PLTW Launch

Stability and Motion: Science of Flight Teacher Resources

Related Documents

See “Files” section in the LMS.

Preface

Air is all around us. We know that air can hold up heavier-than-air objects such as kites, gliders, and airplanes, but how does it do that? What forces act on an airplane or glider? Students will use aerodynamic concepts to explain how the motion of air and other forces act on gliders and other aircraft.

Gliders and other aircraft use wings to develop the lift needed to fly. Wing shapes, sometimes called airfoils, provide lift. Wings must have the proper angle of attack, which is the angle at which a wing meets the flow of air. The airfoils, because of their design, can overcome gravity acting on the aircraft. Research has shown that a wing with a streamlined shape and a body or fuselage that is streamlined can help overcome drag.

In this module students will learn about the forces involved in flight as well as Newton’s Laws of Motion. Then they will design, build, and test an experimental model glider to find out how air and other forces affect its flight. In addition, they will apply a design process to the problem of delivering aid to an area where supplies must be airlifted in and dropped to the ground from an aircraft.

In this lesson a story line has been written involving three students, Angelina, Suzi, and Mylo, as they learn about aeronautics. The lesson is structured in such a way that the teacher may choose to read the story to the students in order to build listening skills, or the teacher may have students read the story on their own as part of class work or homework.

Transfer

Students will be able to independently use their learning to:

1. Evaluate a problem in a novel situation.
2. Apply a step by step design process to solve a problem.
3. Predict the effects of balanced and unbalanced forces on the motion of an object.

Understandings

Students will understand that:

1. Engineers have a step by step approach for looking at and solving a problem called the design process.
2. Engineers and designers create new products and technology to meet a need or want that meets specific criteria for success, including constraints on materials, time, and cost.

3. Engineers generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
4. Engineers propose a solution to develop for a design problem after evaluating multiple possible designs.
5. Prototypes can be evaluated and improved upon by a series of fair and controlled tests to identify a product's strengths and limitations.
6. Engineers write down everything they do to document their work, organize their thoughts, and show their steps in an engineering notebook.
7. Engineers share their work with and get feedback from others at many points throughout the design process.
8. Balanced and unbalanced forces have effects on the stability and motion of an object.
9. In order to fly, an airplane must overcome weight with sufficient lift and must overcome drag with sufficient thrust.
10. A glider is a non-motorized airplane that depends on wing shape to generate lift to maintain flight.
11. Newton's three laws of motion are observed in objects in flight.
12. Observations and measurements of an object's motion may reveal a pattern that can be used to predict future motion.

Knowledge

It is expected that students will:

- Explain what happens at each step of the design process.
- State questions that engineers may ask when gathering information about a situation people want to change.
- Identify the differences between invention and innovation.
- Describe the motion and stability of an object with balanced forces.
- Describe the motion and stability of an object with unbalanced forces.
- Identify the forces working on an airplane in flight.
- Describe how the major parts (fuselage, wings, and horizontal stabilizers) of a glider affect the overall balance of an airplane during flight.
- Describe how Newton's laws apply to flight.
- Explain how the center of gravity affects an aerospace vehicle in distributing weight.

Skills

It is expected that students will:

- Follow a step by step approach to solving a problem.
- Identify specific constraints such as materials, time, or cost that engineers and designers must take into account given a specific design problem.

- Brainstorm and evaluate existing solutions to a design problem.
- Generate multiple solutions to a design problem while taking into account criteria and constraints.
- Use a decision matrix to compare multiple possible solutions to a design problem and select one to develop, taking into account how well each solution meets the criteria and constraints of the problem.
- Plan fair tests in which variables are controlled to identify a product's strengths and limitations.
- Perform fair tests in which variables are controlled to identify a product's strengths and limitations.
- Organize and maintain an engineering notebook to document work.
- Share findings and conclusions with an audience.
- Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
- Analyze the features and benefits of different types of wings.
- Make observations and measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
- Demonstrate how glider parts interact and affect the flight of the glider.

Essential Questions

Students will keep considering:

1. How do balanced and unbalanced forces impact airplane flight?
2. How does working on a team help when solving a design problem?

