PLTW – Stability and Motion: Forces and Interaction

OUTLINE

Introduction: Management, Engineering, Design Process

Activity 1: Introduction to Forces

In this activity students will learn about forces including effort and resistance forces. Students will review related concepts from the previous module including: balanced and unbalanced forces, opposing forces, and Newton's Laws of Motion. K1, K2, K4, K5, K6, K7, S10

Activity 2: Simple Machines and Forces

In this activity students will build and explore three simple machines including a lever, inclined plane, and pulley. Students will 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. K4, K5, K6, K7, S10, S11

Activity 3: Forces and Interactions in Compound Machines

In this activity 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. K1, K2, K3, K4, S1, S2, S3, S10, S11

Project: Magnetic Interactions

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. S11, S12

Problem: Animal Rescue

In this problem students design and build a prototype of a mechanism that can uncover and rescue a trapped zoo animal. K1-3, S1-9, S13

Stability and Motion: Forces and Interactions Summative Assessment

K4, K5, K6, K7, S10, S11, S12

BHAG: Learners will evaluate a problem and create a structure that rescues a tiger from a moat based on their exploration of simple machines and engineering in order to recognize that they are real engineers who can solve unique problems.

GOALS

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.

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.
- PS2.A: Forces and Motion - Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.
- PS2.A: Forces and Motion - The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.
- PS2.B: Types of Interactions - Objects in contact exert forces on each other.
- PS2.B: Types of Interactions - Electric, and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.
- 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.
- ETS1.A Defining and Delimiting Engineering Problems – Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into accounts.
- ETS1.B Developing Possible Solutions – Research on a problem should be carried out before beginning to design a solution. At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.

- Crosscutting Concept – Influence of Science, Engineering, and Technology on Society and the Natural World - People's needs and wants change over time, as do their demands for new and improved technologies.
- Crosscutting Concept – Influence of Science, Engineering, and Technology on Society and the Natural World - Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.
- Crosscutting Concept – Patterns - Patterns of change can be used to make predictions.
- Crosscutting Concept – Cause and Effect - Cause and effect relationships are routinely identified.
- Crosscutting Concept – Cause and Effect - Cause and effect relationships are routinely identified, tested, and used to explain change.

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.

See 3 column table for the bigger picture and alignment of outcomes, activities, and assessments.

PLTW – Stability and Motion: Forces and Interaction
Management and Introduction

Learning Target(s):
SWBAT explain their responsibilities and expectations as a PLTW learner.

Procedures:

1. Introduction - Tell students that they will be working as real engineers to build machines that solve problems.
2. PLTW Management Discussion - Display the slideshow on the board while students view their own copy on their Chromebook.
   a. Go over the steps for success with responsibilities and expectations.
   b. Discuss jobs and collaboration.
   c. Discuss preparation and clean-up.
   d. Review iPad rules.
3. PLTW Management Exit Ticket - Students complete an exit ticket about the responsibilities and expectations for PLTW success.
4. Prepare Materials (time dependent)
   a. Show and organize materials.
   b. Count materials in bags and label them with contents.
   c. Students explore materials and how the pieces fit together.

Differentiation (as needed):
In addition to the student accessibility standards inherent in the way we develop PLTW courses, PLTW supports purposeful student accessibility in the following ways:

- Courses support standard accessibility practices and techniques including the use of video captions, alternative text descriptions, and compatibility with screen readers. (Note: Features may vary based on course development date.)
- Some of the newer PLTW course developments feature a Student Accommodation section to help support you in adjusting course activities, projects, or problems to be accessible for your students.
- A non-digital, PDF version of the student course curriculum is available for use.

Materials: iPads, Chromebooks, VEX kits, slideshow, exit tickets

Success Criteria: Students complete an exit ticket (Google Form) on PLTW responsibilities and expectations with accuracy.

PLTW – Stability and Motion: Forces and Interaction
Introduction to Engineering

Learning Target(s):
SWBAT describe the role of engineers in today's world. SWBAT compare and contrast the design process with the scientific method and explain what happens at each step of the design process. SWBAT state questions that engineers may ask when gathering information about a situation people want to change.

