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SYLLABUS: Physics 231 *Physical Computing*

Spring Semester 2025 – 4 credit hours

Instructor of Record:

Dr. Stefan Jeglinski (Dr J)

- Phillips 174
- jeglin@physics.unc.edu

Location:

Lecture: Synchronous In-person

- MF 9:05a-9:55a Phillips 247

Lab: Asynchronous

- All sections: Do not attend.

TAs:

- Yihan Liu
  - 4th year grad student in Appl Phys Sci
- Hannah Perkins
  - completed PHYS231 in SP23
- Jae Hwan Ryu
  - completed PHYS231H in SP24
- Victor Hoppenot
  - completed PHYS231 in SP24

Canvas: https://canvas.unc.edu/
PHYS231.ALL.SP25
*click on **Home** for links*

Office Hours:

M 10:15–11:15a
F 10:15–11:15a
Other TBA
By appt:
https://calendly.com/jeglin/phys231

We'll get to the course details in a moment – meanwhile there are three important things to understand about this course for SP25:

1. This course has just been transferred to Canvas from Sakai. Typos and deadlinks are possible. Please report these to #general-25 (Discord).
2. This course has no textbook. In lieu of buying an expensive textbook, you should plan to purchase your own uCs – often uCs are cheaper than a textbook anyway. I do have loaner options, but the loaner approach could cause you to fall behind depending on demand, and stocks are limited. *The course site includes details on what to get and cost – click on Support in the left sidebar*.
3. This course has an honors component. See details further down in syllabus and contact the instructor to clarify or change your status in the course.

Finally, please read this syllabus carefully – this course doesn't operate like any of your other courses, and even if you've spoken to previous 231 students about how this course works, there are new modifications.

That said, I can promise that you'll learn more than usual from this course, have more fun than usual in this course, and quite possibly gain future employment more directly, either in the private sector or while still in school as a result of the skills you will pick up in this course! – Dr J

This syllabus has a FAQ that most students ~~would~~ ~~will~~ must find interesting.

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Course Goals and Key Learning Objectives: Physical Computing is an introduction to the interaction between computers and sensors and actuators. To implement the sensing, we must first *measure* the environment. We then respond to the measurement in an attempt to *control* the environment. The environment can be either local (e.g., adjusting the speed of a motor in response to some mechanical process controlled by the motor) or remote (e.g., sensing the presence of a person in a remote location and turning a light on/off in response). This sense-and-control pathway is facilitated by a computing unit that makes control decisions based on sensor readings in the form of a *feedback loop*. This computing units is the *uC*, which you will often see abbreviated as **uC** in this course. In addition to the uC, our tools are software, electronic sensors, a variety of analog and digital electronic components, and algorithms that anticipate and respond in ways that humans perceive as NOT inherently computerized.

Instructional Philosophy. The course is structured to work well for either in-person or remote learning; however, the course is officially in-person and attendance will be measured as part of your grade. Our approach to achieving the course goals is somewhat experimental, but importantly the approach mirrors the real world of employment more than other college courses – answers won't always be found by looking them up, the answers that are supplied may be incomplete or suboptimal, and you will rely on outside help more than you may be used to. Our *goal* is to introduce you to the world of the uC and the programming and support electronics that's required. Your *objective* in part will be to find completions or optimizations to well-specified assignments. In broad strokes, the course will consist of four components: lectures, labs, assessments, and a feasibility proposal exercise. Each of these components will be worth a certain number of "credits" (CR) toward course completion. In much the same way that you get your undergraduate degree, you will choose from a minimum number of required core CR (that all students must complete) and a number of elective CR. This approach will allow you to tailor the course to your interests, while still guaranteeing that you are minimally competent from the instructor's point of view. Each of the four components are described in more detail below:

Lectures. Lectures are scheduled twice per week, in person. We plan to record lectures, but you should attend unless you have an excused prearrangement with the instructor; *live attendance at the synchronous lecture time is the only way to earn CR from lecture – if you don't attend you will not earn that CR but it's possible to make it up elsewhere*. That said, there will sometimes be unannounced live assessments (short quizzes) that take place during lecture time. You'll get zeros for those assessments if you're not there – make the CR up elsewhere. The goal of the lectures is to deliver as much technical information as possible in the allotted time so that you can do the labs, and to give you practice with certain concepts. *Students that elect not to attend lectures will find it more difficult to complete the course with a satisfactory grade*.

PollEv. Attendance will be recorded via either PollEverywhere *or sometimes by announced or unannounced real-time assessment*. Instructions for signing up for PollEv can be found on the Canvas Home page. When PollEv is used to measure attendance, a "raw" score will appear in the gradebook whose format is "231 Ln." This raw score is a measure of what you actually answered (not scored on correctness). For example, if there were 3 questions, and we only did two of them, and you only answered one of them, your score would be 33%. In another part of the gradebook, a true attendance score of 100 will appear if you provided any answers. *Students who answer only the first question may be judged as not present*. If you see a zero for attendance but you were in attendance, please send the instructor the spreadsheet history of your answers from your PollEv account so it can be checked. Claiming you were at lecture when you were not actually at lecture will be considered an Honor Code violation. If you miss a lecture, that's cool, but you're an adult – own up to it, check the video, and make it up later!

