PURDUE UNIVERSITY | College of Engineering

Engineering Faculty Document
No. 34-24
October 10, 2023

TO: The Engineering Faculty

FROM: The Faculty of the Weldon School of Biomedical Engineering

RE: New Engineering Curriculum Change for the B.S. Degree in Biomedical Engineering

TITLE:
Curriculum Change for the Bachelor's Degree in Biomedical Engineering

DESCRIPTION:

The faculty of the Weldon School of Biomedical Engineering has approved the following changes to the curriculum for the B.S. degree in Biomedical Engineering effective for the students entering the School in the Fall Semester 2024. This action is now submitted to the Engineering Faculty with a recommendation for approval.

The following changes emerged from our efforts to align the BME curricula currently taught in West Lafayette and Indianapolis, selecting the most impactful materials, activities and assessments from each location in courses with overlapping learning outcomes. The faculty from both campuses had extensive conversations and committed to delivering course content, assessment, and pedagogy the same in both locations.

The proposed changes are summarized below with links that connect to relevant individual EFDs elsewhere in this document.

A. Separate lecture and lab components of BME 20700 into BME 23100 (lecture) and BME 23101 (lab) and keep both in Spring of second year.

This course is being separated into lecture and lab portions to a) allow more in-class lecture time to cover fundamental principles of Bioinstrumentation and Circuit Theory; as well as b) allow us to evaluate student performance in each course component (lecture and lab) on its own merit.
- BME 23100 EFD
- BME 23101 EFD

B. Replace BME 20600 with BME 21401 and move to Fall of second year.

This laboratory course will provide the practical component for the lecture course BME 21400 Introduction to Biomechanics and is expected to be taken concurrently with the lecture. The biomaterials topics previously taught in sophomore-level BME 20600 Biomechanics & Biomaterial Laboratory will now be covered in BME 32001: Biomolecules and Biomaterials Laboratory to provide a

practical component for newly created BME 32000 Introduction to Biomaterials Science and Engineering (accompanying EFDs). Separating the topics related to biomechanics (BME 21401) and biomaterials (BME 32001) into two separate laboratory courses ensures a better alignment of the labs with the corresponding BME 21400 and BME 32000 lectures, and enables the creation of a new Biomaterials depth area building upon strengths in the IUPUI BME department.
- BME 21401

C. Create BME 31300 as a Depth Area option for Biomechanics and Biomaterials Depth areas, replacing BME 30400.

This course will replace and combine BME 30400 Biomedical Transport Fundamentals, currently offered in West Lafayette, and BME 44200 Biofluid Mechanics, currently offered in Purdue University Indianapolis, to provide an integrated course introducing the principles of fluid dynamics in application to biomedical problems. This course (BME 31300) will be mandatory for junior-level students in the Biomechanics and in Biomaterials Areas of Depth. The presentation of the material will be focused on fluid dynamics in cardiovascular circulation. Most of the topics related to heat and mass transport that were covered in BME 30400 will be shifted to more advance Biotransport technical selective courses. Removing more advanced heat and mass transport topics from this introductory course (BME 31300) would allow the instructor to provide more practical examples and better relate the theory to cardiovascular flow in health and disease.
- BME 31300

D. **Create BME 32000 Biomaterials course for Fall of third year, required for all BME undergraduates.**

This new course is created to introduce students to materials science fundamentals essential for all areas of BME specialization and will be mandatory for all junior-level students. The material will provide a solid foundation for more advanced classes in the newly created Biomaterials Area of Depth as well as provide the breadth of knowledge to students in other Areas of BME specialization. The practical counterpart for this course will be provided in the newly developed Biomolecules and Biomaterials Laboratory BME 32001.
- BME 32000

E. Create BME 32001 Biomolecules and Biomaterials lab, replacing BME 20500 and moving to Fall of third year; required for all BME undergraduates.

This course is being created to provide practical components for two prior or co-occurring lecture courses: BME 22000 Biomolecules: Structure, Function, and Engineering Applications and BME 32000 Introduction to Biomaterials Science and Engineering. BME 32001 will contain the lab material previously taught in sophomore-level BME 20500 Biomolecular and Cellular Systems Laboratory as well as the new lab material for junior-level BME 32000. The addition of cell

culture modules to 32001 and the creation of an experimental based design project are the most significant changes from the previous BME 20500 laboratory.
- BME 32001

F. **Create Biomaterials Depth Area option consisting of BME 31300 and BME 38800.**
This will divide the BME Biomechanics and Biomaterials Area of Depth into two separate Areas of Depth to leverage the strength of Purdue University Indianapolis in biomaterials sciences and provide a more focused training to students interested in this BME specialization. As a majority of the students are selecting Biomechanics and Biomaterials Area of Depth, creating two separate Areas will improve the depth of training in each Area by providing relevant courses and class capacity.

G. **Increase credit hour for BME 38000 from 1.0 to 2.0.**
This course has grown over the last two years and the increase in credit hours reflects and matches with the Purdue University Indianapolis professional development credit hours as well. This change updates the credits to more accurately reflect the work and content taught in the course.
- BME 38000

H. **Course number and prerequisite updates to reflect the changes summarized above. These changes were approved the BME undergraduate curriculum committee as Fast Track EFDs which are linked below.**
- Prerequisites were updated for BME 46000 (to include recently approved BME 20200 as a prereq), BME 25600 (to allow broader coding prerequisites to be used, and add an online section), BME 33000 (previously BME 30100) and BME 36000 (to reflect course number updates)
  - BME 46000 EFD
  - BME 25600 EFD – coding
  - BME 25600 EFD – online section
  - BME 33000 EFD
  - BME 36000 EFD
- Design courses were updated for prerequisites. BME 38900 (to include newly approved BME 20200 as a prereq, reflect course number updates, and add the new biomaterials depth area courses), BME 48901 (reflect course number updates, and add the new biomaterials depth area courses).
  - BME 38900 EFD
  - BME 48901 EFD
- Course numbers were updated to reflect their position in the depth areas.

- BME 32200 statistics were added (BME 35700, BME 38900) as an alternative for students in Indianapolis.
  - BME 35700 EFD
  - BME 38900 EFD
- BME 22000 and BME 47000 prerequisites were updated to reflect a change in when the courses are offered as well as when the accompanying lab will be offered.
  - BME 22000 EFD
  - BME 47000 EFD
- Prerequisites were updated based on feedback from instructors on the necessary skills to be successful in the course combined with where these skills will be taught in the updated curriculum (BME 31400, BME 43100, BME 45000)
  - BME 31400 EFD
  - BME 431000 EFD
  - BME 45000 EFD

I. **Separate Ethics/Policy Healthcare (EPH) from General Education category into its own 3-credit hour category, dropping the General Education requirements from 24 credits to 21 credits.**

   This will enable us to allow more course options for students for the EPH and eliminate the confusion of non-General Education courses counting for the EPH but not for General Education.

J. **Eliminate Unrestricted Elective requirement**.

   These credits are replaced by BME 32000, BME 23101, and an increase in credit hours for BME 38000. This elimination maintains the overall required credit hours for a BS-BME at 130 credits.

RATIONALE: Collectively, these changes reflect efforts to:
a) increase the breadth and depth of training in specialized areas of BME by creating a new biomaterials depth area,
b) better coordinate labs with corresponding lectures,
c) align the BME curriculum currently taught in West Lafayette and Indianapolis, selecting the most impactful materials, activities and assessments from each location in courses with overlapping learning outcomes.

Nan Kong
Professor and Interim Head
Weldon School of Biomedical Engineering

Contents

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: New 200 level course – BME 21401: Biomechanical Analysis Laboratory

The Faculty of the Weldon School of Biomedical Engineering has approved the following new 200-level course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

BME 20600 Biomechanics & Biomaterial Laboratory
Semesters offered: Spring
Total number of credits: 1 (1 credit lab)
Concurrent Prerequisites: BIOL 23000 and BME 21400
Major Restriction: Biomedical Engineering only

TO:

BME 21401 Biomechanical Analysis Laboratory
Semester offered: Fall
Total number of credits: 1 (1 lab credit)
Concurrent Pre-requisite: BME 21400
Prerequisites: (PHYS 17200 or [ENGR 16100 and ENGR 16200]) and (MA 16600 or MA 16200)
Major Restriction: Biomedical Engineering only

COURSE DESCRIPTION:

BME 21401 provides hands-on training in engineering and biological principles of biomechanics. Topics include translation of theoretical vector and equilibrium calculations to three-dimensional body problems, computer aided design and finite element analysis, harvest and storage of biological samples, and tension, compression and bending testing with mechanical testers. A design project reinforces the mechanical testing skills learned in class, combining skill-building in group work and experimental design. This course will prepare students for deeper study of biomechanics.

RATIONALE:

This laboratory course will provide the practical component for the lecture course BME 21400 Introduction to Biomechanics and is expected to be taken concurrently with the lecture. The *biomaterials* topics previously taught in the sophomore-level BME 20600 Biomechanics & Biomaterial Laboratory will now be covered in BME 32001: Biomolecules and Biomaterials Laboratory to provide a practical component for newly created BME 32000 Introduction to Biomaterials Science and Engineering (accompanying EFDs). Separating the topics related to biomechanics (BME 21401) and biomaterials (BME 32001) into two separate laboratory courses ensures a better alignment of the labs with the corresponding BME 21400 and BME 32000 lectures. Prerequisites were adjusted to reflect the changes in the content and to be consistent with the accompanying lecture course (BME 21400).

This course (BME 21401) is being created to achieve 3 goals:
To provide a practical component for the BME 21400 lecture and move the topics related to *biomaterials* to the new BME 32001 laboratory course (aligned with BME 32000 lecture).
Facilitate curriculum integration with existing IUPUI BME programs and courses.
Update course numbers to more closely align depth area courses, and for lab course numbers to better align with the corresponding lectures.

BME 21401 Syllabus

Course Information

Course # and title: BME 21401: Fundamentals of Biomechanical Analysis

Lab Sections: Day Time LOCATION

Day Time LOCATION
Day Time LOCATION
Day Time LOCATION
Day Time LOCATION
Day Time LOCATION
Day Time LOCATION

Instructional modality: Face-to-Face

Course Credit Hours: 1

Pre-requisites: PHYS 17200 Modern Mechanics
MA 16600 Analytic Geometry and Calculus II
or
MA 16200 Plane Analytic Geometry and Calculus II

Co-requisite: BME 21400 Introductory Biomechanics

Instructors' Contact Information

Course Instructor: Instructor Name Phone: (XXX) XXX-XXXX
Office: MJIS #### OH: by appointment/open-door

Course TAs:

TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu

Office Hours: TBA

Monday - Thursday
7:00 - 9:00 pm

TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu

Course Description

BME 21401 provides hands-on training in engineering and biological principles of biomechanics. Topics include translation of theoretical vector and equilibrium calculations to three-dimensional body problems, computer aided design and finite element analysis, harvest and storage of biological samples, and tension, compression and bending testing with mechanical testers. A design project reinforces the mechanical testing skills learned in class, combining skill-building in group work and experimental design. This course will prepare students for deeper study of biomechanics.

Learning Resources, Technology & Texts

Required Materials: • Paper or printable electronic notebook
(e.g., Microsoft Word; remember that MS Office is free for all students)
Fusion 360 Student License (Free)

Course Web Page: https://purdue.brightspace.com

Access the course via Purdue's Brightspace learning management system. Begin with the Start Here tab, which describes how the course Brightspace is organized. It is strongly suggested that you explore and become familiar not only with the site navigation but with content and resources available for this course. See the Student Services widget on the campus homepage for resources such as Technology Help, Academic Help, Campus Resources, and Protect Purdue.

Learning Outcomes

Upon completion of the course, you will be able to:
Describe the importance of regulatory guidance documents and voluntary consensus standards as they relate to the design, development, and testing of new therapeutic and diagnostic devices.
Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (SO 4).
Implement the experimental design process, including proper maintenance of a design laboratory notebook and use of appropriate statistical analysis methods, as it applies to mechanical performance of materials used for medical device design (SO 6).
Independently employ fundamental tools, testing procedures, and analyses relevant to computer-assisted design (CAD), FEA, and biomechanics, for rapid prototype development, analysis of mechanical properties of tissues, materials, and devices (SO 7).
Reflect on your knowledge and experiences that contribute to your understanding of what it means to be an engineer.

