Course Information

- BME 56100 – Preclinical and Clinical Study Design
- CRN xxxxx
- Meeting time: Wednesday 4:30-5:45 pm Eastern time for in-person sections; additional time required to view asynchronous course material
- 3.0 Credit Hours
- Course Brightspace page: tbd
- On-campus location: MJIS 1083
- This course is designed for online as well as on-campus delivery. All course sections (on-campus and online) are combined into one section within Brightspace. Students will find lecture resources and recordings, assignments, grades, and other class-related materials in Brightspace.
- Prerequisites: None

Instructor Contact Information

- Instructor: Aaron Lottes, PhD, MBA, Associate Professor of Engineering Practice, Weldon School of Biomedical Engineering
- Teaching Assistant: tbd
- Office Location: MJIS 1021F; 765-496-6024
- Email Address: lottes@purdue.edu
- Office hours: by appointment
- Instructor may be reached via email, Brightspace, office location, or phone

Course Description

Medical devices are developed, manufactured, and distributed in a highly regulated environment. This course concerns the preclinical and clinical study design processes for obtaining FDA marketing approval for biomedical devices. Prior to marketing a medical device, specific governmental approval is required dependent on the type of device and the risk associated with the device. This course is part of a three-course series dealing with various aspect of regulatory science of medical devices. Regulatory science considers the scientific and technical foundations that support the practical testing and regulations that ensure the safety and effectiveness of medical devices.

The practice of Biomedical Engineering concerns itself with the design, development, and testing of medical devices that will be commercialized to improve or sustain life. Medical device companies, and the engineers they employ, have an ethical and legal responsibility to robustly examine the safety and performance of these devices through preclinical and clinical testing. This course covers the responsible conduct of preclinical and clinical study research necessary for obtaining marketing approval, with a focus on US FDA requirements, and using a risk-based approach to ensuring safety and effectiveness of medical devices. Topics will include non-clinical benchtop testing, evaluation of device-tissue interactions and how they may be studied with pre-clinical animal models to predict safety and performance, statistical considerations for study design, and ethics related to responsible conduct of pre-clinical and clinical research.

Learning Resources, Technology & Texts

- Biodesign: The Process of Innovating Medical Technologies, 2nd Edition
    - The textbook for this course will be utilized to support lectures, homework, and quizzes.
- Additional readings will be provided throughout the course via Brightspace
- Software/web resources
    - Microsoft Office (MS Office is free for all students)
    - Statistical Analysis Package – JMP, Minitab (available through Purdue Software Remote)
- Brightspace page
    - You can access the course via Brightspace. 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 Help tab for resources.

Learning Outcomes

By the end of the course, you will be able to:

1. Identify testing strategies for the design and development of a safe and effective medical device.
2. Demonstrate knowledge of quality, regulatory, marketing, and business considerations/perspectives in designing and implementing a preclinical and clinical study strategy.
3. Outline the course of medical device development, from feasibility through post-market sustainability, and identify the major milestones throughout the process.

Methods of Evaluation: Homework, Projects, Quizzes, Participation in weekly discussion

Course Schedule

A tentative schedule of topics is attached at the end of this syllabus. Guest speakers from industry and FDA will provide insight, expertise, examples, and case studies on certain topics.

Here is a link to the Purdue Academic Calendar for 2021-2022. Key dates include:

- August 23 – Classes Begin
- September 6 – Labor Day – NO CLASS
- October 11-12 – October Break – NO CLASS
- November 24-27 – Thanksgiving Vacation – NO CLASS
- December 11 – Classes End
- December 13-18 – Final Exams
- December 21 – Grades Due
- December 19 – Commencement

Assignments

Your learning will be assessed through a combination of participation, quizzes, homework assignments, and a final project spread throughout the academic period. Details on these assignments, including a schedule of due dates, rubrics to guide evaluation, and guidelines on discussion participation and evaluation will be posted on the course website.

Grading Scale

In this class, grades reflect the sum of your achievement throughout the semester. You will accumulate points as described in the assignments portion above, with each assignment graded according to a rubric. At the end of the semester, final grades will be calculated by adding the total points earned and translating those numbers into the following letters.

Grading Scale:
A+ = (≥96%)
A = (≥92%)
A- = (≥89%)
B+ = (≥86%)
B = (≥82%)
B - = (≥79%)
C+ = (≥76%)
C = (≥72%)
C- = (≥69%)
D = (≥60%)
F = (below 59%)

Policy on academic honesty:

The commitment of the acts of cheating, lying, stealing, and deceit in any of their diverse forms (such as the use of ghostwritten papers, the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and not tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest. Any student committing academic dishonesty will receive a grade of 0 for the assignment, and subsequent offenders will receive a failing grade for the class. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered.

Academic Integrity

Purdue's 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 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.

