2018 New Jersey
Governor's School of Engineering and Technology
at Rutgers University

Core/Elective Classes
July 1, 2018 - July 27, 2018
All students will take both of the following “Core Courses”:

Core Class: Modern Physics
Instructor: Michael Gentile, Department of Physics and Astronomy, Rutgers University

Physics discoveries in the 20th and 21st centuries radically changed the way humans think about the universe we live in. They range from the wondrous (the possibility of time travel) to the bizarre (that the universe is somehow aware of all possible ways things can happen, and that our reality is the result of those possibilities combining together).

We are at the dawn of a new era in being able to examine our world, both on the very largest scales (the universe), and on the very smallest (the quarks and electrons that make up all matter). The most sensitive astrophysical instruments ever built will fly high above the earth and let us peer back in time to the earliest moments of the universe, letting us learn ever more about how the universe came to be, or if it had a beginning at all. The largest particle accelerator ever built went online in 2009 and will likely answer some of the most fundamental questions we have about the basic building blocks of the universe. It may even show us that our universe has more dimensions than the space and time that we are familiar with. This course is about the some of the most exciting physics of the last 100 years, how they were discovered, and what we might expect to learn in the near future.

* Prerequisites: Note that Modern Physics does not require that you have taken a physics course previously in high school. In fact, the topics that will be covered (particle physics, relativity, quantum mechanics, etc.) were chosen so that they won't overlap much with high school physics courses. In previous years, only about half of the Governor's School students had taken physics prior to attending the program, yet this didn't affect their ability to find an equal footing in this class.

Core Class: Robotics
Instructor: Andy Page, Rutgers OIT- Enterprise Systems, Systems Architect

Our robotics course engages students in team-based design challenges, using Lego Mindstorms NXT kits and a series of aftermarket sensors. Students will work in teams of 4 to build and program robots to solve design challenges and complete tasks. These challenges are quite competitive and help to unify the Governor's School experience.

This year, Robotics will focus on autonomous robotics. Unlike typical Robotics competitions, GSET robotics are run entirely without human control utilizing their sensors to choose behaviors. A series of guided lab exercises in the first week of the program will help everyone get up to speed with basic robotics programming.

Over the course of the program, each team of students will build two full robots. The first robots will compete to successfully navigate a maze while completing additional tasks. Our second and final competition this year will be Sumo-wrestling, in which teams will design robots that compete head to head in a Sumo-wrestling combat.

* Prerequisites: None.
Core Program Assignment: Reading/Discussions
Instructor: Jean Patrick Antoine, Associate Director, Governor’s School of Engineering & Technology

All scholars will participate in a pre-program reading assignment. We are pleased to announce that this summer’s reading will be “David and Goliath” by Malcolm Gladwell:

All Governor’s School scholars are required to read the book and will be scheduled to meet in groups during the program to discuss interesting topics. After reading the book, come prepared with a list of topics to discuss.

* Prerequisites: None.
Students will take 1 of our 5 “Elective A” courses:

Elective A: Game Design

*Instructor(s): Pavithra Lakshminarayan, Creator & Chief, Mindbytes*

How would you like to present a video game designed by you at the “National STEM Videogame Design Challenge”? Come to the “Game Design” program from Mindbytes and we will show you how. How often while you were playing a game, have you felt that some things could have been different about it, or even better? Well, here is your chance to try your hand at it. The “Game Design” course will introduce you to the process of creating a game, from design to creating characters and scenes to translating them into a game. You will start by creating a game design document and also learn how to manage your own project. You will pick a theme, design a game and also build an interesting method of evaluating the game you build. What are you waiting for?

*Prerequisites: None, but programming skills help*

Elective A: Renewable Sustainability

*Instructor(s): Ashley Pennington, Chemical & Biological Engineer*

The purpose of course is to provide engineers with a broad and hands on knowledge of various sustainable engineering methods. Students will build a solid foundation on the electrical, chemical, biological, and engineering related theory behind renewable and sustainable processes. Topics covered are in the areas of sustainable farming, coastal and ocean processes, and various facets of sustainable energy, from biofuels to batteries, solar and wind energy, as well as cogeneration. For Guest Lectures we invite professors, postdoctoral researchers, or advanced PhD candidates to speak on how their research ties into the sustainability topic currently being discussed. At the end of each lecture students will be asked to write Jeopardy questions, over the course of the summer students must have completed 1 question in each difficulty category. Questions may be used in the Rutgers Energy Institute Outreach Jeopardy Game.

*Prerequisites: None*

Elective A: Integrated Circuit Computer Design

*Instructor(s): Dr. Michael Caggiano, Professor in Electrical & Computer Engineering, Rutgers University*

The students will learn and become proficient in a computer design language that analyzes electrical and electronic circuits. We will use a free downloadable circuit program that can be loaded onto a school computer or even a student laptop. The generic program is called SPICE, Simulation Program with Integrated Circuit Emphasis. The free student version is called LTSPICE. It is a simpler program that has smaller data library of devices but will be ample for our purposes. This class will be very useful for future Electrical and/or Computer Engineers, since undergraduate courses often involve intensive circuit simulation projects. This course will give the high school students a good head start over those that have no experience at all with computer design tools.