Procedures:

1. Introduction - In this PLTW unit, you will be engineers. What is an engineer? Do you know any real-life engineers?
2. Define engineering and discuss types.
    a. Use student definitions and look it up using Google, Echo Dot, etc. to create a definition of engineering.
    b. List types of engineers together.
    c. Connect to PLTW - How can an engineer use stability, motion, forces, and interactions to meet a human need or want?
3. Design Process Discussion
    a. Review the steps of the scientific method. (Question, Hypothesis, Experiment, Observe and Record, Analyze, Share Results)
    b. Show a graphic of the PLTW engineering design process. (Ask, Explore, Model, Evaluate, Explain)
    c. Create a class venn diagram on the Promethean Board to compare and contrast the scientific method with the design process. (Post on GC.)
    d. Think and discuss - What questions do engineers ask when solving a design problem?
4. Conclusion - Tell your shoulder partner the steps of the design process.

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Materials: Chromebooks, Echo Dot, design process graphic, Promethean Board

Success Criteria: Students complete a venn diagram as a class that compares and contrasts the scientific method with the design process using at least three differences and three similarities.

PLTW – Stability and Motion: Forces and Interaction
Activity 1: Introduction to Forces

Learning Target(s):
SWBAT identify forces acting on an object. SWBAT describe the motion and stability of an object with balanced forces. SWBAT describe the motion and stability of an object with unbalanced forces. SWBAT identify simple machines and explain how they make work easier.

Procedures:
DAY 1

1. Put students into groups with one iPad per group. Students should log-in to PLTW on the iPad following teacher directions. Students access module and explore the capabilities. Explain that this is where the course will be (connect to similarity of Google Classroom).
2. Introduce and pass out Launch Logs - Explain that this will be their record of learning and should be completed thoroughly, like real-life engineers at their job. They will be taking notes as they research, creating sketches, and answering conclusion questions.
3. Read the "Stability and Motion: Forces and Interactions Introduction" (the story) with students. Students use iPads to access the story, and teacher displays the story on the board. Explain that even though the story is fictional, we can be inspired as engineers.
4. Discuss the story - Teacher guides students to think like engineers.
    a. What is the problem?
    b. What do you need to know to be able to design a solution to the problem?
    c. What skills will be needed to solve the problem?
5. Tiger Research (time dependent) - Students can learn more about tigers and view a live tiger cam (http://sdzsafaripark.org/tiger-cam).

DAY 2

1. Students get iPads and Launch Logs ready with their groups.
2. Read the introduction to Activity 1 with students (in student guide).
3. Show students the "Procedures" section in their student guide. Explain that this will be followed as we work through the activity.
4. Prepare Launch Logs - Students label a new page with "Forces" as the heading.
5. Video Presentation - Students work through the "Introduction to Forces" presentation by clicking the link in the student guide. Inform students that the presentation is interactive, and they will be required to complete drag and drop activities to prove their knowledge. The presentation is approx. 9 minutes and can be watched as many times as necessary.
6. Launch Log Tasks - In their Launch Logs, each student needs to…
    a. Sketch two teeter totters, one that is balanced and one that is unbalanced.

   b. Create a sketch that shows a push or a pull. Label the effort force and the resistance force on your sketch.
   c. 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).
7. Early finishers can watch the video presentation again or conduct tiger research.

DAY 3

1. Review vocabulary learned so far - force, balanced, unbalanced, push, pull, effort, resistance, friction, work, gravity. Practice vocabulary on Quizizz.
2. Read "How Do You Lift a Lion?" by Robert E. Wells
   a. Guide students to think about how forces, interactions, and motion are being used to complete the tasks.
   b. Reference simple machines shown in the book and their importance.
3. Video Presentation - Students work through the "Simple Machines" presentation by clicking the link in the student guide on iPads in groups. Inform students that the presentation is interactive and can be paused as needed, and they will be required to use a piece of paper in the shape of a right triangle and a pencil to complete the activity. Assist students as they make a screw. The presentation is approx. 5 minutes and can be watched as many times as necessary.
4. Early finishers can practice using simple machines online (http://interactivesites.weebly.com/simple-machines.html).

DAYS 4-5

1. Review the six types of simple machines.
2. Students get into groups with iPads and VEX kits.
3. Groups use VEX components to build a model of a wheel and axle. (The load can be VEX components also.)
4. Using Flipgrid, each group creates a presentation of their model.
   a. Show and describe the wheel and axle.
   b. Describe how this simple machine could make work seem easier.
   c. Give examples of wheels and axles in real life.
   d. Each group shares their presentation with the class.
5. Conclusion Questions - Students answer conclusion questions individually in the Launch Log. (This will be collected and graded as a formative assessment.)
6. Early finishers can practice using simple machines online (http://interactivesites.weebly.com/simple-machines.html).

