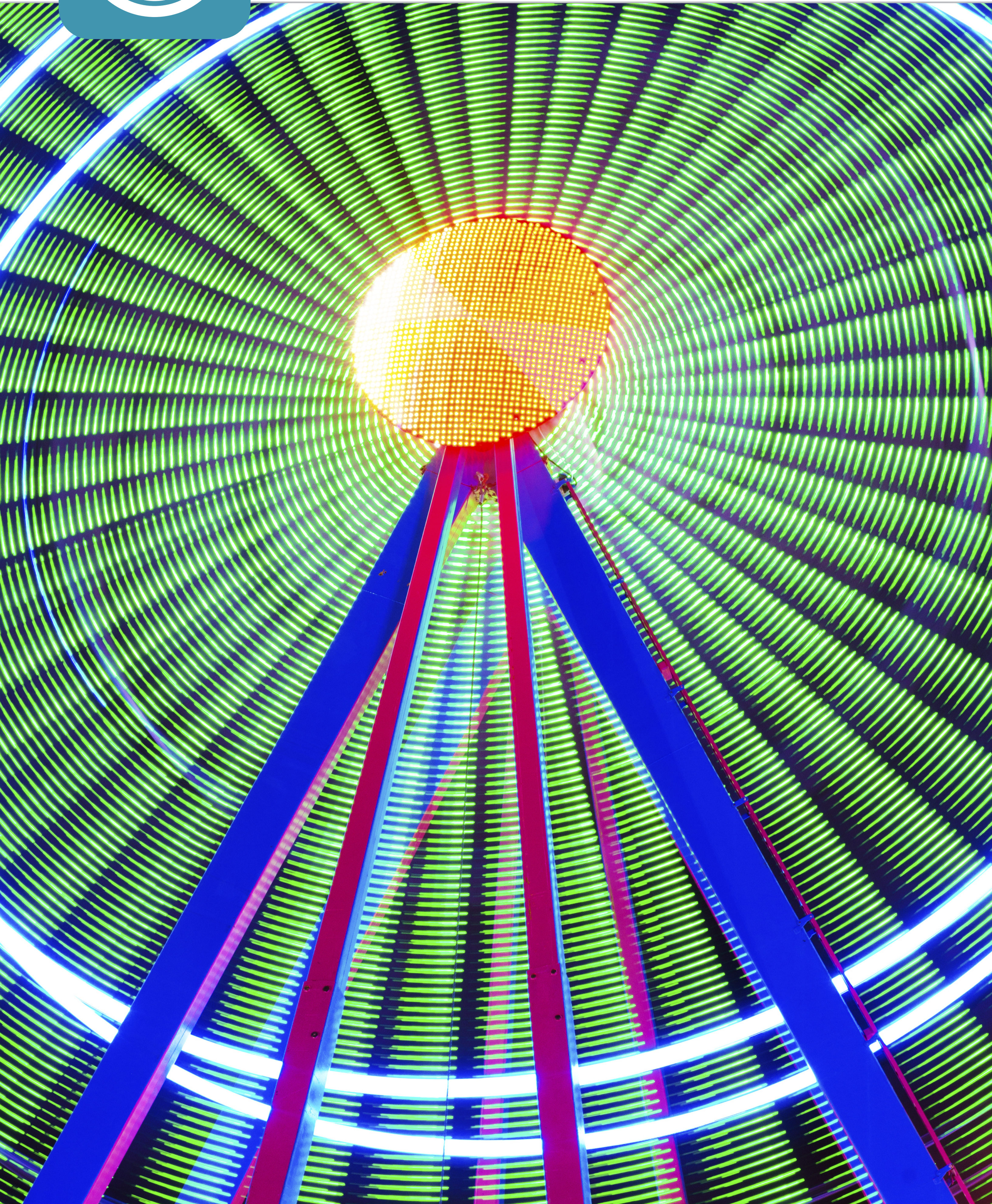
INNOVATION & PROGRESS

Amusement of the Future



STEM Road Map Curriculum Module Overview

Amusement of the Future

STEM Road Map Module Theme and Grade Level: Innovation and Progress, Grade 6

STEM Road Map Module Topic: Amusement of the Future
Lead disciplines: Science/Social Studies

Module Summary

This module taps into students' prior experiences with amusement parks and connects these experiences to a variety of science and social studies concepts including energy transfer, understanding technical texts, communicating with multimedia, and the influences of technology on society. Students are challenged to work in teams to create a prototype of an amusement park and to develop a marketing piece for their parks (adapted from Johnson et al., 2015; see https://www.routledge.com/products/9781138804234).

Established Goals/Objectives

By completing this module, students will understand the big ideas around energy transfer, including potential and kinetic energy. Students will also practice their English/Language Arts (ELA) skills by understanding technical texts, creating multimedia communication products and creating arguments for the claims they make based on the evidence of the investigations.

Challenge and/or Problem for Students to Solve

Student teams will be challenged to produce a prototype of an amusement park that includes a variety of rides and attractions. Students will synthesize their understanding of the role of amusement parks in society with their understanding of scientific concepts associated with amusement parks to create their prototypes. Students will use the engineering design process (EDP) to build and test small-scale prototypes, and will develop marketing pieces for their amusement parks.

Content Standards Addressed in STEM Road Map Module

Next Generation Science Standards

MS-PS3-1 Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object.

MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

MS-PS3-4 Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample.

MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

Common Core Mathematics

MP1 Make sense of problems and persevere in solving them.

MP2 Reason abstractly and quantitatively.

MP3 Construct viable arguments and critique the reasoning of others.

MP4 Model with mathematics.

MP5 Use appropriate tools strategically.

MP6 Attention to precision.

