INTRODUCING STUDENTS TO MICROELECTRONICS AND THE PHYSICS OF ROCKETRY

Ready, Set, Launch! provides teachers with instructional videos to introduce students to microelectronics and the physics of rocketry. The videos also cover the procedure of launching a rocket and analyzing data collected.

To be prepared for our 2-day PD workshop, we strongly recommend you watch the following pre-work videos before arrival. Total watching time is 84 minutes.

If you have time and would like to see other videos associated with Ready, Set, Launch!, the full suite of program videos is provided after the pre-work videos.

Pre-work videos

2.01 Intro to Rocket Hardware (3:02)

- This video gives a brief history of model rocketry. There is also a hardware overview and concept terms important to rocketry are introduced.
- https://siue.yuja.com/V/Video?v=5788783&node=25570969&a=75841419&autoplay=1

2.02 Rocket Bodies (5:03)

- This video gives a brief description of rocket parts that will be significant for the build and design process.
- https://siue.yuja.com/V/Video?v=5936685&node=26411038&a=121843590&autoplay=1

2.03 Rocket Engines (4:18)

- This video discusses motor function and components, understanding model rocket motor labels, and model rocket motor classifications.
- https://siue.yuja.com/V/Video?v=5788959&node=25572086&a=112363164&autoplay=1

2.04 Recovery Systems (3:12)

- This video discusses how parachutes function, the equation for drag force, the equation for terminal velocity, and parachute size matters.
- https://siue.yuja.com/V/Video?v=5788789&node=25571023&a=1613637126&autoplay=1

2.05 Launch Controller (2:14)

- This video covers how launch control systems function.
- https://siue.yuja.com/V/Video?v=5788790&node=25571030&a=383099464&autoplay=1

2.07 Electronics Bay (5:58)

- This video describes the electronics bay or avionics as the "brains of the rocket" and discusses common avionics components and their uses.
- https://siue.yuja.com/V/Video?v=5800597&node=25705145&a=763866019&autoplay=1

2.15 Phases of Flight (2:21)

- This video discusses the phases of flight for a single stage model rocket, including launch, motor burn, coasting, apogee and parachute deployment, descent, and search and recovery.
- https://siue.yuja.com/V/Video?v=5800666&node=25706554&a=193879399&autoplay=1

3.02 Center of Gravity (7:50)

- This video discusses how the center of gravity is determined and provides an example problem. Kinematics equations map out the physics of the center of gravity.
- https://siue.yuja.com/V/Video?v=5801792&node=25727076&a=99917299&autoplay=1

3.03 Center of Pressure (7:25)

- This video discusses how the center of pressure is determined and provides an example problem. The importance of the center of pressure and its location behind the center of gravity are emphasized.
- https://siue.yuja.com/V/Video?v=5801777&node=25726909&a=203016971&autoplay=1

3.05 Low-Velocity Stability (3:46)

- This video discusses rocket stability at launch and compares passive vs active guidance for a rocket launch.
- https://siue.yuja.com/V/Video?v=5801762&node=25726643&a=33562543&autoplay=1

3.06 High-Velocity Stability (5:14)

- This video discusses stable vs. unstable flight and what it means if a rocket is too stable.
- https://siue.yuja.com/V/Video?v=5801755&node=25726557&a=148569360&autoplay=1

3.07 Weight, Thrust, and Impulse (3:43)

- This video provides meaning to common rocketry terms and their contribution to the rocket's performance.
- https://siue.yuja.com/V/Video?v=5801807&node=25727397&a=54470056&autoplay=1

3.08 Thrust-to-weight ratio (3:59)

- This video brings attention to the impact of various thrust to weight ratios and their effect on stability and performance.
- https://siue.yuja.com/V/Video?v=5801803&node=25727298&a=124258022&autoplay=1

3.10 Motor and Ignitor (1:45)

- This video breaks down the components of a solid model rocket motor and how the ignitor is inserted.
- https://siue.yuja.com/V/Video?v=5801794&node=25727125&a=204293904&autoplay=1

4:13 Intro to Microelectronics Hardware (4:13)

- This video gives an overview of the hardware used for the avionics bay and the importance of learning to categorize electronics and draw connections to industry.
- https://siue.yuja.com/V/Video?v=5974444&node=26516375&a=112989427&autoplay=1

4.14 Raspberry Pi (4:03)

- Introduces the microcomputer used for this project and how it allows all data to be stored in a single location.
- https://siue.yuja.com/V/Video?v=5974421&node=26516255&a=136405360&autoplay=1

4:15 Navio2 (2:31)

- This video describes the heart of our avionics system, the Navio2. This shield (add-on board) attached to the Raspberry Pi introduces new hardware and software functionality.
- https://siue.yuja.com/V/Video?v=5974407&node=26516171&a=56577360&autoplay=1

4.17 GNSS Receiver & GPS Antenna (2:57)

- This video describes how the two-part system of Global Position System (GPS), detecting satellite signals, and the Global Navigation Satellite System (GNSS), receiving signals and translating them into measurements, work together to determine position. This is a passive system only for receiving signals, not tracking the user.
- https://siue.yuja.com/V/Video?v=5974428&node=26516291&a=61763330&autoplay=1

5.01 Launch Introduction (2:42)

- This video reviews what the actual launch will look like and discusses the important concepts and procedures that will be covered to prepare for the big launch day.
- https://siue.yuja.com/V/Video?v=5814103&node=25904257&a=182462326&autoplay=1

5.02 Launch Environment (3:19)

- This video covers the critical factors influencing the launch and the surrounding area with an emphasis on adherence to the NAR guidelines for launch lugs, minimum site dimensions, and wind speeds.
- https://siue.yuja.com/V/Video?v=5814105&node=25904266&a=196302421&autoplay=1

5.03 Picking an Appropriate Launch Site (4:08)

- This video delves deeper into the impact of wind on the launch and landing of the rocket. Wind gradient and weather cocking are introduced, and the video discusses how to compensate for these in order to land in a desirable area.
- https://siue.yuja.com/V/Video?v=5814109&node=25904313&a=136993494&autoplay=1

5.04 Launch Pad Setup (4:08)

- This video reviews what the actual launch will look like and discusses the important concepts and procedures that will be covered to prepare for the big launch day.
- https://siue.yuja.com/V/Video?v=5814115&node=25904373&a=93728124&autoplay=1

5.08 Launch Procedure (1:19)

- This video guides users on how to properly operate the launch controller for a safe launch.
- https://siue.yuja.com/V/Video?v=5815464&node=25916455&a=54883592&autoplay=1

INSTRUCTIONAL UNITS

In this section you can find the breakdown of the 7 instructional units associated with Ready, Set, Launch!, including a brief unit description, SGSS standards alignment, unit objectives, next-steps. Descriptions, key words, and links for each video are also included.