Assignments

Assignments/Deliverables	Sub-totals	Totals
Prelab Problem Quizzes (Individual)	*15 %*	
Post-lab Analysis (Notebook, post-lab questions)	*25 %*	
Lab Practical (Individual)	*15 %*	
*Individual Participation**	*15 %*	

Final Design Project	*20 %*	
Ethics Assignments	*10 %*	
		100 %

* *For full credit, you must complete online course evaluations and submit evidence of survey completion. Furthermore, TA/Peer Review (individual) may reduce an individual's grade.*

For each lab, you will be required to complete a pre-lab quiz and a post-lab analysis. You are expected to maintain a laboratory notebook throughout the course of the semester for each lab, which will be the first section within the laboratory notebook. Following is a description of what is expected for each.

Best Practices for Completing Team-Based Assignments: The majority of assignments for this course will be completed with students working as part of a team, with each student being evaluated based on their ability to work and communicate as a team. Effective teamwork requires effective communication amongst group members. Each team member, whether operating in person or remotely, needs to take responsibility for respectfully communicating their thoughts and ideas as well as listening to those of others. All team members are expected to contribute equally and fully toward completion of each assignment. For this reason, it is important to set work expectations and timelines so that each member can plan, manage their time, and act accordingly. Also, remember each team member brings different strengths and weaknesses, so take this into account when assigning individual tasks. In situations where team members are not participating as expected, please contact your section TA and the Laboratory Coordinator immediately.

PreLab Quizzes & Online Material: It is expected and required that students perform the PreLab assignment individually prior to the Monday of each lab week. This involves reading and understanding the laboratory procedure, watching online lecture videos and instructional videos. Each weekly PreLab assignment can be found in the laboratory manual and all lecture and instructional videos are available through BrightSpace. PreLab activities include individual completion of short PreLab quizzes administered via Gradescope that test your retention of PreLab material. These quizzes are open note.

PostLab Assignment Submissions: Each weekly PostLab assignment can be found in the laboratory manual. Weekly PostLab questions, problems, and data analysis are highlighted in red throughout the laboratory manual. All requested information should be provided within the designated sections of the PostLab Appendix and submitted as a team via Gradescope by the designated due date. Post-lab writeups are considered a group assignment and are to be completed with your lab group. Each individual student is responsible for what your group turns in. Groups should allow time between completion and submission of the assignment for each group member to review the material prior to submission.

Ethics Assignments: Ethics assignments will be completed in conjunction with the animal harvest and tissue storage lab. Students will complete and individual pre-reading and reflection prior to lab attendance, hold a discussion on the ethics of animal research with their group members during lab and complete the ethics discussion worksheet as a group.

Integrated Design Project and Milestone Submissions: In this course you will have the opportunity to apply what you learn in weekly laboratories to the early-stage engineering design of a medical device that employs rapid prototyping (3D printing, otherwise known as additive manufacturing). This includes

maintenance of an electronic design laboratory notebook (see Appendix A of Design Project), information gathering, problem definition, idea generation, evaluation and decision making, and creation of a final video presentation. Each week, there is a design project milestone that must be completed and submitted as a team via Gradescope by the designated due date. Refer to the Design Project document on Brightspace for specific details on Milestones. Milestone due dates are summarized in the Course Schedule.

Laboratory Practical: Students will individually complete a laboratory practical that will be administered during the module. This performance exam will evaluate a student's ability to practice essential skills and techniques learned throughout the course. Specific skills that may be included as part of the laboratory practical include:

Accurately transfer a volume of fluid using an appropriately selected micropipette under aseptic and/or non-aseptic conditions

Accurately transfer a volume of fluid using an appropriately selected serological pipette under aseptic and/or non-aseptic conditions

Calculate and create dilution curves, with spectrophotometric validation

Calculate and create a cell suspension at a specified cell density

Perform a hemocytometer count to accurate determine the density (cells/mL) of a cell suspension

Describe the fundamental reagents and process used when passaging adherent and suspension cells

Describe best practices associated with mechanical testing along, including management of common pitfalls

Perform a mechanical test on a material using specified testing parameters, including data transfer, data analysis (e.g., stress and strain calculation), and proper display of data in graphical form

Describe fundamental differences between standard elastic and viscoelastic materials and the types of tests used to evaluate viscoelastic materials.

Evaluate test data and identify and perform an appropriate statistical test

Late Submissions: No late PreLab quiz submissions will be accepted. Late laboratory submissions and design project submissions will lose 25%/day including weekend days. Late work will be counted as submitted once emailed to the section TA or the overall Lab Coordinator.

Online Course Evaluations: Online course evaluations for this class are considered assignments, which must be completed to full point credit. You are asked to submit to the evidence of the semester's evaluation/survey completion on Gradescope prior to the associated due date. If no evidence of evaluation/survey completion is submitted you will receive a zero for the assignment. The late policy of 25%/day will also be applied to proof submission.

Grading Scale

The following grading scale is guaranteed; final grades may be curved at the instructors' discretion.

Letter Grade	Percentage	GPA score
A+	≥ 100	4.0
A	≥ 94	4.0
A-	≥ 90	3.7
B+	≥ 87	3.3
B	≥ 83	3.0
B-	≥ 80	2.7

Letter Grade	Percentage	GPA score
C+	≥ 77	2.3
C	≥ 73	2.0
C-	≥ 70	1.7
D+	≥ 67	1.3
D	≥ 63	1.0
D-	≥ 60	0.7
F	< 60	0

Re-grade Policy: Students have one week after the return of a graded assignment to protest a grade; after this time, grade disputes will not be accepted. Papers submitted for a re-grade will be completely re-evaluated (i.e., the entire paper will be re-graded, not only the portion under protest), which means that students may lose additional points for mistakes missed during the first grading process.

Topics Covered

Fundamentals of Vector and Equilibrium Calculations

Accuracy and precision in measurement

Power tool safety and operation

Computer Aided Design

Creating and modifying sketches, creating solid bodies, constraining designs, preparing engineering drawings, 3D printing considerations

Finite Element Analysis

FEA theory, application of constraints, application of load, mesh specification and convergence

Ethics of animal use in research

Tissue harvest techniques

Considerations in storage of biological tissues for mechanical testing

Tensile testing

Material choice, test set-up, operation of mechanical testers, data analysis

Compression testing

Material choice, test set-up, operation of mechanical testers, data analysis

Three-point bending testing

Test set-up, operation of mechanical testers, data analysis

Force-Displacement Curves

Important landmarks, limits to linear analysis, normalization of data to stress-strain

Stress-Strain Curves

Important landmarks, limits to linear analysis

Statistical analysis

T-test (paired, unpaired), ANOVA, Tukey's HSD post-hoc analysis

Experimental Design

Group Management

Academic Integrity

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted

anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies.

Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that assignment, and at the instructor's discretion may result in a failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered.

Nondiscrimination Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

Accessibility

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Mental Health/Wellness Statement

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am – 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc., sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you are struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global

crisis as it related to COVID-19, students may submit requests for emergency assistance from the Critical Needs Fund.

Emergency Preparation

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructors' control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email. You are expected to read your @purdue.edu email on a frequent basis.
Active Emergency Response: **In case of fire, evacuate the building via the east doorways (towards S. Russell St.) if they are free of hazards. Do not use the west doorways as a primary exit as those will be the doors accessed by emergency responders and fire personnel. The primary Emergency Assembly Area location (after evacuating the building) is the outside courtyard and main entrance to Hockmeyer. This entrance faces Martin Jischke Drive. The secondary Emergency Assembly Area location, in case of inclement weather, is the interior main lobby of Hockmeyer.**

If "sheltering" owing to a tornado warning, immediately proceed to the MJIS basement hallway via the stairwell. Do not use the elevators. Be prepared to kneel facing a wall and cover your head. If "sheltering" owing to an active shooter, building intruder, or a civil disturbance on campus, follow police instructions. In the absence of instructions, seek a safe location, preferable a room without windows that can be locked or secured by barriers.
Course Schedule (tentative)
*The instructor reserves the right to modify the following schedule as necessary

LAB	ACTIVITY	LAB SKILLS
1	Vectors and Equilibrium	Power tool operation: miter or table saw, cordless drill, measurement with measuring tape/rulers
2	Computer Aided Design and Finite Element Analysis	Modeling and Analysis
3	Animal Harvest and Tissue Storage	Ethics Discussion, Proper handling of dissection tools, Proper storage of biological tissue for future mechanical testing
4	Mechanical Testing: Tension	Tension testing, measurement with calipers, statistical analysis
5	Mechanical Testing: Compression	Compression testing, statistical analysis
6	Mechanical Testing: 3-point Bending	Bending Testing, handling of biological samples, statistical analysis
7	Lab Practical	
8	Mechanical Testing: Design Project	

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite and Course Number Change to BME 20100 Biomolecules: Structure, Function, and Engineering Applications
The Faculty of the School of Biomedical Engineering has approved the following requisite and course number change to BME 20100. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.

Requisite and Course Number Change for BME 20100 Biomolecules: Structure, Function, and Engineering Applications

FROM:
BME 20100 Biomolecules: Structure, Function, and Engineering Applications
Term offered: Spring, Lecture, Cr. 3
Prerequisites: (MA 16200 or MA 16600 or MA 18100)
Concurrent prerequisites: (CHM 11600 or CHM 12400 or CHM 13600 or CHM 12901) and BIOL 23000 and BME 20500
Major Restriction: Biomedical Engineering only
TO:

BME 22000 Biomolecules: Structure, Function, and Engineering Applications
Term offered: Spring, Lecture, Cr. 3
Prerequisites: (MA 16200 or MA 16600) and (CHM 11600 or CHM 13600 or CHM 12901) and BIOL 23000
Major Restriction: Biomedical Engineering only

RATIONALE:
Our course number is changing to better align with areas of depth. Because this course was moved to the spring (previous EFD change); now CHM 11600 and BIOL 23000 (and equivalents) have been found necessary as **pre**requisites to be successful in the course. The BME lab (BME 20500) is no longer required as a concurrent prerequisite because that lab content is being combined into a different lab that will now be offered in the Junior year. MA 18100 and CHM 12400 are no longer in the course catalog (may have been retired).

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: New 200 level course – BME 23100: Bioinstrumentation and Circuit Theory
The Faculty of the Weldon School of Biomedical Engineering has approved the following new 200-level course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

BME 20700: Bioinstrumentation and Circuit Theory
Semesters offered: Spring
Total number of credits: 3 Cr. Lecture
Concurrent Pre-requisites: MA 26200 or (MA 26500 and MA 26600)
Prerequisites: PHYS 24100 OR PHYS 27200
Major Restriction: Biomedical Engineering only

TO:

BME 23100: Bioinstrumentation and Circuit Theory
Semesters offered: Spring
Total number of credits: 3 Cr. Lecture
Concurrent Pre-requisite(s): MA 26200 or (MA 26500 and MA 26600)
Prerequisites: PHYS 24100 OR PHYS 27200
Major Restriction: Biomedical Engineering only

COURSE DESCRIPTION:

In this course, we'll delve into the core principles of circuit theory, covering topics such as voltage-current relationships in resistive and reactive components, Ohm's Law, Kirchhoff's Laws, and source equivalency. We will also explore advanced concepts like transient responses, AC impedance, and the dynamic behavior of first and second-order systems. Students will gain proficiency in phasor analysis of sinusoidal signals, complex number calculations, signal sampling, and spectral analysis. We'll also touch on linear time-invariant systems, frequency response, and both the design and implementation of filters. A portion of the course will focus on control systems via the s-domain. To enrich your understanding and skill set, we will also introduce programming through Python, which will facilitate data processing and deepen your conceptual grasp. This course serves as a preparatory steppingstone for BME 33000 (Bioelectricity), equipping you with the essential physics knowledge and skills required for more advanced studies.

RATIONALE:

This course is being created to separate the lecture and lab components of the previous BME 20700 (combined lecture and lab) course. BME 23100 (this EFD) will contain the updated lecture portion of what was previously BME 20700. BME 23101 (accompanying EFD) will contain the newly reimagined lab portion of what was previously BME 20700. Together, BME 23100 and BME 23101 will replace BME 20700.

This course (BME 23100) is being created to achieve 3 goals:
To allow more in-class lecture time to cover fundamental principles of Bioinstrumentation and Circuit Theory.
To evaluate performance in each course (BME 23100 and BME 23101) on its own merit.
To facilitate curriculum integration with existing IUPUI BME programs and courses.
Course number is changing to better align with areas of depth.

