Purpose
The resources provided in this document are not required to be used in preparation for your lab. They are simply resources that we thought might be helpful to you and engaging for your students. It is your choice to use them and you may pick as few or as many to implement as you like.
**If you are receiving a Title I scholarship for your lab, you are required to implement a vocabulary or journal activity prior to your lab visit.*

Grade Levels
2-12

Lab Summary
They love to ride them, now they'll love to build them! Students explore potential and kinetic energy and apply what they learn to build their own roller coasters made of foam tubing, tinker toys, and marbles.

Common Core Math
Grade 2: Measurement and Data 2.MD.1

Common Core Language Arts Standards
Speaking and Listening
Grade 2: SL.2.1a-c, SL.2.2a, SL.2.3
Grade 3: SL.3.1b-d, SL.3.3, SL.3.4a
Grade 4: SL.4.1b-d, SL.4.4a
Grade 5: SL.5.1b-d, SL.5.4
Grade 6: SL.6.1b-d
Grade 7: SL.7.1b-d
Grade 8: SL.8.b-d
Grades 9-12: SL.9-10.1b-d, SL.11-12.1.b-d

Student Outcomes
Students will:
- Demonstrate that gravity is a naturally occurring force that pulls objects toward the center of the Earth.
- Describe and demonstrate the difference between potential and kinetic energy.
- Work as a team to complete a given design challenge with constraints.

State and National Standards Connections
Next Generation Science Standards

	Engineering Design	Physical Science	Disciplinary Core Ideas	Crosscutting Concepts	Science and Engineering Practices
Grade 2	K-2-ETS1-1 K-2-ETS1-2 K-2-ETS1-3		PS2.A ETS1.A PS3.C ETS1.B ETS1.C	Cause and Effect Structure and Function	1, 2, 3, 6
Grade 3	3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3	3-PS2-2	PS2.A ETS1.A PS2.B ETS1.B PS3.A ETS1.C	Patterns Cause and Effect Influence of Engineering, Technology, and Science on Society and the Natural World	1, 2, 3, 6

Grade 4	3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3	4-PS3-1 4-PS3-2 4-PS3-4	PS3.A ETS1.A PS3.B ETS1.B ETS1.C	Energy and Matter Influence of Engineering, Technology, and Science on Society and the Natural World	1, 2, 3, 6
Grade 5	3-5-ETS1-1 3-5-ETS1-2 3-5-ETS1-3	5-PS2-1	PS2.B ETS1.A ETS1.B ETS1.C	Cause and Effect Energy and Matter	1, 2, 3, 6
Grades 6-8	MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	MS-PS3-2 MS-PS3-5	PS3.A ETS1.A PS3.B ETS1.B ETS1.C	Energy and Matter Structure and Function	1, 2, 3, 4, 5, 6
Grades 9-12	HS-ETS1-2 HS-ETS1-3	HS-PS2-1 HS-PS3-3	PS3.B ETS1.A ETS1.B ETS1.C	Energy and Matter Systems and System Models Structure and Function	1, 2, 3, 4, 5, 6

Preparing for the Lab Experience

There are many ways to help prepare your students before the lab and help them reinforce their knowledge after the lab, including the content you are covering in the classroom. Below you will find a chart of some materials we offer to help support your classroom.

	Description	Recommended	Time, Materials & Support Needed
Lab Journal	Includes: • Vocabulary • Pre- and post-journal • Venn diagram • Tech Interactive notes & connections • Questions about the lab	• Pre-lab activities • Activities during field trip • Post-lab activities • Vocabulary definitions and journal prompts provided in this resource guide*	• 5-60 minutes (1+ days) • Print the journals • Assemble the journals • Writing utensils
Lab Related Activities			
Balloon Hovercraft	Your students will deepen their understanding of potential and kinetic energy and learn that these energies are not only found in rollercoasters.	• Either pre- or post-lab • The relationship between friction, force & energy	• 40 minutes • Specialized materials: • Old CDs