Day-by-Day Plans

Time: 10 instructional hours

***NOTE:** In preparation for teaching this module, it is strongly recommended that the teacher read the Stability and Motion: Science of Flight Teacher Resources document, including the Understandings, Knowledge, and Skills addressed in the module.*

Part 1: Balanced and Unbalanced Forces

60 – 80 minutes

- The teacher introduces the lesson with the fictional story about Angelina, Suzi, and Mylo and their adventures while learning about aeronautics and flight.
- The teacher introduces students to the Learning Management System (LMS) and assists students with the login process on the Canvas app. For the remainder of the module, the students will access the assignments in the LMS and record their work in their individual Launch Logs.
- Students read *Part 1: The Adventure Begins* located in the Stability and Motion: Science of Flight module in the Learning Management System (LMS). Optional: The teacher will read the story aloud as students follow along.

- The teacher continues the class by asking the following questions to engage students in thinking about flight and forces. These questions are not meant to be answered at this time, only to generate discussion and interest as well as to activate prior learning.
    - What objects fly?
    - What is a force?
    - How do airplanes and other aircraft fly?
- The teacher introduces Activity 1.1 Balanced and Unbalanced Forces. In this activity students learn about forces and describe the motion of an object with balanced or unbalanced forces. Students also ask questions engineers may ask when gathering information about a situation involving balanced and unbalanced forces.
- Students work in pairs to complete the activity and record all sketches and written responses in their Launch Logs.
- The students may either follow the Teeter Totter presentation found in the Canvas app or may follow the written directions in Activity 1.1.
- The teacher may choose to bend the paper clips for the students ahead of time if desired.
- The conclusion questions may be answered individually in the Launch Log, entered into the LMS, or may be discussed in large or small groups.
- The teacher guides the students on the logout procedure for the Learning Management System. Students should logout of the LMS at the conclusion of each session.

Part 2: Forces: Lift, Drag, Thrust, and Weight

60 - 80 minutes

- The teacher introduces Activity 1.2 Forces: Lift, Drag, Thrust, and Weight. In this activity students learn about forces working on an airplane in flight. Students research the forces involved in flight and Newton's Laws of Motion. Students also explore forces with hands-on activities designed to introduce the forces of lift, drag, thrust, and weight.
- The teacher assists students as they explore the forces involved in flight while using the Aero! app on the tablets. Students spend approximately 10 minutes using the app as an introduction to forces involved in flight.
- Note: The Aero! app designates the downward force on the bird as gravity. Throughout the module the downward force on an object is referred to as weight caused by the natural phenomena of gravity. This is a minor distinction and at the elementary level may be considered interchangeable for the purposes of this lesson.
- The teacher guides students to the presentation in the Stability and Motion: Science of Flight module in the LMS entitled Forces of Flight. Students work through the presentation on their tablet and respond to questions in their Launch Logs.

- The teacher leads a discussion on the four forces as students complete the presentation.
- The teacher distributes one hand-launched propeller to each pair of students and demonstrates how to use the device by spinning the axle between the palms of one's hands. If completing this activity inside or where students are very close to each other, the teacher may wish to require safety goggles for students.
- Students take turns launching the propellers and discuss the questions in the procedure of the activity.
    - What caused the propeller to fall back to the ground?

      The force of the weight of the propeller caused it to fall back to the ground.
    - What created lift for the propeller?

      The propeller blades created lift as they rotated through the air.
- The teacher reinforces the concepts of thrust and drag by implementing a demonstration with student participation.
    - Prepare the following:
        - 1 paper airplane out of cardstock
        - 1 sheet of cardstock taped to a wood dowel similar to a flag
    - Use a leaf blower or a hair dryer on cool setting only. Place the cardstock flag in the stream of air. Have student volunteers turn the cardstock in the stream of air and explore the amount of resistance or drag they feel from the air as they rotate the cardstock flag to vary the surface area in contact with the air.
    - Have student volunteers throw a paper airplane into the stream of air with the goal of having the airplane hit the origin of the air stream.
- Students take turns as volunteers and discuss the questions in the procedure of the activity.
    - How did you hold the paper to make the drag as small as possible?

