Stability and Motion: Forces and Interactions Teacher Resources

Related Documents

See “Files” section in the LMS.

Preface

Forces and interactions are at work all around us. We experience pushes and pulls, resistance forces, gravity, and friction in our daily routines. In this module students will gain understanding of forces and interactions using multiple modalities. They will explore, design, sketch, and build both simple and compound machines that demonstrate the use of forces. Students will also test the forces of magnets as they build skills and knowledge that can be applied in solving an open-ended, real-world situated problem. From the scaffolded learning that comes from the activities, project, and problem of this module, students will be able to predict the effects of a force on an object.

The design problem for this module will be presented to students through a fictional story. The problem will involve rescuing a trapped zoo animal. Solving this problem will require that students plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

As students work through this module on Stability and Motion: Forces and Interactions, they will also be engaged in hands-on experiences with how engineers use a step-by-step process to solve problems related to our wants and needs. Students will evaluate a problem in a novel situation—rescuing a zoo animal—and will apply the design process as they develop a solution.

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 a force on 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. Mechanisms can be used individually, in pairs, or in systems.
10. Magnetic interactions may occur between two objects not in contact with each other.
11. Newton's three laws of motion describe forces and interactions between objects.

Knowledge

It is expected that students will:

- Explain what happens at each step of the design process.
- Pose questions that engineers may ask when gathering information about a situation people want to change.
- Identify the differences between invention and innovation.
- Identify forces acting on an object.
- Describe the motion and stability of an object with balanced forces.
- Describe the motion and stability of an object with unbalanced forces.
- Explain how Newton's laws describe forces and interactions between objects.

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, taking into account criteria and constraints.
- Use a decision matrix to compare multiple possible solutions to a design problem and select one to develop, considering 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.
- Distinguish the attributes and components of the six simple machines.
- Make observations and measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.
- Identify the cause and effect relationships of magnetic interactions between two objects not in contact with each other.
- Apply scientific ideas about magnets and simple machines to solve a simple design problem.

Essential Questions

Students will keep considering:

1. How can an engineer use forces and interactions to meet a human need or want?
2. What questions do engineers ask 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: Forces and Interactions Teacher Resources document, including Understandings, Knowledge, and Skills addressed in the module.* *The day-by-day plans call for students to access the curriculum using the Canvas app on a tablet. The activity, project, and problem documents may also be accessed through files in the course on the LMS.*

Part 1: Introduction to Forces

60-80 minutes

- The teacher introduces students to the Learning Management System (LMS) and assists students with the login process. For the remainder of the module, the students will access the assignments in the LMS and record their work in their individual Launch Logs.
- The teacher assists students in accessing the Stability and Motion: Forces and Interactions module in the Learning Management System. Students select the "Intro" icon to access the fictional story that introduces the design problem for this module. The teacher may read the story orally or allow the students to read the story on their tablets.

- After reading the fictional story, the teacher leads the students in a discussion about the problem posed in the fictional story. The teacher guides the students to think like an engineer as they begin the Ask phase of the Design Process. Students consider:
    - What is the problem?
    - What do you need to know to be able to design a solution to the problem?
    - What skills will be needed to solve the problem?
- (Optional) Students may wish to learn more about tigers and their habitat. The San Diego Safari Park website (www.sdzsafaripark.org) includes a live streaming Tiger Cam and information on endangered tigers.
- The teacher introduces Activity 2.1 Introduction to Forces. In this activity students learn about forces, including effort and resistance forces. After reading the introduction, the teacher directs students to select the Procedure icon to access the plan for this activity.
- Prior to starting this activity, the teacher introduces students to the Launch Log as a place to document their work throughout the module. Students take notes as they research, create sketches, and answer conclusion questions in this notebook.
- Students work in pairs to complete the activities in the Introduction to Forces presentation and record all sketches and written responses in their Launch Logs. Students will complete drag and drop activities in the presentation and are asked to complete the following tasks in their Launch Logs:
    - Sketch two teeter totters, one that is balanced and one that is unbalanced.
    - Create a sketch that shows a push or a pull. Label the effort force and the resistance force on your sketch.
    - Describe how friction is at work in two images (one of a child pushing a ball and one of a child sliding down a slide).
- After completing and discussing the Introduction to Forces presentation, the teacher reads *How Do You Lift a Lion?* by Robert E. Wells. The teacher guides the students to think about how forces, interactions, and motion are being used to complete the tasks as the book is read.
- Simple machines are used throughout *How Do You Lift a Lion?* To provide an overview of the six types of simple machines, students work through the Simple Machines presentation. The presentation is accessed through the Canvas app and is found in Activity 2.1.
    - As part of the Simple Machines presentation, students will need a pencil and a piece of paper in the shape of a right triangle to complete the activity about the screw simple machine.
- Students continue to follow the procedures for Activity 2.1 Introduction to Forces by working with a group to create a model of a wheel and axle using VEX IQ®

components. To represent the load, students use VEX IQ® components. In addition the teacher may provide materials for student use.

- If this is the first time students will work with the VEX IQ equipment, the teacher may wish to allow students time to explore how the pieces fit together and how the kit is organized. The PLTW VEX IQ construction kit contents can be found in the Dashboard of this module.
- Students follow the procedures to create and share a simple presentation of their model using the Popplet Lite app. The teacher concludes the group presentations and discussion by telling students that they will continue to explore simple machines in Activity 2.2 and Activity 2.3 as they build skills and knowledge that will be used to solve the animal rescue design problem.
- The conclusion questions may be answered individually in the Launch Log 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 log out of the LMS at the conclusion of each session.