Play Potential	Students use what they have learned about kinetic energy, potential energy and rollercoaster engineering to design either a piece of playground equipment or an amusement park ride to be more inclusive of all people.	• Post-lab activity • In this design challenge, they will learn about how to accommodate people of diverse physical needs	• 60 minutes
Energy Red Light Green Light	Students will deepen their understanding of potential and kinetic energy and learn that these energies are not only found in rollercoasters!	• Pre-lab with vocabulary support • Post-lab to reinforce concepts of energy	• 20 minutes • Need a large open space to run
Rubber Band Fling	Student teams will investigate the correlation between stretched length of a rubber band (potential energy) to the distance it travels (kinetic energy).	• Pre-lab with vocabulary support • Post-lab to reinforce concepts of energy	• 30-40 minutes

*To print lab journals, lab-related activities, or additional teacher resource guides for this lab or others, visit us at https://www.thetech.org/educators/labs.

Related Links and Games

The following links and games provide additional information about roller coaster engineering, history and physics behind rides. We are not endorsing the following organizations, but feel that the information may be of benefit to your students and may help enhance the learning experience of the lab.

- **Popular Mechanics for Kids – Coasters:** Learn about how roller coasters work and how they are maintained. https://www.youtube.com/watch?v=QXMJqsJkvHs
- **Amusement Park Physics – Roller Coasters:** This site has great interactive tools to teach students and teachers about roller coasters from their history to their science. http://www.learner.org/interactives/parkphysics/index.html
- **How Stuff Works – Roller Coasters: Converting Energy:** This site offers a lot of explanation into the physics of how roller coasters work. We suggest it for grades 5 and up. http://www.howstuffworks.com/roller-coaster2.htm
- **Friction Ramp**: This game challenges students to explore friction and which surfaces work best to guide a skateboarder down a ramp. http://www.learninggamesforkids.com/motion-games/friction-ramp.html
- **PBS Kids WHOAHler Coaster:** This game is a great tool for younger kids to practice building a roller coaster and see how the shape of the roller coaster affects potential and kinetic energies. Flash 6 plug-in required. https://pbskids.org/fetch/games/coaster/index.html
- **Coaster Creator:** This game by JASON Learning allows older kids to practice building a roller coaster, including designing the cart appearance, and see how the hills and loops store and convert energy throughout. https://assets.jason.org/resource_assets/4851/8673/coaster.html
- **Highlight a Physicist - 20th Century Physicists:** https://www.thefamouspeople.com/20th-century-physicists.php

Related Texts

The following titles may provide students with a greater contextual understanding of the physics of roller coasters. Included in the list are narratives (fiction/nonfiction), referential texts and books that extend learning beyond the scope of the lab. We are not endorsing the following authors, but feel that the information may be of benefit to your students and may help enhance the learning experience of the lab.

Narratives

- "Roller Coaster." By Marla Frazee.
  - Recommended for grades 2-4.
  - Twelve people set aside their fears and ride a roller coaster, including one who has never done so before.

Reference

- "The Thrills and Chills of Amusement Parks (Science and Fun)." By Jordan D. Brown.
  - Level 3 Ready-to-Read
  - A nonfiction all about the science behind the fun of amusement parks. From rollercoasters to bumper cars, young scientists will flip when they learn about the science behind amusement parks in the fun, fact-filled read!
- "Roller Coasters." By Robert Coker.
  - Recommended for grades 6-12.
  - Raintree Fusion Edition: Recommended for Grades: 2-5.
  - Containing more than 150 images of the world's most terrifying rides, this book puts readers in the front seats of some of the largest coasters ever built. Spanning the whole history of roller coasters, from the 15th century to 2002, the book offers an in-depth look at the evolving technology of coaster design and construction.
- "Calling All Innovators: Roller Coasters." By Kevin Cunningham.
  - Recommended for grades 3-7.
  - A fascinating look at how people in science, technology, engineering, and math (STEM) careers are helping to build our future.
- "Coasters 101: An Engineer's Guide to Roller Coaster Design." By Nick Weisenberger.
  - Recommended for grades 9-12.
  - An examination of the numerous and diverse aspects of roller coaster engineering. This book includes the science and mathematical formulas that engineers use when designing the technology of some of today's greatest coasters. A technical study.
- "Basher Science: Physics: Why Matter Matters!" By Dan Green.
  - Recommended for grades 4-12.
  - "Does the subject of gravity make your eyelids droop? Fear not! This book comes to the rescue by mixing science and art to bring the world of physics to life. With a gaggle of wacky characters to explain the building blocks of our universe, this unique little book makes learning physics fun!" (www.basherbooks.com) A creative introduction to physics concepts.
- "Basher Science: Extreme Physics: Take a Quantum Leap... To the Edge of Science." By Dan Green.
  - Recommended for grades 4-12.
  - "Learning about the amazing research that is revolutionizing physics, from the pioneering experiments taking place in the hunt for the Higgs Boson to antiparticles and teleportation." (www.basherbooks.com)