Copyright

Online educational environments, like all learning environments, should provide opportunities for students to reflect, explore new ideas, post opinions openly, and have the freedom to change those opinions over time. Students enrolled in and instructors working in online courses are the authors of the works they create in the learning environment. As authors, they own the copyright in their works subject only to the university's right to use those works for educational purposes (Visit Purdue University Copyright Office). Students may not copy, reproduce or post to any other outlet (e.g., YouTube, Facebook, or other open media sources or websites) any work in which they are not the sole or joint author or have not obtained the permission of the author(s).

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. More details are available on our course Brightspace table of contents, 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. More details are available on our course Brightspace under Accessibility Information.

Mental Health 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're 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.

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 instructor's 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 or phone. You are expected to read your @purdue.edu email on a frequent basis.

Emergency Preparedness for Classrooms

Emergency preparedness is your personal responsibility. Purdue University is actively preparing for natural disasters or human-caused incidents with the ultimate goal of maintaining a safe and secure campus. Please review the following procedures:

- For any emergency text or call 911.
- There are more than 300 Emergency Telephones (aka blue lights) throughout campus that connect directly to the Purdue Police Department (PUPD). If you feel threatened or need help, push the button and you will be connected right away.
- If we hear a fire alarm, we will immediately evacuate the building and proceed to the outside courtyard and main entrance to Hockmeyer; in inclement weather, proceed to the interior main lobby of Hockmeyer.
- If we are notified of a Shelter in Place requirement for a tornado warning we will stop classroom or research activities and shelter in the lowest level of this building away from windows and doors. Our preferred location is the basement hallway via the East stairwell; do not use the elevators.
- If we are notified of a Shelter in Place requirement for a hazardous materials release, we will shelter in our classroom shutting any open doors and windows.
- If we are notified of a Shelter in Place requirement for an active threat such as a shooting, we will shelter in a room that is securable preferably without windows.

For more details, review the MJIS building emergency plan: https://www.purdue.edu/ehps/emergency_preparedness/bep/mjis-bep.html.

Course Evaluation

During the last two weeks of the semester, you will be provided with an opportunity to give feedback on 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 10 days to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. I strongly urge you to participate in the evaluation system.

Additionally, the instructors are open to your feedback at any time during the course. Please let us know what we can improve about this course and what you find most useful.

Disclaimer

This syllabus is subject to change as we progress through the semester.

THE SCHEDULE BELOW IS FROM THE SPRING 2021 SEMESTER AND IS PROVIDED FOR INFORMATIONAL PURPOSES ONLY. UPDATES AND CHANGES IN THE SCHEDULE, CONTENT, AND ASSIGNMENTS WILL BE MADE FOR THE FALL 2021 SEMESTER.

Week	Date of Class	Class	**Main Topic** *Note: Presentation titles and guest speakers are subject to change.*	**Readings** (*Biodesign, 2nd ed.)*	**Assignments**
1	19 Jan 2021	1	**Introduction to BME 56100: Preclinical and Clinical Study Design**	Biodesign: Chapter 1 & 2	
	21 Jan 2021	2	**Medical Device Regulations, FDA Structure, and Regulatory Classification**	Chapter 4, Section 2 https://www.mpo-mag.com/issues/2014-09-01/view_features/how-do-good-laboratory-practice-regulations-apply-to-medical-devices/ FDA Guidance: "Classification of Products as Drugs and Devices & Additional Product Classification Issues" (familiarize yourself with the general content, you do not need to read the entire thing)	Introduction Assignment Due Friday @ 11:59 PM
2	26 Jan 2021	3	**Market Viability and Reimbursement**	Chapter 4, Section 3 Chapter 4, Section 4 Chapter 5, Section 6	Quiz 1 Questions Due Tuesday @ 11:59 PM
	28 Jan 2021	4	**Regulatory Classification and Pathways and Regulatory Strategy – The Pre-Submission Process**	Chapter 5, Section 4 https://www.fda.gov/medical-devices/overview-device-regulation/classify-your-medical-device FDA Guidance: "Requests for Feedback and Meetings for Medical Device Submissions: The Q-Submission Program" (familiarize yourself with the general content, you do not need to read the entire thing) https://www.mastercontrol.com/gxp-lifeline/to-pre-sub-or-not-to-pre-sub-weighing-the-value-of-the-fda-s-pre-submission-program/	Quiz 1 Submission Due Sunday @ 11:59 PM