Labs. There are no explicit labs times, which should be listed as TBD in Connect Carolina. Unless you're getting honors credit, it doesn't matter which lab section you're enrolled in. Labs will be *asynchronous* (generally done completely on your own time and at your own pace). How to get CR for labs will be covered in a later section of the syllabus, and each lab on Canvas will include specific details for credit. A large variety of labs will be available – some will require a local presence (e.g., a lab that requires an oscilloscope in the electronics room), while many if not most can be done remotely. Outside of the required "Core" labs, students will choose which labs to do and when to do them, and even the order in which they do them, within the limits of due dates and prerequisites. Each lab will provide a certain number of CR toward finishing the course. At a bare minimum, students should expect to spend at least 4 hours per week preparing for and working on the lab activities themselves, completing 2 or 3 of them, and an extra amount of time preparing a video submission and an assessment. *About 40% of the CR in the course will be awarded as a result of completing labs*.

Students are encouraged to create their own labs or to create extensions to the existing labs (hereafter referred to as "free labs"). Such free labs could be randomly focused (unrelated to each other), or they could be focused on a larger goal that could be described as a "single project." This aspect of the course allows you to find and pursue what interests you (e.g., hardware, software, prototyping), and may require specific equipment or parts. Any free lab *will require instructor approval and negotiation of credits*. Free labs which focus on software alone will be discouraged but not explicitly disallowed – we will listen to software-only proposals, but the bar will be set high against them. To receive credit for free labs, you must a) demonstrate a working lab as you do for the regular labs and b) provide a written outline to the instructor that can be used to turn your free lab into a "real" lab, either this semester or in a future semester. *The free labs are high-cost but high-impact – you should expect to work more hours if you do any free labs.*

Assessments. The course will see a regular stream of quizzes and exams. Virtually every lab will also include a Gradescope assessment.

Feasibility Proposal. Every student will be required to write a Feasibility Proposal. Part of this assignment is to carefully define what such a proposal is and its parameters, so we're not describing it in detail here. You'll be given an "imaginary product" to consider, and you'll be responsible for framing the question of whether it's possible to achieve the realization of the imaginary product, given constraints (e.g., financial, technical, ethical, other). This assignment will be a combination of short answer questions on Gradescope and a longer proposal in essay format. *Each lab in the course begins with a listing of goals and technical objectives, which are the two most important components of a feasibility proposal*. Therefore, each lab can be viewed as a dry run for feasibility and provides written examples that can be leveraged. The proposal is envisioned as a 7-page effort consisting of Abstract, Background, Significance, Technical Objectives, and Measures of Success.

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This Course is About Technology. To be successful in this course, you must shift from an academic mindset to a technology mindset. The focus is on *instrumentation skills and is **insanely** technical*. Many physics classes require analytical insights that are non-intuitive and can be difficult to learn; in contrast, insights in this class are more rule-oriented and fact-based – the rules aren't too difficult, but uCs behave in a very specific way and you must follow the rules precisely and without fail for them to work.

Don't think about the labs (or even combinations of free labs) as complete projects in and of themselves – any *real* projects you do with uCs (e.g., robots, autonomous vehicles) will be realized *outside* of this course, in the future, on your own time and because of your own dedication, either as part of a hobby or a job or your higher education. Your task is to find ways to extend human capabilities of sensing and control to machines, one small piece at a time. Students who complete this course will possess *employable* skills in programming, analog/digital electronics and assembly, instrumentation, and prototyping.

You may find it interesting that 95% of the material in this course can be found merely by looking for it on the internet and "following directions;" however, if you use the internet as your main resource, you can look forward to incomplete, disorganized, incorrect, and outdated information. To learn the same material on your own using the internet would easily take the average student a year if not more.

Prerequisite: PHYS114 or PHYS118 or permission of the instructor. We're required to list these prereqs officially because this course is an elective for the PHYS BS/BA, APPL Minor and COMP BA; however, the instructor pretty much lets anyone into the class. *If you have ABSOLUTELY NO physics or programming or electronics experience, this course will be more challenging and will take more of your time, but it's designed to bootstrap those with no experience*.

Textbook. Textbooks on the topics in this course are mostly obsolete the moment they are published; in lieu of a textbook, you are asked to purchase your own uC(s) and supporting equipment. Some resources are available through course reserves or can be checked out electronically, but few are modern. In large measure, you will get your information first from Canvas, then the instructor or TA, and then the internet.

Use of AI. Students are expected to follow these UNC-developed AI guidelines:

1. AI should help you think, not think for you. You may be able to use AI tools to brainstorm ideas, research topics, and analyze problems, but you must decide what's appropriate and accurate.
2. Engage responsibly with AI. Evaluate AI-generated outputs for potential biases, limitations, inaccuracies, false output, and ethical implications. *Do not make personal or confidential data available to AI tools*.
3. Any AI use must be open and documented. You should declare, explain, and cite any use of AI in the creation of your work using applicable standards (e.g., APA, MLA, course guidelines) as set by the instructor. Understand that you are ultimately 100% responsible for your final product.