Tech Interactive Gallery and Exhibit Connections

Outside the group entrance (Ground Level)

- *Science on a Roll (Ball Machine on Park Ave)*: Witness an elaborate demonstration of the transfer of energy in motion.
  - Connection to the lab:
    - Explores the vocabulary used in the lab including: force, gravity, potential energy and kinetic energy.
  - Activities to complete at the exhibit:
    - Pick a ball and follow it throughout its journey through the ball machine contraption.
  - Questions to guide student learning:
    - Why does the ball need to be taken to the top?
      - *The ball is taken to the top in order to store the greatest amount of potential energy*
    - At what part of the ball machine does it store the most amount of potential energy?
      - *The top of the track*

Design Challenge Learning Resources

Design Challenge Learning is a dynamic way for learners to become creative problem-solvers. The below link will take you to short guides created by educators at The Bowers Institute on facilitating design challenges, promoting engineering and fostering innovator mindsets.
https://www.thetech.org/content/bowers-institute/resources

Writing Prompts

The following writing prompts and questions are just a few examples of journal topics to incorporate writing into your students' lab experience. If you feel that one of the below prompts does not meet your needs, you are welcome to use your own, but please make sure it is related to the chosen lab experience. If you have a related writing prompt you would like to share with The Tech and other teachers, please let us know on our teacher survey that will be available in the lab.

Most of the writing topics could be used as either pre-lab or post-lab writing. You may choose the prompts that work best for your class and schedule.

Pre-Visit Writing Topics/Prompts

Generic

- We will be attending __*lab name*__ at The Tech Interactive; what do you think we will learn about in the lab? What do you want to know about this topic? What do you already know about this topic?
- We will be attending _*lab name*__ at The Tech Interactive; what are you looking most forward to in this lab? Why?

Specific to Physics of Roller Coasters

- A new student at your school has never seen or heard of a roller coaster before. Explain to your classmate what a roller coaster is and what it is like to ride one.
- My favorite roller coaster is _____. It is my favorite because...
- Imagine your favorite roller coaster. Which one is it and where is it? How do you think it works?

Post-Visit Writing Topics/Prompts

Generic

- We learned a lot in our _*lab name*_ lab. What were your two favorite things you learned in the lab? Why?
- The principal is excited to hear all about your lab experience. Explain what you did and learned about in the lab since she or he was unable to attend the lab.

Specific to Physics of Roller Coasters

- (Take pictures of student roller coaster designs and review them as a class) What problems did you have making these roller coasters? How did you solve these problems? How would you iterate your design now?
- You and your team created an amazing roller coaster in the lab. If your roller coaster was turned into a real roller coaster, would you ride it? Why or why not?
- The marble you used to test out your roller coaster must have had a wild ride! Write a story describing your roller coaster ride from the marble's point of view.

Pre-Visit Vocabulary

These are words and concepts that we will discuss in the lab. Your students' experience will be enhanced if they are familiar with these terms prior to your visit. Below you will find several graphic organizers and games to aid in your vocabulary review.