CCSS.M.Content.6.RP.A.3. Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

CCSS.M.Content.6G.A.3. Draw polygons in the coordinate plane given coordinates for the vertices; use coordinates to find the length of a side joining points with the same first coordinate or the same second coordinate. Apply these techniques in the context of solving real-world and mathematical problems**.**

CCSS.M.Content.6.G.A.4. Represent three-dimensional figures using nets made up of rectangles and triangles, and use the nets to find the surface area of these figures. Apply these techniques in the context of solving real-world and mathematical problems.

CCSS.M.Content.6.SP.B.5b. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.

Common Core English/Language Arts (ELA)

CCSS.ELA - RI.6.1 Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.

CCSS.ELA - RI.6.4 Determine the meaning of words and phrases as they are used in a text, including figurative, connotative, and technical meanings.

CCSS.ELA - RI.6.7 Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.

CCSS.ELA - W.6.1 Write arguments to support claims with clear reasons and relevant evidence**.**

CCSS.ELA - W.6.1a Write arguments to support claims with clear reasons and relevant evidence.

CCSS.ELA - W.6.1b Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.

CCSS.ELA - W.6.1c Use words, phrases, and clauses to clarify the relationships among claim(s) and reasons.

CCSS.ELA - W.6.1e Provide a concluding statement or section that follows from the argument presented.

CCSS.ELA - W.6.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

CCSS.ELA - W.6.2a Introduce a topic; organize ideas, concepts, and information, using strategies such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.

CCSS.ELA - W.6.2b Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples.

CCSS.ELA - W.6.2d Use precise language and domain-specific vocabulary to inform about or explain the topic.

CCSS.ELA - W.6.2f Provide a concluding statement or section that follows from the information or explanation presented.

CCSS.ELA-Literacy.SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

CCSS.ELA-Literacy.SL.6.1a Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.

CCSS.ELA-Literacy.SL.6.1b Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.

CCSS.ELA-Literacy.SL.6.1c Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

CCSS.ELA-Literacy.SL.6.2 Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.

CCSS.ELA-Literacy.SL.6.5 Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.

CCSS.ELA-Literacy.L.6.1 Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.

21st Century Skills Addressed in STEM Road Map Module

21st Century Skills	Learning Skills & Technology Tools (from P21 framework)	Teaching Strategies	Evidence of Success
21st century interdisciplinary themes	Economic, Business, & Entrepreneurial Literacy	Business plan basics will be introduced to support students in knowing how to make appropriate economic choices, and entrepreneurial skills to enhance workplace productivity and career options	Students will present their models and marketing pieces to the class.
Learning and innovation skills	Creativity and Innovation Critical Thinking and Problem Solving Communication and Collaboration	Teachers will have students use a wide range of idea creation techniques (such as brainstorming) and elaborate, refine, analyze and evaluate their own ideas in order to improve and maximize creative efforts Teachers will create	Students will receive teacher and peer feedback in a formative way to inform the products that they develop throughout the PBL module

		learning environments that help students to demonstrate originality and inventiveness in work and understand the real world limits to adopting new ideas Teachers will help students accept failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes	
Information, media and technology skills	Information Literacy Media Literacy ICT Literacy	Teachers will give students strategies to access information efficiently (time) and effectively (sources); students will have opportunities to practice using information accurately and creatively for the issue or problem at hand	Students will use reliable and relevant resources (both print and electronic) to build and integrate their knowledge on the design of amusement parks.
Life and career skills	Flexibility and Adaptability, Initiative and Self-Direction, Social and Cross Cultural Skills, Productivity and Accountability, Leadership and Responsibility	Teachers will give strategies that help students work effectively in a climate of ambiguity and changing priorities and incorporate feedback effectively Teachers will ask students to set goals with tangible and intangible success criteria which leads to using time and managing workload efficiently	Students will have to work collaboratively in groups as well as be able to integrate their independent work into a group project Students will have to set benchmarks for accomplishing deliverables in order to reach the goals set by the PBL module

Launch

To launch the module, students will investigate close-up photos of people riding amusements and discuss why people seek thrill rides. The main goal of the launch is to connect the idea that people seek emotionally based thrills with the physics and engineering of amusement rides and games and to convey the message that physics and engineering are an integral part of generating these emotions. The video and accompanying website looks like a research project on amusements, but is actually a manipulation of a video to look like a real park. However, the extreme nature of the rides in the video and the ways the "scientists" talk about the rides engage the interest of students and clearly state the ways the rides use physical characteristics to evoke thrills.

Prerequisite Key Knowledge

Prerequisite key knowledge	Application of knowledge	Differentiation for students needing knowledge
Students should be able to use electronic and print media to find new information from reliable sources. Students should be able to summarize information gathered from several sources. Students should be able to measure linear distance and time in metric units. Students should be able to use simple arithmetic operations (adding, subtracting, multiplying, dividing).	Students will participate in an Internet scavenger hunt to find the amusement ride that is the tallest, fastest, most loops in the world. Students will research safety features of amusements. Students will apply measurement and arithmetic operations to build an amusement park prototype.	Teachers can provide a list of reliable sources for students to use. Teachers can highlight key information from the reliable resources for students to synthesize. Teachers can review measurement skills and provide opportunities for practice throughout the module. Teachers can review arithmetic operations and provide opportunities to apply operations to real life situations.

Desired Outcomes and Monitoring Success

Desired Outcome

Students will understand that potential and kinetic energy play a major role in amusement park rides. Students will be apply to use the engineering design process (EDP) to create a solution to a team challenge.

Evidence of Success in Achieving Identified Outcome

Performance Tasks

Rube Goldberg machine design and analysis (see rubric in Lesson #2)

- Building of Rube Goldberg machine given design specifications
- Analysis of energy transfer in machine
- Analysis of potential and kinetic energy in machine

Trebuchet design and analysis (see rubric in Lesson #2)

- Building of trebuchet given design specifications
- Analysis of potential and kinetic energy in machine

Amusement Park Prototype

- Working in groups collaboratively
- Creating a marketing component that effectively highlights the features of their amusement park

Assessment Plan

The assessment plan is created with a suite of formative and summative assessment, deliberately designed to support student work in the final culminating challenge. Formative assessments are designed in the lessons for teachers to check student knowledge before moving on to other topics, and offering teachers information to re-design or re-teach lessons if needed. Formative assessments in the lessons lead to summative assessments that have rubrics incorporated into the lesson plans. The summative assessments are designed for students to be able to analyze and synthesize the information they learned to that point, allowing for creative communication of what students know and can do.

