Velocity Curve	3.4 (292-303), 3.6 (326-327)			**(39-40)**
	F	February 3		**EXAM REVIEW**				
Week 5	**M**	February 6		**Exam I**				
	W	February 8	**CARDIOVASCULAR**	Blood, Compliance, Vessel Structure				
	F	February 10	**Spring Recess - NO CLASS**					
Week 6	**M**	February 13		Heart Anatomy, Electrophysiology	5.4 (516-524)			**(117-119), (131-133)**
	W	February 15		Electrophysiology, Cardiac Cycle (partly)	5.4-5.5 (516-522), 5.6 (544-545)			**(131-143), (153-158)**
	F	February 17		Cardiac Cycle, Action Potential	5.5-5.6 (516-518, 528-536)			**(131-143)**
Week 7	**M**	February 20		**RECITATION: PS 5.1/5.2 Help**				
	W	February 22		ECG, Mean Axis Depolarization	5.4 (522-524), 5.6 (537-545), Clinical applications (544)			**(143-144)**
	F	February 24		ECG Case Studies	5.6 (537-545), Clinical applications (544)			**(143-144)**
Week 8	**M**	February 27		ECG, Cellular Basis for Contractility	5.5 (534-536), 5.7 (547-552, 554-555)	"Sympathetic stimulation...", "Parasympathetic stimulation...", "Cardiac glycosides..." (552-553) - lot of details given, only need to know what's gone over in class		**(144-148)**
	W	March 1		Cardiac Function Curve	5.8 (556-563)	"thermal dilution method" (563)		**(148-154), (158-163)**
	F	March 3		**RECITATION: PS 5.3 Help**				
Week 9	**M**	March 6		Hemodynamics, Cardiac Output	5.9 (568-576)			**(119-131),(158-163)**
	W	March 8		Venous Return Integration	5.12 (599-606)			**(158-163)**
	F	March 10		Venous Return Integration, **EXAM REVIEW**	5.12 (599-606)			**(158-163)**
Week 10	**M**	March 13	**CLASS**					
	W	March 15	**CLASS**					
	F	March 17	**CLASS**					
Week 11	**M**	March 20		**Exam II**				
	W	March 22	**RESPIRATORY**	Diffusion, Compliance	6.1 (623-631)			**(189-191), (197-209)**
	F	March 24		Lung Volumes, Gas Exchange	6.1 (623-631), 6.2 (633-641)	for pages 636-638, lot of details given, only need to know what's covered in class		**(189-191), (191-194), (197-209)**
Week 12	**M**	March 27		**be present)**				
	W	March 29		Lung Volumes, Gas Exchange	6.3 (642-650)			**(194-197), (209-216), (225-231)**
	F	March 31		Gas Transport	6.4 (656-663)			**(211-225)**
Week 13	**M**	April 3		Acid-Base Physiology, Respiratory Compensation	6.5 (665-670)			**(237-241), (311-318), (324-336)**
	W	April 5		**RECITATION: PS 6.1/6.2 Help**				
	F	April 7	**RENAL/URINARY**	Body Volume, Osmolarity	7.1 (689-696)			**(1-4), (11-14), (246-255)**
Week 14	**M**	April 10		Kidney Function, Glomerular Filtration (partly)	7.2, 7.3 (698-704, 705-713)			**(245-247), (261-267)**
	W	April 12		Glomerular Filtration, Reabsorption (partly)	7.3, 7.4 (705-713, 719-728)			**(267-276)**
	F	April 14		Component Reabsorption	7.4 (719-728), 7.5 (730-738)			**(267-276), (276-286)**
Week 15	**M**	April 17		**RECITATION: PS 7.1/7.2 Help**				
	W	April 19		Water and Salt Transport , **EXAM REVIEW (may be after class hours)**	7.5 (730-738)			**(267-276), (276-286), (300-303)**
	F	April 21		**Exam III**				
Week 16	**F**	April 28						

GENERAL NOTE: Summaries are a great review. Appendices are never a part of required reading unless stated. Clinical applications are nice to have a look at but also not required unless otherwise stated.

Rapid Interpretation of EKG's. Dale Dubin. 6th edition is an excellent resource for ECGs

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