Terms and Definitions

Energy	The ability to do work.
Force	An influence (push or pull) on a body or system, causing a change in movement or shape.
Gravity	A force that pulls objects toward the center of the Earth.
Kinetic Energy (KE)	The energy of motion. An object in any form of motion has kinetic energy (e.g., running, walking, dancing, flying, etc.).
Mechanical Energy	Energy possessed by an object due to its motion or its stored energy of position. Mechanical energy can be either kinetic (energy of motion) or potential (stored energy of position).
Potential Energy (PE)	The energy of position; energy that is stored and held in readiness — waiting to move (e.g., a ball held in the air, sitting still, waiting motionless).

Advanced Vocabulary – these terms may come up in your lab depending on time constraints:

Acceleration	A change in velocity over a period of time. That means if you change how fast you are going or change the direction you are moving, it counts as acceleration!
Position	A location in space usually denoted by a set of coordinates relative to some arbitrary origin (i.e., x & y coordinates).
Velocity	A change in position over a period of time. Velocity includes not only the speed of an object, but what direction it moves.

Vocabulary Activities

Graphic Organizers

- *Frayer Graphic Organizer:* The Frayer Graphic Organizer is a great tool for vocabulary development. It allows students to write their own definitions, define characteristics, and provide examples and non-examples. This tool will lead your students to a deeper understanding of the vocabulary and how it relates to their lives. On page 11 you will find a blank Frayer Graphic Organizer for your use in the classroom.
  - For more information on the Frayer Model and how to implement it, please visit the following link: http://www.theteachertoolkit.com/index.php/tool/frayer-model
- *Vocabulary Graphic Organizer:* This graphic organizer is a great tool for younger students as well as English Language Learners. Although very similar to the Frayer Model, this graphic organizer includes a drawing of the vocabulary term and its use in a sentence. On page 12 you will find a blank Vocabulary Graphic Organizer for your use in the classroom.
- *Circle Map:* This graphic organizer is a great tool for helping all students develop an overall sense of a topic. It is also very helpful for beginning and early intermediate English Language Learners. This graphic organizer lets students brainstorm what a term or concept means to them and provides a frame of reference for the term. On page 13 you will find a blank Circle Map for your use in the classroom.
  - For more information on the Circle Map and other Thinking Maps, please visit the following link: http://thinkingmaps.com/why-thinking-maps-2/

Review Strategies

For younger students (grades 2-3) and second language learners, just reviewing the words and their definitions may not be enough for full comprehension. Below, you will find some examples of Total Physical Response (TPR) actions for the above vocabulary words to help students model and fully grasp the vocabulary at hand. There is also an age-appropriate vocabulary matching worksheet on page 14.

Vocabulary Term	TPR Action
Gravity: A force that pulls objects toward the center of the Earth.	Have students jump in the air. (They use energy to jump, gravity pulls them back down).
Energy: The ability to do work.	Have students jog in place.
Force: A push or pull on an object, causing a change in movement or shape.	Have students pull their chair out and push it in.
Kinetic Energy: The energy of motion.	Have students wave their arms up in the air.
Potential Energy: The energy of position; energy that is stored and held in readiness – waiting to move.	Have students hold arms up in air without moving them.