Unless you've been living under a rock, you know what an LLM is (Large Language Model) and how it can be used and misused. LLMs are a game-changing resource for programming in both C and Python, not to mention other programming languages. In addition, LLMs have significant knowledge about uCs, sensors, and electronics. **Access to an LLM is virtually a necessity for this course**. Select an LLM and create an account. *Unless otherwise specified in an assignment, you're free to use LLMs in this course under one limiting rule: you must always acknowledge the extent to which the LLM assisted you in solving your assignments*. See FAQ for more!

Required Materials:

- Multiple uCs – details can be found under **Support/Required Hardware** on Canvas. At the very least, you should purchase a specialized Arduino uC (Cytron UNO aka "purple" Arduino) for use in the course.
- Secondary electronics components:
  - breadboards, wiring kits, etc.
  - for more details, see Canvas under the **Required Hardware** tab.
- Tertiary electronics components
  - instructor-supplied items such as servo and stepper motors.
  - details will be delivered in first week of class.
- Wireless-enabled laptop with at least 2 USB ports; Windows[1]/macOS[2]/Linux[3]
- Scientific calculator: for lab activities and exams
- BeAM Makerspace access – see below.

Communication with Instructors or TAs. The official method of communication in this course is e-mail; however, only critical communications will be sent by e-mail or as posted announcements to Canvas. *Most of our communication and collaboration will instead take place via a Discord server*. See the Canvas Home page for Discord details. *Students who miss important communications because they don't check their Discord or e-mail do hereby agree to be docked accordingly, without recourse*.

Attendance. Students are expected to attend and participate in every lecture. Attendance in lecture will be measured by using PollEverywhere or in-person assessments. You can miss up to two lectures for any reason without penalty. After two absences, you must show cause and provide acceptable documentation for missing lecture. There is no attendance relevant to labs – only submission of the required work for credit. If you miss lectures or lab deadlines due to illness or a larger conflict, you must communicate this promptly to the instructor, preferably before the lecture time or lab due date, but as soon as possible under all circumstances. Students are responsible for learning any material that is missed due to absence. Valid excuses for absences include:

- Severe illness with doctor's or Dean's note or UAA.
- Grave family circumstances (UAA).
- Religious reasons (UAA or EOC determination).
- Participating in University-sanctioned events with supporting documentation.
- Travel for other classes with supporting documentation.
- Specifically, pre-planned personal trips or family vacations are not valid excuses.

Note: two free misses constitute between 5% and 10% of the attendance and is considered a generous concession. If you miss class, you miss class –- please own up to it. As a general rule, we don't consider UAAs or absences due to illness until after you use up your two freebies.

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[1] Windows 10 and 11 are officially supported.

[2] Our impression is that you'll be OK if you've upgraded to Sequoia **(**macOS 15.x); however, compatibility is *not* a guarantee because we've never taught the course using Sequoia – you may have to get creative if we discover any incompatibilities. Sonoma (macOS 14.x) is supported. Older macOS systems can be supported.

[3] Some software is not compatible with Linux (e.g., Adobe Illustrator); you may have to maintain a separate Windows or macOS operating system on the same or another computer. *Officially, we support Ubuntu v20 and v22*.

Quizzes/Exams. An unspecified number of short quizzes and evaluations will be administered, including two longer midterm exams and a comprehensive final exam. These assessments will be a combination of in-class, take-home, and/or on-line using either Gradescope or Canvas. The dates and coverage of the midterms are tentatively set as follows and are *subject to change*:

- Midterm 1: Feb 14–21 (take-home 1, covers Lectures 01–09, Core Labs 00–08)
- Midterm 2: Mar 24–Mar 31 (take-home 2, covers Lectures 01–19, Core Labs 00–15)
- Final Exam:
    - Take-home portion: Apr 21–Apr 30 at noon.
    - In-class portion: **noon-3pm** on **Wed Apr 30** (set in stone, not negotiable)
    - Comprehensive (covers all Lectures, all Core Labs, other labs, and topics TBA)

The feasibility proposal information will be released as soon as is practical and is due on Apr 20.

Other Important Dates:

- Mon Jan 20: MLK, no class.
- Mon Feb 10: well-being, no class.
- Mon Mar 10: spring break, no class.
- Fri Mar 14: spring break, no class.
- Fri Apr 18: holiday, no class.
- Mon Apr 28: LDOC!

ARS Students: If you have ARS accommodations, register this course via ARS so that the instructor can find out and plan for those accommodations, and contact the instructor immediately with details.

Course Collaboration. Our enrollment is typically dominated by Physics and Computer Science majors. Physics majors are typically good at analytical aspects of the course (and electronics if they've already taken PHYS451). In contrast, CompSci majors are typically good at programming. If you're neither of these majors, you may feel intimidated – try to suppress this feeling, because we promise to include enough material to frustrate everyone.