Major Group Products
The prototype amusement park is the major group project for this module.

Major Individual Products/Deliverables
The major individual products include participation in group activities, the individual amusement park ride or game prototype, and evidence of use of the engineering design process (EDP)

Resources

School-based Individuals: Media specialists to help find reliable resources for research projects.

Technology: Instructional technology specialists to help with Excel spreadsheets, timeline software, and multi-media production instruction.

Community: Area amusement park for field trip.

Materials: Materials lists are included within each lesson.

STEM Road Map Module Timeline

Week One

Day 1	Day 2	Day 3	Day 4	Day 5
Lesson 1 *Faster, Higher, and Safer* Introduce features of amusements by showing a video and by class discussion. Introduce the module challenge. In the Tallest, Highest, Fastest activity, students choose an amusement ride and search for extreme examples. Students explore an interactive roller coaster design website.	*Lesson 1* *Faster, Higher, and Safer* Introduce potential and kinetic energy and energy conversions. Introduce the engineering design process (EDP) Student teams create Rube Goldberg machines.	*Lesson 1* *Faster, Higher, and Safer* Student teams continue work on their Rube Goldberg machines and present them to the class.	*Lesson 1* *Faster, Higher, and Safer* Students design and build trebuchets. Team trebuchet competition.	*Lesson 1* *Faster, Higher, and Safer* Students conduct Internet searches to understand safety concerns associated with amusement parks.

Week Two

Day 6	Day 7	Day 8	Day 9	Day 10
Lesson 2 Amusement of the Future Design Challenge Students research various amusement park maps and explore considerations for the future of amusement parks. Students form teams to create their amusement parks.	*Lesson 2 Amusement of the Future Design Challenge* Students create their individual ride or game prototypes, ensuring that their prototypes fit the overall park and are scaled appropriately for the available space.	*Lesson 2 Amusement of the Future Design Challenge* Teams assemble the individual rides and games into a comprehensive amusement park. Teams begin work on a marketing piece for their parks.	*Lesson 2 Amusement of the Future Design Challenge* Students complete their marketing piece and present their park and marketing component to the class.	*Lesson 2 Amusement of the Future Design Challenge* Field trip to amusement park (can be moved to any day of Lesson 1 or Lesson 2)

Lesson Plan #1

Amusement of the Future – Grade 6

Lesson Title

Faster, Higher, and Safer

Lesson Summary

In this lesson, students will investigate types of energy transfer and run simulations to consider design factors for amusements such as speed, height, and sustainability. Students will investigate potential to kinetic energy conversions and physics concepts related to amusement park rides by creating Rube Goldberg devices and trebuchets. The engineering design process (EDP) will be introduced during this lesson, and students will use this process to structure their work in the various activities throughout the module.

Essential Question(s)

What types of energy are involved with amusement rides that go extremely fast and whip around sharp angles?

How do you get amusement rides such as roller coasters to move quickly to provide thrills and still be safe for the riders?

What ecological impact do amusement parks have on the community?

Established Goals/Objectives

Students will distinguish the different types of energy (mechanical, chemical, sound, etc.) and be able to explain transfer from one type of energy to another (kinetic and potential).

Students will be able to measure kinetic energy of a moving object.

Students will explain the sustainability issues involved with running an amusement park.

Students will use a computer simulation to successfully balance the thrill of an amusement ride (speed, spin) with the safety of the rider so that the ride is compelling but safe.

Time Required

5 days

Necessary Materials

Computers with Internet access

Paper

Pencils

Plastic container lids

Large gumdrops

Plastic spoons

Large size craft sticks

Cardstock

Kitchen towels

Thumbtacks

Boards for ramps

Various materials that can be used for Rube Goldberg machines (see Science Activity/Investigation below)

construction paper
marbles
small paper cups (such as Dixie cups)
paper towel tubes
string
jumbo paper clips
rubber bands
PVC pipe
Masking tape
Foam pipe insulation
Craft sticks
Toothpicks
Balloon
Dominoes
Plastic funnel
Empty water bottles
Rubber bands

Screen to play video (computer or LCD projector)

Devices with Internet access for roller coaster interactive website

Content Standards Addressed in STEM Road Map Module Lesson

Next Generation Science Standards

MS-PS3-1
MS-PS3-2
MS-PS3-4
MS-PS3-5

Common Core Mathematics

MP1
MP2
MP3
MP4
MP5
MP6
CCSS.M.Content.6.RP.A.3.
CCSS.M.Content.6.SP.B.5b.
CCSS.M.Content.6G.A.3
CCSS.M.Content.6.G.A.4

Common Core ELA

CCSS.ELA - RI.6.1
CCSS.ELA - RI.6.4
CCSS.ELA - RI.6.7
CCSS.ELA - W.6.1
CCSS.ELA - W.6.1a
CCSS.ELA - W.6.1b
CCSS.ELA - W.6.1c
CCSS.ELA - W.6.1e
CCSS.ELA - W.6.2
CCSS.ELA - W.6.2b
CCSS.ELA - W.6.2d
CCSS.ELA - W.6.2f
CCSS.ELA-Literacy.SL.6.1
CCSS.ELA-Literacy.SL.6.1a
CCSS.ELA-Literacy.SL.6.1b
CCSS.ELA-Literacy.SL.6.1c
CCSS.ELA-Literacy.SL.6.2
CCSS.ELA - W.6.2a
CCSS.ELA-Literacy.L.6.1