BME students have requested this expanded interaction with the fundamentals within this new course to a) better support their success in the accompanying lab (BME 23101), and b) support their success in upper-level bioinstrumentation and bioelectricity courses such as BME 33000: Bioelectricity (accompanying fast-track EFD).

Course Information
Course # and title: BME 23100: Bioinstrumentation and Circuit Theory

Lecture: TBD

Instructional modality: Face-to-Face

Course Credit Hours: 3

Pre-requisites: PHYS 241 Electricity and Optics
Co-requisite: MA 262 Linear Algebra and Differential Equations **OR**
MA 266 Differential Equations

Instructors' Contact Information
Course Instructors: ???? Office: MJIS ????
Email: ???? Phone: ????
Office Hours: by appointment

Dr. Yunjie Tong Office: MJIS 2019
Email: tong61@purdue.edu Phone: (765) 494-0198
Office Hours: by appointment via email

Course TAs: TBD
Office Hours:

BME Resource Center

MJIS 1097

7-9pm (M & W)

BME 23100 Syllabus
Course Description

In this course, we'll delve into the core principles of circuit theory, covering topics such as voltage-current relationships in resistive and reactive components, Ohm's Law, Kirchhoff's Laws, and source equivalency. We will also explore advanced concepts like transient responses, AC impedance, and the dynamic behavior of first and second-order systems. Students will gain proficiency in phasor analysis of sinusoidal signals, complex number calculations, signal sampling, and spectral analysis. We'll also touch on linear time-invariant systems, frequency response, and both the design and implementation of filters. A portion of the course will focus on control systems via the s-domain.

To enrich your understanding and skill set, we will also introduce programming through Python, which will facilitate data processing and deepen your conceptual grasp. Additionally, we will utilize SPICE software for hands-on design and simulation of analog circuits.

This course serves as a preparatory steppingstone for BME 330, equipping you with the essential physics knowledge and skills required for more advanced studies.

Learning Resources, Technology & Texts

Required Text: Hayt, Kemmerly, Phillips, & Durbin. *Engineering Circuit Analysis* (9^{th} ed.)

McGraw-Hill, 2019. ISBN-13: 9780073545516/9781259989452/9781259989513

Note: Previous editions are acceptable

Course Web Page: https://purdue.brightspace.com

Access the course via Purdue's Brightspace learning management system. Begin with the Start Here tab, which describes how the course Brightspace is organized. It is strongly suggested that you explore and become familiar not only with the site navigation but with content and resources available for this course. See the Student Services widget on the campus homepage for resources such as Technology Help, Academic Help, Campus Resources, and Protect Purdue.

Learning Outcomes

Upon completion of the course, you will be able to:

Solve problems using basic principles, conventions, and procedures involving voltages, currents, and power.

Describe the current-voltage relationships for resistors, capacitors, and inductors.

Solve problems using Ohm's Law, Kirchoff's Voltage Law, and Kirchhoff's Current Law.

Determine the transient and steady state responses of first-order RL and RC circuits.

Analyze circuits that use operational amplifiers.

Understand Frequency Response and understand simple and complex filter design.

Understand the basic concepts of making measurements from living systems including special electrodes at the electrode/tissue/cell interface.

Understand the basic concepts of passive and active analog filters for signal conditioning of physiological measurements, including passive RLC filters.

Design and simulate analog circuits using SPICE.

Create simple Python code to plot, analyze, and denoise physiological data. Build functions to simulate a simple bioinstrumentation system.

Assignments

Reading	*1/week*		*10%*
Jupyter Notebook	*1/week*		*5%*
Homework	*1/week*		*15%*
Quizzes	*1/week*		20 %
Exams	*breakdown:*		50 %
	Exam I (Midterm)	*25 %*	
	Exam II (Final)	*25 %*	
Total			**100 %**

Communication Policy: Please note that email is the best way to get your questions answered the quickest. You can expect to receive a response to your message within 48 hours, often much sooner during normal business hours. Please use "BME 23100" in the subject line. To devote time to my family, I do not typically check email during the hours of 6 pm and 6 am on weekdays, and I do not check often on the weekends. Any messages received during these times will receive my attention once I am back online.

Quick note on McGraw-Hill Connect (MHC): McGraw-Hill Connect (MHC) is required for this course. Reading, quizzes and a portion of the homework will be assigned through the online interface and be used in each chapter we cover.

Reading (10%):

Reading will be completed through MHC which is accessible in my Brightspace site. All readings will be available by the first day of class. Assigned readings must be completed by 9:00 AM on the date specified in the syllabus to receive credit.

Jupyter Notebook (5%)

Python programming assignments will be due in Jupyter Notebook one day prior to the corresponding lecture.

Each student will get one dropped quiz per semester.

Quizzes (20%):

Weekly quizzes will be administered through MHC. Each quiz will be open for 5 days and will be due at midnight on the posted due date - **No late submissions are accepted**. Three attempts are allowed, with a 5% loss of points for the second, and again the third attempt. After the Quiz is due, the questions will remain open so that they can be used for studying purposes for the exam. The instructor will post a detailed solution to Brightspace.

Each student will get one dropped quiz per semester.

Homework (20%)- includes MHC practice problems and Detailed problems:

MHC Practice Problems: A set of practice problems will be assigned each week and completed in MHC. You will have unlimited attempts using the online interface. MHC does an excellent job of giving step by step solutions- so this is a great opportunity to get the critical practice needed for circuit analysis. The instructor will post a detailed solution for each problem to Brightspace. The problems will be graded for completion.

Detailed Homework Problems: A 3-4 problems set will be assigned each week and graded for the correct

approach and solution. If Python is used, please provide the code and any necessary figures.

These problems must be turned in through Brightspace by the date and time indicated. This will typically be at 9:00 am at the start of class.

Each student will get one dropped HW assignment per semester.

HOMEWORK POLICY: The BME department scans all graded homework assignments for ABET assessment and accreditation purposes. All written assignment must be scanned and turned in using Brightspace. A simple cell phone picture is not good enough. Either using a true scanner, or a scanning app is required. If we cannot see the assignment, it will not be graded. In addition, please adhere to the following guidelines (**note that assignment will not be graded if you do not follow this rules**):

Use plain white paper only, and only write on one side of page.

Clearly print your name, course number, assignment number and date at the top of the first page.

On each subsequent page, write either your name or initials.

Number each page, sequentially, and indicate the total number of pages (e.g. page 3/5)

Solutions to the detailed problems worked out by the professor will be provided. It is the student's responsibility to discuss unclear points with the TA or instructor.

Homework Expectations: Write up solutions as if you were producing a report for your boss who had asked you, the engineer, to solve these problems as part of your job. Submitted work should be neat and easy to follow and include all necessary information to understand the problem you are trying to solve and how you solved it. As noted above, the process is as important as the solution and the process will be graded. A correct answer without the work will not receive credit. If we cannot read and/or understand what you have done, we can't give you partial credit or provide useful feedback.

Exams: There will be two closed-book exams that will take place mid-semester and during finals week at the end of the semester. These exams will cover all topics addressed in the lecture.

Attendance Policy: You will not pass this class if you do not attend. Regular class attendance and participation is required. Although I will not take attendance, I do know who is present. Failure to put forth a sincere effort to master the course material will have a negative impact upon your final grade. Failure to attend class (If you miss more than half of the required activities within the first 25% of the course without contacting me) and participate in homework, quiz, and related lecture assignments may result in administrative withdrawal from this course.

Grading Scale

The following grading scale is guaranteed; final grades may be curved at the instructors' discretion.

Letter Grade	**Percentage**	**GPA score**
A+	≥ 100	4.0
A	≥ 94	4.0
A-	≥ 90	3.7
B+	≥ 87	3.3
B	≥ 83	3.0
B-	≥ 80	2.7
Letter Grade	Percentage	GPA score
C+	≥ 77	2.3

C	≥ 73	2.0
C-	≥ 70	1.7
D+	≥ 67	1.3
D	≥ 63	1.0
D-	≥ 60	0.7
F	< 60	0

Re-grade Policy: Students have the right to contest any grades throughout the semester. If a student feels an assignment has been inappropriately graded, the student must submit one typed page indicating the source of the problem and an explanation for the re-grade submission. Along with this document, the original assignment must be returned. Students have one week after the return of a graded assignment to protest a grade; after this time, grade disputes will not be accepted. Papers submitted for a re-grade will be completely re-evaluated (i.e., the entire paper will be re-graded, not only the portion under protest), which means that students may lose additional points for mistakes missed during the first grading process.

Topics Covered

Introduction to Python and LTspice (1 lecture)

Fundamentals of electrical measurements and properties, Ohm's law, parallel/series circuits (1 lecture

Resistive models of biological systems (2 lectures)

KCL, KVL

Nodal/Mesh analysis

Useful Techniques for Linear Circuit Analyses (2 lectures)

Linearity, Superposition principle, Source transformation

Thevenin/Norton Equivalent

Resistor-Capacitor-Inductor and RC Circuits (2 lectures)

Capacitors, Inductors

RC Circuits

Operational Amplifier (OP Amp) (2 lectures)

Operational amplifiers

Op-Amp practices

Math tools refresher (phase, Euler's expression. Real/imaginary number) (1 lecture)

Sinusoidal response of linear circuits, phasor notation (1 lecture)

Fourier series and Fourier Transform (1 lecture)

___**Midterm**_____

Phasor analysis of RC circuits (1 lecture)

Basic Filter Design (2 lectures)

Basic Filter Design

Op-Amp using filtering.

RLC Circuits, Bandwidth, Q (2 lectures)

RLC circuits

Bandwidth, Q

Transfer function for circuits (1 lecture)
Circuit Analysis in the *s*-Domain (Laplace Transform) (2 lectures)
S-Domain and Laplace Transform
Practices
Impulse response function, Convolution and Laplace Transform (2 lectures)
Impulse response function, Convolution
Convolution and Laplace Transform
Electrodes & Wheatstone Circuit (biological signal handling) (1 lecture)
AC circuit power analysis (1 lecture)
Research-related topic (1 lecture)

Final

Course Procedures
During a typical week there will be two lectures.

Format of lecture period: The lecture period is devoted to covering the week's topics through traditional lecture and active learning activities.
Attendance Policy during COVID-19
Students are expected to attend all classes in-person unless they are ill or otherwise unable to attend class. If they feel ill, have any symptoms associated with COVID-19, or suspect they have been exposed to the virus, students should stay home and contact the Protect Purdue Health Center (496-INFO).

In the current context of COVID-19, in-person attendance cannot be a factor in the final grades. However, timely completion of alternative assessments can certainly be part of the final grade. Students need to inform the instructors of any conflict that can be anticipated and will affect the timely submission of an assignment or the ability to take an exam.

Laboratory engagement is extremely important and associated with your overall success in the course. The importance and value of course engagement and ways in which you can engage with the course content even if you are in quarantine or isolation, will be discussed at the beginning of the semester. Student survey data from Fall 2020 emphasized students' views of in-person course opportunities as critical to their learning, engagement with faculty/TAs, and ability to interact with peers.

Only the instructors can excuse a student from a course requirement or responsibility. When conflicts can be anticipated, such as for many University-sponsored activities and religious observations, the student should inform the instructors of the situation as far in advance as possible. For unanticipated or emergency conflicts, when advance notification to the instructors is not possible, the student should contact the instructors as soon as possible by email, through Brightspace, or by phone. In cases of bereavement, quarantine, or isolation, the student or the student's representative should contact the Office of the Dean of Students via email or phone at 765-494-1747. Our course Brightspace includes a link to the Dean of Students under Campus Resources.
Academic Guidance in the Event a Student is Quarantined/Isolated

If you must quarantine or isolate at any point in time during the semester, please reach out to the instructors via email so that we can communicate about how you can continue to learn remotely. Work with the Protect Purdue Health Center (PPHC) to get documentation and support, including access to an Academic Case Manager who can provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Your Academic Case Manager can be reached at acmq@purdue.edu. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify the instructors via email. We will make arrangements based on your particular situation.

Classroom Guidance Regarding Protect Purdue

The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, properly wearing a mask in classrooms and campus building at all times (e.g., mask covers nose and mouth, no eating/drinking in the classroom), disinfecting desk/workspace before and after use, maintaining appropriate social distancing with peers and instructors (including when entering/exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not properly wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss the next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

Academic Integrity

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies.

Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that assignment, and at the instructor's discretion may result in a

failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered.

