Class Syllabus

Personnel

Instructor: Dr. Mark Palmeri

- Email: mark.palmeri@duke.edu[1]
- Office Hours: `http://meet.palmeri.io`
  - 258 Hudson Hall Annex
  - `https://duke.zoom.us/my/mark.palmeri`

Lab Master: Matt Brown (matt.brown@duke.edu)

Teaching Assistants:

- Rebecca Hogewood (rebecca.hogewood@duke.edu)
- Nikhita Gopisetty (nikhita.gopisetty@duke.edu)
- Nikhil Gadiraju (nikhil.gadiraju@duke.edu)

Course Times & Locations

Lecture: Tues & Thurs from 12:00–13:15 in Wilkinson 126

Lab: Thurs from 13:45–16:45 in the POD or Fri from 08:30–11:30 in Chesterfield 5704 [2]

Course Objectives

This course focuses on developing medical device prototyping skills that will be used in future project and design courses, with a focus on preparing our students for positions in the medtech industry. Students will work individually to complete design tasks that will be tested to quantitative specifications. Students will gain hands-on experience with device fabrication, debugging, testing and failure analysis.

Upon completion of this course, students should be able to:

- Perform functional decomposition and develop user action flow chart
- Utilize ECAD (KiCad) for:
  - Electronic schematic capture
  - Printed circuit board (PCB) layout
- Modular breadboarding of circuits to translation to testable PCBs
- Design a battery-powered device that:
  - Accepts analog and digital user input
  - Outputs analog and digital outputs
  - Performs logic using discrete electronics (e.g., logic gates, 555 timers)

[1] Response times will be way faster via Teams.

[2] A campus shuttle runs to/from the E-quad; details can be found here: `https://parking.duke.edu/buses/downtown-shuttle`.

  - Passes testable specifications to 95% CI
- Implement electronic logic on microcontroller (ESP32 or equivalent platform)
  - Modular / testable code development in C
  - Software version control (`git`)
  - Interupt Service Routines
  - Pulse Width Modulation
- Utilize CAD (Onshape) for:
  - Device enclosure design with UI/UX considerations
  - Input / Output considerations
  - Size / weight constraints
  - Preparation of mechanical drawings
- 3D printing of designs
  - Assembly of discrete enclosure pieces
  - Use of mechanical fasteners
- Write technical analysis documents / reports

Prerequisites

- Introduction to Design (EGR101)
- Introductory Circuit Analysis (ECE110 or equivalent, corequisite)

Resources

Hardware

One of the following development kits is **required** hardware for this semester:

- Arduino Nano 33 BLE
- Arduino Nano 33 Sense
- Arduino Nano Every[3]

Textbooks

All of these books contain valuable content and will be referenced throughout the semester. If you are looking to pursue a career in medical device design, then it may be worth having one of these as a reference.

- Practical Electronics for Inventors (Scherz & Monk) [Fourth Edition][4]
- The Art of Electronics (Horowitz & Hill) [Third Edition]
- Product Design and Development (Ulrich, Eppinger)
- Design of Biomedical Devices and Systems, King, Fries & Johnson

[3] This board is being used in BME354L this semester.
[4] This is available online through the Duke Library.

Online Resources

We will be using the following [E]CAD packages:

- Onshape[5] [6]
- KiCad [7] [8]

These are cloud tools or cross-platform for installation on your personal computers.

- Teams - "Slack-like" tool for live chat, team discussion, asking questions and resource sharing
- diagrams.net - software / hardware flowcharts, functional decomposition
- Git - version control software
- GitLab - version control / project mangement
- One of the following for firmware development:
  - Visual Studio Code with PlatformIO extension
  - Arduino IDE

Attendance & Participation

Class participation, including lecture attendance, team meetings, and scheduled lab time, contributes to your class grade. Not being able to participate in class activities due to illness should be reported using the Short Term Illness Form (STIF) **before** the missed class activity.

If you have a non-illness-related reason for not being able participate in a class activity or meet an assignment submission deadline, please reach out to Dr. Palmeri as soon as possible to discuss the situation.

Students are responsible for obtaining missed lecture content from other students in the class. Lectures will be recorded via Panopto and available via Sakai.

Class Schedule

The following table is an overview of activities this semester (always use Gradescope for the latest information on assignment due dates).

TUESDAY	THURSDAY
Jan 10th **1**	12th **2** Syllabus Review, Functional Decomposition & User Action Flowcharts **Lab:** Software Installations

[5] Note, this is a specific Duke instance of Onshape, not the public one. You will be invited to join by Dr. Palmeri.

