

# 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))
- Ayush Shetty ([ayush.shetty@duke.edu](mailto:ayush.shetty@duke.edu))

## Course Times & Locations

**Lecture:** Mon & Wed from 08:30–09:45 in Wilkinson 136

**Lab:** Fri from 08:30–11:30 in 5704 Chesterfield (Design Suite) <sup>2</sup>

## Course Objectives

This course will give students experience with the design, function and deployment of medical electrical equipment. Students will have hands on experience with electronic hardware and software development, along with gaining experience with biosignal transduction into circuits.

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

- Transduce electronic biosignals
- Develop firmware using Zephyr as a bare-metal super-loop and a Realtime Operating System (RTOS)
- Embed firmware on the Nordic nRF52833 DK, including ADC, PWM, timers and BLE.
- Version control software / firmware development using (`git`)
- Utilize callbacks / interrupt service routines for realtime event detection and response.
- Perform electronics schematic capture, using heirarchical sheets.
- Layout single- and double-sided printed circuit boards.
- Know what traces, cabling and connectors to use for power and signals.
- Make design choices between AC and battery power sources.
- Use different data encoding and communication protocols, including UART, I2C, SPI, and BLE
- Outline procedures to adhere to relevant industry and safety standards (e.g., UL, IEC60601, IEC62304) for FDA 510k clearance.

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<sup>1</sup>Response time 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>.

## Prerequisites

- Introductory Circuit Analysis (ECE110 or equivalent)
- Medical Software Design (recommended, BME547 or equivalent experience [git and C])
- Instrumentation / Mechatronics (recommended)

## Resources

### Hardware

The following development kit is **required** hardware for this semester: nRF52833 DK

### 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]
- The Art of Electronics (Horowitz & Hill) [Third Edition]
- Design of Biomedical Devices and Systems (King, Fries, Johnson)
- 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:

- KiCad<sup>34</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
- Visual Studio Code - supported IDE for Nordic nRF Connect tools
- Git - version control software
- GitLab - version control / project management
- Zephyr Project Documentation
- nRF Connect SDK Fundamentals

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<sup>3</sup>Please download and install the stable version (currently v6.0.10). Do not install the v7.x release candidate!

<sup>4</sup>If you know Altium Designer, you are welcome to use it instead, but the class will only support KiCad.

## 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).

MONDAY	WEDNESDAY	FRIDAY
Jan 9th 1	11th 2 Syllabus Review & Software Installations	13th 3 <b>Lab:</b> Personal Laptop Software Installation & Configuration
16th MLK Holiday (No Class)	18th 4 ECAD: Schematic Capture	20th 5 <b>Lab:</b> KiCad Schematic Capture
23rd 6 ECAD: PCB Layout	25th 7 ECAD: PCB Layout	27th 8 <b>Lab:</b> KiCad PCB Layout
30th 9 Digital Data Encoding & Logic	Feb 1st 10 ADC and DAC	3rd 11 <b>Lab:</b> ADC & Data Encoding
6th 12 Instrumentation: Amplification & Level Shifting	8th 13 Instrumentation: Filtering	10th 14 <b>Lab:</b> Amplification & Filtering
13th 15 Envelope Detection: Rectification, Synchronized Demodulation	15th 16 Quadrature Demodulation	17th 17 <b>Lab:</b> Envelope Detection
20th 18 Introduction to Microcontrollers	22nd 19 Introduction to Zephyr (RTOS)	24th 20 <b>Lab:</b> Crash Course in C / git / Nordic Dev Academy

MONDAY	WEDNESDAY	FRIDAY
27th Zephyr: Blinking LED, Callbacks / ISRs, Debugging with JTAG	Mar 1st Pulse Width Modulation	3rd <b>Lab:</b> Zephyr Modulating LED Brightness
6th Zephyr: Timers	8th Generating a Tone	10th <b>Lab:</b> Generating Tone & Sampling Analog Signal
13th Spring Break (No Class)	15th Spring Break (No Class)	17th Spring Break (No Class)
20th Zephyr: Multi-Tone / Volume Speaker Circuit	22nd ECAD: Multi-Tone Speaker Circuit	24th <b>Lab:</b> PCB Layout Speaker "Shield"
27th Communication Protocols: UART, I2C, SPI & beyond	29th Bluetooth Low Energy (BLE)	31st <b>Lab:</b> Nordic Dev Academic (UART & I2C)
Apr 3rd BLE: GATT / Custom Services	5th BLE: Notifications	7th <b>Lab:</b> Bluetooth Low Energy
10th AC Power: Circuit Breakers, Polarity, Grounding, Shock Risk Reduction	12th Battery Power: Battery Types, Voltage Regulation, Li-Ion Recharging Considerations	14th <b>Lab:</b> TBD
17th TBD	19th TBD	21st 41

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%  $\rightarrow$  50%  $\rightarrow$  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.