Upsilon Lab *Fall 2018 Quarterly Report*

an Official UCLA Physics & Astronomy Department Sponsored Organization

Prepared by Krish Kabra, President & Grant Mitts, President

For Release on January 25th, 2019

"A lab for undergraduates, by undergraduates."

Mission

The mission of Upsilon Lab is to provide undergraduate students in the UCLA Physics & Astronomy department the opportunity to learn valuable skills to succeed in their future endeavors, whether in research, engineering, or other fields.

Quarter Highlights

- Eight active projects with thirty-five active members. Read about their progress on **pages 4-10**.
- All but one of the current projects will continue into Winter 2019, along with two new projects. Additional project ideas for prospective managers. Interested in applying? Read more on **page 11**.
- We are expecting for around forty-five total members for Winter 2019. This represents an approximately-10% capture of Physics & Astronomy undergraduate majors.
- We received a small grant from the Physics & Astronomy Department for our in-house projects.
- Contact us through our website! **upsilonlab.pa.ucla.edu** or **upsilonlab.org**.

Fall 2018 Summary

The beginning of the academic year saw Upsilon Lab continue on for its 3rd quarter under the new leadership of **Krish Kabra** and **Grant Mitts**.

In this time, we had thirty-five active members, working on eight active teams with eight active managers, for a total of forty-three department undergraduates involved directly in active projects.

Our eight active teams for this quarter are listed below. More information is included later in the report, on the respective project pages.

Advisory Board

The 2018-2019 Advisory Board is composed of three Department professors:

Prof. Jean Turner, Chair

Prof. David Saltzberg

Prof. HongWen Jiang

We would like to profusely thank the Advisory Board for their help and advice throughout the quarter, and their continued support throughout Spring 2018.

Pilot Waves

Sponsored by Prof. Seth Putterman

Managed by Alexander Tolstov

Project Description

Pilot wave theory is an alternative interpretation of quantum mechanics, originally created by De Broglie and later refined into Bohmian mechanics. This research group will design, propose, and create an experiment that replicates the hydrodynamic pilot wave results shown in the John Bush paper, *Pilot-Wave Hydrodynamics*, such as demonstrating a relationship between droplet movement, its radius, and bath acceleration. In order to do this, the group uses a speaker to vibrate a petri dish containing silicone oil to allow for the creation of droplets that remain on the surface without coalescing with the oil. The group also aims to see if the droplets are able to undergo double slit diffraction.

Quarter Project Highlights

During the fall quarter, the group worked in Prof. Puttermans lab, redesigning and improving the experimental apparatus. The first three weeks of the quarter were spent on verifying the accuracy of the data acquisition devices, like the accelerometer, to see if they were precise enough for future data collection. The second half of the quarter was spent on modifying and improving the petri-dish set up. Team members were working on image processing, Arduino light strip programming, and further experimental design. Other team members were tasked with creating an apparatus for the creation of uniform droplets, and 3D-printing a single slit diffraction well.

Quarter Membership Roster

Obed Camacho

Rebecca Lewis

David Su

Lucas Zhang

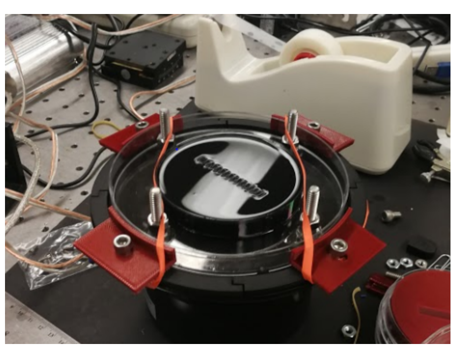


Figure 1: Pilot waves experimental apparatus showing oil droplets vibrating

PID with Microcontroller

In-House

Managed by Helena Huang

Project Description

A Proportional-Integral-Differential (PID) controller is a device used to make educated guesses with a systems history to predict its future and to control physical parameters using that knowledge. For example, most cars use PID controllers to control their speed they look at the current speed, where its going (derivative) and where its been (integral). In this project, team members will design a car together, and learn how to program a microcontroller (MCU), specifically an Arduino development board which utilizes the ATmega328p, to control the movement of the car so that it maintains a certain distance with the object in front of it. This will include how to interpret signals from a distance sensor, how to store and manipulate data for PID control, and how to output a signal to control the motion of the car.

