# Summer of Innovation

## AERONAUTICS
## 4th – 9th grade

## Introduction

The goal of the NASA Summer of Innovation Aeronautics camp is to excite young minds and inspire student trainees toward future science, technology, engineering, and mathematics (STEM) pursuits. Raising trainee achievement in STEM pursuits begins by leading trainees on a journey of understanding through these highly engaging activities. The activities and experiences in this guide come from across NASA's vast collection of educational materials.

This themed camp outline provides examples of one-day, two-day, and weeklong science and engineering programs. Each day contains 6-8 hours of activities totaling more than 35 hours of instructional time. The camp template will assist you in developing an appropriate learning progression focusing on the concepts necessary to engage in learning about aeronautics. The Aeronautics camp provides an interactive set of learning experiences that center on the math and design principles of flight design. The activities scaffold to include cooperative learning, problem solving, critical thinking, and hands-on experiences. As each activity progresses, the conceptual challenges increase, offering trainees full immersion in the topics.

## Intended Learning Experiences

Through the participation in these camps future scientists and engineers will have the opportunity to explore aeronautics. Student trainees gain learning experiences that help make scientific careers something they can envision in their lives. Trainees realize that they have the potential to make a contribution to this field and ignite their curiosity to see what they might create during the program. The learning experiences also anticipate that trainees will have the opportunity to:

- Gain a foundation for learning the math and science principles essential for aeronautics
- Apply the engineering design process for various projects
- Demonstrate the concepts of aerodynamics
- Raise awareness of the skills needed for a career with NASA and other STEM fields
- Apply understanding of flight to the design, construction, and test flight of a shoebox based glider
- Use technology to discover air traffic control related concepts

## Professional Development

Educator Professional Development (PD) experiences are available. Webinars, NASA Digital Learning Network (DLN) programs, training videos, and online meeting spaces will help you implement the program. We hope that you and your trainees have a memorable and successful experience implementing these activities.

### Professional Development Resources

- The NASA Educator Online Network is a great resource for STEM educators to share and learn about STEM topics. The Aeronautics program hosts a group that will provide a place for sharing about the activities, additional resources, extension ideas, and support.
- Visit the Summer of Innovation homepage for an extensive catalog of news, media resources, and educational materials.
- If you need a unit for grades 9-12, with more advanced math and physics concepts, please see
  - Flight Testing Newton's Laws
  - Pushing the Envelope: Educator Guide teaches math, physics and chemistry concepts for grades 8-12

## Format of the Guide

**The Six E's**
Each day or section of activities utilizes the 5-E Instructional Model. Included in this program guide is a sixth 'E' for Excite. This additional 'E' shows you how to incorporate NASA's unique information and resources to excite trainees with career connections, real world examples, spinoffs from NASA research, and more. Learn more about the 5-E Instructional Model.

**$** Requires simple materials common in the classroom or relatively inexpensive to obtain.

**$$** Requires purchasing unique materials such as poster board, duct tape, or hot glue guns.

**$$$** Requires purchasing or building higher-cost items, though many are one-time purchases that may used for many trainees over several years.

| Title | Overview | Time | Cost | Additional Resources |
|---|---|---|---|---|
| The title hyperlinks to the activity. | An overview describes the main concepts and strategies used in the lesson, activity, or demonstration. | The time listed includes time for an introduction, activity time, and conclusion time. | Please find this camp or the activity you are using in the Resource Repository for more information on costs and tips. | Suggested resources may include additional lesson plans, posters, images, or other learning support materials. |

**Engage: Question?**

**Icons may appear throughout the program**

A computer symbol means you may need one or more computers or other technology, though alternatives are available.

**Journal**

Journals are an optional element of your camp. Throughout the camp template, you will find reflective questions, ideas, and guidance in creating a journal. Journals also provide trainees with a unique souvenir of their experiences. Learn more about how scientists and engineers use journaling at NASA by watching this eClip video: Journaling in Space.