[6] If you know Fusion 360 or SolidWorks and would rather use those CAD packages, you are welcome to, but the class will only support Onshape.

[7] Please download and install the stable version (currently `v6.0.10`). Do not install the `v7.x` release candidate!

[8] If you know Altium Designer, you are welcome to use it instead, but the class will only support KiCad.

TUESDAY	THURSDAY
17th **3** CAD: Intro to Workflows	19th **4** CAD: Assemblies & Mechanical Drawings **Lab:** CAD (Flange & Bushing)
24th **5** CAD: Tips on more complicated parts	26th **6** CAD: Hybrid III in-class work time **Lab:** CAD (Hybrid III 6 y/o)
31st **7** ECAD: Introduction to KiCad Schematic Capture	Feb 2nd **8** ECAD: Timer Circuit Schematic Capture **Lab:** Timer Circuit Schematic Capture
7th **9** Timer Circuit Schematic Revision: Footprints, PCB Exclude, BOM	9th **10** Timer Circuit Augmentation (Functional Decomposition) **Lab:** Timer Circuit Augmentation
14th **11** ECAD: KiCad PCB Layout	16th **12** ECAD: Timer Circuit PCB Layout **Lab:** Timer Circuit PCB Layout
21st **13** Enclosure Design	23rd **14** Enclosure Design **Lab:** Enclosure Design / 3D Printing
28th **15** Finalize PCBs / Submit for Fabrication	Mar 2nd **16** Time Circuit Testing **Lab:** Timer Circuit Testing
7th **17** Project Integration	9th **18** Project Integration **Lab:** Project Integration, 3D Printing, PCB Fabrication
14th Spring Break (No Class)	16th Spring Break (No Class)
21st **19** PCB Testing	23rd **20** PCB Testing **Lab:** PCB Testing
28th **21** Introduction to Microcontrollers	30th **22** Microcontrollers: ISR, PWM, Timers **Lab:** Project Integration & Testing

TUESDAY	THURSDAY
Apr 4th **23** PCB Testing & Debugging	6th **24** PCB Testing **Lab:** PCB Testing
11th **25** Microcontroller Overview & Functional Decomposition	13th **26** Introduction to Firmware Development (PlatformIO) **Lab:** Project Time
18th **27** Version Control Overview (`git`)	20th **28** Firmware Development **Lab:** Project Time
25th **29** LDOC: TBD	27th **30**

Final Project Due: May 01, 2023 at 09:00

Grading

The following grading scheme will be used for this course:

Participation	15%
Midterm Projects & Deliverables	50%
Final Project Report	35%

Final Course Grades

This course is not "curved" (i.e., a distribution of grades will not be enforced), and a traditional grading scheme will be used (e.g., 90-93 = A-, 94-97 = A, 97-100 = A+).

Failing the course can happen with a cummulative score < 65 or not completing all of the assignments.

All grades will be posted to Gradescope throughout the semester to track your performance.

Gradescope

All graded assignments, associated due dates (usually Fridays at 17:00), and grades/feedback will be posted on Gradescope. Regrades must be submitted via Gradescope. **You must associate the pages of your submission with the grading rubric criteria during the submission process.** Failure to do so will result in lost assignment credit.

Late Policy

Permission to submit an assignment late should be sought from Dr. Palmeri as far in advance as reasonably possible, but no less than 48 hours in advance, except in cases of illness.

Assignments submitted within the late window on Gradescope will be penalized 5%. Unexcused late assignments outside of the Gradescope late submission window will lose 25% of their potential point value for each 24 hour period beyond the due date (i.e., 100% →75% → 50%...).

All assignments must be satisfactorily completed by each student to pass the class, even if no credit will be awarded based on the late policy.

Regrades

Any regrading requests need to be made via Gradescope within one week of grades for a given assignment being returned using Gradescope. You must provide a description of why you feel a regrade is appropriate. Requesting a regrade could lead to additional loss of credit when an assignment is re-evaluated.

There will be a combination of individual and team-graded assignments. Some assignments will have an opportunity to be resubmitted based on grading feedback at the discretion of Dr. Palmeri.

Duke Community Standard & Academic Honor

Engineering is inherently a collaborative field, and in this class, you are encouraged to work collaboratively on your projects. The work that you submit must be the product of your and your group's effort and understanding. All resources developed by another person or company, and used in your project, must be properly acknowledged.

All students are expected to adhere to all principles of the Duke Community Standard. Violations of the Duke Community Standard will be referred immediately to the Office of Student Conduct. Please do not hesitate to talk with Dr. Palmeri about any situations involving academic honor, especially if it is ambiguous what should be done.