- We encourage you to make connections in the class – join the Discord server immediately (invite on Home page), ask questions, and make friends.
- Find someone you can rely on to bring you up to speed and speak to the instructor and/or TA about any insecurities you have or experience – we are here to help, not to hinder!
- In this day and age, uC skillsets are infinitely variable; the TAs and even the instructor may not have certain skillsets that some students bring to the course. Everyone is strongly encouraged to share their skillsets and ideas so that we may ALL learn!

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Grading. A common misconception is that grades reflect how much you learn in a class or how much you apply yourself ("effort"). No physics professor grades on this basis, and the department discourages it. This course is not graded in either fashion – grading is instead based on mastery alone. Grades will be determined by considering credits earned in the course – each component of the course is worth a specified number of credits (CR). The *Course Grade Table* below summarizes the CR structure and how it related to your course grade:

Category	Number	CR	Max CR (A+)	93% CR (A)	Percent Total
Lectures	27	0.2	5.4	5.0	7%
Quizzes	16	0.5	8	7.4	10%
Core Labs	16	variable	22	20.5	28%
Midterms	2	7.5	15	14.0	19%
Final	1	7.5	7.5	7.0	10%
F Practice	1	2	2	1.9	3%
F Proposal	1	8	8	7.4	10%
Add'l Labs	variable	variable	10	9.3	13%
Total			77.9	72.4	100%

PoV: Labs		
Labs @14 weeks	Labs @15 weeks	Core Labs 22CR
2CR per week	2CR per week	Other Labs 10CR
= 28 CR total	= 30 CR total	= 32CR total

Penalized with negative credit if not done – See FAQ

PoV: Types of Work	
Assessments	39%
Labs	41%
Proposal	13%
Participation	7%
Total	100%

Grade	Min CR
A+	78
A	72
A–	69
B+	66
B	63
B–	60

Grade	Min CR
C+	57
C	54
C–	51
D+	48
D	45
F	<45

There will be no rounding – this table was difficult enough to create as it is! If you want a higher grade, just do another lab! We promise it will pay off in a career more than any other XC at UNC.

Lab Requirements. In general, labs will include the following components to get credit, although not every lab will require every component:

1. Demonstration of working lab (video acceptable in many or most cases).
2. Code upload.
3. Demonstration of knowledge gained (Gradescope assessment).

Notes:

- Details of requirements for each lab will be specified as part of that lab.
- As a rule, you normally get full credit of very close to it for each lab because won't finish/submit on Gradescope until you're more or less ready with fully correct answers and done with all tasks.
- If the grader determines that you haven't completed the lab, you'll be asked to return to show mastery of the material or resubmit material for partial credit; *this option may not apply to every aspect of the assignment*.
- In certain cases, the grader may award you a high but not full percentage of the CR if you haven't mastered the material, but judges that you will reasonably learn the material elsewhere in the course; an example of this might be "imperfect but mostly working code" that you would reasonably understand better before the end of the course.
- You are free to submit work and answers to the labs as many times as you like before the deadline.
- Lab deadlines are *extremely* lenient – don't ask for non-penalty extensions except in extraordinary circumstances. You may submit lab work after each deadline for 50% credit.

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16 (0x0F) Core Lab Topics: **parts kit not required** **parts kit required**

00 uC Intro and Blink 3CR	01 02 Arduino Digital I/O 2CR	03 04 05 IMU phyphox + 33 3CR	06 C and Python Coding 2CR
07 4-bit counter 2CR	08 Analog Input (ADC) 1CR	09 10 11 IoT nodeMCU 4CR	12 MIDI Teensy 2CR
	13 Serial Port Secrets 1CR	14 Bluetooth 1CR	15 TBD 1CR

Incompletes:

- Incompletes (grade of IN) in this course are *strongly* discouraged. You signed up for this course in the spring because you and the Instructor of Record expect you to take the course in the spring – *you didn't sign up for this course in the spring so you could take it in the summer*.
- Any equipment or components loaned to students that are not returned by the Registrar's grade submission deadline will result in an IN grade until such equipment is returned or replaced by the student, and a registration hold will be placed on the student's record with Academic Advising. *The instructor will clearly denote which equipment in the course will be subject to this IN rule*.

Makerspace Presence. Simple design and manufacture will be optional parts of some labs (there are exceptions for Honors work where a Makerspace component is required). Therefore, all students are encouraged to complete the on-line orientation, on-line lasercutter training, and on-line 3D printer training at the BeAM Makerspace to gain access to BeAM. If you don't already have access to the Makerspace, you must sign up for ***in-person*** orientation (BeAM 101) and training for at least the laser cutters and the 3D printers. *Students are strongly encouraged to become oriented and trained as soon as possible!*

Photograph and Video Release Form. Registration at BEAM includes a photograph/video release form. If you agree to submit this form, you may be recorded or photographed during a class or presentation or at the Makerspace, and/or for publicity about this course. We may document both the everyday activities and any project work, and the course may be highlighted on the Physics Dept web page, other UNC publications, or even outside news organizations or social media if warranted. If you don't want your image to be used in such ways, do not sign the form, and alert the instructor so we can make efforts to guarantee your privacy.