Nondiscrimination Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.

Accessibility

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Mental Health/Wellness Statement

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am – 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc., sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you are struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it related to COVID-19, students may submit requests for emergency assistance from the Critical Needs Fund.

Emergency Preparation

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructors' control. Relevant changes to this course will be

posted onto the course website or can be obtained by contacting the instructors or TAs via email. You are expected to read your @purdue.edu email on a frequent basis.

Active Emergency Response: **In case of fire, evacuate the building via the east doorways (towards S. Russell St.) if they are free of hazards. Do not use the west doorways as a primary exit as those will be the doors accessed by emergency responders and fire personnel. The primary Emergency Assembly Area location (after evacuating the building) is the outside courtyard and main entrance to Hockmeyer. This entrance faces Martin Jischke Drive. The secondary Emergency Assembly Area location, in case of inclement weather, is the interior main lobby of Hockmeyer.**

If "sheltering" owing to a tornado warning, immediately proceed to the MJIS basement hallway via the stairwell. Do not use the elevators. Be prepared to kneel facing a wall and cover your head.

If "sheltering" owing to an active shooter, building intruder, or a civil disturbance on campus, follow police instructions. In the absence of instructions, seek a safe location, preferable a room without windows that can be locked or secured by barriers.

Course Schedule (tentative)

WEEK OF	WEEK	LECTURE TOPIC 1	LECTURE TOPIC 2	ASSIGNED TEXT READING
8/23	1	Introduction to Python and LTspice	Fundamentals of electrical measurements and properties, Ohm's law, parallel/series circuits	Ch. 1, Ch. 2, Ch. 3
8/30	2	Resistive models of biological systems 1: KCL, KVL	Resistive models of biological systems 2: Nodal/Mesh analysis	Ch. 4, Appx. 1
9/6	3	Linearity, Superposition principle, Source transformation	Thevenin/Norton Equivalent	Ch. 5, Appx. 2
9/13	4	Capacitors, Inductors	RC Circuits	Ch. 7.1-7.4, 7.6-7.7, Ch. 8.1-8.8
9/20	5	Operational amplifiers	Op-Amp practices	Ch. 6 & 7.5
9/27	6	Phase, Euler's expression. Real/imaginary number	Sinusoidal response of linear circuits, phasor notation	Appx. 5, Ch. 10, Ch. 15.1-15.2
10/4	7	Fourier series and Fourier Transform	Review	
10/11	8	***Midterm***	Phasor analysis of RC circuits	

10/18	9	Basic Filter Design	Op-Amp using filtering	Ch. 15.7-15.8, Ch. 17.1-17.3, Appx. 4, Appx. 6
10/25	10	RLC circuits	RLC circuits, bandwidth, quality factor	Ch. 9, Ch. 15.1-15.6
11/1	11	Transfer function for circuits	Laplace transforms, **s**-domain	Ch. 14.1-14.3, Appx. 7
11/8	12	Laplace transforms, **s**-domain (practices)	Impulse response function, Convolution	Ch. 14.4-14.12
11/15	13	Convolution and Laplace Transform	Electrodes & Wheatstone Circuit	
11/22	14	AC circuit power analysis	AC circuit power analysis	Ch. 11
11/29	15	Research-related topic	Review	Posted to Brightspace
12/6	16			
12/13		***Exam II (Final) – date/time TBD***		

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: New 200 level course – BME 23101: Bioinstrumentation and Circuit Theory Lab
The Faculty of the Weldon School of Biomedical Engineering has approved the following new 200-level course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

BME 20700: Bioinstrumentation and Circuit Theory
Semesters offered: Spring
Total number of credits: 3 Cr. Lecture
Concurrent Pre-requisites: MA 26200 or (MA 26500 and MA 26600)
Prerequisites: PHYS 24100 OR PHYS 27200
Major Restriction: Biomedical Engineering only

TO:

BME 23101: Bioinstrumentation and Circuit Theory Lab
Semesters offered: Spring
Total number of credits: 1 (1 lab credit)
Concurrent Pre-requisites: BME 23100 and [MA 26200 or (MA 26500 and MA 26600)]
Prerequisites: PHYS 24100 OR PHYS 27200
Major Restriction: Biomedical Engineering only

COURSE DESCRIPTION:

Introduction of laboratory instruments used to measure physiological events. Stimulation and conduction of electric signals within the mammalian nervous system and other excitable tissues are demonstrated. Fundamental circuit elements and concepts include resistance, capacitance, inductance, op-amps, impedance, voltage, current, power, and frequency, following the content introduced in BME 231. Fundamental analog measurement concepts include adequate bandwidth and amplitude and phase linearity. Integrative design project emphasizes the practical aspects of quantitative physiological measurements. This course is to prepare learners with sufficient physics knowledge and lab skills to pursue the Bioinstrumentation and Imaging Depth Areas. Moreover, students are introduced to programming (using Python) to deepen the understanding of basic concepts and learn basic skills in data processing. SPICE software will be used throughout the course to design/simulate various analog circuits.

RATIONALE:

This course is being created to separate the lecture and lab components of the previous BME 20700 (combined lecture and lab) course. BME 23101 (this EFD) will contain the newly reimagined lab portion of what was previously BME 20700. BME 23100 (accompanying

EFD) will contain the updated lecture portion of what was previously BME 20700. Together, BME 23100 and BME 23101 will replace BME 20700.

This course (BME 23101) is being created to achieve 3 goals:
To evaluate performance in each course (BME 23100 and BME 23101) on its own merit.
Facilitate curriculum integration with existing IUPUI BME programs and courses.
Course number is changing to better align with areas of depth.

BME students need this lab (BME 23101) to a) translate their theoretical understanding from BME 23100 (accompanying lecture course) to practical applications, and b) support their success in upper-level design labs as well as depth area courses such as BME 33000: Bioelectricity (accompanying fast-track EFD).

BME 23101 Syllabus

Course Information

Course # and title: BME 23101: Bioinstrumentation and Circuit Theory

Lecture Sections: Tuesday 4:30 - 5:45 pm MJIS 1097
Thursday 4:30 - 5:45 pm MJIS 1097

Lab Sections: Tuesday 10:30 - 1:20 pm MJIS 1061
1:30 - 4:20 pm MJIS 1061
Wednesday 8:30 - 11:20 am MJIS 1061
1:30 - 4:20 pm MJIS 1061
Thursday 10:30 - 1:20 pm MJIS 1061
1:30 - 4:20 pm MJIS 1061
Friday 8:30 - 11:20 am MJIS 1061
1:30 - 4:20 pm MJIS 1061

Instructional modality: Face-to-Face

Course Credit Hours: 2

Pre-requisites: PHYS 241 Electricity and Optics
Co-requisite: MA 262 Linear Algebra and Differential Equations **OR**
MA 266 Differential Equations

Instructors' Contact Information

Course Instructor: Instructor Name Phone: (XXX) XXX-XXXX
Office: MJIS #### OH: by appointment/open-door

Course TAs:
TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu

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TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu
TA – TA@purdue.edu

Office Hours: TBA

Monday - Thursday
7:00 - 9:00 pm

Course Description

Introduction of laboratory instruments used to measure physiological events. Stimulation and conduction of electric signals within the mammalian nervous system and other excitable tissues are demonstrated. Fundamental circuit elements and concepts include resistance, capacitance, inductance, op-amps, impedance, voltage, current, power, and frequency. Fundamental analog measurement concepts include adequate bandwidth and amplitude and phase linearity. Integrative design project emphasizes the practical aspects of quantitative physiological measurements. This course is to prepare learners with sufficient physics knowledge and lab skills to pursue the Bioinstrumentation and Imaging Depth Areas. Moreover, students are introduced to programming (using Python) to deepen the understanding of basic concepts and learn basic skills in data processing. SPICE software will be used throughout the course to design/simulate various analog circuits.

Learning Resources, Technology & Texts

Supplemental Text: Hayt, Kemmerly, Phillips, & Durbin. *Engineering Circuit Analysis* (9th ed.)
McGraw-Hill, 2019. ISBN-13: 9780073545516/9781259989452/9781259989513
Note: Previous editions are acceptable

Required Materials: • Paper or printable electronic notebook
(e.g., Microsoft Word; remember that MS Office is free for all students)

Course Web Page: https://purdue.brightspace.comAccess the course via Purdue's Brightspace learning management system. Begin with the Start Here tab, which describes how the course Brightspace is organized. It is strongly suggested that you explore and become familiar not only with the site navigation but with content and resources available for this course. See the Student Services widget on the campus homepage for resources such as Technology Help, Academic Help, Campus Resources, and Protect Purdue.

Learning Outcomes

Upon completion of the course, you will be able to:
Appraise the validity of established bioelectricity hypotheses and circuit models based on quantitative physiological measurements (1.1, 1.3)).
Document procedures, measurements, and subsequent data analysis in clear and cohesive laboratory reports (3.4, 3.5, 6.2, 6.3, 6.4, 6.5).
Design an analog bioinstrumentation measurement system meeting prescribed specifications to accurately record a physiological event. (1.3, 1.4, 2.1, 2.2, 2.3, 2.7)
Design and simulate analog circuits using SPICE (1.1, 1.3, 1.4).

Create simple Python code to plot, analyze, and denoise physiological data. Build functions to simulate a simple bioinstrumentation system (1.1, 1.3, 1.4, 8.1)
Recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (4.2, 4.4, 9.1)
Assignments

Assignments/Deliverables	Sub-totals	Totals
Prelab Problem Quizzes (Individual)	*10 %*	
Post-lab Analysis (Notebook, post-lab questions)	*30 %*	
Lab Skills Activities	*5 %*	
Lab Practical (Individual)	*20 %*	
*Individual Participation**	*15 %*	
Final Design Project	*20 %*	
		100 %

* *For full credit, you must complete online course evaluations and submit evidence of survey completion. Furthermore, TA/Peer Review (individual) may reduce an individual's grade.*

For each lab, you will be required to complete a pre-lab quiz and a post-lab analysis. You are expected to maintain a laboratory notebook throughout the course of the semester for each lab, which will be the first section within the laboratory notebook. Following is a description of what is expected for each.

Pre-lab: Prior to each laboratory session, students are expected to read over the laboratory material and the assigned textbook reading. Pre-labs can be found on Brightspace but will require students to refer to their lab manual/text for more information. **Pre-lab exercises are to be completed and submitted online before coming to lab.** By completing this assignment, you will better understand the lab and lecture concepts and form expectations for the lab activities. Please note that although pre-labs are completed online, you should keep a notebook showing your work for all calculations.

Pre-lab Quizzes: To ensure students come prepared to class, there are pre-lab quizzes on Brightspace that should be completed by the beginning of laboratories. The quizzes will be in the format of short answer, true/false, and multiple-choice questions. The intent of the quiz is to encourage students to come prepared for that day's laboratory exercise. The score achieved on the quiz will be factored into the pre-lab grade associated with that laboratory.
IMPORTANT: Students who do not turn in a Pre-lab quiz by the start of their lab section will be awarded a zero for that assignment.

Lab Skills Activities: Students will select four lab skills activities to complete throughout the semester. These skills will explore areas beyond the regular scope of the weekly lab activities to broaden each student's skillset. These may be completed in lab after the work for the session is complete, during open lab hours, or as homework as access to software allows. All four activities must be completed before the start of the design project in week 14 of the semester and demonstrated to a TA/Instructor for credit. Please see Brightspace for a list of available activities.

Notebook: During the laboratory exercises, each team will be expected to keep a notebook, electronic preferred. The entries should follow the standard notebook layout with the **Title** of the lab, a brief statement of the **Objective** of the activity, the **Procedure** followed, and any **Results** obtained. The circuits in the lab will also be simulated and tested in LTSpice. The **LTSpice schematics** of the circuits should be provided when possible. **Conclusions** must also be provided for each part of the lab activity. The results section should include all relevant observations and data. These observations/thoughts may be important in the post-lab analysis. Calculations and numerical information used or obtained in the experiment must be explicitly included in the notebook, including the simulated results from LTSpice. If hand-written, all entries in the lab notebook are to be written in ink; if you make a mistake, simply cross out the mistake by making an X through the area and make the correction next to it. It is expected that all work is well organized. The notebook entries will be graded for their organization and content.
Note: Late notebooks will <u>not</u> be accepted.