*Prerequisites: Will need a laptop for class*
Elective A: Fundamentals of Radio-Controlled Flight
Instructor(s): Robert Panco, RU Airborne Team Lead, Rutgers AIAA

The objective of this class is for students to acquire, understand, and apply fundamental knowledge of aerodynamics and structures. As part of this class, the students will study the aerodynamic and propulsive aspects of some model airplanes. As a class, the students will discuss the differences between them and predict aircraft performance. They will also be lead through constructing these aircrafts in small groups. Throughout the construction process, individuals will take turns on flight simulator programs to enhance their understanding of aircraft controls. Finally, the airplanes will be flown and compared to predictions.

*Prerequisites: None

Elective A: Join a Virtual Research Group
Instructor(s): Dr. Jonathan Singer, Professor in Mechanical & Aerospace Engineering, Rutgers University

A persistent dilemma facing modern undergraduate education is the challenge of providing research experience given resource constraints. This elective offers a pilot study of a virtual research group (VRG) module. Specifically, the VRG will employ a mixture of fundamental lectures on materials assessment techniques (e.g. microscopy, spectroscopy, X-ray diffraction, and mechanical testing) and data from scientific literature to investigate a topic of materials research in much the same way any non-virtual research group would. Students will be asked to interpret different forms of data in a holistic fashion, separating artifacts and excess information from what is needed to answer the question at hand. This approach will simulate the discovery process generally reserved for graduate-level study, developing students’ critical thinking skills along with knowledge of materials science. Through their participation and feedback, students will be integral to furthering the VRG module, and the results of the elective will be a part of a manuscript on education research. In this way, students will help build a tool to enable investigation-based education in environments lacking the extensive laboratory resources of a major research institution.

* Prerequisites: None.
Students will take 1 of our 4 “Elective B” courses:

**Elective B: Everything’s Material! Diving into the Exciting Field of Material Science and Engineering**

*Instructor(s): Kimberly Scott, Materials Science and Engineering, Rutgers University*

Material science and engineering is one of the most highly interdisciplinary and dynamic engineering disciplines. Material scientists and material engineers seek to understand the fundamental relationships between the structure, properties, processing and performance of materials in an effort to synthesize new materials, develop or improve processes for making materials and understand the role of materials in the changing environment of tomorrow. In this course, students are introduced to the field of material science and engineering by examining and analyzing the core categories of materials: everything from polymers to ceramics to crystals. Through hand-on experience and research facility tours, students will understand the fundamental relationships and see a small portion of future developments in this growing field.

*Prerequisites: None.*

**Elective B: Earthquake Resistant Structures**

*Instructor(s): Dr. Husam Najm, Department of Civil Engineering Director of Undergraduate Program, Rutgers University, and Graduate Students in Civil Engineering, Rutgers University*

The purpose of this class is to analyze, design and experimentally validate the response of a five story balsa building to earthquake loading. [Explore and analyze effects of site conditions on earthquake ground motion and select the site that provides optimum conditions for future construction.] Students will work in groups to analyze and design an optimum, five story wooden frame building with bracing for provided dead and earthquake loading. The building design will be in a scale of 1:20, and students will verify the building's performance under earthquake loading on a shake table.

*Prerequisites: None.*

**Elective B: Fundamentals of Micro- and Nanofabrication**

*Instructor(s): Dr. Jeff Zahn, Professor in Biomedical Engineering, Rutgers University*

This course will review fundamental processing techniques used in micro and nanofabrication processes. You will discuss additive (e.g., thin film deposition), subtractive (e.g., etching), and lithographic patterning process which constitute the workhorse of solid state fabrication allowing features from 10s of nanometers to millimeter size scale to be produced. You will investigate how these individual processes are used to create devices from transistors and integrated circuits, microelectromechanical systems (MEMS) physical sensors such as accelerometers, chemical sensors, biosensors and microfluidic devices and discuss the principles on which these devices function. You will conduct a workshop where students will lithographically pattern a substrate with an image of their choosing and deposit a metal film through physical vapor deposition (PVD) which will reproduce the image in metal. You will also explore replica molding of polymer films which is commonly used in device fabrication to create features of the order of micrometers.

*Prerequisites: None.*
Imagine saving a child's life with a plastic coin, building an incubator from scrapped car parts, or zapping malaria-ridden mosquitoes dead right out of the sky.

This course focuses on the creative approaches to resolving the health problems deemed most devastating by the World Health Organization. Many of these conditions - both living conditions and health conditions - are most pervasive and most deadly in low-resource settings. You will learn about these diseases, how multiple engineering disciplines work together to solve them, and how these solutions affect (or don't affect) communities socially, economically, and culturally. Most importantly, this course aims to open the discussion to how significant simple solutions can be when the ideas and principles of the users are respected and considered; What is the point of life-saving technology if no one will use it?

* Prerequisites: None.
Suggested Engineering Interests: Any. This course is specifically designed to be relevant to many disciplines.