BeAM Links of Interest:

- Home page: https://beam.unc.edu
- Registration: https://beamreg.oasis.unc.edu/login/auth
- BeAM Scheduling: https://beam.unc.edu/hours/
- BeAM Training: https://beam.unc.edu/trainings/

Extra Credit

Any student that proposes and completes course work that combines a 231 lab and Makerspace design and manufacturing will receive extra CR to be negotiated on an individual basis.

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FAQ

Cool – so we're gonna do robotics? No. *Learn about robotics?* A little. *Build a robotic arm?* Sorry, no. *Maybe design an autonomous vehicle?* Not enough time. *A non-autonomous vehicle?* Probably not enough time. *How about a motorized wheel that rolls by itself?* Possibly, but you'd be surprised at how much work that takes when you design it yourself.

Hmmm – well what are we gonna do then? You're going to set yourself up to do everything in the previous question. In large measure, the reason you won't be able to "do robotics" is a lack of time, not a lack of skill. That said, the honors section is going to get closer to robotics than previous versions of this course, and the "right student" may accomplish quite a bit in the robotics category. We'll see how it plays out – that's all we can say.

Well what if I do robotics anyway, can I get extra credit? That's a fantastic idea and yes – if you present your work at the SP25 Makerfest you will receive extra CR. Details to be clarified.

What about something other than robotics, could I get extra credit? Possibly, but the details must be arranged with the instructor. The course's extra credit focus will be on presentation at the SP25 Makerfest. Details to be clarified.

What is a CR in terms of time/effort? *(see Course Grade Table)*. Each lecture counts as ⅕CR. This value is a balance between low stakes and zero accountability. Full lecture attendance provides between 5% and 10% of your course grade (a higher percentage for merely attending lecture than most introductory physics classes). A 1CR lab will involve on the order of 1½–3 hours of contact time/work (depends on outside effort and your willingness to get help) to achieve the lab goals depending on your skill set; the given factor of 2 could still vary widely depending on the student. Depending on how you count it (14-15 weeks and roughly 2CR lab work per week), you're looking at about 30CR for labs, which translates to 45–90 hours total. If you come to class and do 2CR labs every week, that's approximately 4–8 contact hours + outside effort). Stronger students therefore might expect to put in about 5 contact hours plus outside effort; weaker students about double.

Can we share equipment or parts to cut costs? Yes, but everyone is required to do their own work. Be careful about sharing – if you loan your parts or equipment to a colleague, you may not be able to get it back right away even if everyone is being responsible.

How will the requirement to do our own work be enforced? We have our ways, but primarily this must work on the honor system. You are bound by the Honor Code of the University, and we expect students to commit to it and to report any knowledge of violations. We will do several in-class assessments in which it will be difficult to collaborate; therefore, your best approach will be to learn and know the material yourself, not only for the integrity of the academic mission but also for the development of your skillsets.

So, we're allowed to collaborate, or not? To be clear, you are not only allowed to collaborate but encouraged to! As adults, you should know when you're crossing a line, or you should ask an instructor if unsure. At the heart of technology development is the need to collaborate, and this course will mirror that environment as much as possible – rodeos are the perfect opportunity. I fully expect each of you to help each other in this course – ask questions and provide answers, but when you get checked off for a lab, your work must be your own!

Wait what's a rodeo? (see collaboration question above) Your instructor works at UNC during certain weekends, and this provides a perfect opportunity to collaborate with your peers and get help from the instructor. The rodeos will be put on the calendar as time allows. You should consider making connections with your peers in class and arrange to come in and work together. The labs then go faster, and questions get immediate expert answers.

I know how to ask questions, but how do I know when to provide an answer on Discord or to my peers when it comes to labs? The instructors will try to lead by example here. We're unlikely to just provide you with a "here this works do this" answer. Instead, we will focus on where your questions might be vague or misdirected and provide relevant hints. Those of you that have already figured things out will be encouraged to do the same. The material in this course is *highly* technical, and you will feel a special kind of power as a result of knowing details and nuances. Not to mention, your future employment may well depend on the kinds of technical details and skills you develop here – successfully explaining concepts to your peers will further cement your knowledge.

Is it possible to use fewer uCs, forfeit the credits associated with those uCs, and make up the credits using other uCs? Yes, but we can't answer this question definitively. There are too many combinations of acceptable work to explain how you might do this. If such a calculation is your game, then proceed at your own risk. Although the great global supply chain crisis of 2020–2023 appears to be over, it's possible that you could be impacted by lack of parts availability. We will address this in real time during the course.

The RPi is kind of expensive – can I do the course without it? Short answer: yes, but you must find the CR to do it. Longer: based on lessons learned from previous versions of this course, the RPi work will be a major focus for the honors section, for which loaners are available. Therefore, non-honors students will be able to do well without the RPi work; however, if you are not honors, you'll still be able to do the RPi labs and get credit. The difference is that a non-honors student can give up on the honors material at any time without repercussion. And again, a limited number of loaners are available.