21st Century Skills

Economic, Business, & Entrepreneurial Literacy
Creativity and Innovation
Critical Thinking and Problem Solving
Communication and Collaboration
Information Literacy
Media Literacy
ICT Literacy
Flexibility and Adaptability,
Initiative and Self-Direction,
Social and Cross Cultural Skills,
Productivity and Accountability,
Leadership and Responsibility

Key Vocabulary	Definition
Chemical energy	Energy given or needed that changes the arrangement of atoms or molecules
Cost-benefit analysis	The comparison of what an activity costs versus the outcomes or benefits of the activity.
Energy transfer	Conversion of one type of energy to another such as from mechanical energy to heat energy or from chemical energy to sound energy.
Friction	Force that opposes motion and can cause a change in energy to heat or sound.
Heat energy	Energy that changes the temperature of an object, typically caused by friction
Kinetic energy	The energy of movement.
Mechanical en-ergy	Energy that pushes or pulls a material object into a different position
Potential energy	The amount of stored energy in a physical situation. This could be due to the height of an object that has potential to be converted to kinetic energy because of gravity.
Simple machines	The six machines that make up all other complex machines. They are inclined plane, wedge, screw, lever, wheel and axel, and pulley.
Sound energy	Energy that vibrates an object and causes it to make a sound, typically caused by friction
Sustainability	The ability to have an event or product that takes the least amount of

Key Vocabulary	Definition
	non-renewable resources
Total energy	The sum of kinetic and potential energy at any point in an object's trajectory is equal to the total energy of a system.
Trebuchet	A slingshot device used to launch an object a large distance. Trebuchets have been used throughout history as weapons, and can be a variety of sizes and designs.

Teacher Background Information

Students will be constructing a Rube Goldberg device to demonstrate potential energy to kinetic energy conversions and to consider methods they might use as they build their amusement ride prototypes in the module challenge. There are a variety of Rube Goldberg competitions – both online and live – and many universities have teams that compete at very high levels. Purdue University has hosted one for over 20 years. See the internet materials below for Ferris State's entry to this competition. Because of the popularity of the machine designs, there has been a documentary about the topic called "Mousetrap to Mars." See here for the trailer - https://vimeo.com/3845644. Other websites that may be useful to you include:

10 Rube Goldberg Machines – http://coolmaterial.com/roundup/rube-goldberg-machines/

Rube Goldberg Machine Competition – Ferris State entry https://vimeo.com/4687067

The way things go (scroll down for the video link)
http://www.lomography.com/magazine/203371-the-way-things-go-art-films-with-rube-goldberg-machines

Students will also construct simple trebuchets in this lesson to demonstrate potential energy to kinetic energy conversions and consider methods for constructing their amusement rides. The following resources may be useful:

Watch the following video of the "Punkin Chunkin" sport to understand what a trebuchet does:
https://www.youtube.com/watch?v=qC6RJxFEMfY

The following video describes how to build a mini-trebuchet:
https://www.youtube.com/watch?v=DwZA3WS2fB4

Paper trebuchet: https://www.youtube.com/watch?v=gjEME1HIsQ8

You should be familiar with the calculations for kinetic energy ($KE=1/2mv^2$) and potential energy ($PE=mgh$) and understand that total energy is equal to the sum of KE and PE (assuming that no energy is lost to friction), and understand that total energy remains constant for any closed system.

Students will use the engineering design process (EDP) to structure their work as they solve problems in teams throughout the module. A graphic containing the steps of the EDP is included within this lesson. You should become familiar with these steps and be prepared to assist students in applying them to their problem solving work.

Lesson Preparation

Preview all videos for appropriate language and identify points to stop the video to explain concepts to students as needed.

Gather the materials for the Rube Goldberg machine activity and the Launch It trebuchet activity.

Learning Plan Components

Introductory Activity/Engagement

To launch the module, watch the following 6 minute 35 second video of the Centrifuge Brain Project: https://www.youtube.com/watch?v=RVeHxUVkW4w. Note: this is an art project that emphasizes important features of amusements and why people design amusements.

Ask students the following questions after they watch the video:

What things do you think were the most important in this video?

What are the characteristics the researchers investigated?

Examples:

- Spinning
- Height
- Feeling of weightlessness
- Speed

What kinds of experienced did the designers try to simulate? What was their inspiration?

The video mentions "6 g's;" what do you think that means?

What does the scientist mean by "gravity is a mistake?"

Why do you think people go to amusement parks and ride the rides?

Would you ride these rides? Do you think they are real? Why or why not?

Explain to the class that this video and website are actually an art project, but it is based in science, engineering, and mathematics.

Investigate the website of the Centrifuge Brain Project: http://www.icr-science.org/index.htm

Ask students, "Would you ride these rides? Why or why not?"

Have students choose one of the rides and make estimates to determine the speed (distance divided by time) that the people are travelling.

Introduce the module challenge, telling students that they are going to act as engineers who design and create amusement parks and the rides in them.

Activity/Investigation

Tallest, Highest, Fastest

Students will choose one type of amusement ride or game and find the fastest, highest, longest drop, or other superlative associated with it. For example, if a student chose roller coaster, she should look up the fastest, tallest, and steepest coaster (see below for Internet resources for the example). Then, students should create data tables that are appropriate for collecting the information such as speed at the slowest point, speed at the fastest point, duration of ride, height requirement. If a student chose a Ferris wheel, they may look up largest diameter or most luxurious cabins. Students who choose games can examine the level of skill needed for games of different designs.

Teachers should encourage students to make a wide variety of choices for their amusement ride or game because in the challenge at the end of the module groups will need experts on many different types of rides to work together to design a park incorporating a variety of elements (not just roller coasters). As an alternative, students may also want to design many different types of roller coasters for a park focusing on roller coasters such as Cedar Point (https://www.cedarpoint.com/). Note that the roller coasters and thrill rides on the Cedar Point website have the speeds of each ride and the manufacturer of each ride. This information may be useful when students design their rides.