Post-Lab Analysis: Post-lab analyses will **always** include the analysis and interpretation of the data obtained during the laboratory exercises. A Jupyter Notebook based on Python will be given for each lab, which will help you understand the relevant concepts of the lab. You will be expected to run the examples in Google Colab and make your own python programs as asked. A few textbook problems that cover the lecture topics may be assigned. In addition, you will be expected to answer questions posed involving application and integration of the relevant concepts covered in that lab. *All post-lab assignments may be typed or handwritten (as long as you print clearly); the post-lab should **not** be embedded within your in-lab notebook observations and data.* Please note that you must show work for all calculations and **circle or box your final solution**. Each group in the lab is to complete and turn in his/her own post-lab assignment for grading with <u>only their partner(s)</u>.
Note: If the post-lab analysis is not turned in <u>within the first 15 minutes</u> of lab, it will be considered late, and the assignment will be automatically assigned a 20% grade deduction. An additional 10% deduction, will be added for each additional day the assignment is late.

Grading Scale
The following grading scale is guaranteed; final grades may be curved at the instructors' discretion.

Letter Grade	**Percentage**	**GPA score**
A+	≥ 100	4.0
A	≥ 94	4.0
A-	≥ 90	3.7
B+	≥ 87	3.3
B	≥ 83	3.0
B-	≥ 80	2.7
Letter Grade	Percentage	GPA score
C+	≥ 77	2.3
C	≥ 73	2.0

C-	≥ 70	1.7
D+	≥ 67	1.3
D	≥ 63	1.0
D-	≥ 60	0.7
F	< 60	0

Re-grade Policy: Students have the right to contest any grades throughout the semester. If a student feels an assignment has been inappropriately graded, the student must submit one typed page indicating the source of the problem and an explanation for the re-grade submission. Along with this document, the original assignment must be returned. Students have one week after the return of a graded assignment to protest a grade; after this time, grade disputes will not be accepted. Papers submitted for a re-grade will be completely re-evaluated (i.e., the entire paper will be re-graded, not only the portion under protest), which means that students may lose additional points for mistakes missed during the first grading process.

Topics Covered

Fundamentals of electrical measurements and properties, Ohm's law
Resistive models of biological systems
KCL, KVL, nodal analysis, conductivity of physiological solutions
Generation and measurement of bioelectric signals
Linearity, Thevenin equivalent, practical circuit models of voltage sources and voltmeters
Time varying bioelectric signals
Capacitors, step response of RC circuits
Bioelectric amplifiers
Operational amplifiers
Sinusoidal response of linear circuits
Lead/lag networks, phasor notation
Frequency response of RC models & frequency content of physiological signals
Phasor analysis of RC circuits, Fourier series
RLC model of the cochlea
2^{nd} order linear systems, step response, frequency response
Recording of physiological signals
Differential and Instrumentation amplifiers, common mode rejection ratio
Instrumentation design
Adequate magnitude and phase linearity and bandwidth, signal distortion, filtering

Course Procedures

During a typical week there will be one laboratory. The *lecture course* will introduce and cover the circuit analysis techniques to be utilized in one or more of the accompanying laboratories. The *laboratories* have been designed to provide a hands-on learning environment to explore and relate the circuit analysis concepts to bioelectricity (BME 301) and measurement of physiological events. As such, an attempt was made to create lab activities that contain either a wet lab experiment or a measurement of a physiological event on a living subject. Students successfully completing this course will obtain understanding of the criteria required to faithfully reproduce a physiological event as well as the ability to design, construct, and test simple measurement circuits.

Format of laboratory period: The pre-lab assignments are due online before coming to lab. There will be a brief introduction (5 – 15 minutes) to the lab provided by the Teaching Assistants at which time a brief quiz may be given. Students then execute the lab.
Laboratory Attire: Safety regulations require that you wear long pants (or equivalent) and closed-toe shoes while working in the laboratory.
Lab Group Composition: At the start of the semester, students will be paired into lab groups. Most lab groups will contain two students. No lab group will contain more than 3 students. The instructor of the course reserves the right to reassign lab partners at any point during the semester.

Completion of every lab is required to pass. Make-up work will be considered and assigned on a case-by-case basis. Email the lab coordinator to schedule a time to make-up the lab. ***To receive credit for the lab, a student must be in the lab on time, no more than 15 minutes late. A student who is more than 15 minutes late and who does not have an excused reason may receive a zero on the lab, including pre-lab quiz, laboratory notebook, as well as post-lab analysis.***

Format of office hours: Lab office hours will be held Monday through Thursday in MJIS 1097 from 7:00 – 9:00pm each week. If you are unable to attend the assigned office hours, please consult with a TA to set up alternative arrangements. Instructor office hours are open-door or made by appointment as indicated on the first page of the syllabus.
Academic Integrity
Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies.

Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that assignment, and at the instructor's discretion may result in a failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered.

Nondiscrimination Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. A hyperlink to Purdue's full Nondiscrimination Policy Statement is included in our course Brightspace under University Policies.
Accessibility

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.

Mental Health/Wellness Statement

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am – 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc., sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you are struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it related to COVID-19, students may submit requests for emergency assistance from the Critical Needs Fund.

Emergency Preparation

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructors' control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email. You are expected to read your @purdue.edu email on a frequent basis.

Active Emergency Response: **In case of fire, evacuate the building via the east doorways (towards S. Russell St.) if they are free of hazards. Do not use the west doorways as a primary exit as those will be the doors accessed by emergency responders and fire personnel. The primary Emergency Assembly Area location (after evacuating the building) is the outside courtyard and main entrance to Hockmeyer. This entrance faces Martin Jischke Drive. The secondary Emergency Assembly Area location, in case of inclement weather, is the interior main lobby of Hockmeyer.**

If "sheltering" owing to a tornado warning, immediately proceed to the MJIS basement hallway via the stairwell. Do not use the elevators. Be prepared to kneel facing a wall and cover your head.

If “sheltering” owing to an active shooter, building intruder, or a civil disturbance on campus, follow police instructions. In the absence of instructions, seek a safe location, preferable a room without windows that can be locked or secured by barriers.

Course Schedule (tentative)

WEEK	LAB ACTIVITY	ACCOMPANYING LECTURE TOPIC
1	*Lab 0 (Part 1) - LTSpice Walkthrough and Python Notebook*	Ohm’s law, Kirchhoff’s circuit laws (KCL & KVL)
2	Lab 0 (Part 2) – Intro to Components & Measurement Devices	Equivalent resistance, nodal analysis, mesh analysis
3	Lab 1 - Intro to voltage, current, resistive components, and measurement principles	Linearity, superposition, source transformation, Thévenin and Norton equivalents
4	Lab 2 – Simulation of core-resistive model and equivalent resistance	Capacitors & inductors, RC & RL circuits (1)
5	Lab 3 – Further analysis of voltage, current, and resistive circuits	Capacitors & inductors, RC & RL circuits (2)
6	Lab 4 – RC, RL, RLC intro and time constant measurement	Operational amplifiers, instrumentation amplifier
7	Lab 5 – Op-amps and Bioelectric Amplifiers	***Review***
8	***No lab***	Sinusoids, steady-state response, phasors
9	***Lab Practical (LTSpice, Circuit build, troubleshooting, circuit analysis, data presentation)***	Basic filter design, intro to Fourier analysis
10	***No Lab***	***Spring Break***
11	Lab 6 - Frequency response of RC circuits (phase, core-conductive model)	RLC circuits, resonance, bandwidth, quality factor
12	Lab 7 - Frequency content of physiological signals and bandwidth **(add RL)**	Laplace transforms, **s**-domain
13	Lab 8 - The RLC Model of the cochlea **(add RL)**	Electrodes, point response function, convolution
14	Design Project	Nerve stimulation
15		AC circuit power analysis
16		***Review***
Finals		

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite Changes to BME 25600: Physiological Modeling In Human Health
The Faculty of the School of Biomedical Engineering has approved the following requisites changes to BME 25600. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite Change for BME 25600: Physiological Modeling In Human Health

FROM:

BME 25600: Physiological Modeling In Human Health
Term Offered: Spring, Cr. 3
Pre-requisites: MA 16600 or MA 16200
Concurrent prerequisites: CS 15900 or ENGR 14200
Major Restriction: Biomedical Engineering only

TO:

BME 25600: Physiological Modeling In Human Health
Term Offered: Spring, Cr. 3
Pre-requisites: MA 16600 or MA 16200
Concurrent prerequisites: CS 15900 or CS 17600 or CS 18000 or ENGR 14200
Major Restriction: Biomedical Engineering only

RATIONALE:

Students can take alternatives to CS 15900 so this will eliminate the need to provide students with overrides and provide them with clarity regarding pre-requisites.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Adding online delivery section to an existing course BME 25600: Physiological Modeling in Human Health
The Faculty of the School of Biomedical Engineering has approved the following change to BME 25600. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requested Change for BME 25600: Physiological Modeling In Human Health

FROM:

BME 25600: Physiological Modeling In Human Health
Term Offered: Spring, Cr. 3
Pre-requisites: MA 16600 or MA 16200
Concurrent prerequisites: CS 15900 or CS 17600 or CS 18000 or ENGR 14200
Major Restriction: Biomedical Engineering only

TO:

BME 25600: Physiological Modeling In Human Health
Term Offered: Spring, Cr. 3
Adding asynchronous online delivery for just one of the two sections of this course.
Pre-requisites: MA 16600 or MA 16200
Concurrent prerequisites: CS 15900 or CS 17600 or CS 18000 or ENGR 14200
Major Restriction: Biomedical Engineering only

RATIONALE:

The growth of the BME program requires the offering of two course sections. One instructor, Babbs, is part-time at Purdue, while the other, Hiles, is full-time at Cook Biotech which necessitates asynchronous instruction. From years 2012 to 2020 this course was taught in an in-person; however, all lectures were recorded with Boilercast then being available 24/7. All exams including section and final exams have been 100% online since 2016. In the year 2021 we had two sections, one in-person and one asynchronous online. In the spring semesters of years 2022 and 2023 we had two in-person sections to accommodate an expanded class size, but over half the students did not attend lecture in person, instead choosing to watch lectures and take the exams all online. Given that teaching both sections in person is not sustainable for the teaching staff, and based on student attendance preferences we will revert to the paradigm used in 2021. We are requesting permission to teach just one section in-person and the second section asynchronous online only. Students will be given the option of which section they want to register for.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: New 300 level course – BME 31300: Biofluid Mechanics
The Faculty of the Weldon School of Biomedical Engineering has approved the following new 300-level course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

BME 30400: Biomedical Transport Fundamentals
Semesters offered: Fall
Total number of credits: 3 (3 lecture credits)
Prerequisites: (MA 26200 or [MA 26500 and MA 26600]) and ME 20000
Major Restriction: Biomedical Engineering only

TO:

BME 31300: Biofluid Mechanics
Semesters offered: Fall
Total number of credits: 3 (3 lecture credits)
Prerequisites: (PHYS 17200 or [ENGR 16100 and ENGR 16200]) and MA 26100 and (MA 26200 or [MA 26500 and MA 26600])
Major Restriction: Biomedical Engineering only

COURSE DESCRIPTION:

Fundamental concepts and principles of fluid mechanics in the context of biomedical applications. Governing equations of flow and transport are derived from the first principles and applied to conditions characteristic of the human circulatory system.

RATIONALE:

This course will replace and combine BME 30400 Biomedical Transport Fundamentals currently offered in West Lafayette and BME 44200 Biofluid Mechanics offered in Indianapolis to provide an integrated course introducing the principles of fluid dynamics in application to biomedical problems. This course (BME 31300) will be mandatory for junior-level students in the Biomechanics and Biomaterials Areas of Depth. The presentation of the material will be focused on fluid dynamics in cardiovascular circulation. Most of the topics related to heat and mass transport that were covered in BME 30400 will be shifted to more advanced Biotransport technical selective courses. Removing more advanced heat and mass transport topics from this introductory course (BME 31300) would allow the instructor to provide more practical examples and better relate the theory to cardiovascular flow in health and disease.
This course (BME 31300) is being created to achieve 4 goals:

- Incorporate more practical examples demonstrating applications of the derived flow equations to biomedical problems and better relate the theory to cardiovascular flow conditions in health and disease.

- Introduce biological fluid mechanics principles to junior-level students in BME program in West Lafayette and Indianapolis.
- Provide a required BME Area of Depth course in both the Biomechanics and Biomaterials Areas to serve as a solid foundation for more advanced courses in fluid dynamics, mass transport and heat transfer.
- Facilitate curriculum integration with existing IUPUI BME programs and courses.