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Materials: iPads, Chromebooks, Promethean Board, Launch Logs, VEX kits, “How Do You Lift a Lion?” book

Success Criteria: Students draw accurate sketches in Launch Logs. Students build an accurate wheel and axle. Students create and share a presentation about a wheel and axle using Flipgrid. Students correctly answer conclusion questions individually in Launch Logs.

PLTW – Stability and Motion: Forces and Interaction
Activity 2: Simple Machines and Forces

Learning Target(s):
SWBAT identify forces acting on an object. SWBAT describe the motion and stability of an object with balanced forces. SWBAT describe the motion and stability of an object with unbalanced forces. SWBAT identify simple machines and explain how they make work easier. SWBAT distinguish the attributes and components of six simple machines. SWBAT make observations and measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

Procedures:

DAYS 1 - 3: Inclined Plane

1. Review vocabulary learned so far - force, balanced, unbalanced, push, pull, effort, resistance, friction, work, gravity, energy, simple machine.
2. Discuss the inclined plane.
    a. An inclined plane is a simple machine that is a sloping (or slanted) ramp that can be used to raise or lower a load by sliding. The slanted ramp helps to move things between lower and higher levels.
    b. Where do we see inclined planes being used?
    c. How do inclined planes make work easier?
3. Build the inclined plane in groups using iPads and VEX kits.
    a. Open the Autodesk® Inventor® Publisher tablet application on your tablet.
    b. Use the table of contents to select 3.2 Inclined Plane. Remember that you can compress the table of contents to view the full screen by selecting the left arrow pair at the top of the screen.
    c. Work through the building steps to build the inclined plane and box.
    d. Slide the box up the inclined plane several times. Get a sense for how much effort force you need to push the box up the ramp.
    e. Now place the box on the surface next to the tallest part of the inclined plane and then lift the box up to the same height as the top of the ramp. Again, get a sense for how much effort you needed to lift the box up to the top of the ramp.
4. Launch Log Tasks
    a. Draw the box on the inclined plane in your Launch Log.
    b. Measure the tallest part of the inclined plane and the length of the ramp. Label the drawing with your measurements.
    c. Which distance is greater, the length of the ramp or the height of the ramp?
    d. Did lifting the box or pushing the box up the inclined plane require more effort on your part? Explain your thinking.
5. Using Flipgrid, each group creates a presentation of their model.

a. Show and describe the inclined plane.
b. Describe how this simple machine could make work seem easier.
c. Each group shares their presentation with the class.

DAYS 4 - 6: Lever

1. Discuss the lever.
    a. A lever is a simple machine that moves a load around a fulcrum using a force. The force is applied to the lever arm which pivots at the fulcrum.
    b. Where do we see levers being used?
    c. How do levers make work easier?
2. Build the lever in groups using iPads and VEX kits.
    a. Open the Autodesk® Inventor® Publisher tablet application on your tablet.
    b. Use the table of contents to select 3.2 Lever. Remember that you can compress the table of contents to view the full screen by selecting the left arrow pair at the top of the screen.
    c. Work through the building steps to build the lever.
3. Launch Log Tasks
    a. Draw the lever and label the lever arm and fulcrum in your Launch Log.
    b. Test the function of the lever you constructed by pressing down on one side and then the other. Try to get a sense of how much effort force you must exert to lift the other side. Remove one of the tires and stack it on top of the one at the other end. Use one hand to move the lever so the tires move up and down. Again, try to get a sense of how much effort force you must use to lift the other side. Change the position of the fulcrum by moving the pivot point away from the tires as shown at right. Press on the lever arm on the same side as the fulcrum (furthest from the tires) in order to move the tires up and down.
        i. Did this require more or less effort force than when the pivot point was in the center of the lever? Explain your answer.
    c. Change the position of the fulcrum by moving the pivot point close to the tires as shown at right. Move the tires up and down again.
        i. How did moving the fulcrum close to the tires change the amount effort force you needed to move the tires up and down? Why do you think there was a difference?
4. Using Flipgrid, each group creates a presentation of their model.
    a. Show and describe the lever.
    b. Describe how this simple machine could make work seem easier.
    c. Each group shares their presentation with the class.

