TENTATIVE SCHEDULE

Note: The labs actually done may differ from this list due to equipment malfunction, new labs being added to the curriculum, or other contingencies.

Date	Topic	Lab	Activities
8/27	1 - Introduction to the Pico W	Getting Started, ch. 1 – 3	Solder PicoW pins Install latest version of micropython on PicoW Install Thonny First programs. Page in parenthses. Challenge: *Loop the Loop* (29). Challenge: Higher or lower (32). Challenge: *Complex Numbers* (hand out). Challenge: *Color code resistors* (43).
9/3	2 – Physical Computing	Getting Started, ch. 4 – 6 Pin functions, resistors. Modules and imports. Threads. IRQ's	Challenge: *Longer & Shorter Light Ups* (49). Challenge: *Multiple LED's* (53). Challenge: *Buttons and LED's* (57). Challenge: *Improve with Second Button* (66). Challenge: *Timings* (74). Print reaction time. Challenge: *Timings* (79). Print time.
9/10	3- PicoW Interfaces	Getting Started, ch. 7 – 9 IRQ's. ADC, hex. File storage.	Challenge: *Customization*. Add second alarm and print which one. Challenge: *Customization*. Add light sensor. Challenge: Stop program if no more storage.
9/17	4 – a	Getting Started, ch. 10, Appendix C. Communication: I2C, SPI. Communication: Programmable IO Using WiFi.	Challenge: display and log temperature and light. Challenge: Make a moving light pattern.
9/24	5 – a	Capacitors*	(Labs & projects marked * have an outline below.)
10/1	6 – b	Project Function Generator*	Solder and program Pico W high-speed DAC as an arbitrary waveform generator.
10/8	7 – a	RC Filters	Build single pole RC high- and low pass filters. Measure and characterize them with the Function Generator.
10/15	8 – a	Diode and LED's.	Use the Function Generator as a low speed DAC to measure I-V curves of resistors, and diodes. Measure turn-on voltage of visible LED's. Program addressable LED strips.
10/22	9 – a	Op Amps	Large gain circuit and transimpedance photodiode amplifier.

10/29	10 – a	Stepper Motors	Use Pico W with motor driver boards to move a linear stage driven by stepper motors. Work on Crane Operator's Trick.
11/5	11 – a	Project: Pendulum	Add a second Pico W with IMU to pendulum bar, powered by a battery. Program Pico W's to communicate, moving to stationary. Test. Measure small amplitude period and damping.
11/12	12 – a	Project: Pendulum	Add stepper motor driver that moves pivot with amplitude and frequency. Demonstrate *over the top* and challenge.
11/19	13 – a		Measure large amplitude period versus amplitude.
12/3	14 – a		Try to find period 2 motion.
Final			Presentations and final paper.

Lab and Project Notes

Capacitors

Use a capacitor to make an oscillator. The picoW turns on a digital output to charge a capacitor through an RC circuit. When it reached 2/3 Vcc, it turns off, when it reached 1/3 Vcc, it turns back on. The goals are to build and model this device, measure it, and make a timer with a given period.

Project Function Generator

Basic idea is to use the picoW digital outputs to drive an R-2R DAC. Once this is characterized, it can be programmed using **`pio`** and **`dma`** to make a very high speed arbitrary waveform generator. This programming is an advanced topic that will not be covered; they will just use the given python code.

They will modify the program to make a sine wave with parameters of amplitude and frequency.

RC Filters

(I2S) to create a sine wave with an . This drives an RC filter, and the ADC measures the output. The goal is to measure the RC filter's amplitude response versus frequency. Do both a high- and low-pass RC filter.

Diodes & LED's

Use PicoW + DAC to measure transfer curve of a diode. Fit to exponential. Repeat with red, green, and blue LEDs.

Digitally control modern LED strips. Program different patterns.

Op Amps

Use low voltage dual op amps. One op amp makes a virtual ground. The second is available for circuits.

Make a high gain amplifier and demonstrate.

Make a transimpedance amplifier that is an interface with a sensitive photodiode.

Stepper Motors

Use a motor driver breakout board to drive a stepper motor that moves a linear stage.

Work on crane translation problem.

First potentiometer control of pendulum position.

Challenge: Move pendulum so no initial or final transients.

See Am. J. Phys. 90, 169–176 (2022).

Project: Rigid Pendulum

This is a multi-week project that involves more instrumentation, and more advanced analysis and simulation.

1. Add stepper motor driver that moves pivot with amplitude and frequency.

Record pendulum amplitude vs. drive frequency. Try to keep angle small. Look for phase change while going through resonance.

2. Demonstrate over the top and challenge.

Challenge students to program stepper to start from stationary and end with pendulum in continuous *over the top* motion.

3. Measure large amplitude period versus amplitude.

4. Try to find period 2 motion.