World's fastest roller coaster-http://www.telegraph.co.uk/travel/travelvideo/11015985/The-worlds-five-fastest-steel-roller-coasters.html

World's steepest roller coaster-
http://www.telegraph.co.uk/news/worldnews/asia/japan/8626139/Worlds-steepest-roller-coaster-opens-in-Japan.html

Tallest roller coaster-
http://www.orlandosentinel.com/travel/attractions/theme-park-rangers-blog/os-fury-325-worlds-tallest-coaster-skyscraper-20150327-post.html

Students will then use the Annenberg Learner Amusement Park Physics interactive website to design roller coaster features that create thrills but demonstrate safety issues:
http://www.learner.org/interactives/parkphysics/parkphysics.html

Rube Goldberg Machines

For the next portion of the lesson, students will build Rube Goldberg machines and analyze the energy transfers, noting extreme points of potential and kinetic energy.

Students will create a Rube Goldberg Machine, a contraption that performs a simple task in a very complicated way using a chain reaction of energy transfers. Students will review the websites below for examples of Rube Goldberg machines and watch the 8 minute video “Something for Nothing” (circa 1940) (found here https://en.wikipedia.org/wiki/Rube_Goldberg_machine) that features Rube Goldberg explaining a door-opening machine, describes the impossible likelihood of a perpetual motion machine, and introduces piston-driven engines.

Criteria for building the Rube Goldberg machine include the following:

- Machine should pop a balloon
- Should use simple machines (lever, pulley, inclined plane, wedge, screw, and wheel and axle)
- Must identify where mechanical energy converts to heat energy or to sound energy
- Must identify the highest and lowest points of potential energy, and the highest and lowest points of kinetic energy

Continue facilitating a discussion of the physics principles applied to the motion of the amusement park rides and games. Ask students what distance, time, speed, acceleration, mass, force, energy, and work have to do with the following features of an amusement park:

- Spinning
- Height
- Feeling of weightlessness
- Speed

Ask students how they would maximize speed, acceleration, force and height with the rides they have re-searched.

Launch It!

Students will perform an investigation create a trebuchet, or slingshot. As an option, students will video the launch and calculate the kinetic and potential energy for 5 positions throughout the flight of an object. After students gather their data, facilitate a discussion to explain how the kinetic and potential energy has changed, but the total energy stayed the same throughout the launch.

Watch the following video of the “Punkin Chunkin” sport to understand what a trebuchet does: https://www.youtube.com/watch?v=qC6RJxFEMfY

Teachers should conduct a whole class discussion identifying the working parts of a trebuchet.

Students should also watch the following video on how to build a mini-trebuchet: https://www.youtube.com/watch?v=DwZA3WS2fB4

If you are unable find the resources for the mini-trebuchet, students can build one from paper as demonstrated in this video: https://www.youtube.com/watch?v=gjEME1HIsQ8

The goal of this class is to build a trebuchet that launches a gum drop in an elliptical trajectory that can be filmed and goes through a photogate to measure the final speed of the object at the end of the trajectory path.

[Optional: Once students create a trebuchet that launches the object (large gumdrop) in an elliptical path that can be filmed clearly with a smart phone or other camera device and can move the object through the photogate to measure final speed, they have accomplished the goal. Students will calculate the potential energy and compare it to the measured final kinetic energy in mathematics class. The film must have a clear picture of a 30cm ruler in a vertical position in order to calculate scale.]

Facilitate a discussion to explain how the kinetic and potential energy has changed, but the total energy stayed the same throughout the launch. Discuss how the principles in this activity might apply to creating an amusement park ride.

Hold a team competition for distance and accuracy of trebuchets.