1. INTRODUCTION

This video provides a course overview of theoretical, hands-on, and analysis components. Goals are presented for design/hardware (background concepts, terminology, and hardware, transferrable skills), build (introduction of and accounting for error), launch (picking a launch site, assembly of motor, using a launch system), and analysis (comparing observed and predicted data, suggesting improvements/iteration supported by data) components. Viewers are also introduced to critical rocket subsystems.

Objectives for this unit:

- Students will have a path for working through the theory of rocket flight and construction, launch, and analysis of a model rocket.

After this unit, you're ready to:

- Students will be ready to begin Unit 2, Rocket Hardware.

NGSS STANDARDS ALIGNMENT*

HS-ETS1: Engineering Design

- ***HS-ETS1-2****: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*

VIDEOS (7:38 total)

1.01 Intro to Single Stage Rocket (7:38)

This short module introduces students to the project, what its goals are, and what students will be learning.

Key concepts: Roadmap to project, learning goals

Link:
https://siue.yuja.com/V/Video?v=5788518&node=25568921&a=1561679309&autoplay=1

2. ROCKET HARDWARE

Rocket Hardware videos highlight each component of the rocket body, exploring the function and relevance of each. The purpose of this unit is to familiarize students with the rocket body and to prepare students for the rocket build in the next unit.

Objectives for this unit:

- Students should understand what hardware is required for rocket flight.
- Students should understand the function of each piece of hardware and why it is necessary.

After this unit, you're ready to:

- Students will be ready to begin Unit 3, Rocket Design, where they will learn how the physics behind these hardware components enables rockets to fly.

NGSS STANDARDS ALIGNMENT*

HS-PS2 Motion and Stability: Forces and Interactions

- ***HS-PS2-3:*** *Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS3: Energy

- ***HS-PS3-3****: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

VIDEOS (1 hr 7 min total)

2.01 Intro to Rocket Hardware (3:02)

This video gives a brief history of model rocketry. There is also a hardware overview and concept terms important to rocketry are introduced.

Key concepts:
materials, recovery systems, motors, avionics, launch instruments, air resistance, avionics, thrust, impulse

Link:
https://siue.yuja.com/V/Video?v=5788518&node=25568921&a=1561679309&autoplay=1

2.02 Rocket Bodies (5:03)

This video gives a brief description of rocket parts that will be significant for the build and design process.

Key concepts:
nosecone, body tubes, shock cord, parachute, wadding, fins, motor, shroud lines, lunch lugs, coupler, electronics bay, centering rings, payload

Link:
https://siue.yuja.com/V/Video?v=5936685&node=26411038&a=121843590&autoplay=1

2.03 Rocket Engines (4:18)

This video discusses motor function and components, understanding model rocket motor labels, and model rocket motor classifications.

Key concepts:
energy source, safety, ejection, nozzle, motor casing, delay charge, ejection charge, black powder, composite fuel, single use vs. reloadable

Link:
https://siue.yuja.com/V/Video?v=5788959&node=25572086&a=112363164&autoplay=1

2.04 Recovery Systems (3:12)

This video discusses how parachutes function, the equation for drag force, the equation for terminal velocity, and parachute size matters.

Key concepts:
parachutes, deployment, drag force, terminal velocity

Link:
https://siue.yuja.com/V/Video?v=5788789&node=25571023&a=1613637126&autoplay=1

2.05 Launch Controller (2:14)

This video covers how launch control systems function.

Key concepts:
launch controller setup and safety

Link:
https://siue.yuja.com/V/Video?v=5788790&node=25571030&a=383099464&autoplay=1

2.06 Launch Environment (3:19)

This video contains a detailed description of launch control system components and the requirements for a launch site.

Key concepts:
launch pad, launch rail, launch location

Link:
https://siue.yuja.com/V/Video?v=5788793&node=25571041&a=1591748067&autoplay=1

2.07 Electronics Bay (5:58)

This video describes the electronics bay or avionics as the "brains of the rocket" and discusses common avionics components and their uses.

Key concepts:
altimeter, IMU, microcontrollers, microcomputers, batteries, telemetry, GPS

Link:
https://siue.yuja.com/V/Video?v=5800597&node=25705145&a=763866019&autoplay=1

2.08 LiPo Batteries I (6:43)

This video explains how batteries work and explains how rechargeable batteries are special.

Key concepts:
cathode, anode, charge, current, reverse, electrolyte

Link:
https://siue.yuja.com/V/Video?v=5788802&node=25571116&a=2029685516&autoplay=1

2.09 LiPo Batteries II (6:49)

This video differentiates between lithium ion and lithium polymer batteries. The rationale for using lithium polymer (LiPo) batteries for this project is discussed, and the video discusses power converters, capacity, and internal resistance.

Key concepts:
cathode, anode, charge, current, reverse, electrolyte

Link:
https://siue.yuja.com/V/Video?v=5788816&node=25571167&a=1101833710&autoplay=1

2.10 Power Converters I (3:10)

This video discusses current types and the need for power converters. It also sets up a basic boost converter circuit.

Key concepts:
alternating current, direct current, power, voltage, current, inductor, capacitor, switch

Link:
https://siue.yuja.com/V/Video?v=5788819&node=25571176&a=227065156&autoplay=1

2.11 Power converters II (11:59)

This video explains the physics and process of a converter boosting power.

Key concepts:
inductor, diode, capacitor, switch, load, voltage, current, resistance, v=ir

Link:
https://siue.yuja.com/V/Video?v=5800643&node=25706189&a=2032108171&autoplay=1

2.12 Telemetry Radio (3:29)

This video discusses the need for communication to relay data mid-flight, both to the vehicle and from the vehicle.

Key concepts:
collect data, downlink, uplink, tel int

Link:
https://siue.yuja.com/V/Video?v=5800648&node=25706262&a=452499057&autoplay=1

2.13 GPS (3:03)

This video explains how global positioning systems use 3-way communication between transmitters, satellites, and receivers to track location.

Key concepts:
GPS, transmitter, receiver, FCC license, latitude, and longitude coordinates

Link:
https://siue.yuja.com/V/Video?v=5800652&node=25706314&a=873982398&autoplay=1

2.14 Airflow & Cameras (2:55)

This video presents issues that should be considered when including a camera in the rocket payload

Key concepts:
video, durability, camera shroud

Link:
https://siue.yuja.com/V/Video?v=5800659&node=25706430&a=1773309503&autoplay=1

2.15 Phases of Flight (2:21)

This video discusses the phases of flight for a single stage model rocket, including: launch, motor burn, coasting, apogee and parachute deployment, descent, and search and recovery.