# One-Day Camp: Aeronautics

This day is designed to introduce the basic concepts of aeronautics and the engineering design process. The focus of Day One is on introducing trainees to the principles involved in what makes an airplane fly, parts of plane, and the four forces of flight. Trainees will also design and build simple demonstrations of the concepts of lift, drag, thrust, and gravity. Several activities set up as stations around the room will allow the trainees to investigate each force.

| Title | Overview | Time | Cost | Additional Resources |
|---|---|---|---|---|
| **Engage: Test Flight** | | | | |
| Fluttering Fun | Trainees will Investigate the concept of center of gravity and determine the center of gravity of a two-dimensional object by balancing it on the top of a pencil. See page 41. | 0.5 hrs | $ | |
| **Explore: Four Forces of Flight** | | | | |
| Four Forces of Flight | Trainees will demonstrate the Four Forces of Flight at each of 8 stations set up around the room. (Link takes a while to download.) See intro on page 143.<br>• Gravity Experiment 2- Which One Wins? (pg. 162)<br>• Gravity Experiment 4 – Falling Water (pg. 164) or<br>• Gravity Experiment 6 – Paper Shape (pg. 165)<br>• Lift Experiment 1 & 2– Chin Up & Paper Pull (pg. 183)<br>• Lift Experiment 5 & 6 – Air Dance and Wing It (pg.185)<br>• Thrust Experiment 1– Balloon Jets (pg. 206)<br>• Thrust Experiment 3 – Pop the Cork (pg. 207)<br>• Drag Experiment 2 – Parachute Fun (p. 208) | 2.0 hrs | $$ | |
| **Explain: Four Forces of Flight** | | | | |
| Rotor Motor | Trainees will build simple paper models and test in different conditions and with different weights | 0.5 hrs | $ | |
| **Elaborate: Anatomy of an Airplane** | | | | |
| Parts of an Airplane | Trainees will labels parts of the XB-70A research aircraft and T-34C Support Aircraft. | 0.5 hrs | $ | Another source for information about parts of plane |

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| **Evaluate: Airfoils** | | | | |
| Sled Kite | Trainees build a sled kite that models a type of airfoil called a parawing. Then go outside to test and fly the kites. | 1.5 hrs | $ | Educator Training Video |
| **Evaluate: Debrief** | | | | |
| Debrief | Review key concepts of the day:<br>• Four Forces of Flight<br>• Gravity<br>• Drag<br>• Lift<br>• Thrust<br>• Airfoil<br>• Parts of Airplane | 0.5 hrs | | 'Wright' Way Videos |
| **Excite: NASA Connection** | | | | |
| Video from eClips | At any point during the day, trainees can watch this video from eClips<br>• NASA 360: NASA and the Future of Aeronautics | 0.5 hrs | | |

# Two-Day Camp - Day One: Aeronautics

This two- day is designed to introduce the basic concepts of aeronautics and the engineering design process. The focus of Day One is on introducing trainees to the principles involved in what makes an airplane fly, parts of plane, and the four forces of flight. Trainees will also design and build simple demonstrations of the concepts of lift, drag, thrust, and gravity. Several activities set up as stations around the room will allow the trainees to investigate each force. Day Two will focus on expanding basic aeronautics knowledge by building and testing gliders.