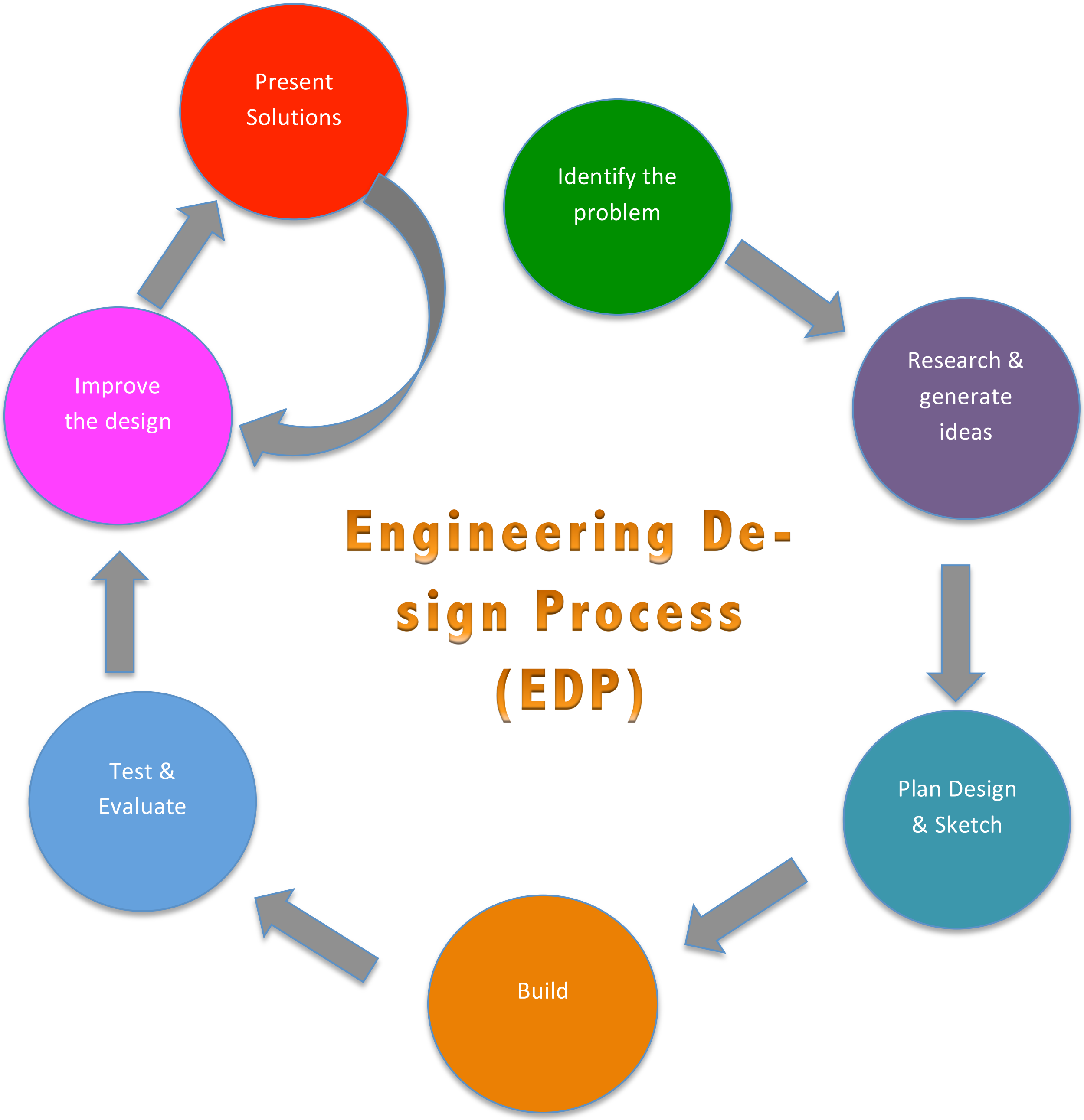
EXPLAIN

Students should understand the concepts of potential energy (stored energy) and kinetic energy (the energy of motion) for this lesson. Additionally, students should be familiar with simple machines as devices that reduce the amount of human energy input necessary to accomplish a task. Simple machines include lever, pulley, inclined plane, wedge, screw, and wheel and axle.

Core physics concepts in the field of Newtonian Mechanics may be relevant to students' work in this module. Key concepts are distance, time, speed (use speed and velocity interchangeably here) acceleration, mass, force, energy, and work. Students should be able to understand that distance and time are related to speed, and that speed and time are related to acceleration. Also students should know that mass and acceleration are related to force and that force requires energy to do work. Note: using speed and velocity interchangeably is appropriate here because there is no need to introduce vectors.

You may wish to facilitate a discussion showing that force can be applied in a straight line, demonstrating Newton's three laws, but also force can cause an object to travel in a circle, which is centripetal force. Students may have heard of centrifugal force, but this is a fictitious force one uses to describe themselves as the object in motion when they are going in a circle. Actually what is happening from an external frame of reference is that an object traveling in a circle will continue to try to go in a straight line (because of Newton's first law of inertia), but when centripetal force pulls in the object toward the center point of the circle, the object is forced into the path of a circle. You can demonstrate this by taking a ball on a string and spinning it above your head like a helicopter propeller. To demonstrate that the object will travel in a straight line, you can let go of the string (carefully) and notice that the ball will no longer travel in a circle. Similarly, students can demonstrate this phenomena by taking a sturdy paper plate and cutting a pie piece out of it (about ¼ of the plate will work). Then students can take a marble and spin it around the rim of the inside of the plate. When the marble reaches the cut out part, it will immediately travel in a straight line. This demonstrates that the force does not come within the marble (a common misconception), but is caused by the paper plate pushing the marble into a circle.

Students will use the engineering design process (EDP) throughout this module to structure their work. Students should understand that the EDP is a process used by engineers to solve problems, and involves a series of steps. A graphic of the EDP is provided on the next page. You may wish to have students track their progress through the EDP by creating a page for each step. Students can include sketches, notes, and ideas on these pages that can be assembled to create a research notebook.


Present Solutions
Identify the problem
Research & generate ideas
Engineering Design Process (EDP)
Improve the design
Plan Design & Sketch
Test & Evaluate
Build

Extend/Apply Knowledge

Students should conduct Internet searches to compile safety concerns for amusement rides and for the park traffic flow in general. This knowledge will be the starting point for the development of the final report in the next lesson. Students should create a matrix in Word similar to the short example below to illustrate what they found in their research.

Sample matrix with a few entries:

Safety Concern	Why it is a concern	What I still need to know to build my park
Mechanical Operations	Machines break down due to friction, so they must be inspected at regular intervals; American Society for Testing and Materials sets standards	How often do the inspections need to be done? Who do I contact to get inspectors to my park? How much does it cost?
Age of ride	Older rides have less safety technology and are more prone to breakdowns	How do I upgrade the ride for safety?
Rider physical condition	To prevent legal issues, amusement parks need to post signs to warn people with medical conditions if they might not be safe on the ride	How do I personalize safety concerns beyond the one size fits all signs without scaring away customers?

Assessment

Performance Tasks

Rubric for Rube Goldberg Machine

	Emerging	Competent	Advanced
Machine must function to complete task	Machine does not accomplish a simple task	Machine accomplishes a simple task with a simple set of steps	Machine accomplishes a simple task with an extremely complex set of steps
Must have at least 3 different simple machines	Rube Goldberg machine has less than 3 different simple machines	Rube Goldberg machine has 3 different simple machines	Rube Goldberg machine has more than 3 different simple machines
Must identify at least 2 positions when energy transfer happens from mechanical to heat or sound	Students identify less than 2 different positions where mechanical energy is transferred to sound or heat	Students identify 2 different positions where mechanical energy is transferred to sound or heat	Students identify more than 2 different positions where mechanical energy is transferred to sound or heat
Must identify the highest and lowest points of potential energy, and the highest and lowest points of kinetic energy	Students identify only highest and lowest points of potential energy, or the highest and lowest points of kinetic energy	Students identify highest and lowest points of potential energy, and the highest and lowest points of kinetic energy	Students identify the change in kinetic and potential energy throughout the duration of the machine operation and present it on a graph
Machine works as intended	Machine takes more than 3 tries to work as intended	Machine takes 2-3 tries to work as intended	Machine works as intended on the first try
Other comments:			