Quarter Project Highlights

We began the quarter by researching on PID control methods. Then, members started to learn and practiced basic C++ coding on Arduino IDE. We went through if statements, loops, functions, and arrays. By building small Arduino projects with LEDs, push-buttons, and servos, members familiarized themselves with Arduino and gained basic electronic skills. Members also learned soldering while assembling a toy car for the project. Next quarter, we will be implementing PID control to the car we built.

Quarter Membership Roster

Hannah Boyer

James Snyder

Jason Jin

Matthew Zimmer

Yueyun Che

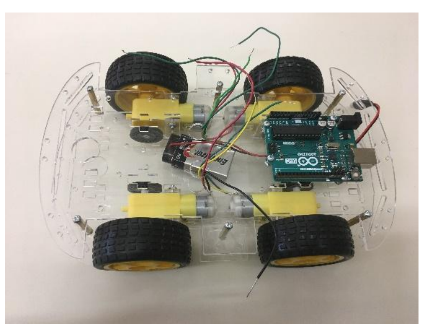


Figure 2: Built car chassis to be used for implementing distance PID control

Cyclotron Motion Simulation

In-House

Managed by Jared Rivera

Github: https://github.com/jaredrivera2314/CyclotronMotion

Project Description

Cyclotron motion is the motion that charged particles undergo in a magnetic field such that they move outward in a spiral path. Team members use Python to simulate the motion of charged particles undergoing cyclotron motion. They will then apply this simulation to physical systems to predict outcomes of potential experiments, one example of which includes determining plasma wave behavior in the atmosphere using cyclotron accelerators, and another example being determining particle trajectories in a particle collider.

Quarter Project Highlights

Our group of 8 active members made a lot of good progress this Fall and weve set ourselves up for a successful rest of the year. We started the quarter with basic Python tutorials (a summary of which can be found on the linked GitHub page above along with the rest of our mini-projects and current code-base), then moved on to learning principles of physical simulations. Were typically taught physics in the continuum (calculus, continuous space-time, etc.), so we had to first discuss coarse-graining all variables so that we could work on discrete computational methods. This included making CourantFriedrichsLewy condition arguments, performing numerical integration with Runge-Kutta 4, and reviewing the appropriate physics (basic EM and kinematics) so that we could coarse-grain it properly. We wrapped that up with a mini-project simulating the classic force-on-a-block problem from introductory mechanics.

We then moved on to progressing the actual cyclotron simulation code-base. We first made improvements to the architecture of last Springs code, mostly in terms of variable declaration, indexing, logic, and exporting of figures. We then identified that wed like to move on to isochronous cyclotron and synchrotron models, so we performed a literature review to support that. In that time, we did a study on the effect of in-plane magnetic fields on the particle trajectory to mimic Earths magnetic field and found that when implementing field strengths as small as those of Earths there were no significant effects on the final particle extraction velocity.

In the last few weeks of the quarter we broke ground on the two new models, mostly in implementing the Lorentz factor as a function of other independent variables. We also recreated the experimental method of putting a square-wave electric field through the cyclotron gap for jump acceleration in place of the logic-based method previously opted for. This new method will be implemented in all future models, and we hope to have the isochronous cyclotron and synchrotron models operational by the end of Winter quarter to perform comparisons with the current model and experiment. We eventually hope to apply this to particle collision simulations or an experimental project. Below is a statement from one of this years new members about their thoughts on the project so far:

> My experience has been very positive. I leaned about how to code simulations via the example of a cyclotron, learned how to use Runge-Kutta, and finally how to interact with papers that I was unfamiliar with. I feel like I gained useful tools through this process. I really enjoyed the atmosphere and interacting with everyone on a weekly basis.

Quarter Membership Roster

Umaima Afifa

Aanchal Singla

Christopher Ong

Hassan Farhat

Matthew Tran

Erika Hoffman

Calvin Lee

Solar Batteries & Charging Analysis

In-House & Partnership with the UCLA Renewable Energy Association

Managed by Emma Peavler

Project Description

As the effects of non-renewable energy resources (i.e. coal, oil etc) are compounding the issue of global warming, the creation of practical and manufacturable renewable energy sources is necessary for the future of humanity. This experiment group will be designing, simulating and creating solar energy storage devices using lithium ion battery cells (18650) and various solar panels. In this experiment team members will learn and use basic programming knowledge to simulate the efficiency of various solar panels and optimize a design that allows for the maximum return on investment for each solar pack. Members will also be able to engineer and build the energy storage packs for optimized use.

