

Brief Project Descriptions for Online ISEC 2021

This summer, we are offering a variety of projects covering a broad scope of scientific fields and interests. However, the availability of these projects are dependent on the availability of both the Mentor team and the accepted participants. This availability may change and we will do our best to communicate these changes as they are determined. Please note that not all projects are planned to be offered in both sessions, and not all Mentors will be available for more than one session. Once we accept Online ISEC 2021 participants, we will provide more information about project and Mentor availability. Please direct any questions to our [Contact Us](#) page.

- **Introduction to Quantum Mechanics**

Mentor: Carlos

- A conceptual introduction to quantum mechanics for beginners. Participants will complete a brief literature review and a further discussion about basic quantum phenomena: photoelectric effect, electron double-slit interference, and -of course- Schrödinger's cat.

- **Advanced Topics in Quantum Mechanics**

Mentor: Carlos

- This project will study advanced quantum phenomena by allowing participants to choose from a variety of topics to explore (quantum decoherence, quantum thermodynamics, and alternative interpretations of quantum mechanics). Most topics will be developed through a brief literature review and group discussions, although some might include numerical simulations. Depending on the topic chosen, knowledge of linear algebra, QM postulates, entangled quantum systems, and coding languages such as Matlab and Python might be required.

- **Writing a Science Fiction Story**

Mentors: Carlos and Oz

- This project is both a creative and scientific challenging project that asks participants to craft a scientifically accurate story, choosing some physical phenomena that you want to include, and make sure you narrate your story according to the laws of physics. This might entail a multidisciplinary research on numerous topics - or not!

- **Exploring genetic material of COVID-19**

Mentor: Elif

- This project will give participants a basic understanding of genome analysis by using data concerning the genetic material of COVID-19. A beginner-level version of this project will cover annotation of mutations, while a more advanced-level project will teach participants how to make a clustering analysis.

- **Introduction to bioinformatics concepts**

Mentor: Elif

- This project will give participants a detailed understanding of genome analysis steps by comparing different bioinformatics algorithms. A beginner-level will use online tools to carry out comparisons, and a more advanced version will run these algorithms using command line actions.

- **Geobiology of Archean & Precambrian Environments**

Mentor: Hayley

- Participants will simultaneously learn about the early Earth environments of the Archean and Precambrian while tackling the basics of writing a literature review. Specifically, you will learn the basics & scope of geologic history, including theories & hypotheses of early Earth marine & continental environments, emergence of life, fossilization, and analogous studies in astrobiology.

- **Environmental Science and Justice**

Mentor: Hayley

- Participants become familiar with ‘environmental justice’ through an activist lens by addressing the following learning outcomes 1) what does is environmental justice activism? 2) what do environmental justice advocates/activists believe & do? 3) how does science play into it? 4) Who are some environmental justice advocates/activists you should know?

- **Reconstructing Environmental Parameters Using Stable Isotopic Signals of Biomineralizing Organisms**

Mentor: Hayley

- Participants will learn the basics of stable & clumped isotopes systems as environmental proxies; why organisms coupled with isotopic analyses are a

unique way to probe environmental parameters; and will learn basic data analysis, statistics, graphing etiquette, and scientific reading & technical writing skills. Note: this project can be split among up to 2-4 groups of 2 participants each.

- **The Molecular Universe**

Mentor: Miriam

- In this project you will be a detective identifying molecules in the spectra of a star forming cloud. Specifically, you will identify spectral lines, and determine if the gas cloud is moving. Data could include molecular clouds near the center of our galaxy, Sgr A*, and around other stars in our nearby stellar neighborhood.

- **Interstellar Dust Grains**

Mentor: Miriam

- In this project you will use photometric observations to derive the temperature of interstellar dust of the interstellar medium, and calculate the molecular gas mass. You will learn what the black body emission is, as well as the Planck function and the dust opacity.