But how important is learning the RPi – can I really do the course without it? The RPi has become a ubiquitous device in the hobby and technical markets – if you avoid it, you're doing yourself a disservice. With respect to this course, written assessments will in part assume that you have experience working with the RPi; although these assessments will not be exceedingly detail-oriented, you will do better on the assessments if you have hands-on experience.

The RPi is unavailable – can I do the course without it? Many supply chain pressures of the recent years (e.g., pandemic, Ukraine) appear to have been eliminated; RPis appear to be both available and at pre-pandemic prices. The newer RPi 5 is more expensive but the older RPi4 or RPi3 are widely available. There should be no problem acquiring an RPi.

My time is pretty tight this semester; can I choose a smaller number of more difficult labs (higher CR), or a larger number of less difficult labs (lower CR), to get the same credit and grade? In principle, yes, but it's difficult to predict the outcome of all scenarios. We don't suggest that you get too creative; work on this with the instructor in advance.

I'm a perfect student, with 100% scores for everything (including exam scores) and perfect attendance before considering any additional labs. What's my grade? Your total CR is 78–10 = 68 (B+) so you only have to do a 2–3 additional labs to get an A, but wouldn't you rather be an A+ student even if UNC doesn't allow grades of A+?

I didn't do Core Lab 06 (2CR) because I really really hate programming and don't get it – what's the damage? If you didn't do Core Lab 06, the maximum score you can get from the Core Labs is 22–2 = 20. You'll then be penalized for the Core Lab you didn't do – total CR from Core Labs = 20–2 = 18 instead of the maximum possible 22.

I'm 100% perfect at everything else, but I only got 50% scores on the 2 midterms and the final and I didn't do any additional labs because I have too much other work. Where do I stand? Max CR is 78. The midterms and finals are worth 22½CR and the additional labs are 10CR. Your CR is therefore 78–½(22½)–10 = 57 (C+). Hey Cs get degrees but you can reconsider the additional labs and make up for the poor exam performance by doing some.

I was too busy or not interested and decided to skip the feasibility proposal. Can I make this up with more labs? Yes, but let's look at this. The feasibility proposal is worth 10CR. You don't get those 10 but you also get penalized 10CR, so your standing is 78–20 = 58CR (C+). That's not so bad but if you're skipping the proposal you're probably skipping other CR as well (and note we're still assuming perfect attendance and assessment scores). It's a slippery slope – it'll be easier and less stressful to just do the feasibility proposal assignment!

I looked through the syllabus and didn't see any detail specifically on how attendance is graded through Canvas and PollEv. I want to make sure that I'm getting credit for the lectures that I attend. According to the grading table, there are 27 lectures worth ⅕CR each – lectures contribute 5CR toward an A. If your semester lecture average is 100 based on PollEv, you get all 5CR. If your semester lecture average is 50 because you missed half the lectures, you get 2½CR toward the A. To make sure the lectures pull their weight, you would then need to do another 2½CR of labs to make up for the shortfall.

I decided that I don't get anything out of lecture, and they're recorded anyway. I think I should get an A. OK that's fair (but disappointing) – unlike for some assignments, there's no penalty for skipping lectures (unless you're still trying to get credit by doing pollEv from your bed in the morning). If you're otherwise *perfect*, you're losing about 5CR which drops you to between B+ and A– (not bad and just a little work will get you that A). But you're likely to miss important announcements along the way (*are you really going to watch those videos?*), not to mention instructor fickleness or sudden brainstorms like doing a quiz on paper in lecture because the lecture isn't ready yet. You'll be less likely to understand the feasibility proposal, and your lack of daily connection with peers and fine tech brahs will lead to malaise and an increasing tendency to watch Skibidi Toilet. Yeah you're almost surely dropping below the B+.

What specifically will I learn in this class, and what should I know in advance? Specifically, if you choose to, you'll learn: elements of Python and C; analog/digital logic; Boolean algebra; assembly of analog/digital electronic circuits; networking and communication; actuation (motors); sensing and data acquisition; data plotting; machine analysis; instrumentation concepts; and more. In short, you'll end up with the *skills* to build robots or autonomous vehicles, *but for the most part you won't actually do such building in the course without extraordinary dedication*. You'll also have the opportunity to build simple prototypes in the Makerspace (BeAM). This course assumes no prior knowledge of these subjects, but it *will* require *significant* time and effort, much like a hobbyist or employee in a technology company who uses the tools of collaboration, documentation, and *effort* (building/rebuilding until your lab *finally* works).

Will we do any theory or is it all uC programming and circuit-building? Yes, we will delve into at least two advanced subjects: the sampling theorem and its connection to digital signal filtering; and PID (proportional-integral-differential) control. These are inherently mathematical – if you are not comfortable with mathematics, be prepared to seek out extra help from the instructors or TAs.