Part 2: Simple Machines and Forces

140 minutes

To prepare the teacher should ensure that all Autodesk® Inventor® Publisher files for Activity 2.2 have been downloaded and installed in the Inventor® Publisher app on the tablet. A demonstration of how to use the app and how to install the app is provided for the teacher in the Stability and Motion Core Training course. If you prefer not to use an iTunes® account to update your iPad® tablets, you can use an alternative technique via the Canvas App.

- In Activity 2.2 Simple Machines and Forces, students build and explore three simple machines including a lever, inclined plane, and pulley. Students identify effort force and resistance force on each simple machine and identify balanced and unbalanced forces in relation to the stability and motion of the machine.
- The teacher introduces the activity by having students access Activity 2.2 Simple Machines and Forces using the Canvas app on a tablet. Teachers review the animal rescue problem and how students are building skills and knowledge needed to solve the problem. After reading the introduction, students open the procedures for this activity.
- The teacher assists students as they work with a group to build, sketch, and work with three types of simple machines made from VEX IQ® components. The building directions are found on the Autodesk® Inventor® Publisher app. Students record the written work described in the procedures in their Launch Log. The teacher may choose to have groups create only one of the simple machines and then share with the class if desired.
- As students work through this activity, the teacher asks questions and offers guidance in understanding simple machines.
- The conclusion questions may be answered individually in the Launch Log or may be discussed in large or small groups.

Part 3: Forces and Interactions in Compound Machines

120 minutes

- In Activity 2.3 Compound Machines, students will expand their understanding of simple machines to learn about compound machines. Students will create compound machines by combining two or more of the simple machines they explored in the previous activity to solve a simple design problem.
- The teacher leads students in a review of the fictional story and the animal rescue design problem they will be solving. The teacher reminds students that the knowledge and skills they are building will help them to solve the problem.
- The teacher leads students to access Activity 2.3 using the Canvas app on their tablets. After reading the introduction, students open the procedures.
- The teacher guides student groups to work as a design team to create a compound machine following the procedures for Activity 2.3.
- Students present their compound machines to the class using a presentation app such as Popplet Lite or Educreations. The teacher facilitates a discussion about how the ideas of forces and interactions are demonstrated in their compound machines.

Part 4: Magnetic Interactions

60 minutes

- The teacher introduces Project 2.4 Magnetic Interactions and directs students to access the project using the Canvas app on a tablet.
- In this inquiry-based project, students explore the cause and effect relationship of magnetic interaction. Understanding of the use of magnets is another tool for developing a solution to the animal rescue design problem.
- Students access the procedures for Project 2.4. The teacher guides students through Part 1 in which students predict, test, and sort a variety of items based on their magnetic properties.
- Students use the tablet to photograph their prediction and results and discuss the following questions either as small groups or as a class. The teacher may also choose to have students answer the questions in their Launch Logs.
    - Think about how the objects reacted to a magnet. Which of your predictions were correct? Which were not correct?
    - What do the magnetic objects have in common? Use examples from your testing.
- The teacher guides the students through Part 2 in which the students measure the maximum distance where an interaction can be detected between two magnets and between a magnet and a paper clip.
- Each group of students will need a paper copy of Project 2.4 Magnetic Interactions Data Sheet. Students line up the magnets as shown on the Data Sheet and slide the magnet at the 2 inch mark toward the other magnet. Students mark on the ruler where the magnet or paper clip showed a reaction to the force by moving. Students test each interaction three times.

- After the students complete the first test with the paper clip and magnet, they will make a prediction about using two magnets to attract the paper clip instead of one.
- Students complete the tests and then talk about the results they recorded either as a group or class.
- Students follow the rest of the procedure to measure the distance between a magnet and iron filings. They explore the cause and effect relationship of magnetic forces.
- Students answer questions in their Launch Logs. Examples of correct responses to the questions are included below.

  1. Describe what happened when the magnets had the same pole together as shown below. Was the interaction a push or a pull? Explain.

     When the magnets had the same pole together, the magnet moved away from the one that was moved close to it. This interaction is a push because the first magnet pushed the second one away with the force of the magnetic interaction.

  2. Describe what happened when the magnets had opposite poles together as shown below. Was the interaction a push or a pull? Explain.

     When the magnets had opposite poles together, the magnet moved toward the one that was moved close to it. This interaction is a pull because the first magnet pulled the second one toward it with the force of the magnetic interaction.

  3. Where have you seen magnets used? Was the interaction with the magnet a push or a pull?

     Answers may vary. Students may give examples such as magnetic closures or toys.

Part 5: Animal Rescue

200 minutes

- In this problem students design and build a prototype of a mechanism that can rescue a trapped zoo animal.
- The students access Problem 2.5 Animal Rescue using the Canvas app on a tablet. 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 consider the problem, criteria, and constraints.
- The students follow the Ask step and record responses in their Launch Log.
- The teacher guides the students as they 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 as they 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 2.5 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 animal rescue device.
- 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 test their animal rescue device by attempting to rescue their trapped plastic animal. The teacher guides the students in documenting their evaluation of the device.
- Students use the camera app on their tablet to record the animal rescue.
- The student groups discuss the results to determine if their device solved the problem.
- The teacher guides the students as they 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 animal rescue device 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: Forces and Interactions 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 that a pattern can be used to predict future motion.
- 3-PS2-3. Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other.
- 3-PS2-4. Define a simple design problem that can be solved by applying scientific ideas about magnets.
- 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-ETS1-1. 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.A.2 Measure and estimate liquid volumes and masses of objects using standard units of grams (g), kilograms (kg), and liters (l). Add, subtract, multiply, or divide to solve one-step word problems involving masses or volumes that are given in the same units, e.g., by using drawings (such as a beaker with a measurement scale) to represent the problem.
- 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.