DAYS 7-8: Pulley

1. Discuss the pulley.
    a. A pulley is a simple machine that uses grooved wheels and a rope, cable, or chain to raise or lower a load.

    b. Where do we see pulleys being used?
    c. How do pulleys make work easier?
2. Build the pulley in groups using iPads and VEX kits.
    a. Open the Autodesk® Inventor® Publisher tablet application on your tablet.
    b. Use the table of contents to select 3.2 Pulley. Remember that you can compress the table of contents to view the full screen by selecting the left arrow pair at the top of the screen.
    c. Work through the building steps to build the pulley.
3. Launch Log Tasks
    a. Draw the pulley system you created in your Launch Log. Label the pulleys and the load they are supporting.
    b. When you pull down on one tire, which way does the other tire go? Add arrows showing the movement directions to your drawing. Then label the arrows with the words "Effort" and "Resistance." Repeat pulling down each tire several times until you get a sense of how much effort force you need to apply to move the other tire.
4. Using Flipgrid, each group creates a presentation of their model.
    a. Show and describe the pulley.
    b. Describe how this simple machine could make work seem easier.
    c. Each group shares their presentation with the class.

DAY 9: Conclusion

1. Discussion:
    a. Review four simple machines built and tested (wheel and axle, inclined plane, lever, pulley). How do they make work easier?
    b. What is energy? How do these simple machines transfer energy?
2. Conclusion Questions - Students answer conclusion questions individually in the Launch Log. (This will be collected and graded as a formative assessment.)
    a. How do simple machines transfer energy?
    b. Describe one common simple machine in your life and how it makes your work effort easier for each of the following:
        i. An inclined plane
        ii. A lever
        iii. A pulley
3. Take apart each simple machine and return the parts to the proper kit.
4. Early finishers can find simple machines around the school and post pictures of them to their ePortfolios to share with the class.

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- A non-digital, PDF version of the student course curriculum is available for use.

Materials: iPads, Chromebooks, Promethean Board, Launch Logs, VEX kits

Success Criteria: Students draw accurate sketches in Launch Logs. Students build an accurate inclined plane, lever, and pulley. Students create and share a presentation about the inclined plane, lever, and pulley using Flipgrid. Students correctly answer conclusion questions individually in Launch Logs.

PLTW – Stability and Motion: Forces and Interaction
Activity 3: Forces and Interactions in Compound Machines

Learning Target(s):
SWBAT explain what happens at each step of the design process. SWBAT state questions that engineers may ask when gathering information about a situation people want to change. SWBAT identify the differences between invention and innovation. SWBAT identify forces acting on an object. SWBAT follow a step by step approach to solving a problem. SWBAT Identify specific constraints such as materials, time, or cost that engineers and designers must take into account given a specific design problem. SWBAT brainstorm and evaluate existing solutions to a design problem. SWBAT distinguish the attributes and components of the six simple machines. SWBAT make observations and measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.

Procedures:

1. Discussion
    a. Review vocabulary learned so far.
    b. Based on your knowledge of simple machines, what do you think a compound machine is?
    c. Create a definition of compound machine as a class based on student ideas.
        i. Common misconception - Clarify that a compound machine is not two simple machines side by side.
    d. Where do we see compound machines being used?
    e. If simple machines make work easier, what do you think compound machines do?
2. Prepare to build a compound machine with design teams following the engineering design process.
    a. Explore ideas as a team - Think of ways to combine two or more simple machines to complete a task. Record all of the ideas in your Launch Log.
    b. Sketch an idea that you came up with in your Launch Log. Your team members should do the same with their ideas in their Launch Logs. All ideas do not need to be the same.
    c. Compare your sketch with your team members' sketches.
    d. Discuss all of the different sketches.
    e. Record in your Launch Log:
        i. What simple machines did your team members choose?
        ii. What simple machines did you choose?
        iii. What is the work that the compound machines will do?
    f. Revise any sketch in your Launch Log so that you and your team members have a final sketch of your team's final design idea.