Key concepts:
launch, thrust, burn, acceleration, max velocity, coast, momentum, apogee, ejection, parachute, drift, recovery

Link:
https://siue.yuja.com/V/Video?v=5800666&node=25706554&a=193879399&autoplay=1

3. ROCKET DESIGN

The goal of this topic is to help students meet the engineering component of this course: to design the optimal payload for their rocket, allowing it to achieve the desired apogee. This goal is met as students explore the many factors that impact a rocket's flight, including forces acting on the rocket, aerodynamic features of the rocket, and the rocket's mass. Rocket Design is split into three sections: Stability and Performance, Analytical Model, and OpenRocket Computational Model.

Objectives for this unit:

- Students understand the physics of rocket flight.
- Students are able to set up equations of motion to model their own rocket flight.
- Students are able to use more sophisticated models to predict and analyze theoretical rocket performance and optimize design.

After this unit, you're ready to:

- Students can make an OpenRocket model of the rocket they will build.
- Using a simulation, students can model the effects of changing payload mass, motor thrust, and wind conditions on rocket behavior.
- Students are ready to begin Unit 4, Rocket build.

NGSS STANDARDS ALIGNMENT*

HS-PS2: Motion and Stability: Forces and Interactions

- ***HS-PS2-1:*** *Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration*
- ***HS-PS2-3:*** *Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS3: Energy

- ***HS-PS3-1****: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known*
- ***HS-PS3-2****: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).*
- ***HS-PS3-3****: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

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HS-ETS1: Engineering Design

- ***HS-ETS1-2****: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering*
- ***HS-ETS1-4****: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.*

3.a STABILITY AND PERFORMANCE

The first unit, Stability and Performance, begins with the introduction of science concepts critical to rocketry, such as center of Gravity and Center of Pressure. Students continue to gain foundational understanding as they learn the significance of weight and area distribution as it relates to the rocket's stability.

VIDEOS (46 min total)

3.01 Introduction to Rocket Design (3:52)

This video provides an overview of the design process for the project's model rocket and the importance of performing simulation to determine the appropriateness of the rocket design.

Key concepts:
parameters, engine systems, design software, constraints, apogee, stability, center of pressure, center of gravity

Link:
https://siue.yuja.com/V/Video?v=5801586&node=25724001&a=180588974&autoplay=1

3.02 Center of Gravity (7.50)

This video discusses how the center of gravity is determined and provides an example problem. Kinematics equations map out the physics of the center of gravity.

Key concepts:
center of gravity, balance, mass, kinematics equations

Link:
https://siue.yuja.com/V/Video?v=5801792&node=25727076&a=99917299&autoplay=1

3.03 Center of Pressure (7:25)

This video discusses how the center of pressure is determined and provides an example problem. The importance of the center of pressure and its location behind the center of gravity are emphasized.

Key concepts:
center of pressure, center of gravity, aerodynamic forces, lift, drag

Link:
https://siue.yuja.com/V/Video?v=5801777&node=25726909&a=203016971&autoplay=1

3.04 Equilibrium (2:31)

This video examines the three types of equilibrium: stable, unstable, and neutral and their impact on a rocket's flight.

Key concepts:
pitch, roll, yaw, stable equilibrium, unstable equilibrium, neutral equilibrium, stability

Link:
https://siue.yuja.com/V/Video?v=5801773&node=25726783&a=2837954&autoplay=1

3.05 Low-velocity Stability (3:46)

This video discusses rocket stability at launch and compares passive vs active guidance for a rocket launch.

Key concepts:
aerodynamic stability, launch rail, active guidance, passive guidance

Link:
https://siue.yuja.com/V/Video?v=5801762&node=25726643&a=33562543&autoplay=1

3.06 High-velocity Stability (5:14)

This video discusses the factors of stable vs. unstable and what it means if a rocket is too stable.

Key concepts:
center of pressure, center of gravity, angle of attack, aerodynamic stability, equilibrium, center of pressure, center of gravity, static margin

Link:
https://siue.yuja.com/V/Video?v=5801755&node=25726557&a=148569360&autoplay=1

3.07 Weight, Thrust, and Impulse (3:43)

This video provides meaning to common rocketry terms and their contribution to the rocket's performance.

Key concepts:
weight, thrust, impulse, specific impulse

Link:
https://siue.yuja.com/V/Video?v=5801807&node=25727397&a=54470056&autoplay=1

3.08 Thrust-to-weight ratio (3:59)

This video brings attention to the impact of various thrust to weight ratios and their impact on stability and performance.

Key concepts:
weight, thrust, acceleration

Link:
https://siue.yuja.com/V/Video?v=5801803&node=25727298&a=124258022&autoplay=1

3.09 Engine/motor discussion (4:16)

This video discusses the differences between liquid and solid motors and the optimal applications for each.

Key concepts:
liquid engines, complexity, efficiency, solid motors, cryogenic, non-cryogenic semi-cryogenic

Link:
https://siue.yuja.com/V/Video?v=5801797&node=25727204&a=213234437&autoplay=1

3.10 Motor and Ignitor (1:45)

This video breaks down the components of a solid model rocket motor and how the ignitor is inserted.

Key concepts:
nozzle, propellant, delay charge, ejection charge, starter (ignitor), leads

Link:
https://siue.yuja.com/V/Video?v=5801794&node=25727125&a=204293904&autoplay=1

3.11 Motor Selection (2:02)

This video considers the factors (i.e. classification, thrust) to consider in determining an appropriate motor for your specific rocket needs.

Key concepts:
motor class, impulse, diameter, thrust

Link:
https://siue.yuja.com/V/Video?v=5802053&node=25732626&a=168688844&autoplay=1

3.b ANALYTICAL MODEL

The second unit of Rocket Design, Analytical Model, transitions to using a theoretical, analytical model to solve for rocket flight parameters. The videos walk students using Newton's Second Law (F=ma) to write Kinematic Equations of Motion (EOMs) for the boost and coast phase of the rocket. The sum of the coast and boost heights are then used to determine the maximum height (apogee) the rocket will travel. Conversely, this process can be reversed to solve for the mass needed to reach a target altitude. Students will be shown an example problem and then be asked to apply the learning to create their own Google Sheets or Python analytical model.

VIDEOS (42 min total)

3.21 Derive and Describe Rocket Equations of Motion (9:47)

This video describes the dynamics of a rocket and how the Equations of Motion and simplifying assumptions are used to predict apogee.

Key concepts:
acceleration, velocity, position, thrust, equations, mass, phase, motor, assumptions, forces

Link:
https://siue.yuja.com/V/Video?v=5802187&node=25735144&a=55286960&autoplay=1

3.22 Solving Approximate Equations of Motion for Altitude (no drag) 11:34

This video provides walks through how to derive the apogee from the boost and coast phase, an example problem, and the reverse process for calculating the mass of a target altitude.

Key concepts:
acceleration, velocity, position, thrust, equations, mass, phase, motor, assumptions, forces, coast

Link:
https://siue.yuja.com/V/Video?v=5802334&node=25737665&a=185160010&autoplay=1

3.23 Solving Equations of Motion using Google Sheets (11:54)

This video provides an example for reference on how to create a Google Sheets spreadsheet for rocket dynamics analysis.