Quarter Project Highlights

This quarter, Upsilon Solar Team partnered with UCLAs Renewable Energy Association (REA) to begin programming a solar cell simulator using Python. This simulator will input the qualities of a given material to generate a set of example particles to represent a portion of a cell made of the material. Then, photons will strike the cell, and the program will track the subsequent flow of electricity by simulating the collisions between the photons and the cells atoms. The desired output will be data such as the current and voltage within the material and the cells temperature, and calculations such as efficiency and power output of the material. It will also create current-voltage graphs that describe solar cells. This quarter, Solar Team began creating the simulation, but primarily focused on learning the required Python skills. Next quarter, the team will further develop the program.

Quarter Membership Roster

Amir Amhaz

Gregory Chang

Pedro Godoy

Efficient Electricity Generation

In-House

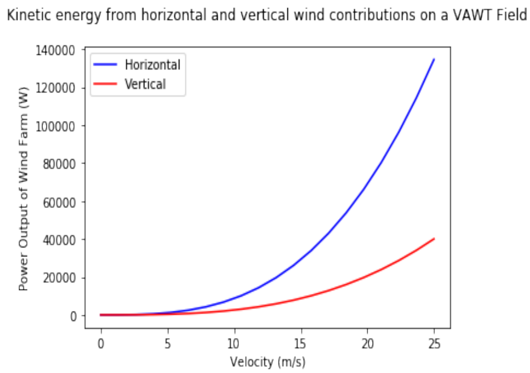
Managed by Wynne Turner

Project Description

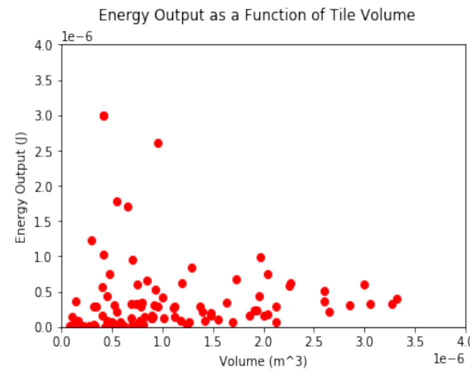
To meet increasing energy demands, scientists are researching electricity generation using novel methods such as thermoelectrics, photovoltaics, wave power, and other methods. Thermoelectric materials generate electricity from temperature differences between their layers, photovoltaics generate electricity using light, and wave power is a way to utilize wind waves to generate power. Team members will create simulations of these methods using Python, optimizing for maximized efficiency. These simulations can be used as a basis for actual power generators in the future.

Quarter Project Highlights

Member utilize Python text to develop and build coding skills related to optimization simulations.This quarter, our members each focused on a form of efficient electricity generation method. One member focused on creating effective simulations of wind turbines and discovering factors that lead to increased energy output such as the size of the blades, the location, and the orientation of the turbine. For example, a comparison run between turbines oriented in the traditional horizontal fashion and those oriented vertically was simulated as seen in figure 3a. This performance test involved maximizing energy outputs through position optimization in addition to reduction of frictional losses. Another member focused on piezoelectric tiles (PZT) for her method of energy generation as seen in figure 3b. She most recently simulated the relationship between energy output and the volume of the tile, as shown in the second figure.



(a) Comparison run between turbines oriented in the traditional horizontal fashion and those oriented vertically



(b) Energy output and the volume of the piezoelectric tiles (PZT)

Figure 3: Plotted simulations of different forms of electricity production.

Quarter Membership Roster

Mercedeh Khazaieli - New Manager

Trey Knudson

Casey (Cassandra) Armstrong

Asad Ukani

Meryem Kaleli

Elementary Particle Detection

Sponsored by Prof. Nathan Whitehorn

Managed by PJ Smigliani

Project Description

Cloud chambers were used in the discoveries of the positron (1932) and the muon (1936) by Carl Anderson, who was awarded the Nobel Prize in Physics for his positron discovery. In this project, team members will learn about elementary particles, design and build a cloud chamber, and use it to detect muons reaching the earth. Team members can then choose to use it to observe the fluctuations in muon flux at high altitudes, which entails a field trip to a nearby mountain with the built cloud chamber. Members can also measure certain quantities such as the muons charge to mass ratio with the chamber. The cloud chamber may also be put on display in the Physics and Astronomy Building.

Quarter Project Highlights

This quarter the team obtained all of the required materials to build a the cloud chamber. By working with Professor Whitehorn the team was able to move into a lab where we have put together the basic components of the cloud chamber. Professor Whitehorn has also helped us acquire dry ice from the UCLA chemistry department so that at the beginning of next quarter we will be able to start creating the cloud of isopropyl alcohol. This quarter we also discussed how we would go about programming the image recognition software so we can begin to test and implement our ideas once the chamber is running.