        i. Label each type of machine.
        ii. Decide who will build each machine.
3. Build the compound machine with design teams using VEX kits.
    a. Each team member should create one simple machine that will fit together and transfer a force to the next simple machine with a push or a pull.
4. Using Flipgrid, each group creates a presentation of their compound machine.
    a. Show and describe the compound machine.
    b. Show the compound machine in action.
    c. Describe what the compound machine does. How does it make work easier?
    d. What could the compound machine your team created be used for?
5. Conclusion
    a. Show Flipgrid video presentations of each team's compound machine.
    b. Discussion
        i. Compare and contrast the compound machines.
        ii. What compound machines do we use in real life? How do they help us?
    c. Conclusion Questions - Students answer conclusion questions individually in the Launch Log. (This will be collected and graded as a formative assessment.)
        i. How do you think compound machines make work seem easier? Use evidence from this activity.
        ii. Create a chart in your Launch Log. Name the simple machines you used in your complex machine design and indicate whether they make the task easier or more difficult.
6. Early finishers can find compound machines around the school and post pictures of them to their ePortfolios to share with the class.

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- A non-digital, PDF version of the student course curriculum is available for use.

Materials: iPads, Chromebooks, Promethean Board, Launch Logs, VEX kits

Success Criteria: Students draw accurate sketches in Launch Logs. Students create and share a presentation about their compound machine using Flipgrid. Students correctly answer conclusion questions individually in Launch Logs.

PLTW – Stability and Motion: Forces and Interaction
Project: Magnetic Interactions

Learning Target(s):
SWBAT make observations and measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. SWBAT identify the cause and effect relationships of magnetic interactions between two objects not in contact with each other.

Procedures:

1. Discussion
    a. You have learned that a force is a push or a pull. Do objects need to touch to be able to push or pull each other? Can you think of an example where they would not need to touch?
    b. When objects push or pull each other, they interact. These interactions show that a force is acting on an object. Your body weight pulls you back to the ground when you jump. This is your body interacting with gravity. What other interactions can you think of in your life?
2. Predict and Test
    a. Teams receive a bag of items and should spread them out in their work area.
    b. Divide the objects into two groups. One group will include objects that you predict will interact with a magnet, and the other group will include objects that you predict will not interact with a magnet.
        i. Take a photo of the two groups with the iPad.
    c. Test the magnetic interaction of each object by touching each object with the magnet.
        i. Divide the objects into two groups again. One group will include objects that interacted with the magnet, and the other group will include objects that did not interact with a magnet.
        ii. Take a photo of the two groups with the iPad.
        iii. Compare the results to your predictions by examining the two photographs.
    d. Discuss the following questions with your team and reflect in your Launch Logs.
        i. Think about how the objects reacted to a magnet. Which of your predictions were correct? Which were not correct?
        ii. What do the objects in the magnetic interaction group have in common? Use examples from your testing to explain.
3. Gathering and Analyzing Data in Launch Logs
    a. Teams use data sheets, magnets, and paper clips to test 4 interactions.

   b. Make a prediction before each test - Will the distance change when you use two magnets to pull the paper clip?
   c. Test, record, and discuss results with your team.
   d. Measure the distance where you start to observe an interaction between the iron filings and a magnet using the steps below.
      i. Hold the packet of iron filings in one hand at about eye level.
      ii. Hold a magnet at least 6 inches from the bag of filings.
      iii. Have a partner hold a ruler between the bag of filings and the magnet.
      iv. Slowly move a magnet up toward the filings with the other hand.
      v. Have a partner measure the distance between the magnet and iron filings when you first see movement from the interaction.
   e. Repeat the experiment two more times and record your observations in your Launch Log. Talk about your results with your team.
4. Conclusion
   a. Discussion - How can your knowledge of magnetic interactions help you solve problems?
   b. Conclusion Questions - Students answer conclusion questions individually in the Launch Log. (This will be collected and graded as a formative assessment.)
      i. Describe what happened when the magnets with the same pole were brought together. Was the interaction a push or a pull? Explain.
      ii. Describe what happened when the magnets with opposite poles were brought together. Was the interaction a push or a pull? Explain.
      iii. Where have you seen magnets used? Was the interaction with the magnet an example of a push or a pull?
5. Early finishers should prepare a list of questions they would like to ask real engineers using their ePortfolios.

Differentiation (as needed):

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- Some of the newer PLTW course developments feature a Student Accommodation section to help support you in adjusting course activities, projects, or problems to be accessible for your students.
- A non-digital, PDF version of the student course curriculum is available for use.

Materials: iPads, Chromebooks, Promethean Board, Launch Logs, VEX kits

Success Criteria: Students record predictions and observations in Launch Logs. Students correctly answer conclusion questions individually in Launch Logs.