Key concepts:
acceleration, velocity, equations, intervals, forces, timestep, altitude, apogee, graph

Link:
https://siue.yuja.com/V/Video?v=5802310&node=25737318&a=101303304&autoplay=1

3.24 Solving Equations of Motion in Python (9:01)

This video provides an example for reference on how to create a Python scriptfor rocket dynamics analysis.

Key concepts:
Python, matplotlib, numpy, parameters, acceleration, velocity, equations, intervals, forces, timestep, altitude, apogee, plot

Link:
https://siue.yuja.com/V/Video?v=5802343&node=25737822&a=128612411&autoplay=1

3.c OpenRocket COMPUTATIONAL MODEL

The third unit introduces students to the software OpenRocket. OpenRocket is used to perform simulations and generate data for a designed rocket's anticipated flight path. This data will be useful for optimizing rocket design, as well as for comparing it to the data generated in the analytical model. The videos in this unit provide instructions for downloading the software and becoming familiar with the critical variables. An OpenRocket file of the model rocket fabricated for this project is provided for exploration and for estimated flight parameters. This unit will be utilized by students who have the ability to download/access the software. Students without that capability will submit two chosen designs (based on their analytical models) to the teacher to be run through OpenRocket. This will allow for the determination of the payload mass that will be used for their rocket launch.

VIDEOS (1 hr 3 min total)

3.12 Install OpenRocket on Mac (3:12)

This video provides a walkthrough of installing OpenRocket open-source software on a Mac computer.

Key concepts:
download, application, simulation, designs, java

Link:
https://siue.yuja.com/V/Video?v=5802047&node=25732589&a=89006406&autoplay=1

3.13 Install OpenRocket on Windows (3:05)

This video provides a walkthrough of installing OpenRocket open-source software on Windows.

Key concepts:
download, application, simulation, designs, java

Link:
https://siue.yuja.com/V/Video?v=5802045&node=25732568&a=43503580&autoplay=1

Note: OpenRocket is not currently compatible with Chromebooks unless the Chromebook is run in developer mode.

3.14 Designing a Rocket in OpenRocket I (6:47)

This video demonstrates how to model the upper body of our rocket in OpenRocket.

Key concepts:
Components, nosecone, diameter, length, appearance

Link:
https://siue.yuja.com/V/Video?v=5802043&node=25732548&a=146420548&autoplay=1

3.15 Designing a Rocket in OpenRocket II (8:20)

This video demonstrates how to model the lower body of our rocket in OpenRocket.

Key concepts:
tube length, material, fin sweep, height,

Link:
https://siue.yuja.com/V/Video?v=5802042&node=25732516&a=53125167&autoplay=1

3.16 Adding a Motor and Parachute in OpenRocket (8:15)

This video covers critical factors for motor and parachute selection, along with how to import a specific motor into your rocket model.

Key concepts:
motor, parachute, dimensions, configuration, drag coefficient

Link:
https://siue.yuja.com/V/Video?v=5802039&node=25732498&a=49212485&autoplay=1

3.17 Rocket Weight (5:28)

This video demonstrates the effects of mass addition and its placement on stability and apogee.

Key concepts:
mass component, stability, payload, density, gravity

Link:
https://siue.yuja.com/V/Video?v=5802038&node=25732470&a=147533955&autoplay=1

3.18 OpenRocket Simulations I (7:49)

This video walks through how to set up appropriate parameters for an OpenRocket simulation and plotting a rocket flight.

Key concepts:
simulation, axis, plot, degrees, conditions, altitude, graph

Link:
https://siue.yuja.com/V/Video?v=5802037&node=25732458&a=119336350&autoplay=1

3.19 OpenRocket Simulations II (9:20)

This video shows how to use OpenRocket to plot different iterations for comparison in determining an optimal rocket configuration. Several examples provided examine critical factors like apogee.

KEY CONCEPTS
simulation, velocity, altitude, distance, motor class, conditions, apogee

Link:
https://siue.yuja.com/V/Video?v=5802055&node=25732691&a=24234833&autoplay=1

3.20 OpenRocket Optimization (8:04)

This video examines the balance between stable and safe vs effective and efficient. We also demonstrate the interactive process of designing a rocket for specific mission objectives.

Key concepts:
Performance, stability, weight, masses, fins, center of gravity, center of pressure, trade

Link:
https://siue.yuja.com/V/Video?v=5802054&node=25732646&a=107320&autoplay=1

3.25 Exporting OpenRocket Resources (3:05)

This video demonstrates how to export images of the rocket design for use in documents.

Key concepts:
export photos, appearance, change component colors

Link:
https://siue.yuja.com/V/Video?v=5802335&node=25737673&a=3756121&autoplay=1

4. ROCKET BUILD

This topic guides students and teachers through the actual construction of the rocket and the preparation of the avionics bay. Rocket build is divided into two units: Rocket Body Construction and Microelectronics Hardware and Software.

Objectives:

- Students understand the process of building a rocket.
- Students should understand the function of each component of the avionics hardware and why each piece is necessary.
- Students are able to set up and use the avionics hardware and software.

After this unit, you're ready to:

- With supervision, students can construct their rocket.
- Students can assemble the microelectronics into an avionics bay.
- Students are ready to begin Unit 5, Rocket Launch.

NGSS STANDARDS ALIGNMENT*

HS-PS2 Motion and Stability: Forces and Interactions

- ***HS-PS2-3:*** *Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS3: Energy

- ***HS-PS3-3****: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*

HS-ETS1: Engineering Design

- ***HS-ETS1-2****: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*

4.a ROCKET BODY CONSTRUCTION

These videos walk the viewer through building the rocket body and the many modifications that must be made to accommodate the avionics bay. The detailed rocket build instruction manual is provided in Appendix A.

VIDEOS (1 hr 2 min total)

4.1 Introduction to the Rocket Built (2:43)

This video presents a brief overview of the major components of the model rocket and the importance of material selection.

Key concepts:
rocket build, hardware, proper procedure

Link:
https://siue.yuja.com/V/Video?v=5804325&node=25769141&a=183995388&autoplay=1

4.2 Assemble Fins (8:30)

This video demonstrates how the fins are cut, glued, and prepared for installation.

Key concepts:
fin construction

Link:
https://siue.yuja.com/V/Video?v=5804313&node=25769026&a=18128352&autoplay=1

4.3 Assemble the motor mount (8:36)

This video walks through construction of the motor mount.

Key concepts:
motor mount construction

Link:
https://siue.yuja.com/V/Video?v=5973203&node=26510593&a=143693342&autoplay=1

4.4 Prepare the Fin Slots (4:35)

In this video, fins slots are cut into the lower body tube in preparation for fin installation.