| Title | Overview | Time | Cost | Additional Resources |
|---|---|---|---|---|
| **Engage: Test Flight** | | | | |
| Fluttering Fun | Trainees will Investigate the concept of center of gravity and determine the center of gravity of a two-dimensional object by balancing it on the top of a pencil. Se page 41. | 15 min | $ | |
| **Explore: Four Forces of Flight** | | | | |
| Four Forces of Flight | Trainees will demonstrate the Four Forces of Flight at each of 8 stations set up around the room. See intro on page 143.<br>• Gravity Experiment 2- Which One Wins? (pg. 162)<br>• Gravity Experiment 4 – Falling Water (pg. 164) or<br>• Gravity Experiment 6 – Paper Shape (pg. 165)<br>• Lift Experiment 1 & 2– Chin Up & Paper Pull (pg. 183)<br>• Lift Experiment 5 & 6 – Air Dance and Wing It (pg.185)<br>• Thrust Experiment 1– Balloon Jets (pg. 206)<br>• Thrust Experiment 3 – Pop the Cork (pg. 207)<br>• Drag Experiment 2 – Parachute Fun (p. 208) | 2.0 hrs | $$ | |
| **Explain: Four Forces of Flight** | | | | |
| Rotor Motor | Trainees will build simple paper models and test in different conditions and with different weights. Educator Tip – this is part of a large activity, just start with the part on p. 44 and p 53. | 0.5 hrs | $ | |

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| **Elaborate: Anatomy of an Airplane** | | | | |
| Parts of an Airplane | Trainees will labels parts of the XB-70A research aircraft and T-34C Support Aircraft. | 0.5 hrs | $ | Another source for information about parts of plane |
| **Evaluate: Airfoils** | | | | |
| Sled Kite | Trainees build a sled kite that models a type of airfoil called a parawing. Then go outside and fly the kites. | 1.5 hrs | $ | Educator Training Video |
| **Evaluate: Debrief** | | | | |
| Debrief | Review key concepts of the day:<br>• Four Forces of Flight<br>• Gravity<br>• Drag<br>• Lift<br>• Thrust<br>• Airfoil<br>• Parts of Airplane | 0.5 hrs | | 'Wright' Way Videos |
| **Excite: NASA Connection** | | | | |
| Video from eClips | At any point during the day, trainees can watch this video from eClips<br>• NASA 360: NASA and the Future of Aeronautics | 0.5 hrs | | |

# Two-Day Camp – Day Two: Aeronautics

| Title | Overview | Time | Cost | Additional Resources |
|---|---|---|---|---|
| **Engage: Jet Engines** | | | | |
| Airplane Dodecahedron<br><br>NASA Aeronautics Research Onboard Interactive | Trainees learn about NASA's jet aircraft as they build a geometric form to hang from the ceiling.<br><br>This on-line interactive presentation identifies technologies and knowledge that NASA researchers have contributed to commercial jetliners, general aviation aircraft, military aircraft and rotorcraft during the past few decades. (This can be a take home if not enough time.) | 2.0 hrs | $ | |
| **Explore: Distance – Rate – Time Ratios** | | | | |
| Smart Skies – Line Up with Math | Videos and simulations that teach trainees how math is used to do distance-rate-time investigations. "LineUp with Math" shows trainees how to apply proportional reasoning to "line up" planes safely with proper spacing at a given intersection of jet routes. | 1-2 hrs | $ | Air Traffic Control App now available |
| **Explain: Lift and Drag** | | | | |
| Right Flight | This activity challenges trainees to learn about basic aircraft design and explore the effects of weight and balance on the flight characteristics of a model glider. Trainees use science process skills to construct and fly a glider made from a foam food tray. | 2.0 hrs | $ | |
| **Elaborate: Lift and Drag** | | | | |
| | Taking the gliders outside for test flight, recording data, and making necessary modifications for improved performance. | 0.5 hrs | $ | |

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| **Evaluate: Debrief** | | | | |
| | Review the key concepts of the day:<br>• Gravity<br>• Drag<br>• Lift<br>• Thrust<br>• Gliders<br>• Distance- rate- time | 0.5 hrs | | |
| **Excite: NASA Connection** | | | | |
| Astronauts /Careers | What do you have in Common? Using NASA websites trainees will learn about aviators and determine what they have in common. | 1.0 hrs | $ | |

# Weeklong - Day One: How Do Planes Fly?

The focus of Day One is to introduce trainees to the principles involved in what makes an airplane fly, parts of plane, and the four forces of flight. Several activities set up as stations around the room will allow the trainees to investigate each of the four forces of flight. Over the course of the week, the trainees working in small teams, will build a shoebox glider. This project will be introduced today.