Scoring guide for Engineering Design Process

	Emerging	Competent	Advanced
Design of Trebuchet	Student generates one design solution to the problem	Student generates more than two alternate design solutions, listing the criteria for success	Student generates a variety of design solutions and justifies solutions with comprehensive set of criteria for success
Methods of testing	Some methods of testing are suggested	Reasonable methods of testing are suggested for some of the listed criteria	Reasonable methods for testing the trebuchet are described for each success criterion outlined
Planning	Student produces a plan that contains some details of the required steps or resources required	Student produces a plan that contains a number of logical steps that include resources and time	Student produces a plan that contains a number of detailed logical steps that describes the uses of resources and time
Other comments:			

INTERNET RESOURCES

Cedar Point Roller Coaster Park: https://www.cedarpoint.com/

World's fastest roller coaster:
http://www.telegraph.co.uk/travel/travelvideo/11015985/The-worlds-five-fastest-steel-roller-coasters.html

World's steepest roller coaster:
http://www.telegraph.co.uk/news/worldnews/asia/japan/8626139/Worlds-steepest-roller-coaster-opens-in-Japan.html

Tallest roller coaster:
http://www.orlandosentinel.com/travel/attractions/theme-park-rangers-blog/os-fury-325-worlds-tallest-coaster-skyscraper-20150327-post.html

Rube Goldberg machine: https://en.wikipedia.org/wiki/Rube_Goldberg_machine)

Mousetrap to Mars trailer - https://vimeo.com/3845644

10 Rube Goldberg Machines – http://coolmaterial.com/roundup/rube-goldberg-machines/

Rube Goldberg Machine Competition – Ferris State entry https://vimeo.com/4687067

The way things go (scroll down for the video link):
http://www.lomography.com/magazine/203371-the-way-things-go-art-films-with-rube-goldberg-machines

World wide artists similar to Rube Goldberg:
(https://en.wikipedia.org/wiki/Rube_Goldberg_machine#Similar_expressions_worldwide)

Punkin Chunkin sport (trebuchets): https://www.youtube.com/watch?v=qC6RJxFEMfY

How to build a mini-trebuchet: https://www.youtube.com/watch?v=DwZA3WS2fB4

How to build a mini paper trebuchet: https://www.youtube.com/watch?v=gjEME1HIsQ8

How much it would cost to build a real-life Jurassic Park:
http://www.buzzfeed.com/alivelez/jurassic-park-would-cost-all-of-the-money#.ptAOwEpKz

Academic Paper – Theme Park Development Costs:
http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1072&context=gradconf_hospitality

Amusement Park Business Plan from a Canadian company :
http://www.bplans.com/amusement_park_business_plan/company_summary_fc.php

How to start an amusement park: http://www.wikihow.com/Start-an-Amusement-Park

Theme Park Insider: http://www.themeparkinsider.com/news/response.cfm?id=2058

How to motivate a group in writing a business proposal:
http://www.24hrco.com/images/articles/html/Pease_Mar13.html

Writing a business proposal from the *Houston Chronicle*:
http://smallbusiness.chron.com/steps-writing-business-proposal-70.html

International Association of Amusement Parks and Attractions (IAAPA): http://www.iaapa.org/

How to calculate attractions' footprints:
http://www.iaapa.org/docs/handout-archive---ops/InconvenientSeminar_CocklinCornthwaite_Richardson_Tues330pm.pdf
http://www.iaapa.org/docs/handout-archive---ops/ProjectGreenWolf_TimBlack8am_NewHandoutsNov10.pdf
http://www.iaapa.org/docs/handout-archive---ops/achieving-20energy-20efficiency_part1.pdf?sfvrsn=2

Money saving – green options for amusement parks:
http://www.iaapa.org/docs/handout-archive---ops/CostEfficientConstruction-Handout_PeakandGraman_Monday.pdf

Amusement Park Physics interactive website:
http://www.learner.org/interactives/parkphysics/parkphysics.html

Jason site for designing roller coasters:
http://content3.jason.org/resource_content/content/digitallab/4859/misc_content/public/coaster.html

Lesson Plan #2

Amusement of the Future – Grade 6

Lesson Title
Amusement of the Future Design Challenge

Lesson Summary
In this lesson students will work in small groups to design an amusement park prototype and a marketing component that highlights the fun features and safety of the park. Groups of 4-5 students should work together, resulting in amusement parks with 4-5 rides per park. An option for a culminating activity is a visit to an amusement park.

Essential Question(s)
How do you collaboratively design an innovative amusement park while considering safety, impact on the community, costs, and marketing?

Established Goals/Objectives
Students will create a drawing, scale prototype drawing or mock-up, and marketing plan for their amusement parks.

Time Required
5 days

Necessary Materials
Computers with Internet access
Rulers
20 x 30 foam board (2 per group of 4-5 students) – to serve as amusement park base
Construction paper
poster board
Craft sticks
Drinking straws
Paper towel tubes

Blank CDs
Pipe cleaners
Glue
Modeling Clay
Various craft paints (acrylic)
Small paint brushes
Markers
Masking Tape
Video camera or smartphone

CONTENT STANDARDS ADDRESSED IN STEM ROAD MAP MODULE LESSON

Next Generation Science Standards

MS-PS3-1
MS-PS3-2
MS-PS3-4
MS-PS3-5

Common Core Mathematics

MP1
MP2
MP3
MP4
MP5
MP6.
CCSS.M.Content.6.RP.A.3.
CCSS.M.Content.6.SP.B.5b.