      The paper was held so the least amount of paper contacted the stream of air.
    - What did you do to make the paper airplane travel into the air stream?

      Increased the thrust or how hard the airplane was thrown into the stream of air.
- The teacher guides students to the presentation in the Stability and Motion: Science of Flight module in the LMS entitled Newton's Laws. Students work through the presentation and take notes in their Launch Logs.
- Optional: The teacher may project this presentation and work through the hands-on activities with the students as a class. The activity requires a pencil and book to demonstrate forces on an object, although any common object may be used.
- Students review the forces involved in flight as they again use the Aero! app on the tablets. Students will spend approximately 10 minutes using the app to apply

what they have learned about forces. The teacher encourages students to watch the arrows indicating the various forces as the bird flies.

- The conclusion questions may be answered individually in the Launch Log or may be discussed in large or small groups.

Part 3: Gliders and Other Aircraft

120 minutes

- The teacher leads students in a review of the fictional story that has been read in the first activity. The teacher then guides the students to read *Part 2: Forces and Flight* located in the Stability and Motion: Science of Flight module in the LMS. Optional: The teacher reads Part 2 of the story aloud as students follow along.
- The teacher leads students to access Activity 1.3 Gliders and Other Aircraft in the LMS on their tablets. Students follow step 2 in the Procedures to view the Gliders and Other Aircraft presentation on their tablets. Students answer questions within the presentation.
- After students have completed the activity, the teacher leads a discussion of what students learned about powered and unpowered aircraft. The teacher reviews the three main parts of a glider presented in the activity: fuselage, wings, and horizontal stabilizer.
- The teacher instructs students to open the Autodesk®123D® Design app on their tablets. One option for design on this app is a glider. Students have the opportunity to assemble a glider using the app.
- In order for the glider pieces to be assembled easily, it is important for students to follow the steps outlined in the procedures:
    - First, add a fuselage, the body of the aircraft, to the grid by double tapping on the fuselage.
    - Choose the type of wing you would like to try. Double tap on a wing to add it to the fuselage.
    - Choose the type of horizontal stabilizer that you would like to try. Double tap a stabilizer to add it to your design.
- In order to capture the glider design, students take a screenshot of the image. If students do not know the procedure for taking a screenshot on the tablet, the teacher demonstrates the process of pressing both the home and power buttons on the tablet at the same time.
- Students answer conclusion questions in their Launch Logs. Examples of correct responses to the questions are included below.

    1. What is a glider? How is it different from a powered aircraft?

        A glider is an aircraft that flies without producing its own thrust. A glider is different from a powered aircraft because a powered aircraft produces its own thrust.

    2. How do you think that the size or shape of the wing will affect how the glider flies?

The size or shape of the wing will affect a glider by changing its lift.

3. If you were able to design a glider, what would it look like and how would it be able to fly? Draw a sketch of your idea.

   Answers will vary.

- The teacher allows student groups to share the glider design they have created and leads a class discussion of the conclusion questions. If time allows, give students the opportunity to create different gliders by selecting different glider wings or horizontal stabilizers.

Part 4: Experimentally Gliding Along

160 minutes

- Detailed instructions and templates may be found in the following documents:
  - *SM.1.3.A.TN GliderPartsCuttingTemplate.pdf*
  - *SM.1.3.A.TN GliderPartsCuttingTemplate-LABELED.pdf*
  - *SM.1.4.P.b CreatingTheLaunchPad.docx*
  - *SM.1.4.P.c LaunchPadRunway_Middle.docx*
  - *SM.1.4.P.d LaunchPadRunway_Partial.docx*
- The teacher introduces Project 1.4 Experimentally Gliding Along and directs students to the project in the Canvas app.
- In this inquiry-based project, students learn how Newton's laws apply to flight. Students investigate how the center of gravity affects an aerospace vehicle and analyze the features and benefits of different types of wings. Students conduct several test flights with their glider and document the effect of modifications including wing type and additional weight. Through these investigations students make observations and measurements of a glider's motion to provide evidence that a pattern can be used to predict future motion.
- The teacher demonstrates the construction and launch of the gliders.
- Students complete the project in teams of two.
- The conclusion questions may be answered individually in the Launch Log, entered into the LMS, or discussed in large or small groups.