Key concepts:
fin slot preparation

Link:
https://siue.yuja.com/V/Video?v=5804275&node=25768466&a=62634235&autoplay=1

4.5 Install the Motor Mount (7:07)

This video shows how to install the motor mount into the lower body tube.

Key concepts:
motor mount alignment and installation

Link:
https://siue.yuja.com/V/Video?v=5804266&node=25768286&a=84846112&autoplay=1

4.6 Install Fins (4:11)

In this video, fins are inserted into the lower body tube.

Key concepts:
fin alignment and installation

Link:
https://siue.yuja.com/V/Video?v=5804275&node=25768466&a=62634235&autoplay=1

4.7 Nose Cone Cut (2:09)

This video shows how to alter the nose cone to accommodate the avionics bay.

Key concepts:
nosecone fitting

Link:
https://siue.yuja.com/V/Video?v=5804266&node=25768286&a=84846112&autoplay=1

4.8 Securing the Nosecone (3:10)

In this video, installation of the nosecone is shown.

Key concepts:
nosecone installation

Link:
https://siue.yuja.com/V/Video?v=5804340&node=25769367&a=168831518&autoplay=1

4.9 Bulkhead generation (6:33)

In this video, the bulkhead is assembled and a hole for the antenna is drilled.

Key concepts:
bulkhead fabrication

Link:
https://siue.yuja.com/V/Video?v=5804335&node=25769266&a=93882091&autoplay=1

4.10 Assembly of the Upper Body Tube (8:17)

In this video, the upper body tube is fully assembled.

Key concepts:
coupler installation on lower body tube, bulkhead installation,

Link:
https://siue.yuja.com/V/Video?v=5814090&node=25904143&a=180914397&autoplay=1

4.11 Install Motor Retainer (3:51)

In this video, the motor retainer ring is installed.

Key concepts:
motor retention, motor retainer ring

Link:
https://siue.yuja.com/V/Video?v=5814063&node=25903969&a=4898518&autoplay=1

4.12 Shock Cord Length Considerations (2:09)

This video shows the critical step of how to measure and tie the shock cord to ensure the rocket stays connected during parachute deployment.

Key concepts:
fitting the shock cord, tying knots

Link:
https://siue.yuja.com/V/Video?v=5814039&node=25903811&a=158488320&autoplay=1

4.b MICROELECTRONICS: AVIONICS HARDWARE AND SOFTWARE

These videos introduce the microelectronics and telemetry. Once components are introduced, their integration and preparation for flight are demonstrated. The purpose of this topic is to prepare the avionics bay for use in flight. One component of preparation involves downloading the program Mission Planner, which allows the avionics bay to send information remotely to your ground control computer. Additionally, you will activate the GPS signal so that your rocket knows its location, and you will calibrate the IMU so that your avionics bay has accurate data about its orientation. These videos will walk you and your students through these vital steps. A more in-depth setup guide for the Navio2 and Mission Planner can be found at:
https://github.com/Brandonh291/Ready-Set-Launch-PD

VIDEOS (2 hrs 5 min total)

4.13 Introduction to Microelectronics Hardware (4:13)

Key concepts:
Avionics hardware, processors, sensors, communications, making connections to industry tools

Link:
https://siue.yuja.com/V/Video?v=5974444&node=26516375&a=112989427&autoplay=1

4.14 Raspberry Pi (4:03)

Introduces the microcomputer used for this project and how it allows all data to be stored in a single location.
electronics and draw connections to industry.

Key concepts:
Raspberry Pi capabilities, sensors, Linux

Link:
https://siue.yuja.com/V/Video?v=5974421&node=26516255&a=136405360&autoplay=1

4.15 Navio2 (2:31)

This video describes the heart of our avionics system, the Navio2. This shield (add-on board) attached to the Raspberry Pi introduces new hardware and software functionality.

Key concepts:
Robot Operating System (ROS), ArduPilot, GNSS, MS5611 barometer, dual IMU

Link:
https://siue.yuja.com/V/Video?v=5974407&node=26516171&a=56577360&autoplay=1

4.16 UART (3:38)

This video explains how the Universal Asynchronous Receiver Transmitter (UART) is used to transmit data packets from the rocket to the ground control station (laptop).

Key concepts:
asynchronous data transmission, data packets

Link:
https://siue.yuja.com/V/Video?v=5974435&node=26516321&a=151484371&autoplay=1

4.17 GNSS Receiver & GPS Antenna (2:57)

This video describes how the two-part system of Global Position System (GPS), detecting satellite signals, and the Global Navigation Satellite System (GNSS), receiving signals and translating them into measurements, work together to determine position. This is a passive system only for receiving signals, not tracking the user.

Key concepts:
GPS antenna, GNSS receiver

Link:
https://siue.yuja.com/V/Video?v=5974428&node=26516291&a=61763330&autoplay=1

4.18 Microelectronics Power Module (4:02)

This video discusses how the component regulates the power (voltage) from the battery to the Raspberry Pi/Navio2 to ensure it has the right amount.

Key concepts:
power regulation, battery life estimation

Link:
https://siue.yuja.com/V/Video?v=5974424&node=26516278&a=35155250&autoplay=1

4.19 Dual IMU (2:58)

This video shows how Inertial Measurement Units (IMUs) combine accelerometer, gyroscope, and magnetometer to determine the 3-D position and orientation of an object.

Key concepts:
IMU, spatial frame of reference, degrees of freedom, accelerometer, gyroscope, magnetometer

Link:
https://siue.yuja.com/V/Video?v=5974414&node=26516208&a=146645224&autoplay=1

4.20 Barometer (3:00)

This video explains how the measure of atmospheric pressure can be used to determine altitude.

Key concepts:
atmospheric pressure, relation of atmospheric pressure to altitude

Link:
https://siue.yuja.com/V/Video?v=5974482&node=26516585&a=33842246&autoplay=1

4.21 Radio Transmitter & Receiver (3:55)

This video defines telemetry as data collected at a distance and explains how we the rocket is able to communicate its health and stability by sending sensor information to ground control.

Key concepts:
transmitters, receivers, frequency, controller channels

Link:
https://siue.yuja.com/V/Video?v=5974411&node=26516202&a=37479840&autoplay=1

4.22 PWM (5:27)

This video discusses how the Pulse Width Modulation (PWM) component regulates the power (voltage) from the battery to the Raspberry Pi/Navio2 to ensure the electronics have the right amount of power.

Key concepts:
pulse width/duration modulation, voltage reduction, duty cycles,

Link:
https://siue.yuja.com/V/Video?v=5974404&node=26516140&a=136115138&autoplay=1

4.23 ADC (2:57)

This video explains the difference between continuous analog signals and discrete digital signals. It also discusses how this conversion is made and the importance of bit levels.

Key concepts:
analog to digital conversion, continuous and discrete signals, bit levels

Link:
https://siue.yuja.com/V/Video?v=5974485&node=26516595&a=54736358&autoplay=1

4.24 I2C (4:27)

This video discusses serial communication using the inter-integrated circuit (I2C) protocol on the Navio2, allowing multiple devices to pass data simultaneously. Advantages and disadvantages of I2C are also discussed.