Common Core ELA

CCSS.ELA - RI.6.1
CCSS.ELA - RI.6.4
CCSS.ELA - RI.6.7
CCSS.ELA - W.6.1
CCSS.ELA - W.6.1a
CCSS.ELA - W.6.1b
CCSS.ELA - W.6.1c
CCSS.ELA - W.6.1e
CCSS.ELA - W.6.2
CCSS.ELA - W.6.2b

CCSS.ELA - W.6.2d
CCSS.ELA - W.6.2f
CCSS.ELA-Literacy.SL.6.1
CCSS.ELA-Literacy.SL.6.1a
CCSS.ELA-Literacy.SL.6.1b
CCSS.ELA-Literacy.SL.6.1c
CCSS.ELA-Literacy.SL.6.2
CCSS.ELA - W.6.2a
CCSS.ELA-Literacy.SL.6.5
CCSS.ELA-Literacy.L.6.1

21st Century Skills

Economic, Business, & Entrepreneurial Literacy
Creativity and Innovation
Critical Thinking and Problem Solving
Communication and Collaboration
Information Literacy
Media Literacy
ICT Literacy
Flexibility and Adaptability,
Initiative and Self-Direction,
Social and Cross Cultural Skills,
Productivity and Accountability,
Leadership and Responsibility

Key Vocabulary	Definition
Blueprint	A technical drawing that is done to describe the actual object and location using a scale.
Impact study	Research done on a topic to determine how a certain action (such as building an amusement park) will affect phenomena such as traffic, wildlife, and tree growth.
Prototype	A model mockup of an object.

Teacher Background Information

In this lesson it is critical to form groups in which each member contributes a distinctly different amusement but with the entire group having a common theme for the whole park. In this way, groups will be well balanced and will create a comprehensive park when members consolidate their amusements. For instance, if students want to create a water park each of the members should have a different idea for one amusement (ride or game) for the water park; these components should collectively comprise an entire water park with 4 to 5 rides or games. Groups can also be formed if students agree that they want to put together a roller coaster park, so that all students have a roller coaster for their amusement, but each roller coaster should have a different emphasis.

Lesson Preparation

Assemble all materials for prototype construction. You may wish to allow students to bring materials from home to use in their prototypes. Make preparations for the amusement park field trip.

Learning Plan Components

Introductory Activity/Engagement

Tell students that they will choose an amusement park that they most want to emulate for their projects. Based on their decisions, they will then form groups. The following website offers various amusement park maps: http://www.themeparkbrochures.net/mainmaps.html.

Provide students with the following instructions and questions:

- Examine the layout of the park on a map. How are the rides placed in the overall park? Where are the refreshments placed?
- Examine where the park is located in relation to other cities/towns. Why do you think the park is located there? Who might be going to the park?
- Locate the most extreme ride. Where is it located in the park? Why do you think it is located there? What is the ride focused on in terms of physical ride for thrills? Why it is designed that way based on KE and PE changes?
- Notice that there are maps of the same park for different years. Choose one and explain how it has changed over time. What might you change for your park in the future?

Have students read the following article about the future of amusement parks from *Mental Floss:* http://mentalfloss.com/article/64377/5-educated-predictions-future-amusement-parks

Ask students to answer the following questions: Which of the 5 predictions do you think are most important for your planned park? Least important? Why?

Have students consider the theme they want for their parks and ask them the following questions:

Why do you want that theme?

Who will be the audience for your park?

Is it going to attract people who like many different kinds of amusements or focus on one type?

Find at least 4 other students in the class who have similar ideas. Discuss until you come to consensus about the theme and audience for your park. What is your final decision?

Activity/Investigation

Students will each build a scale model prototype for an amusement ride or game, however these individual rides or games should be in accord with the team's overall plan for the park. The purpose of this prototype is to explain the physical features of the ride or game. This prototype will not be an operating version, but will rather be a scale model similar to the models that architects use to describe the features of their designs. Students should use the EDP as they create their prototypes. Students can use simple materials such as cardboard, paper, poster board or balsa wood for the prototypes. Encourage students to be creative in designing their rides and making them visually appealing.

Student teams will each be provided with 2 pieces of 20 x 30 foam board. These will serve as the base for their amusement park. All rides/games must fit on the board, and there must be space for visitors to walk between the rides. Students should plan their amusement parks so that there is a flow between rides, with clear entrance and exit points for each and walkways through the park. Teams should use the EDP as they create their parks. Encourage teams to be creative with their park designs and add extra features (ticket booths, trees, park benches, etc.) if they wish.

Students will also plan a marketing component for their park. This may be in the form of a video commercial, a written marketing piece, or other means. The marketing component should include the name of the park, the park's theme and major features, an overview of the park's safety considerations, and a compelling argument for why visitors should come to the park.

Explain

Students will create a marketing component for their proposed park. This can take the form of a video commercial or written marketing piece. Students may want to consider:

- Customers (demographics, needs, buying decisions)
- How the proposed park is innovative compared to other parks
- Advertising outlets (TV, Radio, Internet, Print)
    - Look at advertisements from other amusement parks
- Mission Statement (includes who you're selling to, what you're selling, and your unique selling proposition)
- Price for admission

Extend/Apply Knowledge

Groups will present their prototypes and marketing components to the class.

An optional culminating activity for this module is a field trip to an amusement park.

Assessment

Individual amusement rides or games

Group prototype of amusement park

Group marketing component

Internet Resources

Maps of amusement parks around the world: http://www.themeparkbrochures.net/mainmaps.html.

Summary of water park impact study: http://www.sugar-grove.il.us/Dept_CD/SDD5.pdf

Article with predictions for amusement parks of the future from *Mental Floss:*
http://mentalfloss.com/article/64377/5-educated-predictions-future-amusement-parks

References

Johnson, C. C., Moore, T. J., Utley, J., Breiner, J., Burton, S. R., Peter-Burton, E. E., Walton, J., & Parton, C. L. (2015). The STEM road map for grades 6-8. In C. C. Johnson, E. E. Peters-Burton, & T. J. Moore (Eds.), *STEM road map: A framework for integrated STEM education* (pp. 96-123). New York, NY: Routledge.