Part 5: Glider Design

200 minutes

- Students read *Part 3: Disaster Relief* located in the Stability and Motion: Science of Flight module in the LMS. Optional: The teacher reads the story aloud as students follow along.
- In this problem students analyze flight data from the previous project and suggest improvements to the glider to maximize the amount of relief aid the glider can transport a set distance. As part of a design challenge, students design a unique wing configuration and weight distribution and then evaluate their design through

a controlled test. Students share their findings and conclusions with the class through a multimedia presentation.

- The students access the Problem 1.5 Glider Design assignment on the LMS. The teacher leads students through the introduction section to set the stage for solving the problem.
- The problem and its criteria and constraints are presented in step 1 of the procedure. As students work through the procedure, they will record their work in the problem section of the Launch Log. The procedure guides students through using the engineering design process to solve the problem.
- Design Process:

  Ask

  - The teacher guides a discussion asking the students to again consider the problem and the criteria and constraints.
  - The students follow the Ask step and record responses in their Launch Log.
  - The teacher guides the students through how to complete the self-assessment at the end of the Ask section. The students circle one statement in each row. Teachers also assess student understanding and record comments as needed.

  Explore

  - The teacher leads the students through this step of the design process. Students record their ideas and sketches in the appropriate section of the Launch Log.
  - The teacher guides the students through how to complete the self-assessment at the end of the Explore section. Teachers also assess student understanding and record comments as needed.

  Model

  - The teacher introduces a decision matrix as a way to decide on the best solution. Using the Problem 1.5 Decision Matrix document, students rate the designs of each group member for the three categories. The design with the highest score offers the best solution to the problem.
  - Students use the chosen design to build their glider model.
  - Students document their model by taking photographs using the camera app on their tablet or by sketching the final design in their Launch Log.
  - The teacher guides the students through how to complete the self-assessment at the end of the Model section. Teachers also assess student understanding and record comments as needed.

  Evaluate

  - Students conduct three trial flights of the glider model. The teacher guides students to create a chart in their Launch Log for recording the results of this testing.

- Students use the camera app on their tablet to record the flight of the glider during the testing. An app such as Ubersense can be used to play the recording in slow motion as an option.
- The student groups discuss the results of the trials to determine if their glider solved the problem.
- The teacher guides the students through how to complete the self-assessment at the end of the Model section. Teachers also assess student understanding and record comments as needed.

Explain

- The students present their design, evaluation, and suggestions for improvement as explained below.
- Students complete the Explain section of their Launch Log by describing their evaluation of how the glider solved (or didn't solve) the problem.
- Students present their design, evaluation, and suggestions for improvement to the class. They may use tablet apps such as Educreations™, Stage™, or Popplet Lite in their presentation.
- The teacher guides students to complete the self-assessment at the end of the Explain section. Teachers also assess student understanding and record comments as needed.

- At the conclusion of the module, the students complete the Stability and Motion: Science of Flight Check for Understanding.

National and State Standards Alignment

Next Generation Science Standards

- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.
- 3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Common Core ELA

- RI.3.1 Ask and answer questions to demonstrate understanding of a text, referring explicitly to the text as the basis for the answers.

- RI.3.3 Describe the relationship between a series of historical events, scientific ideas or concepts, or steps in technical procedures in a text, using language that pertains to time, sequence, and cause/effect.
- RI.3.8 Describe the logical connection between particular sentences and paragraphs in a text (e.g., comparison, cause/effect, first/second/third in a sequence).
- W.3.7 Conduct short research projects that build knowledge about a topic.
- W.3.8 Recall information from experiences or gather information from print and digital sources; take brief notes on sources and sort evidence into provided categories.
- SL.3.3 Ask and answer questions about information from a speaker, offering appropriate elaboration and detail.

Common Core Math

- MP.2 Reason abstractly and quantitatively.
- MP.5 Use appropriate tools strategically.
- 3. MD.B.4 Generate measurement data by measuring lengths using rulers marked with halves and fourths of an inch. Show the data by making a line plot, where the horizontal scale is marked off in appropriate units— whole numbers, halves, or quarters.