BME 31300 Syllabus
BME 31300 Biofluid Mechanics
Fall 2024
-

This syllabus is subject to change with notice. For the most recent updates see https://purdue.brightspace.com

All class materials will be available online:
Brightspace: https://purdue.brightspace.com/

Class meetings will be held in MJIS 1097
Tuesday and Thursday 12:00-1:15 PM
Online interaction: Hotseat: https://www.openhotseat.org
Instructors: Vitaliy L. Rayz (WL) and Julie Y. Ji (PUI) **Office hours: TBD**
Email: vrayz@purdue.edu (V.L. Rayz) and jji@iupui.edu (J.Y. Ji) GTAs: TBD

How to Use Office Hours

UTA: **Questions on homework and class concepts,**
GTA: **Questions on homework, class concepts, and exam prep**
Instructor: **Classroom concepts and administrative issues.**

Prerequisite

PHYS 172, Math 261and Math 262/266 or equivalent

Catalog Description

Fundamental concepts and principles of fluid mechanics in the context of biomedical applications. Governing equations of flow and transport are derived from the first principles and applied to conditions characteristic of the human circulatory system.

Learning Outcomes

This course is designed to provide students with a foundation in understanding and solving fluid dynamics and transport problems in biomedical engineering applications.
At the end of the semester, each student will be able to:

Formulate differential equations and determine appropriate boundary conditions to model biomedical fluid mechanics problems
Apply conservation laws of flow physics to describe the fluid flow in various geometries, particularly for flow in a cylindrical tube.
Recognize and quantitatively describe flow conditions characteristic of blood flow in human circulation in health and disease.

Textbook

Biofluid Mechanics: An Introduction to Fluid Mechanics, Macrocirculation and Microcirulation by David Rubenstein, Wei Yin, and Mary D. Frame. Academic Press, 2011 (ISBN: 9780128009444)

Supplemental textbooks:

Transport Phenomena in Biological Systems, 2nd edition. G.A. Truskey, F. Yuan, and D.F. Katz. Pearson Prentice Hall. 2009. (ISBN: 0-13-156988-0)

A Brief Introduction to Fluid Mechanics, 4th Edition by Donald F. Young, Bruce R. Munson, Theodore H. Okiishi, Wade W. Huebsch. John Wiley & Sons (ISBN: 9780470039625)

Vital Circuits: On Pumps, Pipes, and the Workings of Circulatory Systems, Steven Vogel. Oxford University Press, 1992.

Biofluid Mechanics: The Human Circulation by Krishnan B. Chandran, Stanley E. Rittgers, Ajit P. Yoganathan. CRC Press, Taylor & Francis

How Final Grades will be Determined

Assessment Mechanism	Weighting
Hotseat participation and graded responses	**15%**
Homework	**20%**
Midterm exam 1	**20%**
Midterm exam 2	**20%**
Final exam	**25%**

Grade Ranges

Grade	GPA	Value Range
A+, A	4.0	93-100
A-	3.7	90.0-92.9
B+	3.3	87.0-89.9
B	3.0	83.0-86.9
B-	2.7	80.0-82.9
C+	2.3	77.0-79.9
C	2.0	73.0-76.9

C-	1.7	70.0-72.9
D+	1.3	67.0-69.9
D	1.0	63.0-66.9
D-	0.7	60.0-62.9
F	0.0	< 60.0

NOTE: The scale can change per instructor discretion so that a given grade may fall into a lower bin range (i.e. A, A+ could drop down to 83-90) if the instructor deems it necessary. Under no circumstances will the reverse occur.

Course Policies

Grade dispute

If a student believes that a problem was graded incorrectly the student should resubmit, to the instructor, the work and a paragraph describing what error was made in grading. This should be submitted within a week after receiving the disputed grade. The instructor reserves the right to re-grade the entire exam if an error is found. Note that all exams and quizzes are photocopied and archived prior to returning the graded material to the students.

Classroom active learning involvement – 15%

Hotseat will be regularly used to ask questions from the current and previous lectures. A correct answer to the question will earn you a point, while submitting a wrong answer will earn you only a quarter of a point for participation. **Students are expected to respond to Hotseat Polls without discussing the answers with their peers**. Additional involvement by way of asking questions in class during the lectures and attending online office hours will also factor in to the final grade.

Homework 20%

A homework assignment will be handed out for each major topic covered in class. Unless otherwise specified, all homework problems are due in one week and **should be submitted online**. You are expected to solve all assigned problems, although the TAs will grade only some of the problems to determine your homework score. You will be given solutions to all problems to check your work. Questions regarding the homework problems or grading should be addressed to the TAs.

Missed or Late Work

Late work can be submitted with a 10% deduction per late day. No late homework will be accepted once the solution is posted online.

Midterm examinations – 40% Total

The midterm exams will cover material up through the material covered on the date specified in the syllabus timeline. **The exam is open notes and will test your ability to solve problems, not recall facts**.

Final examination 25%

The scheduled final examination time TBD. The exam will be comprehensive (including all covered material) and open notes.

Academic Integrity

Student Honor Pledge - *"As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."*

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern.
Any form of cheating will result in a penalty up to automatic "F" grade for the course. All instances of cheating will be forwarded to the Office of Student Rights and Responsibilities for appropriate disciplinary action.
Helping another student to cheat and cheating are considered equal cases of academic dishonesty and will be treated as outlined above.
Giving another student an electronic copy of your homework, or access to your computer account constitutes cheating on your behalf if that other student copies or uses any files that become implicated in a cheating case.
For a complete definition of academic dishonesty see
http://www.purdue.edu/ODOS/osrr/integrity.htm

Course Evaluation

During the last two weeks of the course, you will be provided with an opportunity to evaluate this course and your instructor. Purdue uses an online course evaluation system. You will receive an official email from evaluation administrators with a link to the online evaluation site. You will have up to two weeks to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. It is strongly encouraged that you participate in the evaluation system.

Tentative Course Schedule **(subject to change)**

DATE	LECTURE
Lecture 1	Course Introduction. Brief history of fluid mechanics. Dimensions and Units.
Lecture 2	Introduction to convective and diffusive transport in biological systems. Continuum, density, and viscosity.
Lecture 3	Convective and diffusive transport – continued: Reynolds and Peclet numbers
Lecture 4	Mathematical background: vectors, temporal and spatial gradients
Lecture 5	Fluid Statics.
Lecture 6	Eulerian and Lagrangian description of the flow. Velocity, acceleration, shear stress.
Lecture 7	Control volume; Reynolds transport theorem; Conservation of mass.
Lecture 8	Linear Momentum Balance; Mass and momentum conservation examples
Lecture 9	Energy Balance; Momentum and energy conservation examples
Lecture 10	Differential Form of the Conservation Equations. Gauss theorem.
Lecture 11	Dimensional analysis and similarity.
Lecture 12	Dimensionless numbers in biofluid dynamics and transport
Lecture 13	Midterm review. Solving example problems.
Lecture 14	**Midterm Exam 1**
Lecture 15	Off, October Break
Lecture 16	Flow viscosity, rate of strain and shear stress tensors.
Lecture 17	Navier-Stokes equation.
Lecture 18	Solving viscous flow problems; Flow in cylindrical tubes
Lecture 19	Solving viscous problems continued; Cylindrical coordinates, concentric cylinders.
Lecture 20	Dimensionless Navier-Stokes equation – High and low Reynolds number flow
Lecture 21	Boundary layer theory
Lecture 22	Blood flow in large arteries; Entrance length, secondary flow, pulsatile flow, turbulence.
Lecture 23	Hemodynamic forces; Flow separation and adverse pressure gradients
Lecture 24	Diffusion of species; Material Balance Equation.
Lecture 25	Convection and diffusion in human circulation.
Lecture 26	Midterm Review. Solving example problems
Lecture 27	**Midterm Exam 2**
Lecture 28	Off, Thanksgiving
Lecture 29	Microcirculation, blood composition, viscometers
Th. Nov 30	Introduction to vessel wall mechanics
Lecture 31	The human circulation in health and disease.
Lecture 32	Summary and Review
TBD	**Final Exam** [Cumulative Topics]

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite Changes to BME 31400: Experimental Methods in Biomechanics
The Faculty of the School of Biomedical Engineering has approved the following requisite changes to BME 31400. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite Change for BME 31400 Experimental Methods in Biomechanics

FROM:

BME 31400: Experimental Methods in Biomechanics
Term Offered: Spring, Cr. 3
Pre-requisites: BME 21400
Major Restriction: Biomedical Engineering only

TO:

BME 31400: Experimental Methods in Biomechanics
Term Offered: Spring, Cr. 3
Pre-requisites: BME 21400 and BME 21401 and MA 26100 and (MA 26200 or [MA 26500 and MA 26600])
Major Restriction: Biomedical Engineering only

RATIONALE:

MA courses and Biomechanics lab (BME 21401) are needed to be successful in this course so are now included as pre-requisites.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: New 300 level course – BME 32000: Introduction To Biomaterials Science And Engineering
The Faculty of the Weldon School of Biomedical Engineering has approved the following new 300-level course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

BME 32000: Introduction To Biomaterials Science And Engineering
Semesters offered: Fall
3 total credits; Lecture
Prerequisites: BME 22000 or BCHM 30700 or BCHM 56100
Major Restriction: Biomedical Engineering only

COURSE DESCRIPTION:

This junior-level course will introduce fundamental materials science and biomaterial concepts to BME students and will lay the foundation for more advanced courses in biomaterials and tissue engineering. The course will introduce the vocabulary and technical concepts in biomaterials science relevant for problems in medical device, biotechnology, or biomaterials industries. The course material will present phenomena at the intersection of materials science and biology.

RATIONALE:

This new course is created to introduce students to materials science fundamentals essential for all areas of BME specialization and will be mandatory for all junior-level students. The material will provide a solid foundation for more advanced classes in the newly created Biomaterials Area of Depth as well as provide the breadth of knowledge to students in other Areas of BME specialization. The practical counterpart for this course will be provided in the newly developed Biomolecules and Biomaterials Laboratory BME 32001 (accompanying EFD).

BME 32000 is being created to achieve 3 goals:
To ensure breadth of BME curriculum by introducing the fundamentals of Biomaterials Science and Engineering
Provide a solid base for more advanced courses offered in Biomaterials Area of Depth
Facilitate curriculum integration with existing IUPUI BME programs and courses

BME 32000 Syllabus
Course Information

Course number and title: BME 320 ***Introduction to Biomaterials Science and Engineering***
Meeting time: TBD

Course credit hours: 3 credits
Prerequisites (if any): BME 22000 FOR LEVEL UG WITH MIN. GRADE OF D-
Information About the Instructor(s)
The key is to provide information as to the ways the student can reach you (Blackboard, email, phone, and/or text). If additional individuals are key contact persons (TAs, co-instructors, etc.), include information for them as well.