- **Interstellar Medium Chemistry**

Mentor: Miriam

- In this project you will do a bibliographic review of some of the first detection of the more than 200 molecules observed in space. You will learn how molecules are formed, and why we can observe them in very different and extreme places of our galaxy, such as in very cold molecular clouds, nearby the supermassive black hole in the Galactic Center (Sgr A*), or in stellar and planetary atmospheres.

- **Moon Colony Research**

Mentor: Oz

- In this project, participants will prepare a review of past, recent and future projects for human missions to the Moon and Lunar Base and Colony, specifically analyzing the weaknesses and strengths of these missions. Finally, Participants will write a report describing an ideal Moon Base and a mission to achieve that idea while using only the existing engineering and scientific developments.

- **Determining Star Formation Regions of a Galaxy**

Mentor: Oz

- In this project, participants will use Hubble Space Telescope observations of a galaxy and write a python code in order to bin, calibrate and create a contour map of star formation region candidates.

- **High Energy Multiwavelength Analysis**

Mentors: Oz and Radka

- In this joint project, participants will form two groups. One group will use NASA tool HEASOFT in order to calibrate and analyze an X-Ray spectrum of an astronomical source and the other group will use Fermitools to analyze LAT data from the Fermi Gamma-Ray Space Telescope. The groups will then combine their results to gain a better understanding of the high energy source.

- **Studying the Solar Cycle Through Sunspots**

Mentor: Radka

- Participants will learn how to program in python or improve their python programming by performing data analysis and statistical analysis on international sunspot data. This project will also include a literature review to better understand the changes that occur throughout the solar cycle

- **Astronomical Image Processing**

Mentor: Radka

- This project will allow students to merge the scientific and artistic aspects of image processing by learning about and carrying out the various steps that are needed to produce a final astronomical image. As part of the project, students will turn raw Hubble data into stunning images.

- **Zero2Hero**

Mentor: Vlad

- This project will teach participants the basics of algorithmic thinking and fundamentals of modern software engineering from scratch. There is a final project for a hands-on experience.

- **Small-Scale Computing**

Mentor: Vlad

- Participants will be required to have coding experience, and access to a raspberry pi. Participants will learn how to use the raspberry camera to make a small smart space. Depending on participants' ability it can include: use of smart lights, external peripherals (e.g. various sensors, sound outputs), and complex algorithms.

- **OK, Computer**

Mentor: Vlad

- Learn about the basics of ML and AI while working on a hands-on project, with a strong focus on understanding the mathematical aspects, especially tensor calculus. The final project will be discussed with the participants, and can be anything from a chatbot to a text analysis algorithm.

- **Now You See Me**

Mentor: Vlad

- This project will focus on the implementation, use of libraries and frameworks, and culminate in building a working and complex application. Participants will use state-of-the-art algorithms, like YouOnlyLookOnce.

- **Data, Data, Data**

Mentor: Vlad

- This project will utilize large-scale and high-performance computing applied to very large data-sets. Participants may engage in cloud computing, and may possibly use data generated by other ISEC projects (to be discussed).

- **Human Morality & Ethics (Religious Morality, Kant & Nietzsche, maybe Positivists)**

Mentor: Yurga

- Morality is one of the fundamental concepts in our lives. It determines almost all of our actions. Without morality, our lives may not have meaning. However, for some of us, moral arguments do not have any meaning since they do not have "truth values," which means that they cannot be either falsified or verified. Hence, this project's aim is to tackle questions like "what is morality?", "what does morally good or morally bad mean?" and "how do we determine which action is morally good or bad?"

- **Critical Thinking on (Natural) Science**

Mentor: Yurga

- It is considered common knowledge that science's aim is to understand and explain the empirical, phenomenal world. Explanations consist of objective truth(s) which are independent from scientists' subjective biases. However, if we abstract ourselves from the methodology of sciences, we will see that there is an organizational social structure that determines the aim and purpose of science, such as in science institutes, universities etc.. As we reflect on these structures in this project rather than the science itself, we are going to tackle the problem of objectivity and the problem of universal truth.