| Title | Overview | Time | Cost | Additional Resources |
|---|---|---|---|---|
| **Engage: Four Forces of Flight** | | | | |
| Air Engines | Explains how air pressure helps a plane to fly and introduce Newton's Laws of Motion. | 0.5 hrs | $ | |
| **Explore: Four Forces of Flight** | | | | |
| Four Forces of Flight | Trainees will demonstrate the Four Forces of Flight at each of 8 stations set up around the room. See intro on page 143.<br>• Gravity Experiment 2- Which One Wins? (pg. 162)<br>• Gravity Experiment 4 – Falling Water (pg. 164) or<br>• Gravity Experiment 6 – Paper Shape (pg. 165)<br>• Lift Experiment 1 & 2– Chin Up & Paper Pull (pg. 183)<br>• Lift Experiment 5 & 6 – Air Dance and Wing It (pg.185)<br>• Thrust Experiment 1– Balloon Jets (pg. 206)<br>• Thrust Experiment 3 – Pop the Cork (pg. 207)<br>• Drag Experiment 2 – Parachute Fun (p. 208) | 2-3 hrs | $$ | |
| **Explain: Four Forces of Flight** | | | | |
| Rotor Motor | Build simple paper models and test in different conditions and with different weights. Educator Tip: this is part of a larger activity just do the Rotor Motor part explained on page p 44 and p. 53 | 0.5 hrs | $ | |
| Engineering Design Process | Trainees will be introduced to a engineering design process. Activity will follow in designing and building a sled kite. | 0.5 hrs | $ | To learn about teaching the "Engineering Design Process" |

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| **Elaborate: Airfoils** | | | | |
| Sled Kite | Trainees build a sled kite that models a type of airfoil called a parawing. | 1.5 hrs | $ | Educator Training Video |
| Can You Make a Shoebox Fly? | Introduction to the weeklong project where trainees will research the dynamics and forces of flight and apply their understanding of flight to the design, construction, and test flight of a shoebox based glider. This can be done as a stand-alone activity or as part of NASA Digital Learning Network.<br>(Link takes a few minutes to load)<br><br>http://www.nasa.gov/offices/education/programs/national/dln/events/Can_A_Shoebox_Fly_Challenge_part_1.html | 0.5 hrs | $ | |
| **Evaluate: Four Forces of Flight** | | | | |
| Debrief | Review key concepts of the day:<br>• Four Forces of Flight<br>• Lift<br>• Thrust<br>• Drag<br>• Gravity<br>• Airfoils | | | 'Wright' Way Videos |
| **Excite: NASA – Future of NASA Aeronautics** | | | | |
| Video from eClips | At any point during the day, trainees can watch this video from eClips<br>NASA 360: NASA and the Future of Aeronautics | 0.5 hrs | | |

# Weeklong Day Two: Lift this Way & Wind Tunnels

Day Two will introduce the milestones in the history of flight and trainees will begin constructing a larger timeline. The trainees will learn about lift and thrust and the impact a wind tunnel can have on improving design. Trainees will build two types of gliders to test in the wind tunnel. The Wright Brothers Invention Process will be introduced and used as a model during the Shoe Box Design Challenge. Today trainees will also learn about developing flight plans, air traffic control communications and phonetic alphabet.

| Title | Overview | Time | Cost | Additional Resources |
|---|---|---|---|---|
| **Engage: History of Flight** | | | | |
| History of Aeronautics/ Flight Timeline Making Time Fly | Trainees will learn about key figures in development of flight and make posters promoting the latest advancements.<br><br>Trainees will research 1-2 points on the internet and include a collage of photos/ drawings for each point of the time line | 30 min – 1 hour | $ | Images/Facts pulled from Courage to Soar pg. 36 |
| Parts of an Airplane | Trainees will labels parts of the XB-70A research aircraft and T-34C Support Aircraft. | 0.5 hrs | $ | Another source for information about parts of plane |
| **Explore: Lift and Drag** | | | | |
| Right Flight | This activity challenges trainees to learn about basic aircraft design and explore the effects of weight and balance on the flight characteristics of a model glider. Trainees use science process skills to construct and fly a glider made from a foam food tray. After initial flights, trainees will test in wind tunnel and after modifications outside. | 1.0 hrs | $ | |