Name of the instructor(s): Dr. Taimoor Qazi
Email Address: tqazi@purdue.edu
Office hours, times and location: TBD
Course Description
This junior-level course will introduce fundamental materials science and biomaterial concepts to BME students and will lay the foundation for more advanced courses in biomaterials and tissue engineering. The course will introduce the vocabulary and technical concepts in biomaterials science relevant for problems in medical device, biotechnology, or biomaterials industries. The course material will present phenomena at the intersection of materials science and biology.
Learning Outcomes
At the end of this course, students should be able to:
- Identify the basic classes of biomaterials and understand their chemical makeup
- Understand the relationship between chemical structure and biomaterial properties
- Understand interactions of implantable biomaterials with proteins and cells
- Describe the major components of the biological response to implanted materials
- Select basic in vitro and in vivo tests to evaluate material biocompatibility
- Understand regulations and standards that dictate biomaterial testing

Learning Resources, Technology, & Texts

Suggested text:
Biomaterials Science: An Introduction to Materials in Medicine by Ratner, Buddy D., et al. 3rd ed. Burlington, MA: Academic Press, 2012.
Assignments and Points
Quizzes: 20% [one quiz per week, top 10 selected for final grade]
Mid-term: 40% [2 x 20%]
Group project + presentation: 10%
Final: 30%

Course Schedule

Introduction to materials science and applications of biomaterials in medicine
Classes of biomaterials: Metals:- properties, application as biomaterials
Classes of biomaterials: Ceramics:- properties, application as biomaterials
Classes of biomaterials: Polymers:- properties, application as biomaterials
Classes of biomaterials: Composite, Hybrid, and Natural Materials
Biomaterials fabrication and manufacturing: methods and state of the art (micro/nano structures, topographies, porosities, shapes, curvatures, etc.)
Testing of biomaterials: characterization methods and analysis of properties

Biodegradability of implantable biomaterials: Bulk and surface properties
Interaction of biomaterials with proteins and cells
Inflammation, wound healing, and the foreign body reaction (FBR) to biomaterial implantation
Immune response to materials; coagulation and blood-material interactions; infections and systemic effects
Biocompatibility and cytotoxicity
Regulatory consideration for biomaterials translation
Clinical application of biomaterials
Project topics (biomaterial applications in…): drug delivery, tissue engineering, wound repair, disease modeling, diagnostics etc.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: New 300-level course – BME 32001: Biomolecules And Biomaterials Laboratory
The Faculty of the Weldon School of Biomedical Engineering has approved the following new 300-level course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

FROM:

BME 20500: Biomolecular and Cellular Systems Laboratory Semesters offered: Spring
Total number of credits: 1 (1 lab credit)
Concurrent Prerequisite: BIOL 23000 and BME 20100
Major Restriction: Biomedical Engineering only

TO:

BME 32001: Biomolecules And Biomaterials Laboratory
Semesters offered: Fall
Total number of credits: 1 (1 lab credit)
Concurrent Pre-requisites: BME 32000
Prerequisites: (BME 22000 or BCHM 30700 or BCHM 56100) and BME 21400 and BME 21401
Major Restriction: Biomedical Engineering only

COURSE DESCRIPTION:

Introductory laboratory experience focused on engineering concepts and practices in the analysis of biomolecules and cells. Topics include fundamental quantitative techniques of analysis, methods of isolation, identification, and quantification of biomolecules and cells, evaluation of biocompatibility, and analysis of integrated bio-systems. This course concludes with an experimental design project.

RATIONALE:

This course is being created to provide practical components for two prior or co-occurring lecture courses: BME 22000 Biomolecules: Structure, Function, and Engineering Applications and BME 32000 Introduction to Biomaterials Science and Engineering. BME 32001 (this EFD) will contain the lab material previously taught in sophomore-level BME 20500 Biomolecular and Cellular Systems Laboratory as well as the new lab material for junior-level BME 32000 (accompanying EFD). The addition of cell culture modules to 32001 and the creation of an experimental based design project are the most significant changes from the previous BME 20500 laboratory.

This course (BME32001) is being created to achieve 3 goals:
Facilitate curriculum integration with existing IUPUI BME programs and courses.
To provide a practical component for the newly designed BME 32000 lecture.
Update course numbers to more closely align depth area courses, and for lab course numbers to better align with the corresponding lectures.

BME 32001 Course Syllabus

BME 32001: Biomolecules and Biomaterials Laboratory
Syllabus and Course Manual
Face-to-Face Instruction
Fall 2025

Instructor of Record/Lab Coordinator:
Dr. Michael Linnes Office: MJIS 1055 Ph: 765-496-2870
email: mlinnes@purdue.edu Office hours: By appointment

Course TAs:

TA Office Hours: Monday – Thursday: 7-9 PM in MJIS 1097

Class Location: MJIS 1053
Lab:
One of the following:
List CRNs and Section times here

Pre-requisites:
BME 20100 Biomolecules -> BME 22000 "Biomolecules: Structure, Function, and Engineering Applications
~~BIOL 23000 "Biology of the Living Cell~~" (No longer needed as it's now a pre-req for BME 22000)
BME 21400 "Introduction to Biomechanical Analysis"
BME 21401 "Fundamentals of Biomechanical Analysis Laboratory"

Course Description:
Introductory laboratory experience focused on engineering concepts and practices in the analysis of biomolecules and cells. Topics include fundamental quantitative techniques of analysis, methods of isolation, identification, and quantification of biomolecules and cells, evaluation of biocompatibility, and analysis of integrated bio-systems. This course concludes with an experimental design project.

Course Learning Outcomes:
Upon completion of the course each student will have the ability to:
Independently describe the theoretical basis of, and put into practice, fundamental analytical tools and techniques used in the isolation, characterization, and quantification of biomolecules and cells. Collect, record, process, statistically analyze, and report experimental data related to the analysis of biomolecules and cells in an accurate and understandable manner
Conceptually design and experimentally evaluate a simple analytical method and/or tool for solving a medically' relevant problem based upon detection/analysis of a specific biomolecular or cellular related abnormality.

Brightspace (Learning Management System): All information regarding this course (syllabi, assignments, assignment submissions, lab manuals, tutorials, videos, etc) will be distributed and collected via purdue.brightspace.com.
Gradescope: All quizzes and graded material will be submitted on Gradescope. Grades will be transferred to Brightspace after each assignment is graded and again at the end of the semester. Any regrades will show in Gradescope, but may not be reflected in Brightspace until the end of the semester.

Required Supplies:
Laboratory Notebook (may be electronic)
Writing Utensil

Credits: 1

Emergency Policy/Procedures:

Campus Emergency Policy: In the event of a campus wide emergency the class outline and course requirements may be subject to change. The course instructor will provide information in regards to changes in the course requirements or course schedule as a result of a campus wide emergency.

Response Procedures:

http://www.purdue.edu/fire/safety_handbook.pdf

Fire Alarm – Evacuate MJIS 1061 through the south door (nearest the elevator); then, leave the building through the doors which exit to the east side of the building (back of the building near the construction of the Herrick Labs extension). Only gather personal items if it does not jeopardize your safety. Assist those who need help. Proceed to the front lawn Lilly Hall of Life Sciences (corner of State St. and S. Russell Dr.) **Report to a course instructor your name before leaving the emergency assembly area.**
All hazards warning (Tornado, hazardous release, civil unrest, etc.) – When you hear the all hazards alarm immediately seek shelter (**Shelter-In-Place**) in a safe location. For a tornado, proceed to the basement of MJIS, using either the stairwell on the northwest side (by the police station) or the southeast side (across from MJIS 1087).
Campus Emergency Policy: In the event of a major campus emergency, course requirements, deadlines, and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. If an emergency should occur, check Brightspace and your Purdue email accounts to learn about modifications to the course.

Overall Expectations:

Academic Conduct: You are expected to behave in a professional and ethical manner in all aspects of this course. Only through rigor and practice does one become a competent engineer that contributes to society. Plagiarism and cheating undermine that process. Plagiarism or cheating will result in a zero for that particular assignment. Instances of unethical behavior will be reported to the Dean of Students Office and will result in a grade reduction of at least one letter grade. If an individual behaves unethically during the semester, the instructor reserves the right to fail the student. For more information, see Purdue University Student Conduct Code at:
https://www.purdue.edu/odos/osrr/resources/documents/academic_integrity.html
The student is also expected to respect course instructors and contribute to a positive atmosphere in the class. Undermining or disruptive behavior will be reflected in your participation grade.

Protect Purdue Pledge:
By attending Purdue you assume the responsibility of being a part of the Boilermaker community and assume the responsibilities of the Protect Purdue Pledge:
Being a part of the Boilermaker community means that each of us must take extraordinary steps to stay well and persistently protect each other, on campus and in the community. Accountable together, I pledge to take responsibility for my own health, the protection of others and help keep the Purdue community safe from spread of COVID-19 and other infections as identified and instructed by the university.
https://protect.purdue.edu/pledge/

Expectations for Laboratory:

Laboratory Attire: Safety regulations require that you wear pants, closed-toe shoes, gloves, and goggles (when necessary) while working in the laboratory. You will not be allowed to work in the lab if you are wearing proper personal protective equipment.

Class Attendance: In the case class is missed due to extenuating circumstances (e.g., death in family, illness), the course instructor should be contacted immediately (prior to class, if possible) and written documentation through the Office of the Dean of Students (ODOS) will be required. Makeup work will be considered and assigned on a case by case basis. *To receive credit for the lab, a student must be in the lab on time, no more than 15 minutes late. A student who is more than 15 minutes late and who does not have an excused reason may receive a zero on the lab.*

Lab Safety: See the lab safety document posted on Brightspace. It provides some general safety precautions and guidelines that apply to all laboratory activities associated with this course. In addition, each lab will spell out specific safety issues that apply to that week's lab activities. For more complete information on laboratory safety items, you may also contact a lab instructor, or call REM directly (4-0121). REM is the Radiological and Environmental Management agency on Purdue's campus; they oversee lab safety practices on campus.

Graded Course Material:

Pre-lab Quizzes & Online Material: It is expected and required that students watch and learn the material presented in the online lectures available through Brightspace. This material is to be learned prior to coming to lab each week it is assigned. The course schedule details when each lecture is assigned. Watching and learning this material is part of the lecture component of the course. This includes the completion of short pre-lab quizzes given in Gradescope that test your retention of the pre-lab material. The pre-lecture quiz is due by 11:59 pm on the Monday before lab. This is the same for all sections. During week 1, this deadline will be extended until Thursday at midnight.

Post Lab Analysis: Each lab protocol will contain answer boxes that need to be filled out. Some of these will be filled out during lab and others will need some work post-lab to complete. These protocols will need to be scanned in and submitted to gradescope no later than Friday at 11:59 PM on the week following your lab week. Most labs you will complete should allow you to finish 80-90% of this document in-lab. This due date is the same for all sections.

One submission is required per lab group. If students do not assign pages in gradescope, 10% may be deducted from the assignment.

Laboratory Notebook: Each lab group must maintain a laboratory notebook or electronic notebook. A lab notebook is used to document work in a research setting; it details what was done, when it was done, and who did it. Whether your career takes you into an industrial or academic research setting, you will be expected to maintain a proper lab notebook. In these settings, notebooks become important legal documents which can be used to submit a patent claim and credit an original discovery. **Electronic notebooks (via Microsoft Word or similar) are encouraged.** Scanned copies of your hard copy notebooks that are completed in a legible manner in ink will also be accepted for this course. There will be periodic **notebook checks** to make sure that you are documenting your work.

Please visit the lab notebook document on Brightspace for further explanation and examples of what should be included in your lab notebook.

Formal Lab Reports*:* At the conclusion of the genetic engineering labs, your group will write a formal lab report. This will include an abstract, introduction, materials & methods, results, discussion/analysis, and conclusion sections. The ability to integrate ideas will demonstrate that you have fully achieved the objectives of the lab exercises; this is an important part of your lab report. It is up to your team to

integrate the concepts from your work in each module; the background and conclusions sections may be excellent choices to tie the experiments and results together. Review the Formal Lab Report Guidelines on Brightspace for more details.

Final Design Project: In this course you will explore the engineering design process: information gathering, problem definition, idea generation, and evaluation and decision making. In addition, an experimental based design project related to biomaterials will be required. Both a final report and a team-based oral presentation will be required upon completion of the design project. Refer to the final design project document on Brightspace for specific details on the design project assignments and due dates.

Final Exam: There will be no final exam for this course during.

Late Submissions: No late pre-lab quiz submissions will be accepted. Late lab reports, notebook checks, formal lab reports, and final design project submissions will lose 25%/day including weekend days. Late work should be submitted to Brightspace or emailed directly to the Lab Coordinator.

Course Reviews

Online Course Evaluations: You must complete all online course evaluations for this class AND submit to the lab coordinator evidence of survey completion before finals week. If no evidence of survey completion is submitted you <u>will receive a zero for the individual participation and rigor part of your grade.</u>

Course Grading:

The following grading scale is a guaranteed minimum; however, based upon student performance, final grades may be curved by the instructor.*

Letter Grade	Percentage	GPA score
A+	≥ 98	4.0
A	≥ 94	4.0
A-	≥ 90	3.7
B+	≥ 87	3.3
B	≥ 83	3.0
B-	≥ 80	2.7
C+	≥ 77	2.3
C	≥ 73	2.0
C-	≥ 70	1.7
D+	≥ 67	1.3
D	≥ 63	1.0
D-	≥ 60	0.7
F	60 >grade>0	0

Grade Breakdown:

30% Individual Grade / 70% Group Grade

Pre-lab Quizes (Individual)	15 %
Post-lab Scans (Group)	25 %
Notebook Checks (Group)	10 %
Formal Lab Report (Group)	10 %
Final Design Project (Group)	25 %
Participation and Rigor (Individual)	15 %*

***** Completion of the course evaluation is included as part of the participation and rigor.

Re-grade Policy: Students have the right to contest any grade throughout the semester. Once an assignment has been graded and returned, students have **1 week** to protest a grade via gradescope; after this time grade disputes will not be accepted.