I'm an honors student – how does this class differ for me? This is a great question and is still evolving. The honors cohort will use the same grading table as other students but will be granted certain flexibilities such as negotiable lab deadlines (within limits), negotiable CR for project work, and negotiable substitution for Core Labs; however, the honors cohort will have more requirements related to RPi, and this may present a challenge.

I'm an honors student – after reading the previous question I feel like the labs might be too difficult so I'm taking the non-honors lab section. You may have good reasons to not enroll in the honors section even though you're in the honors program; however, the reasons shouldn't be related to our material (that is, the reasons should be external to the course). For this semester, the honors work is *intended* to be close to a zero-sum game – I don't expect the honors component to be more than about a 10% change in effort (larger) compared to the non-honors, but that could strongly vary depending on your skillset. We understand the limitations we're imposing on you, and we plan to go out of the way to make the honors segment *rewarding* and the honors grading *non-punitive*. You are ***strongly*** encouraged to reach out to the instructor to discuss your concerns.

Are the regular lectures and honors lectures different? No. Everyone has the same lecture regardless of what the lecture section designation is. Likewise, all the labs are available to all. H-enrollees have their own sections, but this is merely for ConnectCarolina (administrative) purposes.

Why will we have to understand some concepts before they're covered in Lecture? There's more than one answer to this question. Mainly, there's just too much to cover at the start of class, so some things will necessarily require comprehension as part of the labs before you would typically see them in lecture. More generally, this need echoes the entire uC field – getting to functional operation is non-linear and there are very few beginners who understand much of what they're doing when they first do it. We will strive to minimize the impact of this version of a "flipped classroom" with bulletproof documentation. Which leads to the "flip" side of this question – if you see a lab available and are interested to learn about it or especially get ahead, then you're free to choose it even if we haven't covered the source material.

What's the deal with ChatGPT? *ChatGPT* is the best-known example of a *Large Language Model* (LLM), which in turn is the latest and most impactful manifestation of AI in our society. Other well-known LLM examples are Google's *Gemini* and Anthropic's *Claude*. As a rule, we will refer to these technologies as simply GPT (Generative Pre-trained Transformer) or LLM. We don't require that you use one specific LLM, although your experience with different LLMs may lead to different outcomes. These are the main things to keep in mind about LLMs:

1. You're free to use an LLM in this course.
2. You must *always* acknowledge the extent to which an LLM assisted you in solving your assignments, and any type of reflection on your experience will help your score.
3. Many of you are highly unlikely to successfully complete some labs without LLM assistance!

Beyond these statements, we expect you to use AI in the spirit of learning as opposed to the spirit of cutting corners (and certainly not in the spirit of plagiarism). Above all, unless you are directly coding, do not copy/paste LLM answers. Instead, use an LLM to glean information that you can use to learn. If you succeed in doing this, always recast the answers as your own in a way that demonstrates that you

learned something about the material – you must convince the grader that if you were present for an oral exam at that moment, that you would be able to address the question competently. In contrast, if you're using an LLM merely to code, you may use the code as-is; however, such use should be accompanied by comments in the code and a reflection somewhere in the same assignment. You should always strive to make observations about how well LLM-generated code works.

Put yourself in the professor's shoes: if you put a great deal of thought and effort into creating material for the benefit of students and all they do is copy/paste someone else's answer without further attempts at understanding, how would you react?

If I use AI, I may end up submitting a better answer than I could have all by myself. Will I be graded down for this? No. We will view AI, specifically the LLM, as your personal assistant or tutor. Your answers are very likely but not guaranteed to be **better** because of AI. It's up to you to *gain* from this experience. Note: you will be downgraded if you don't acknowledge your use of AI in a reflection.

So how do I use an LLM specifically? There are too many possibilities to list. The most common example would be something akin to a direct request to do your work for you. See Canvas Support for more information.

Really? I just ask the LLM to do all my work for me? You can if you want. But aside from the moral aspects of doing this (see earlier Syllabus guidelines and also Honor code notes further down), we think this will end badly. And specifically, there will be times when you're explicitly prohibited from using an LLM. Your best resource here would be to ask previous students of this course their opinion.

Is that all the FAQs? The above FAQs are likely *not* all you need to know. The FAQ will be updated to provide more information over time. The best way to add to this FAQ is to ask insightful questions!

version 4 – subject to change

PHYS231 Honors

Note: this section is under review and is still subject to change.

PHYS231 has an available honors (H) lab section(s).

- You may enroll in the H section if **either** of these is true:
  - You're in the UNC honors program.
  - Your GPA is 3.0 or above.
- You don't have to be in the H program to enroll in the honors lecture/lab sections.
- You may earn CR for doing H labs regardless of your enrollment status.

H enrollees are differentiated from normal enrollees by the requirement of advanced work. Most of the work will be of a curated nature (that is, honors students are not free to do just anything); however, the instructor is open to discussion about the details. H-enrollees must:

1. Complete a minimum number of H-labs. These typically but not always involve the RPi.
2. Project work (CR negotiated with instructor).
3. List of ideas on Support site of Canvas.

In SP25, the grading scale will be the same as for non-honors students; however, there are significant differences in how I will approach the honors cohot.