PLTW – Stability and Motion: Forces and Interaction
Problem: Animal Rescue

Learning Target(s):
SWBAT....

- 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.
- 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.
- Apply scientific ideas about magnets and simple machines to solve a simple design problem.

Procedures:

1. In teams, students reread the problem and evaluate it. Students think about everything they learned and how they can apply it to solve the problem.
2. Teams view the design process video and graphic and discuss how following the process can help solve the problem.
3. Discussion
    a. Remind students that they will be working with teams to design, sketch, and build a model of an animal rescue device that can rescue a trapped zoo animal. The team will decide how to rescue the animal by lifting and moving it to a safe area.
    b. Criteria/Constraints
        i. Criteria: The group will design, build, and test a device to rescue a trapped zoo animal. The device must safely lift the animal at least 4 inches and set it down in a safe area away from where the animal was trapped. You must include a magnet in your design. Your design

        must include a compound machine consisting of at least two simple machines. A harness for the animal must be created that safely supports the animal and does not pull on the animal's tail, legs, or head.
    ii. Constraints: You are limited to the VEX kit and string.

4. Engineering Design Process - Teams work through the process to create a structure to rescue a tiger from a moat.
    a. ASK
        i. Respond in Launch Log:
            1. What is the need or want that we are trying to fulfill?
            2. What will make the design solution successful?
            3. List the criteria and constraints for the design problem.
        ii. Complete the self-reflection rubric individually. Teacher leaves feedback during conference.
    b. EXPLORE
        i. Investigate the problem. Write or sketch how others have tried to solve a similar problem.
        ii. Brainstorm several ideas that may solve the problem. Create sketches of your ideas.
        iii. Talk to your team and share ideas. Add any additional ideas by writing or sketching. Add labels to your sketch.
        iv. Complete the self-reflection rubric individually. Teacher leaves feedback during conference.
    c. MODEL
        i. Compare the solutions that your team generated during the Explore step. Work collaboratively to choose the best idea for your model using the Decision Matrix.
        ii. Build a model of the design.
        iii. Document the model by sketching the final design and take a picture with the iPad.
        iv. Complete the self-reflection rubric individually. Teacher leaves feedback during conference.
    d. EVALUATE
        i. Describe how you will evaluate or test your solution.
        ii. Conduct and document a controlled test. Record your observations.
            1. Conduct three trials.
            2. Use the iPad camera to videotape the trails.
            3. Record the results of your test in your Launch Log.
            4. Discuss with your team - Was your model able to successfully rescue the tiger?
        iii. Use evidence to identify parts of your design solution that can be improved.

    iv. Complete the self-reflection rubric individually. Teacher leaves feedback during conference.
  e. EXPLAIN
    i. Present your design, evaluation, and suggestions for improvement for your rescue device model on your ePortfolio.
    ii. Complete the Explain section of your Launch Log by evaluating how the animal rescue device solved (or didn't solve) the problem. Include the data you collected to support your conclusions.
    iii. Complete the self-reflection rubric individually. Teacher leaves feedback during conference.

5. Conclusion
    a. Presentations - Teams present their designs, evaluation, and suggestions for improvement to the class.
    b. Discussion
        i. What did the successful models have in common?
        ii. How did the compound machine make it easier to rescue the tiger?
        iii. How would you use the engineering design process in your life to solve problems?
    c. Conclusion Questions - Students answer conclusion questions individually in the Launch Log. (This will be collected and graded as a formative assessment.)
        i. Was your animal rescue model able to successfully move the animal to a safe area? Support your answer with the evidence you recorded in your Launch Log.
        ii. List two changes you would make to improve the design. Why do you think these changes would improve your animal rescue model?
        iii. In this problem, you designed an animal rescue device to lift an animal to safety. What forces and interactions occurred during the rescue?
        iv. Sketch the device. Label the forces and interactions. Include opposing forces such as effort and resistance force.
6. Summative Assessment (test)
    a. 6 short-answer questions based on real-world application of knowledge and skills
    b. Collect and grade.

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- A non-digital, PDF version of the student course curriculum is available for use.

Materials: iPads, Chromebooks, Promethean Board, Launch Logs, VEX kits, test

Success Criteria: Students create a presentation of their ePortfolios and share with the class. Students correctly answer conclusion questions individually in Launch Logs. Students complete an honest self-reflection using the rubrics. All students score 80% or higher on their summative assessment.