3	02 Feb 2021	5	**The Feasibility Process: Defining the Clinical Need, Concept Exploration, and the Testing/Prototyping Cycle**	Chapter 4, Section 5	Quiz 2 Questions Due Tuesday @ 11:59 PM
	04 Feb 2021	6	**Testing in Feasibility: From Clinical Need to Design Requirements**	Chapter 4, Section 6 Chapter 5, Section 2	Quiz 2 Submission Due Sunday @ 11:59 PM
4	09 Feb 2021	7	**Designing Medical Devices for Manufacturing**	N/A	
	11 Feb 2021	8	**Testing Medical Devices in Animals – Principles and Guidance Part 1**	Chapter 4, Section 6 Chapter 5, Section 2	Assignment 1 Due Sunday @ 11:59 PM
5	16 Feb 2021	9	**Testing Medical Devices in Animals – Principles and Guidance Part 2**	N/A	Quiz 3 Questions Due Tuesday @ 11:59 PM
	18 Feb 2021	10	**Technology Translation: Academic Research and Development with a Target Toward Clinical Use** **+** **The Physician Perspective: Medical Device Design/Testing and the Importance of Physician Engagement**	N/A	Quiz 3 Submission Due Sunday @ 11:59 PM
6	23 Feb 2021	11	**Basic Engineering Statistics in Medical Device Design: Part 1**	N/A	
	25 Feb 2021	12	**Basic Engineering Statistics in Medical Device Design: Part 2**	N/A	Assignment 2 Due Sunday @ 11:59 PM
7	02 March 2021	13	**Design Freeze and the Design Control Process**	FDA Guidance: "Design Control Guidance for Medical Device Manufactuers" https://www.mastercontrol.com/gxp-lifeline/how-to-approach-design-control-from-both-fda-and-iso-viewpoints/	
	04 March 2021	14	**External Standards for Medical Device Testing**	N/A	Assignment 3 Due Sunday @ 11:59 PM
8	09 March 2021	15	**Preliminary Hazard Analysis, Failure Mode Analysis, Design Input Requirements, and Acceptance Criteria**	N/A	Quiz 4 Questions Due Tuesday @ 11:59 PM

	11 March 2021	16	**Design Verification, Design Validation and Design Reviews**	Chapter 5, Section 2 https://www.mastercontrol.com/gxp-lifeline/how-to-approach-design-control-from-both-fda-and-iso-viewpoints/	Quiz 4 Submission Due Sunday @ 11:59 PM
9	16 March 2021	17	**Benchtop Testing of Medical Devices Part 1**	N/A	
	18 March 2021	18	**Reading Day – No Class**		
10	23 March 2021	19	**Benchtop Testing of Medical Devices Part 2**	N/A	Assignment 4 Due 3/23 @ 11:59 PM
	25 March 2021	20	**IVDs – Testing Diagnostic Devices**	N/A	
11	30 March 2021	21	**Process Development – Process Verification and Validation**	https://www.mastercontrol.com/gxp-lifeline/process-verification-vs-process-validation/	
	01 April 2021	22	**Clinical Studies – IDEs and Types of Studies**	Chapter 5, Section 3 https://www.mastercontrol.com/gxp-lifeline/what-verification-and-validation-activities-are-required-for-a-first-in-human-study/ Investigational Device Exemption (IDE) – Soma Kalb, FDA https://fda.yorkcast.com/webcast/Play/696d857b34334d5389364ed8c2db3ded1d (27 minutes) Early Feasibility Studies – Andy Farb, FDA https://www.youtube.com/watch?v=oiPhK64Qa2E from 18:06 to 36:12 (18 minutes) Patient Engagement and Patient Input – Michelle Tarver, FDA: https://www.youtube.com/watch?v=Jx4jKGEVYiA (15 minutes)	Assignment 5 Due Sunday @ 11:59 PM
12	06 April 2021	23	**Clinical Studies – Strategies, Operations, and Ethics**	"Fundamentals of Clinical Trials" Chapter 11 (skim)	Quiz 6 Questions Due Tuesday @ 11:59 PM
	08 April 2021	24	**Clinical Studies – Statistics and Study Design**	"Guidelines for Good Clinical Practice" Chapter 5	Quiz 6 Submission Due Sunday @ 11:59 PM

13	13 April 2021	25	**Reading Day – No Class**		
	15 April 2021	26	**Clinical Studies – Real World Evidence**	https://www.fda.gov/news-events/fda-voices/leveraging-real-world-evidence-regulatory-submissions-medical-devices	Assignment 6 Due Sunday @ 11:59 PM
14	20 April 2021	27	**Post-Market Surveillance and Post-Market Clinical Studies**	https://www.greenlight.guru/blog/post-market-surveillance-requirements-medical-devices	
	22 April 2021	28	**Regulatory Submissions of New Medical Devices**	N/A	
15	27 April 2021	29	**Design Changes – Incremental and Innovative**	FDA Guidance: "Deciding When to Submit a 510(k) for a Change to an Existing Device"	
	29 April 2021	30	**Testing as a Result of Regulatory Interactions**	FDA Guidance: "Developing and Responding to Deficiencies in Accordance with the Least Burdensome Provisions"	Final Project May 1 @ 11:59 PM
16	Finals Week	N/A	N/A	N/A	