Key concepts:
inter-integrated circuit (I2C), serial communication, controller and agent devices,

Link:
https://siue.yuja.com/V/Video?v=5974394&node=26516099&a=40072185&autoplay=1

4.25 Introduction to Microcontroller Setup (3:16)

This video is an introduction to the software setup that will be required to set up the Navio2 for rocket avionics.

Key concepts:
flashing operating system, secure shell (SSH) communication, configuring/starting ArduPilot

Link:
https://siue.yuja.com/V/Video?v=5974498&node=26516622&a=214670976&autoplay=1

4.26 Download and Flash the Raspberry Pi OS (2:34)

This video walks through how to install the operating system onto the Raspberry Pi using an SD card.

Key concepts:
flashing an operating system, Raspberry Pi OS, balenaEtcher

Link:
https://siue.yuja.com/V/Video?v=5974496&node=26516611&a=136024180&autoplay=1

4.27 Configuring the Raspberry Pi and Navio2 (3:01)

This video introduces the microcomputer used for this project and how it allows all data to be stored in a single location.

Key concepts:
connecting Raspberry Pi to internet

Link:
https://siue.yuja.com/V/Video?v=5974442&node=26516350&a=192992296&autoplay=1

4.28 Microcontroller Summary (1:56)

This video contains a summary of the Microcontrollers videos thus far, covering the hardware and setup of the Raspberry Pi, Navio2, ArduPilot WiFi, telemetry radio, flashing an OS onto a SD card, and SSH.

Key concepts:
microcontroller review

Link:
https://siue.yuja.com/V/Video?v=5974486&node=26516597&a=75514598&autoplay=1

4.29 Introduction to Mission Planner (2:09)

This video provides a walkthrough for the Ground Control Station (GCS) software, Mission Planner.

Key concepts:
ground control station, Mission Planner, ArduPilot, telemetry

Link:
https://siue.yuja.com/V/Video?v=5989167&node=26574037&a=100151028&autoplay=1

4.30 Installing Mission Planner (2:52)

This video gives an overview of the setup of Mission Planner (PC only) with the Navio2/Raspberry Pi to allow mission planning and data collection for the rocket.

Key concepts:
Mission Planner installation

Link:
https://siue.yuja.com/V/Video?v=5989165&node=26574034&a=70045618&autoplay=1

4.31 Telemetry Radio Setup (3:33)

This video walks through how to set up a connection between the avionics telemetry radio and the Navio2.

Key concepts:
Navio2 connection to telemetry radio

Link:
https://siue.yuja.com/V/Video?v=5974489&node=26516601&a=53475430&autoplay=1

4.32 Connect System to Mission Planner Using Telemetry (4:49)

This video shows how to set up the telemetry antenna for Ground Control (laptop) and the rocket (Navio2/Raspberry Pi) using Mission Planner.

Key concepts:
Telemetry connection to field laptop

Link:
https://siue.yuja.com/V/Video?v=5989155&node=26574014&a=130087720&autoplay=1

4.33 Arming and Disarming the Single Stage Rocket avionics (7:11)

This video shows how to change the settings in the Navio2 to allow the microcontroller to function as rocket avionics, and allow for easier data analysis after launch.

Key concepts:
Navio2 settings, arming/disarming, BitMask parameters, log files

Link:
https://siue.yuja.com/V/Video?v=5989343&node=26575007&a=64352386&autoplay=1

4.34 Calibrate Mission Planner IMU (2:43)

This video shows how to calibrate the accelerometer onboard the Navio2 using Mission Planner.

Key concepts:
accelerometer calibration, Mission Planner

Link:
https://siue.yuja.com/V/Video?v=5989346&node=26575029&a=153991730&autoplay=1

4.35 Calibrate Compass (2:14)

This video demonstrates how to "orient" the avionics by calibrating the Navio2 compass and magnetometer.

Key concepts:
compass and magnetometer calibration

Link:
https://siue.yuja.com/V/Video?v=5989347&node=26575032&a=88617457&autoplay=1

4.36 Calibrate GPS (1:32)

This video provides instruction on how to achieve a GPS Fix using the Navio2 and Mission Planner.

Key concepts:
GPS calibration

Link:
https://siue.yuja.com/V/Video?v=5989345&node=26575019&a=196714624&autoplay=1

4.37 Mission Planner Mapping without WiFi (3:07)

Provides instruction on downloading a saved map of the launch site for use on the Ground Control Station.

Key concepts:
setting position to map vehicle location

Link:
https://siue.yuja.com/V/Video?v=5989344&node=26575017&a=102861024&autoplay=1

4.38 Conclusion

This video is a brief recap of preparing the ground station and how it applies to real-life applications.

Key concepts:
summary of avionics content, connections to industry

Link:
https://siue.yuja.com/V/Video?v=5989334&node=26574963&a=140037969&autoplay=1

5. ROCKET LAUNCH

This topic helps students prepare for the big day: LAUNCH day! In the first section, Prepare for Launch Day, students consider the different aspects of preparing for a rocket launch. The second section, Launch Day, will walk you through the process of actually launching the rocket.

Additionally, your local chapter of the National Association of Rocketry is an invaluable resource for assistance with locating an appropriate launch site as well as launch day support. **Please visit https://www.nar.org/safety-information/model-rocket-safety-code/ to view the NAR Model Rocketry Safety Code and https://www.nar.org/contest-flying/u-s-model-rocket-new-sporting-code/introduction/launching-requirements/ for launch site specifications.**

Objectives:

- Students are able to prepare their rocket for launch.
- Students understand where and how to safely launch a rocket.
- Students are able to troubleshoot common problems with rocket launches.

After this unit, you're ready to:

- You are able to set up your launch site and date.
- Students can pack the parachute and prepare the rocket for launch.
- With supervision, students can set up the launch site and launch their rocket.
- You are ready to proceed to Unit 6, Rocket Data Analysis and Handling.

NGSS STANDARDS ALIGNMENT*

HS-PS2 Motion and Stability: Forces and Interactions

- ***HS-PS2-3:*** *Apply science and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.*

HS-PS3: Energy

- ***HS-PS3-3****: Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.*
-

HS-ETS1: Engineering Design

- ***HS-ETS1-2****: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*

5.a PREPARE FOR LAUNCH DAY

This first section, Prepare for Launch Day, should be completed WELL ahead of the actual launch day, as it provides valuable information related to detailed launch requirements, including how to pick a launch site and launch regulations. Because of the inherent risks to people, property, and equipment, it is critical that launch site regulations are strictly followed.

VIDEOS (21 min total)

5.1 Launch Introduction (2:42)

This video reviews what the actual launch will look like and discusses the important concepts and procedures that will be covered to prepare for the big launch day.