Course Schedule:

			Deliverables		
Week	**Lab**	**Topic:**	**Prelab + Quiz Due 11:59 pm on Mon of lab week:**	**Post-lab Scan Due 11:59 pm on Friday following lab:**	**Formal Report + Notebook Checks**
1	1	Lab Introduction: Pipetting, pH meter, making solutions, introduction to cell culture, Plasmid DNA isolation	x	x	
2	2	Cell culture and microscopy technique	x		
3	3	Cell Culture: Biocompatibility Part I			
4	4	Cell Culture: Biocompatibility Part II		x	
5	5	Genetic Engineering I: Restriction digestion, agarose gel electrophoresis, gel extraction, PCR	x	x	**Notebook Check 1**
6	6	Genetic Engineering II: DNA ligation, transfection, starter culture, sequencing	x	x	
7	7	Synthetic Biology: Transcriptional control, protein expression, and protein isolation	x	x	
8	8	Protein Engineering: Antibodies and Protein detection	x	x	**Notebook Check 2:**
9					**Formal Lab Report**
10	9	Experimental Design Project I			
11	10	Experimental Design Project II			
12	11	Experimental Design Project III			
13					
14		Team-Based Oral Presentations			
15		Written Design Project Due			
16					

*Laboratory topic weeks and assignment due dates are subject to change, as needed.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite and Course Number Change to BME 30100: Bioelectricity
The Faculty of the School of Biomedical Engineering has approved the following requisite and course number change to BME 30100. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite and Course Number Change for BME 30100 Bioelectricity

FROM:
BME 30100: Bioelectricity
Term Offered: Fall, Cr. 3
Pre-requisites: BME 20700 and (MA 26200 or [MA 26500 and MA 26600])
Major Restriction: Biomedical Engineering only

TO:

BME 33000: Bioelectricity
Term Offered: Fall, Cr. 3
Pre-requisites: BME 23100 and BME 23101 and (MA 26200 or [MA 26500 and MA 26600])
Major Restriction: Biomedical Engineering only

RATIONALE:
Course number is changing to better align courses with research areas. Pre-requisite BME 20700 has changed numbers and has been separated into a lecture (BME23100) and lab (BME 23101) portion, so this change is also reflected.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite and Course Number Change to BME 36600 Foundations of Biomedical Data Science

The Faculty of the School of Biomedical Engineering has approved the following requisite and course number change to BME 36600. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.

Requisite and Course Number Change for BME 36600: Foundations of Biomedical Data Science

FROM:

BME 36600: Foundations of Biomedical Data Science
Term Offered: Spring, Cr. 3
Concurrent prerequisites: STAT 35000 or STAT 51100
Major Restriction: Biomedical Engineering only

TO:

BME 35700: Foundations of Biomedical Data Science
Term Offered: Spring, Cr. 3
Concurrent prerequisites: STAT 35000 or STAT 51100 or BME 32200
Major Restriction: Biomedical Engineering only

RATIONALE:

Course number is updated to reflect its place in depth area grouping. Additionally, the BME statistics course taught at Purdue Indianapolis is added to eliminate the potential need for overrides and to provide students with accurate pre-req information.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite Changes to BME 36000: Introduction to Biomedical Imaging
The Faculty of the School of Biomedical Engineering has approved the following requisite changes to BME 36000. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite Change for BME 36000: Introduction to Biomedical Imaging

FROM:

BME 36000: Introduction to Biomedical Imaging
Term Offered: Fall, Cr. 3
Pre-requisites: BME 20700 and ECE 30100
Major Restriction: Biomedical Engineering only

TO:

BME 36000: Introduction to Biomedical Imaging
Term Offered: Fall, Cr. 3
Pre-requisites: BME 23100
Major Restriction: Biomedical Engineering only

RATIONALE:

Pre-requisite BME 20700 has changed numbers and has been separated into a lecture (BME 23100) and lab (BME 23101) portion, so this change is reflected. Only the lecture portion is required as a prerequisite for this course. Additionally, ECE 30100 is removed as a pre-requisite because it was previously used as a way to ensure that students follow a desired path through the depth areas, which is now made more flexible.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Credit, Description and Requisite Changes to BME 38000 Professionalization In Biomedical Engineering

The Faculty of the School of Biomedical Engineering has approved the following credit, description, and requisite changes to BME 38000. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.

Credit, Description and Requisite Change for BME 38000 Professionalization In Biomedical Engineering

FROM:

BME 38000: Professionalization In Biomedical Engineering
Term Offered: Fall, 1 credit Studio
Pre-requisites: BME 29000
Major Restriction: Biomedical Engineering only

This active learning course covers standards of practice, regulatory and legal requirements, and moral and ethical issues; increases awareness of career paths; and addresses current and emerging trends and challenges at the frontiers of the field of biomedical engineering. Most class sessions will consist of a short introduction to a topic followed by a breakout session for active investigation of the topic. During the breakout sessions, course instructors will be available to guide discussion and answer questions.

TO:

BME 38000: Professionalization In Biomedical Engineering
Term Offered: Fall, 2 credit Studio
Pre-requisites: BME 28000
Major Restriction: Biomedical Engineering only

This active learning junior level course will enrich Biomedical Engineering students' professional development, including career exploration strategies and intercultural competency development. This course will prepare students to secure opportunities and succeed in diverse learning and work environments at Purdue and beyond. Most class sessions will consist of a short introduction to a topic and a case study followed by a breakout session for active investigation of the topic. During the breakout sessions, course instructors will be available to guide discussion and answer questions.

RATIONALE:

1) Pre-requisite course number has changed from BME 29000 to BME 28000.
2) The course has become more robust, necessitating an increase in credit hours to accommodate content, assessment and pedagogy of intercultural learning modules.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite Changes to BME 38900: Junior Experimental Design Laboratory
The Faculty of the School of Biomedical Engineering has approved the following requisites changes to BME 38900. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite Change for BME 38900: Junior Experimental Design Laboratory

FROM:

BME 38900: Junior Experimental Design Laboratory
Term Offered: Spring, Cr. 2
Pre-requisites: BME 20100 and BME 20500 and BME 20600 and BME 20700 and ME 20000
Concurrent prerequisites: BME 39000 and (STAT 35000 or STAT 51100)
Major Restriction: Biomedical Engineering only
Repeatable for Additional Credit: Yes - May be repeated an unlimited number of times

TO:

BME 38900: Junior Experimental Design Laboratory
Term Offered: Spring, Cr. 2
Pre-requisites: BME 32000 and BME 21401 and BME 23101 and BME 32001 and (ME 20000 or BME 20200)
Concurrent prerequisites: BME 39000 and (STAT 35000 or STAT 51100 or BME 32200)
Major Restriction: Biomedical Engineering only
Repeatable for Additional Credit: No

RATIONALE:

The BME required lab courses have been redesigned, so these changes are reflected (21401, 23101, and 32001). Additionally, there is a new required biomaterials course (BME 32000) that students must pass to be successful in this course. The new biomaterials course in turn requires content from the previous prereq (BME 201) therefore accounting for those learning outcomes. There is also now a permanent BME alternative (BME 20200) to ME 20000 that covers equivalent material.
This course was also mistakenly set up to be repeatable for additional credit which is corrected with this document.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite and Course Number Change to BME 41000: Neural Engineering
The Faculty of the School of Biomedical Engineering has approved the following requisite and course number change to BME 41000. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite and Course Number Change for BME 41000 Neural Engineering

FROM:
BME 41000: Neural Engineering
Term Offered: Spring, Cr. 3
Pre-requisites: BME 30100 or ECE 30100
Major Restriction: Biomedical Engineering only
TO:

BME 43100: Neural Engineering
Term Offered: Spring, Cr. 3
Pre-requisites: BME 23100 and BME 23101 and (MA 26200 or [MA 26500 and MA 26600])
Major Restriction: Biomedical Engineering only

RATIONALE:
Course number is updated to reflect its place in depth area grouping. Material covered in BME 23100 and BME 23101 and MA 26200/26500/26600 are adequate for students to be successful in the course. BME 30100 or ECE 30100 was previously required for all students. Now that they are no longer required courses, we are removing them as prerequisites so that this course is not limited to only students in the bioinstrumentation depth area.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite Changes to BME 45000 Deep Learning For Medical Imaging
The Faculty of the School of Biomedical Engineering has approved the following requisite changes to BME 45000. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite Change for BME 45000 Deep Learning For Medical Imaging

FROM:

BME 45000: Deep Learning For Medical Imaging
Term Offered: Spring, Cr. 3
Pre-requisites: ECE 30100 or CS 38003
Major Restriction: Biomedical Engineering only

TO:

BME 45000: Deep Learning For Medical Imaging
Term Offered: Spring, Cr. 3
Pre-requisites: (CS 15900 or CS 17600 or CS 18000) and MA 26100 and (MA 26200 or [MA 26500 and MA 26600])
Major Restriction: Biomedical Engineering only

RATIONALE:

Pre-requisites align with required courses for all BME students and better reflect material needed to be successful in the course. ECE 30100 or CS 38003 were previously required to ensure that students have prior exposure to python coding. Students currently receive multiple interactions with various coding languages (including python) throughout the first year and required prerequisite BME courses removing the need for both.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite changes to BME 46000 Cardiovascular Mechanical Support and Devices
The Faculty of the School of Biomedical Engineering has approved the following requisite changes to BME 46000. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite Change for BME 46000 Cardiovascular Mechanical Support and Devices

FROM:

BME 46000: Cardiovascular Mechanical Support and Devices
Term Offered: Fall, Cr. 3
Pre-requisites: BME 25600 and ME 20000 and (MA 26200 or [MA 26500 and MA 26600])
Major Restriction: Biomedical Engineering only

TO:

BME 46000: Cardiovascular Mechanical Support and Devices
Term Offered: Fall, Cr. 3
Pre-requisites: BME 25600 and (ME 20000 or BME 20200) and (MA 26200 or [MA 26500 and MA 26600])
Major Restriction: Biomedical Engineering only

RATIONALE:

BME thermodynamics course (BME 20200) added to be a pre-req equivalent to ME 20000.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite Changes to BME 47000 Biomolecular Engineering
The Faculty of the School of Biomedical Engineering has approved the following requisite changes to BME 47000. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite Change for BME 47000 Biomolecular Engineering

FROM:

BME 47000: Biomolecular Engineering
Term Offered: Fall, Cr. 3
Pre-requisites: (BME 20100 and BME 20500) or BIOL 23000
Major Restriction: Biomedical Engineering only

TO:

BME 47000: Biomolecular Engineering
Term Offered: Fall, Cr. 3
Pre-requisites: BME 22000 or BIOL 23000
Major Restriction: Biomedical Engineering only

RATIONALE:

Changes reflect course number updates (BME 20100 is becoming BME 22000). In addition, the previous BME 20500 lab is being redesigned and moved to the Junior year and therefore cannot be included as a pre-requisite.

TO: The Engineering Faculty
FROM: The Faculty of the Weldon School of Biomedical Engineering
RE: Requisite Changes to BME 48901: Senior Design Project Lab
The Faculty of the School of Biomedical Engineering has approved the following requisite changes to BME 48901. This action is now submitted to the Engineering Faculty with a recommendation for Fast Track approval.
Requisite Change for BME 48901: Senior Design Project Lab

FROM:

BME 48901 Senior Design Project Lab
Terms offered: Fall, Lab 8, Cr. 3
Prerequisite: BME 38900 and (BME 30100 and ECE 30100) or (BME 30400 and BME 31400) or (ECE 30100 and BME 36000) or (BME 35600 and BME 36600)
Concurrent Prerequisite: BME 49000
Major Restriction: Biomedical Engineering only

TO:

BME 48901 Senior Design Project Lab
Terms offered: Fall, Lab 8, Cr. 3
Prerequisite: BME 38900 and (BME 33000 and [ECE 30100 or BME 33100]) or (BME 31300 and BME 31400) or ([ECE 30100 or BME 33100] and BME 36000) or (BME 35600 and BME 35700) or (BME 31300 and BME 38800)
Concurrent Prerequisite: BME 49000
Major Restriction: Biomedical Engineering only

RATIONALE:

The Depth Area courses have been updated. There is a new Biomaterials Depth Area which has been added as an equivalent pre-req to the course.