Quarter Membership Roster

Megan Andrakin

Rachel Bai

Kyle Charbonnet

Younjun Cho

Kristy Fu

Ryan Milton

Data Analysis

In-house

Managed by Mihai Bibreata

Project Description

Project will involve analyzing and visualizing collision data from the Large Hadron Collider in the Python language. Members can expect to put one or more coding proficiencies on their resumes after completing this project. Members with substantial coding experience can furthermore expect to contribute to the machine learning aspects of the project.

Quarter Project Highlights

This quarter, we discussed algorithm complexity analysis, code vectorization using numpy, and data visualization techniques using matplotlib. Additionally, members completed weekly coding exercises which involved creating or implementing algorithms to solve typical problems that might arise in computational heavy research, such as numerical integration, array operations, and data pre-processing.

Quarter Membership Roster

Antoine Delcayre

Vedant Sahu

Aman Desai

High Speed Camera with Raspberry Pi

Sponsered by Prof. Troy Carter

Managed by Sriram Bharadwaj

Project Description

The plasma in LAPD is operated in pulsed mode, for approximately a 10 ms duration once per second. Remarkable physics happens on the timescale of 10 ms, so we need a camera that has a shutter speed in this ballpark, e.g. 10-100 μs. There are several available for over $1000. Instead, we want to look at cheap cameras available for use on a Raspberry Pi. Some claim to have a minimum exposure time of 50 μs, but anything sub-millisecond is useful. This team's goal is to identify a camera suitable for this type of operation and implement it using a Raspberry Pi.

Quarter Project Highlights

This quarter we started using the Raspberry Pi to figure what a suitable setup would be for a high-speed plasma camera. We tried out different languages including C++ and Python and tried to understand what would be the best language to use for our purposes. We settled on python. We started writing a simple code that would be able to capture videos at a sufficiently high frame-rate. The major challenge we are facing is that the Raspberry Pi camera cannot keep up with the speed that we have set using our code. This is the primary challenge that our group is working to overcome.

Quarter Membership Roster

Kyle Willenborg

Matthew Singson

Winter 2019 Goals

We would like Winter 2019 to continue on with the same enthusiasm and dedication seen from our members and managers in Fall 2019. We hope to expand our active member number to at least forty-five total undergraduates. In order to do this, we require the help of fellow upper-classmen in the department to join the Upsilon Lab manager team so that we can continue spreading the skills and knowledge necessary to succeed in future career and research endeavours.

If you are interested in becoming an Upsilon Lab manager, please apply through our website:

upsilonlab.pa.ucla.edu/join-manager

Winter 2019 New Projects

We are excited to announce the addition of two new projects at the start of Week 4:

Solid State Physics Simulations, Basic Upsilon Training

Sponsered by Prof. Stuart Brown

Managed by Ahmad Ali

The focus of our group is to study Solid State Physics which seeks to establish generalized descriptions of materials properties, which can occur from a variety of factors. Professor Browns research now focuses on organic materials where adjusting to certain pressures for these materials can achieve effects such as superconductivity; by analyzing the Spin-Peirals which are localized pairs of electrons and measuring the materials using nuclear magnetic resonance (NMR) you are able to find the physical description for why these organic materials exhibit these properties.

A Course in Introductory Programming for Physics

In-house

Managed by Suyash Kumar

In Physics, and in Math, we often encounter situations where all cannot be said on pen and paper. Mathematical equations are, though compact and convenient, abstract, and are understanding of Physics can certainly benefit from visualization. Thereby, programming becomes an indispensable tool for us for ensuring that the power of visualization remains at our disposal. The goal of this course is to learn programming in Python for Physics simulation.

Apply through our website at:

upsilonlab.pa.ucla.edu/join-member

Winter 2019 Projects Ending

We would like announce the end of the **Data Analysis** group run by **Mihai Bibireata**. Their work reached a conclusion as all the members successfully found research positions in the department. We wish the members and the manager all the best on their future endeavours!

Special Thanks

The Presidents would like to thank:

- The Physics & Astronomy Department for their support and funding in operating Upsilon Lab.
- The Advisory Board for their invaluable advice throughout the course of the quarter.
- Professors Putterman, Whitehorn, and Carter for sponsoring projects this quarter, as well as all of the professors who have sponsored projects in the previous quarters. And to all these professors for their willingness to help the department undergraduates learn about physics from a research perspective.