Key concepts:
launch day preparation overview

Link:
https://siue.yuja.com/V/Video?v=5814103&node=25904257&a=182462326&autoplay=1

5.2 Launch Environment (3:19)

This video covers the critical factors influencing the launch and the surrounding area with an emphasis on adherence to the NAR guidelines for launch lugs, minimum site dimensions, and wind speeds.

Key concepts:
launch location, launch control system, state/local/NAR guidelines, weather conditions, fire hazards

Link:
https://siue.yuja.com/V/Video?v=5814105&node=25904266&a=196302421&autoplay=1

5.3 Picking an Appropriate Launch Site (4:08)

This video delves deeper into the impact of wind on the launch and landing of the rocket. Wind gradient and weather cocking are introduced, and the video discusses how to compensate for these in order to land in a desirable area.

Key concepts:
selecting launch site for safety and rocket recovery, weathervaning/wind cocking, drift

Link:
https://siue.yuja.com/V/Video?v=5814109&node=25904313&a=136993494&autoplay=1

5.4 Launch Pad Setup (4:08)

This video reviews what the actual launch will look like and discusses the important concepts and procedures that will be covered to prepare for the big launch day.

Key concepts:
launchpad assembly, height of blast plate

Link:
https://siue.yuja.com/V/Video?v=5814115&node=25904373&a=93728124&autoplay=1

5.5 Install Recovery Wadding (1:57)

This video discusses the importance of recovery wadding and demonstrates how to install it.

Key concepts:
recovery wadding insertion

Link:
https://siue.yuja.com/V/Video?v=5814116&node=25904389&a=102145501&autoplay=1

5.6 Prepare Recovery System (4:10)

This video walks users through the steps of properly folding the parachute to safeguard deployment.

Key concepts:
parachute folding

Link:
https://siue.yuja.com/V/Video?v=5815473&node=25916571&a=52412459&autoplay=1

5.b LAUNCH DAY

It's LAUNCH Day! This is where your hard work pays off. You will finally take your carefully-built rocket outside and launch it in the air to the target altitude.

Before getting too excited about the launch, you must know a couple of things in advance to ensure a successful and safe flight. This Launch Day section teaches the detailed steps of how to proceed with a rocket launch by providing how to set up a proper launch site and launch rails, how to install and ignite motors, and how to launch your rocket with a launch controller.

You may want to perform two test launches before launching with your avionics package. We will test the first launch with no payload. This ensures that your rocket was appropriately built and that you are following the correct launch steps. We will be using the F15 motor, so please refer to the F15 motor installation video for the first launch. A second test launch may be performed using an F67 motor and a "dummy payload." This launch confirms that the motor can handle the mass of the avionics bay without putting the avionics in danger.

The final launch uses an F67 motor and the full avionics bay, communicating with your ground station. The data to be analyzed later in the course is done with this avionics launch so keep this in mind when you want to start collecting data by properly arming and disarming. Most importantly, have FUN!

Appendix B has launch checklists for before, during, and post-launch, as well as sample launch logs.

VIDEOS (32 min total)

5.7 Prepare Engine (0:43)

This video explains how to safely connect launch controller clamps to the ignitor wires.

Key concepts:
ignitor insertion, connection to launch control system

Link:
https://siue.yuja.com/V/Video?v=5815465&n

5.7a Install F15 Motor (3:10)

This video walks through how to prepare the F15 motor and place the ignitor for the structural integrity launch.

Key concepts:
F15 motor insertion, nozzle, create thrust ring, ignitor insertion, securing ignitor

Link:
https://siue.yuja.com/V/Video?v=7199011&node=30640816&a=164836106&autoplay=1

5.7b Install F67 Motor (2:47)

This video instructs users on how to prepare the F67 motor and place the ignitor for the dummy payload and avionics launches.

Key concepts:
F67 motor insertion, nozzle, built-in thrust ring, ignitor insertion, securing ignitor

Link:
https://siue.yuja.com/V/Video?v=7199019&node=30640841&a=127584072&autoplay=1

5.8 Launch Procedure (1:19)

This video guides users on how to properly operate the launch controller for a safe launch.

Key concepts:
launch procedure, safety protocol

Link:
https://siue.yuja.com/V/Video?v=5815464&node=25916455&a=54883592&autoplay=1

5.9 1st Launch: Rocket Test Launch (1:41)

This video explains the reasoning for the integrity test of the structure and the immediate steps if a misfire should occur.

Key concepts:
stability and structural integrity testing, launch procedures

Link:
https://siue.yuja.com/V/Video?v=5815462&node=25916441&a=107563438&autoplay=1

5.10 1st Launch: Trouble-shooting (3:00)

This video reminds learners that the best part of mistakes is what we can learn from them. Advice is offered on what might have happened and why and how to correct it for the next time.

Key concepts:
structural integrity, recovery separation, recovery system deployment, launch control system connections and battery

Link:
https://siue.yuja.com/V/Video?v=5815461&node=25916423&a=204410788&autoplay=1

5.11 2nd Launch: Dummy Payload (2:43)

In this final test, the rocket is launched with a dummy payload simulating the mass of the avionics bay. This will test the structural integrity of the rocket before using avionics.

Key concepts:
payload simulation, practice, stability

Link:
https://siue.yuja.com/V/Video?v=5815458&node=25916397&a=145568312&autoplay=1

5.12 2nd Launch: Troubleshooting (1:13)

This video discusses troubleshooting rocket hardware problems that may present during the payload simulation.

Key concepts:
payload simulation, troubleshooting structural issues

Link:
https://siue.yuja.com/V/Video?v=5815456&node=25916382&a=3971064&autoplay=1

5.13 Calibrating Mission Planner (3:37)

This video shows how to correctly calibrate and orient Mission Planner, so that it recognizes how the rocket is oriented in real space.

Key concepts:
sensor calibration, orientation, setting parameters, Mission Planner

LINK
https://siue.yuja.com/V/Video?v=5815498&node=25916781&a=56190008&autoplay=1

5.14 Preflight Avionics Check (3:02)

This video reviews all aspects of the avionics in preparation for flight including the Navio2 connection and parameters, telemetry antenna set-up, and GPS acquisition.

Key concepts:
Mission Planner, COM port, baud rate, GPS signals, logging parameters

Link:
https://siue.yuja.com/V/Video?v=5815494&node=25916726&a=140885970&autoplay=1

5.15 3rd Launch: with Avionics (2:20)

This video goes over all the critical components of the rocket to make sure everything runs smoothly and safely for the data collection launch.

Key concepts:
Mission Planner, ArduPilot, pre-launch assembly and preparation

Link:
https://siue.yuja.com/V/Video?v=5815481&node=25916658&a=145700960&autoplay=1

5.16 3rd Launch: Trouble-shooting (0:55)

This video focuses on determining whether a launch didn't go according to plan because of problems with the avionics or the rocket body itself and discusses how to address the issue.