The biggest breakthrough in the H section will be a mix-and-match approach to the Core Labs. Since some (not all) honors students are more advanced or have more experience with this subject, not all the Core Labs may be relevant to their skill set or may be too trivial. Therefore, with instructor permission after negotiation, H students may do other work *instead of the Core Labs*, and by negotiation some or many negative penalties for not doing Core Labs may be waived. Note one possible pitfall to this strategy: exam questions may draw from any Core Lab; therefore, if you decide to not do, or not review, the Core Labs, you may end up with lower exam scores. H students for whom this is material is challenging or new are encouraged to stick to the plan and do minimal project work.

Honor Code. The Honor code and the Campus Code, embodying the ideals of academic honesty, integrity, and responsible citizenship, have for over 100 years governed the performance of all academic work and student conduct at the University. Acceptance by a student of enrollment in the University presupposes a commitment to the principles embodied in these codes and a respect for this significant University tradition. Your participation in this course is with the expectation that your work will be completed in full observance of the UNC Honor Code.

In this course you will be collaborating with other students, so you might be sharing data, results, and ideas; however, you are encouraged to think independently, and any submissions for credit must be in your own words and not copied from someone else. Note the following:

- Individual labs or assignments in this course may be worked on collaboratively but must be reported or described by each student in his/her own words and format only.
- Exams, quizzes, or other assessments will be solely the work of each individual student.
- If you are not sure whether collaboration might constitute an honor code violation, ask the instructor for guidance.
- In contrast to the other bullets here, beware of performing others' work for them – this material requires DOING to learn. Do not dilute your grade for the sake of someone else.

Academic dishonesty in any form is unacceptable, because any breach in academic integrity, however small, strikes destructively at the University's life and work. If you have any questions about the Honor Code, please consult with someone in the Office of the Student Attorney General or the Office of the Dean of Students. Any issues that students encounter related to fairness or inappropriate conduct should be brought to the immediate attention of an instructor or TA.

Accessibility Resources. The university facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability, or pregnancy complications resulting in barriers to fully accessing University courses, programs, and activities. Accommodations are determined through the Office of Accessibility Resources and Service (ARS) for individuals with documented qualifying disabilities in accordance with applicable state and federal laws. See the ARS Website for contact information: https://ars.unc.edu or email ars@unc.edu.

Counseling and Psychological Services. PHYS231 is usually liked by students but can be challenging enough to create anxiety. We strongly encourage you to contact your instructor to discuss your concerns. The university CAPS system is committed to addressing the mental health needs of the student body through timely access to consultation and connection to clinically appropriate services, whether for short or long-term needs. The Heels Care Network website is a place to access the many mental resources at Carolina. CAPS is the primary mental health provider for students, offering timely access to consultation and connection to clinically appropriate services. Go to their website https://caps.unc.edu/ or visit their facilities on the third floor of the Campus Health building for an initial evaluation to learn more.

Title IX Resources. Any student who is impacted by discrimination, harassment, interpersonal (relationship) violence, sexual violence, sexual exploitation, or stalking is encouraged to seek resources on campus or in the community. Reports can be made online to the EOC at https://eoc.unc.edu/report-an-incident/. Please contact the University's Title IX Coordinator (titleixcoordinator@unc.edu), Report and Response Coordinators in the Equal Opportunity and Compliance Office (reportandresponse@unc.edu), Counseling and Psychological Services (confidential), or the Gender Violence Services Coordinators (gvsc@unc.edu; confidential) to discuss your specific needs. Additional resources are available at safe.unc.edu.

version 4 – subject to change

2024 Schedule (for Reference)

the 2025 schedule will track 2024 somewhat

Lecture 01: FDOC, Course Intro
Lecture 02: Course Update, Intro to IDE
Lecture 03: Ohm's Law and LEDs
Lecture 04: Ohm's Law and LEDs / Number Systems
Lecture 05: Number Systems
Lecture 06: Digital Input
Lecture 07: Analog Input
Lecture 08: Digital Gates and Logic

Release of Exam I

Lecture 09: Boolean Algebra
Lecture 10: Course Update
Lecture 11: Serial Port Communication
Lecture 12: Feasibility Proposal Origin Story
Lecture 13: Feasibility Proposal Practice Assignment
Lecture 14: Course Update
Lecture 15: Operational Amplifiers I
Lecture 16: Operational Amplifiers II
Lecture 17: Digital to Analog Conversion (DAC)
Lecture 18: Duty Cycle and PWM

Release of Exam II

Lecture 19: PWM Applications
Lecture 20: Bus Communication and I2C Example
Lecture 21: Fourier Analysis I
Lecture 22: Fourier Analysis II
Lecture 23: Sampling Theorem
Lecture 24: Sampling and Discrete Fourier Transform I

Feasibility Proposal Due
Release of Final Exam Take-home

Lecture 25: Sampling and Discrete Fourier Transform II
Lecture 26: LDOC: Fast Fourier Transform and Spectrum Analysis
Lecture 27: *Did not exist in 2024*

In-class Final Exam