Robophysics boot camp outline:

Introduction: Swimmers are ubiquitous in nature—on land, in sand, and through water. Understanding their effectiveness often relies on complex hypotheses, grounded in differential equations, yet not every environment yields a clear model. Richard Feynman once said, "What I cannot create, I do not understand." Can we truly grasp what enables diverse swimming behaviors without recreating them ourselves? Enter robots—the accessible experimental tools that allow us to test and refine our theoretical frameworks.

However, the world of robotics isn't always readily accessible to physicists and biologists alike. This boot camp aims to change that by empowering students to experience robotic experiments from inception to conclusion. From building and controlling robots to modeling and testing hypotheses, participants will delve into the fundamental principles using one of the simplest swimmers as our guide. Throughout the camp, we'll explore how these robots perform across various environments, refining our models with each experiment.

Day 1: Build the Robot

Morning:

- **Lecture + lab tour (Dan) [9-10:30am]:** Explore the amazing world of swimmers and existing efforts to (mathematically) model their behaviors. Introduce the concept of robophysics—using robots to test biological hypotheses.
- **Break [10:30-10:45]**
- **2-hour Tutorial (Madison) [10:45-12:45pm]:** Learn the basics of robotics. Participants will be introduced to Arduino boards, motors, and assembly techniques for building robots. Each student will receive motors, an Arduino board, and necessary components to construct their robots.
    - **Check point 1**: use the breadboard to flash an LED
    - **Check point 2:** use the Arduino to rotate a motor

LUNCH :)

Afternoon:

- **Workshops (Deniz) [2-5pm]:** Hands-on session where students will assemble and control pre-designed 3-link swimmers. From here, students should form a group of two
    - **Check point 1:** Students should be able to calibrate the motor, assemble the 3-link swimmer with Lego
    - **Check point 2**: Students should be able to control and test the standard 3-link swimmer (w/ and w/o wheels).
    - **Check point 3:** Students should be able to run the robot at temporal frequency

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Day 2: Model the Robot

Morning (Jianfeng, edit this as needed) [9am-12:15am, with break]:

- **1-hour Lecture:** Introduction on geometric mechanics of three-link swimmer.
- **1-hour Tutorial:** Model the 3-link swimmer using a quasi-static approach.
- **1-hour workshop**: Students will run code to model the swimmer and explore modifications. We will provide templates for four modifications. But students are encouraged to explore.
    - Adjusting link sizes (e.g., what if the mid link gets longer? What if the first link gets longer? Related biology?)
    - Different link numbers (e.g., what is the benefit of adding one more link? How much faster can we get?)

Afternoon (Tianyu) [1:30-5pm]:

- **Design Session:** Students will design robots incorporating modifications to test their hypotheses derived from modeling efforts.

Day 3: Test the Robot

Morning (everyone) [9:30-12:30]:

- **Experimental Phase:** Students conduct experiments to validate their modeling hypotheses.
- **Back-up plans:** If the modification does not work, we will ask the students to play around with the gait parameters

Afternoon (everyone)[2-5pm]:

- **Presentation and Discussion:** Share findings and insights from robot experiments related to biology. Students will discuss modifications made, lessons learned, and implications for understanding biological swimmers.

Inventory item:

1. **40 Servos:**

   https://www.amazon.com/Micro-Helicopter-Airplane-Remote-Control/dp/B072V529YD?source=ps-sl-shoppingads-lpcontext&ref_=fplfs&psc=1&smid=A34CQKEVNF2MJX

2. **10 Aduino**

   https://www.amazon.com/Arduino-A000066-ARDUINO-UNO-R3/dp/B008GRTSV6/ref=asc_df_B008GRTSV6/?tag=hyprod-20&linkCode=df0&hvadid=693421862574&hvpos=&hvnetw=g&hvrand

=10775773932766348348&hvpone=&hvptwo=&hvqmt=&hvdev=c&hvdvcmdl=&hvlocint=&hvlocphy=9199231&hvtargid=pla-457497319401&psc=1&mcid=8d4415853f19330eb6cb8c1e7f18a8ed&gad_source=4

3. **10 breadboard**

   https://www.amazon.com/ELEGOO-tie-points-breadboard-Arduino-Jumper/dp/B01EV640I6?source=ps-sl-shoppingads-lpcontext&ref_=fplfs&psc=1&smid=A2WWHQ25ENKVJ1

4. **Power supply?**