Key concepts:
troubleshooting avionics

Link:
https://siue.yuja.com/V/Video?v=5815478&node=25916618&a=70283344&autoplay=1

5.17 Selecting Desired Flight Log Data (7:32)

This video shows how to sift through the massive amounts of data that can be collected by the Navio2 to find the desired flight log data.

Key concepts:
data flash log, parameters, acceleration, velocity, altitude, arming, disarming, Mission Planner

Link:
https://siue.yuja.com/V/Video?v=5816047&node=25922272&a=82441209&autoplay=1

6. ROCKET DATA ANALYSIS AND HANDLING

It's time to see how well your rocket performed! You probably have some idea from the qualitative data you collected while watching your rocket launch, but this next topic will help you derive quantitative data to provide more specific information about your rocket's flight.

This topic, Rocket Analysis and Data Handling, shows you how to manipulate and analyze the data collected during the flight. Data collected onboard your avionics bay is written as binary log files (.BIN). This file is handy for a small flight computer like the Raspberry Pi/Navio2 because they do not take up much storage. However, these files need to be converted into a different format to be usable on a PC for creating data plots in Google Sheets or Python. (Instructions for Mission Planner on Mac are still under development.) The videos walk through the steps of converting the Bin files into log files and, ultimately, into a CSV (comma-separated values) file for your spreadsheet. You'll then have access to all the data and tools needed to get a clear picture of your rocket's performance and how closely your predicted flight pattern matched what actually happened when it left the launch rail.

In the unfortunate event that your launch does not occur, we have made available actual launch data so that students can still perform the data analysis of the expected vs the actual.
You can find the backup launch data inside the IE 106 Single Stage Rocket Example Data at https://github.com/Brandonh291/Ready-Set-Launch-PD

Objectives:

- Students are able to locate and export data files from their launch.
- Students use multiple computational tools to examine experimental data for launch events.
- Students can compare predicted vs. actual data from their launches.

After this unit, you're ready to:

- Start planning how to implement this course into your curriculum!

NGSS STANDARDS ALIGNMENT*

HS-PS2: Motion and Stability: Forces and Interactions

- ***HS-PS2-1:*** *Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.*

HS-PS3: Energy

- ***HS-PS3-1****: Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.*

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HS-PS3: Energy

HS-PS3-2:

Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).

HS-ETS1: Engineering Design

- ***HS-ETS1-4****: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.*

VIDEOS (63 min total)

6.1 Post Processing Flight Data (3:20)

This video demonstrates how to download and convert the .bin flight log from the Navio2 and its conversion to a .log file in preparation for further data processing.

Key concepts:
downloading flight bin files, conversion to log files

Link:
https://siue.yuja.com/V/Video?v=5816125&node=25923021&a=38437273&autoplay=1

6.2 Analysis of Flight Data (7:36)

This video shows how to use Mission Planner to view plots for acceleration, altitude, and velocity data from the launch. It also shows how to understand the graphs in relation to launch events.

Key concepts:
launch data graphing, launch events, mission planner

Link:
https://siue.yuja.com/V/Video?v=5816122&node=25922990&a=19692159&autoplay=1

6.3 Install Spyder on Mac (2:33)

This video walks through how to install the Spyder integrated development environment (IDE) in a Mac OS if you wish to use Python to graph data.

Key concepts:
Spyder IDE installation on Mac, Python

Link:
https://siue.yuja.com/V/Video?v=5816121&node=25922974&a=155331161&autoplay=1

6.4 Install Spyder on Windows (2:04)

In order to use Python to graph data, this video walks through how to install the Spyder integrated development environment (IDE) in Windows OS.

Key concepts:
Spyder IDE installation on Windows, Python

Link:
https://siue.yuja.com/V/Video?v=5816120&node=25922970&a=205694528&autoplay=1

6.5 Export OpenRocket Simulation File (1:48)

This video is a recap of how to export OpenRocket simulations in order to compare predicted data (OpenRocket) to the experimental data of launch.

Key concepts:
export OpenRocket flight simulation data

Link:
https://siue.yuja.com/V/Video?v=5816118&node=25922953&a=144432276&autoplay=1

6.6 Comparison of Predicted vs. Actual Performance (9:27)

This video explains how to use Python to parse and plot the predicted data from OpenRocket with experimental data from the actual rocket launch.

Key concepts:
Python, CSV and .log files, graphing data, launch events

Link:
https://siue.yuja.com/V/Video?v=5816116&node=25922944&a=91933150&autoplay=1

6.7 Kalman Filter

This video discusses the Kalman filter, a crucial component in data handling for many real-life aerospace systems that rely on the optimal balance of sensors and model predictions.

Key concepts:
state estimation algorithm, model behavior vs. sensor measurements, disturbances to the model

Link:
https://siue.yuja.com/V/Video?v=5816115&node=25922932&a=156254766&autoplay=1

6.8 Pulling Data off the Raspberry Pi (6:33)

This video guides users on how to access the flight data from the Navio2/Raspberry Pi using a USB drive.

Key concepts:
Raspberry Pi, mounting a USB flash drive in Raspberry Pi,

Link:
https://siue.yuja.com/V/Video?v=5816182&node=25923398&a=136590664&autoplay=1

6.9 Analyzing Flight Data Using UAV Log Viewer (5:36)

This video shows how users can use UAV Log Viewer to view the rocket trajectory and get a preliminary look at the altitude, velocity, and acceleration.

Key concepts:
Ardupilot UAV log viewer, graphing data, launch events, understanding graphed data

Link:
https://siue.yuja.com/V/Video?v=5816178&node=25923372&a=107027858&autoplay=1

6.10 Parsing Data (6:32)

Provides step-by-step directions on how to convert a BIN file to a LOG file and then from a LOG file to a CSV file using Mission Planner on a Chromebook.

Key concepts:
downloading flight bin files, conversion to log files

Links:
https://siue.yuja.com/V/Video?v=5816177&node=25923370&a=3422592&autoplay=1

LOG parser:
http://spacelab.web.illinois.edu/python-testing/upload-file

6.11 Analyzing Flight Data in Google Sheets (6:36)

This video walks users through importing CSV files into Google Sheets and demonstrates how to plot altitude for predicted vs experimental.

Key concepts:
Google sheets, graphing launch data, comparing theoretical/experimental results, launch events

Link:
https://siue.yuja.com/V/Video?v=5816172&node=25923345&a=122675781&autoplay=1

6.12 Analyzing Experimental Data in Python (3:25)

This video guides user through importing CSV files into Python and shows how to do an initial plot of altitude for the predicted vs experimental.

Key concepts:
Python, graphing launch data, comparing theoretical/experimental results, launch events

Link:
https://siue.yuja.com/V/Video?v=5816167&node=25923302&a=140306476&autoplay=1