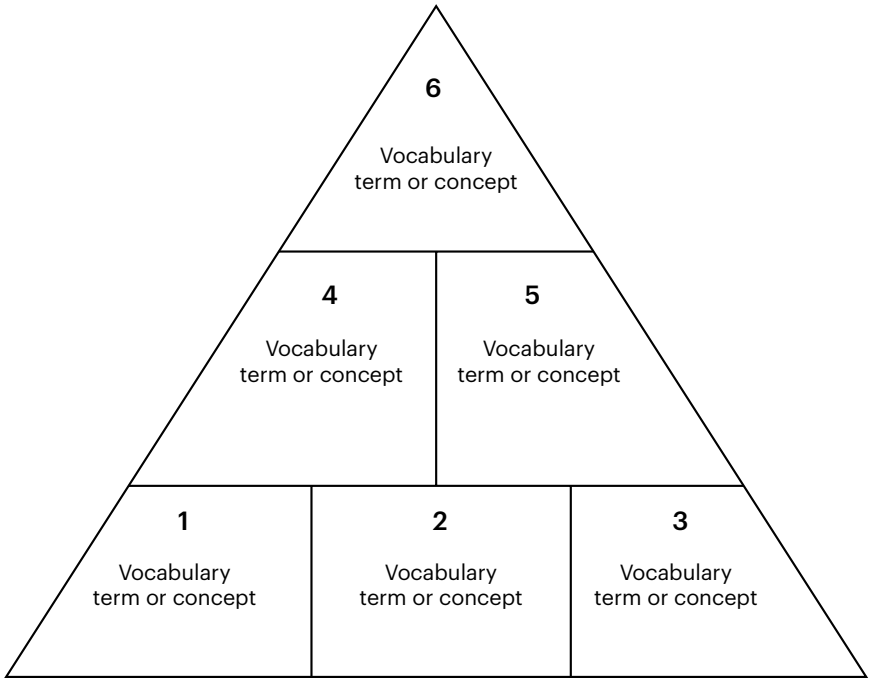
Vocabulary Review Games

- *Quiz, Quiz, Trade:* This is a fun cooperative game for students to review vocabulary terms. For more details and to see an example of Quiz, Quiz, Trade in action, please visit the following link: http://www.theteachertoolkit.com/index.php/tool/quiz-quiz-trade
  1. Create questions or vocabulary cards. On one side of an index card, write the question or vocabulary term; on the other, the answer or definition. Pass out the cards to students. If there are not enough terms for everyone to have a different card, try using different "back" sides to the same cards (e.g., instead of the definition again, have a drawing, a question about the term, characteristics of the term or an example of the term).
  2. Pair up. When all cards have been passed out, students find a partner to quiz with their card.
  3. Hands up. When both partners have completed the quizzes correctly, they put their hand up to show other students that they are ready for a new partner to quiz.
- *Back-words:* This game is part Charades, part 20 Questions. In this review game, students have to guess the vocabulary term that is on their back by asking questions of a partner or having the partner act out the term.
  1. Write your vocabulary terms on index cards. If there aren't enough terms for each student to have a different one, you can make two sets and divide the class into two groups. You may also add in other related vocabulary terms that you have been studying in class.
  2. Tape one term onto the back of each student so that he or she cannot see the word.
  3. Have students pair up. Each partner should look at the word on their partner's back. Partners take turns asking questions or acting out or gesturing about the term that is on their back. (e.g., "Am I an element? Am I part of an atom? Do I make up all matter?") Partners must ask at least two questions before guessing their word.
  4. When both partners have correctly guessed their word, they put a hand up to signal that they are in need of a new partner. Continue game play until everyone has guessed their word.
- *$10,000 Pyramid:* This review game is exactly like the classic game show. Students will work in pairs, taking turns to describe the words and to guess the words.
  1. Break up the terms into two groups. Each partner will take on one group of words.
  2. Have each partner fill out the worksheet on the next page with their group of words.
  3. For the first round, Partner A will be the one describing the term and Partner B will be the one guessing the term. Partner A will describe the term (starting with 1) using the words he or she wrote down on the worksheet. From the description, Partner B will guess what the term is.

4. When Partner B guesses the word correctly, Partner A moves on to the next word.
5. When Partner B correctly guesses all the words in Partner A's pyramid, they switch places and Partner B will describe the terms on his or her pyramid while Partner A guesses the terms.
6. You can time this activity like on the quiz show, but it may intimidate some students

Student Name:_____

$10,000 Pyramid



Write descriptive clues about each vocabulary term or concept:

