

# Class Syllabus

## Personnel

**Instructor:** Dr. Mark Palmeri

- Email: [mark.palmeri@duke.edu](mailto:mark.palmeri@duke.edu)<sup>1</sup>
- 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](mailto:matt.brown@duke.edu))

**Teaching Assistants:**

- Rebecca Hogewood ([rebecca.hogewood@duke.edu](mailto:rebecca.hogewood@duke.edu))
- Nikhita Gopisetty ([nikhita.gopisetty@duke.edu](mailto:nikhita.gopisetty@duke.edu))
- Nikhil Gadiraju ([nikhil.gadiraju@duke.edu](mailto: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 <sup>2</sup>

## 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
  - SPICE circuit simulation
- 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

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<sup>1</sup>Response times will be way faster via Teams.

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

- Performs logic using discrete electronics (e.g., logic gates, 555 timers)
  - 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`)
  - Interrupt 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<sup>3</sup>

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<sup>3</sup>This board is being used in BME354L this semester.

## 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]<sup>4</sup>
- The Art of Electronics (Horowitz & Hill) [Third Edition]
- Product Design and Development (Ulrich, Eppinger)
- Design of Biomedical Devices and Systems, King, Fries & Johnson

## Online Resources

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

- Onshape<sup>5 6</sup>
- KiCad<sup>7 8</sup>

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.

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<sup>4</sup>This is available online through the Duke Library.

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

<sup>6</sup>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.

<sup>7</sup>Please download and install the stable version (currently v6.0.10). Do not install the v7.x release candidate!

<sup>8</sup>If you know Altium Designer, you are welcome to use it instead, but the class will only support KiCad.

## 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 11th   | 1  | 13th   | 2  |
|  |    | Syllabus Review, Functional Decomposition & User Action Flowcharts<br><b>Lab:</b> Software Installations       |    |
| 18th   | 3  | 20th   | 4  |
| CAD: Intro to Workflows  |    | CAD: Assemblies & Mechanical Drawings<br><b>Lab:</b> CAD (Flange & Bushing)                                    |    |
| 25th   | 5  | 27th   | 6  |
| CAD: Tips on more complicated parts                                      |    | CAD: Hybrid III in-class work time<br><b>Lab:</b> CAD (Hybrid III 6 y/o)                                       |    |
| Feb 1st  | 7  | 3rd  | 8  |
| ECAD: Introduction to Schematic Capture                                  |    | ECAD: Pin Designation, ERC, Spice Simulation<br><b>Lab:</b> KiCad Schematic Capture                            |    |
| 8th  | 9  | 10th   | 10 |
| Electronics: Power, Voltage Regulation, Filters, [Light Emitting] Diodes |    | Electronics: Transistors, Logic Gates, 555 Timers, Buttons (Debounce)<br><b>Lab:</b> Circuit Design / Analysis |    |
| 15th   | 11 | 17th   | 12 |
| Timer Project Overview, Functional Decomposition, User Action Flowchart  |    | Project Circuit Design & Schematic Capture<br><b>Lab:</b> Project Circuit Design & Schematic Capture           |    |
| 22nd   | 13 | 24th   | 14 |
| ECAD: Introduction to PCB Layout   |    | ECAD: PCB Layout (Power Traces, Grounding, Test Points)<br><b>Lab:</b> Project PCB Layout                      |    |
| Mar 1st  | 15 | 3rd  | 16 |
| 3D Printing, Fasteners, Panel-Mounted Components                         |    | Project: Physical Enclosure<br><b>Lab:</b> Project CAD   |    |
| 8th  | 17 | 10th   | 18 |
| Project Integration  |    | Project Integration<br><b>Lab:</b> Project Integration, 3D Printing, PCB Fabrication                           |    |
| 15th   |    | 17th   |    |
| Spring Break (No Class)  |    | Spring Break (No Class)  |    |

| TUESDAY   |    | THURSDAY   |    |
|---|----|--|----|
| 22nd<br>PCB Testing   | 19 | 24th<br>PCB Testing<br><b>Lab:</b> PCB Testing   | 20 |
| 29th<br>Introduction to Microcontrollers                          | 21 | 31st<br>Microcontrollers: ISR, PWM, Timers<br><b>Lab:</b> Project Integration & Testing                                  | 22 |
| Apr 5th<br>Crashcourse: C   | 23 | 7th<br>Crashcourse: Software Version Control ( <code>git</code> )<br><b>Lab:</b> Using <code>git</code> and flashing MCU | 24 |
| 12th<br>MCU Project Overview (Blinking and Brightness Modulation) | 25 | 14th<br>Timer & MCU Projects<br><b>Lab:</b> Timer & MCU Projects   | 26 |
| 19th<br>Timer & MCU Projects                                      | 27 | 21st<br>Timer & MCU Projects<br><b>Lab:</b> Timer & MCU Projects   | 28 |
| 26th<br>LDOC: Summary of everything                               | 29 | 28th   | 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 cumulative 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.
- For team submissions, please make sure that assignments have **each team member associated with the submission.**

### 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.

Unexcused late assignments will lose 50% of their potential point value for each 24 hour period beyond the due date (i.e., 100% → 50% → 25%...).

**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.