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| **Explain: Understanding air traffic control communications** | | | | |
| Plan to Fly | Airplane pilots depend on flight plans to provide information to help ensure a successful flight to a destination. In this activity, trainees create a flight plan and determine factors such as departure airport, destination airport, flight route and flying time in hours. Trainees role-play the communication of flight plans between pilot and air traffic controller using the phonetic alphabet. | 1.0 hrs | $ | |
| Wright Brothers Invention Process | Wright Brothers' Invention Process: The process which lead to the first successful airplane is exactly the same process used by NASA engineers today to solve problems. How does it compare to this engineering design process? | 1.0 hrs | $ | |
| **Elaborate: Wind Tunnels** | | | | |
| X 1 Glider | The trainees will build a simple glider and learn how to change the flight characteristics of a glider. Conduct an experiment and will later test the glider in the wind tunnel. | 1.0 hrs | $ | |
| Wind Tunnel Activity | Trainees will test various objects and their glider in wind tunnel. After modifications to gliders, go outside and test performance | 1.5 hrs | $$ | Other Wind Tunnel Ideas |
| **Evaluate: Aerodynamics** | | | | |
| Debrief | Trainees will chart characteristics that improve aerodynamics. And review key concepts of day.<br>• Control surfaces<br>• Airspeed<br>• Glider<br>• Honeycomb Design | 0.5 hrs | $ | |
| **Excite: NASA's Wind Tunnels** | | | | |
| Video | At any time in the day trainees can watch and discuss this video from NASA eClips<br>Our World: Wind Tunnels in Action | 0.5 hrs | $ | |

# Weeklong - Day Three: The Need for Speed - Jet Engines

Day Three trainees will learn about a jet engine through video and online simulations. Trainees will also spend time completing their shoebox gliders and learning about aviation careers. There are some great high-energy music videos with military jets that show the dynamic abilities of the planes. If time, try to show the trainees several of the videos.

| Title | Overview | Time | Cost | Additional Resources |
|---|---|---|---|---|
| **Engage: Jet Aircraft** | | | | |
| Airplane Dodecahedron | Trainees learn about NASA's jet aircraft as they build a geometric form to hang from the ceiling. | 1.0 hrs | $ | |
| **Explore: Career with NASA** | | | | |
| Astronauts /Careers | What do you have in Common? Using NASA websites trainees will learn about aviators and determine what they have in common. | 1.0 hrs | $ | |
| **Explain: How does a jet engine work?** | | | | |
| Engine Sim | Trainees will participate in an interactive educational computer program that allows trainees to design and test jet engines. There is a detailed tutorial. | 1.0 hrs | $ | Beginners Guide to Aeronautics Tutorial |
| Video – How a Jet Engine Works | This video explains the parts of a jet engine and how it works. This additional activity provides a comparison of jet engines. | 0.5 hrs | $ | |

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| **Elaborate: Design of Shoebox Airplane** | | | | |
| Can You Make a Shoebox Fly? | Trainees will spend this session learning about glide slope-aspect ratio and working on the design and construction of their shoebox glider. | 2-3 hrs | $$ | |
| **Evaluate: Review concepts of the day** | | | | |
| Debrief | Review key concepts of the day:<br>• Parts of a jet engine<br>• Compressor<br>• Combustor<br>• Turbine<br>• Glide slope<br>• Aspect ratio<br>• Air foil | 0.5 hrs | | |
| **Excite: What is next for NASA Aeronautics?** | | | | |
| | Discuss Article: NASA Propulsion Experiment Provides Data for more Efficient Jet Engines | 0.5 hrs | $ | |