1. _____

_____

2. _____

_____

3. _____

_____

4. _____

_____

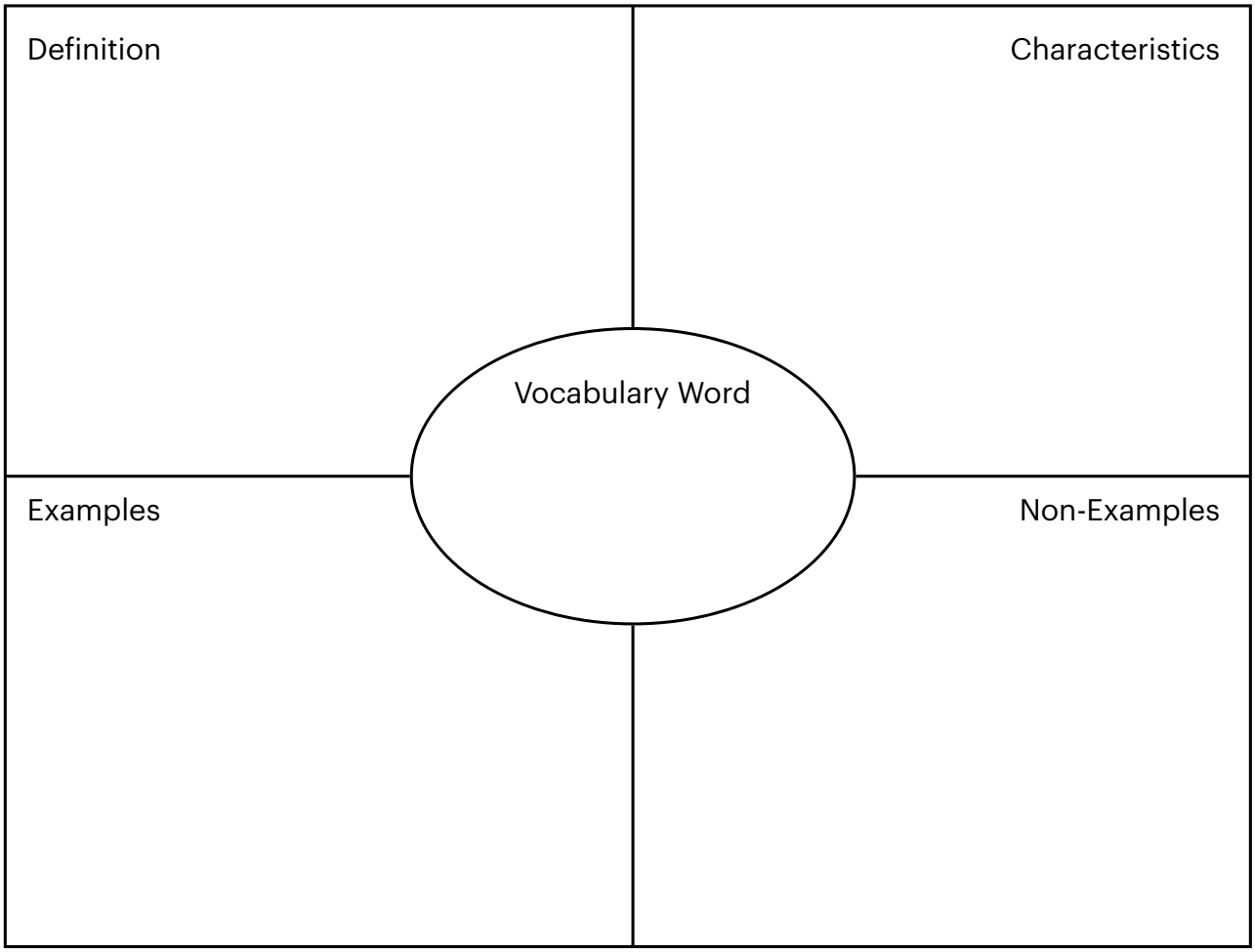
5. _____

_____

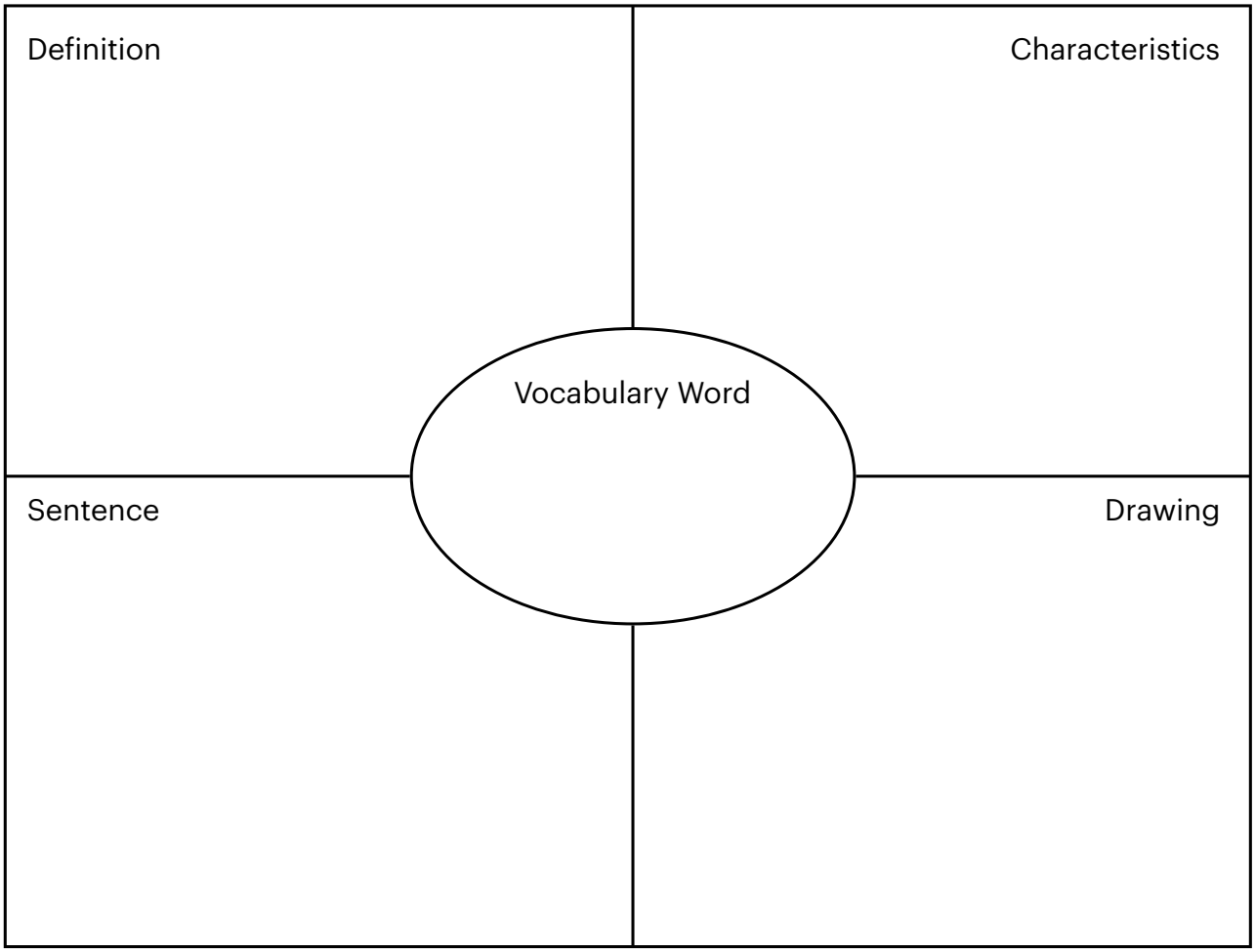
6. _____

_____

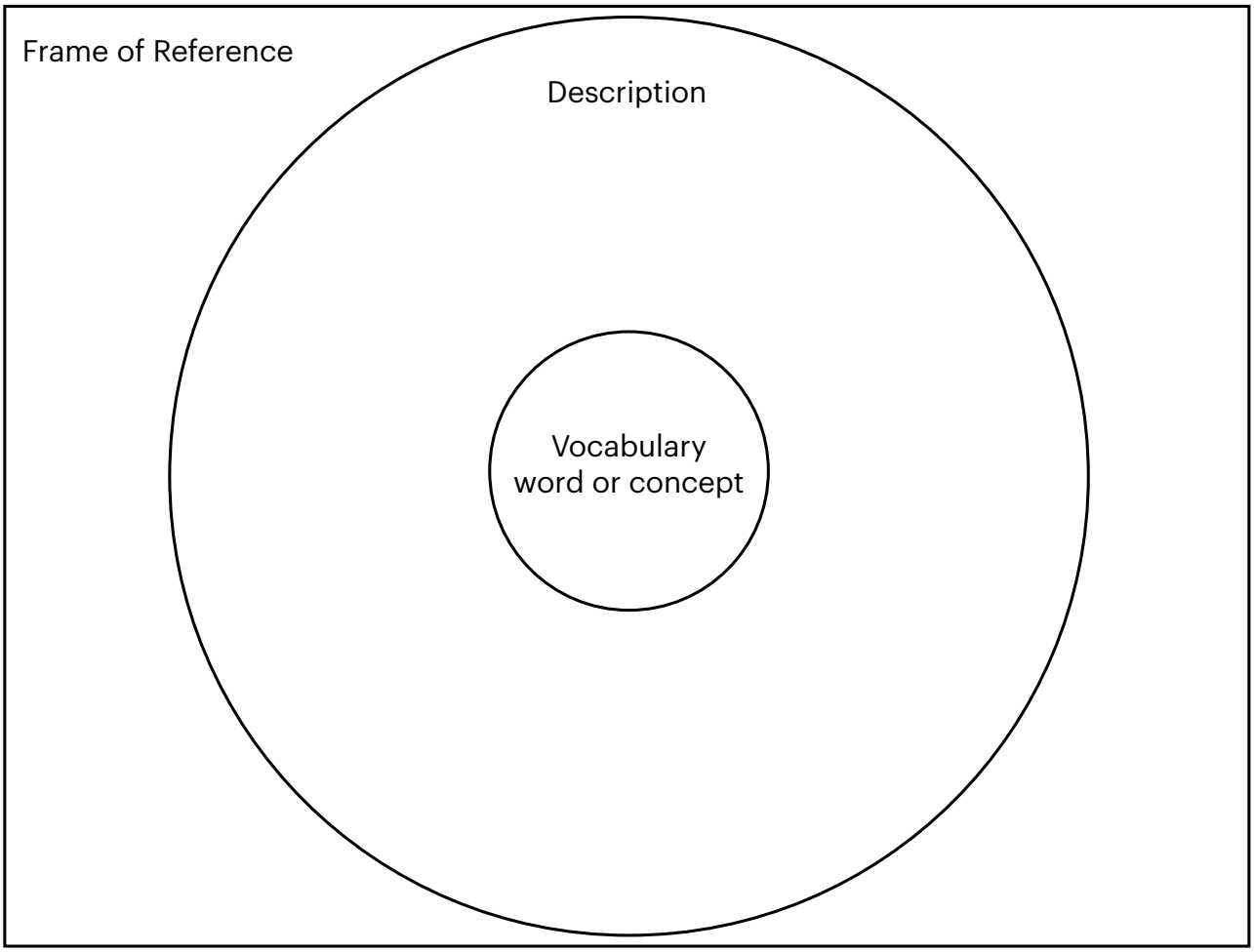
Frayer Graphic Organizer



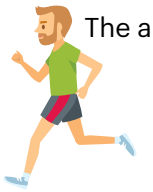
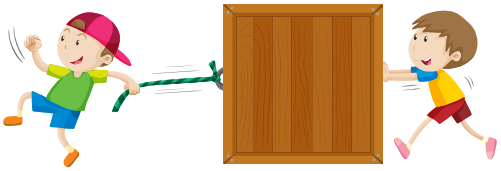
Vocabulary Graphic Organizer



Circle Map


Frame of Reference
Description
Vocabulary
word or concept

Draw a line that will match the vocabulary term to the image and definition on the right.

Vocabulary Words	**Definitions**
Potential Energy	 The ability to do work
Gravity	Energy in motion 
Energy	 A push or pull on an object, causing a change in movement or shape
Kinetic Energy	 The energy of position; energy that is stored and held in readiness waiting to move.
Force	A force that pulls objects towards the center of the earth.