# Weeklong - Day Four: Pushing the Envelope

This common phrase of test pilots is the theme for Day Four activities. Trainees will spend the day testing knowledge gained over the week and prepare theories and ideas for testing on Day Five. Trainees will start the day with making a smaller glider and testing it, then taking those lessons and apply to their shoebox glider. Trainees will also learn about air traffic controllers.

| Title | Overview | Time | Cost | Additional Resources |
|---|---|---|---|---|
| **Engage: Gliders** | | | | |
| Future Flight Equation | Trainees will use algebra to calculate the wing area, wingspan, chord length, and aspect ratio. Using a portable glider catapult to analyze wing geometry based on measurement (distance rating) and observations (glide rating and speed rating).<br><br>Trainees will then design, construct, and test and experimental wing to achieve maximum distance. This activity uses collaborative problem solving strategies and a real-life application.<br><br>This activity can be adjusted for trainees with lower math skills. | 2.0 hrs | $ | Future Flight Equation Video |
| **Explore: Distance-rate-time ratio** | | | | |
| Smart Skies – Line Up with Math | Videos and simulations that teach trainees how math is used to do distance-rate-time investigations. "LineUp with Math" shows trainees how to apply proportional reasoning to "line up" planes safely with proper spacing at a given intersection of jet routes. | 1-2 hours | $ | Air Traffic Control App now available |
| **Explain: Testing of Gliders** | | | | |
| Can You Make a Shoebox Fly? | Trainees will begin testing of gliders and make modifications. | 1.5 hrs | $$ | |

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| **Elaborate: Parachutes** | | | | |
| Parachute Activities | Trainees will design and test parachutes to examine the relationship between drop time, acceleration, and velocity. Activities found on page 77 and 81. | 1.5 hrs | $ | |
| **Evaluate: Key Concepts** | | | | |
| Debrief | Review key concepts of the day<br>• Plane speeds<br>• Drop time<br>• Acceleration<br>• Velocity | 15- 30 min | | |
| **Excite: Aeronautic Spinoffs** | | | | |
| NASA Aeronautics Research Onboard Interactive | This on-line interactive presentation identifies technologies and knowledge that NASA researchers have contributed to commercial jetliners, general aviation aircraft, military aircraft and rotorcraft during the past few decades. | 0.5 hrs | $ | |

# Weeklong - Day Five: Go For Flight

Today is the culmination of the weeklong events. Shoebox gliders will perform their final flights. Trainees will set up displays and demonstrations around the room to highlight what they learned over the week and to explain to parents and invited guests.

| Title | Overview | Time | Cost | Additional Resources |
|---|---|---|---|---|
| **Engage: Air Traffic Controller** | | | | |
| Smart Skies- Fly By Math | "Fly By Math" offers five air traffic control problems that address the safe separation of two planes. | 1.0 hrs | $ | Air Traffic over US for 24 hours Video |
| **Explore: Prepare for Open House** | | | | |
| Building a Table Top Airport | Trainees construct a model airport to identify and understand problems that face architects and planners of real airports. Models allow planners to identify potential problems with airport location, layout and design before expensive construction begins. | 1.0 hrs | $ | |
| **Explain:** | | | | |
| Can You Make a Shoebox Fly? | Trainees will give oral reports on their gliders prior to launch events | 1- 2 hrs | $$ | |
| **Elaborate: Flight Launch Day-Gliders** | | | | |
| Can You Make a Shoebox Fly? | Trainees will make final modifications to their gliders. Then will perform an airshow and record results. | 2.0 hrs | | |
| **Evaluate:** | | | | |
| Open House | Trainees will have stations set up around the room and outside and will demonstrate to parents and community leaders what they learned and did over the week. Awards could be presented if desired. | 1-3 hrs | $ | Award Templates available on Resource Repository. |