

Teacher Tool 271: The Science Behind Roller Coasters Study Guide

Study Guide for Physics 9: The Science Behind Roller Coasters

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The Science Behind Roller Coasters

Dates: April 19, 2018

Times: 9:30 to 10:15 a.m. and 12:00 to 12:45 p.m. Central Daylight Time

Grade Levels: 7-10

Cost: NO CHARGE

Program Description:

How does energy apply to the design of roller coasters? How do roller coaster designers and engineers use the hills, loops, curves, twists, and turns to take advantage of potential energy, kinetic energy, and dissipating energy to create a thrill ride like no other? Join us live April 19 and find out.

More details on the topics explored in the program and the order they will be explored are included in the Program Format section later in this document.

This program is another episode in Educate.Today's ongoing series, *The Science Behind*, that provides high school and middle school students the opportunity to interact live with individuals who apply scientific ideas and principles students are learning in class to everyday objects or processes those experts are working with in the marketplace, laboratory, or research center. To view archived programs, visit <http://educate.today> and search our science and STEM videos.

Find Program Materials At: <https://educate.today/videos/5566>

How To View the Program:

People can join the program live in any of three ways:

1. Via videoconference--We have interactive and view only videoconference slots available for student groups to join the program. Groups interested in connecting this way may do so via H.323 VC connections, Skype, Zoom and/or similar software. When enrolling, please let us know the type of connection you prefer to make, and we will contact you to set up a test call as needed. Interactive slots get face to face question and answer time with the program guests; view only slots can e-mail questions and comments during the program to live@hectv.org. These slots are limited so early enrollment is highly recommended. For videoconference participation, we must have you enrolled no later than April 11, 2017. Contact us at live@hectv.org.

2. Via Internet--All our *The Science Behind* programs are streamed live on the program day via our Educate.Today website at <http://educate.today> and the website of our sister organization HEC-TV at , <http://www.hectv.org>. Just go to the home page at the program time. Since many schools limit streaming video through their firewalls, we recommend testing your ability to view the stream prior to the program by watching one of HEC-TV's archived programs at <http://www.hectv.org>. We also recommend viewing the program live on one computer only and connecting that computer to a television, smart board, digital projector for classroom viewing. Viewers can e-mail their questions and comments during the program to us at live@hectv.org. To receive curriculum materials designed to help you prepare your students for the program, just e-mail us prior to the program at live@hectv.org. Viewing in this way is unlimited; no other sign-in is required unless you wish to receive program prep materials. If the session is listed as full for videoconference participation, we welcome your participation this way as well.

3. Via Television--All our programs are available in the St. Louis metropolitan area on HEC-TV, Charter Communications digital channels 989 or 118-26. All our programs can also be seen on AT&T's U-Verse channel 99. Students viewing in this way can e-mail their questions during the program to live@hectv.org. To view the show live on the program day, just turn on your TV to the appropriate channel.

For Internet and TV viewing, there is no enrollment deadline date. We would appreciate knowing the time of the program you are watching and the grade level and amount of students involved so we can forward that information to our program partners. Such information is extremely helpful in securing funding for more free, interactive, educational programs in the future. To let us know you're viewing the program or to answer any additional questions about the program, please contact us at live@hectv.org.

Archival Viewing:

Can't join us live? No problem! All *The Science Behind* programs are archived on the station website, <http://www.hectv.org> and on the HEC-TV page on iTunesU for on-demand viewing at any time. Archives are usually up and running about a week after the program's original air date.

Program Objectives:

The participant will:

1. interact with engineers and designers working in the field of roller coaster design..
2. use energy principles to explain the changes in speed of a car that traverses a roller coaster track.
3. use kinetic and potential energy observations to predict the speed of a roller coaster car at a particular height on the track when given the initial height of the first drop.
4. gain a greater understanding of the nature of energy and the Law of the Conservation of Energy.
5. The participant will explore methods to design and build roller coasters
6. The participant will engage in critical thinking and creative thinking.

Program Format:

The agenda below provides you the topics to be explored in the program as well as the order of that exploration. A final agenda will be e-mailed closer to the program. That agenda will include advance questions we receive from student groups enrolled for the program. Those advance questions and responses are based on pre-program activities included later in this document, so please review those activities and the related resources available on our website so your students' questions and responses can be part of determining the program's final agenda.

- I. **Welcome and Introduction**—Program guests and students are welcomed to the program and we cover necessary background information to set up the rest of the program. That information includes mentioning “Big Picture Question: How does energy apply to the design of roller coasters?” and reminding everyone of the Law of Conservation of Energy.
- II. **Examples of the Law of Conservation of Energy Put in Practice in Roller Coaster Design**
 - A. Energy Principals
 1. Potential energy—what it is
 2. Kinetic energy—what it is
 3. Dissipating energy—what it is
 4. Example of real roller coaster in action
 - B. Potential Energy and Kinetic Energy
 1. Examples of student roller coaster with student/teacher explanation
 2. Interaction with expert on student roller coaster
 3. Examples of real roller coaster applying the same principle
 4. Questions for students and expert from participating students
 - C. Dissipating Energy
 1. Example of student roller coaster with student/teacher explanation
 2. Interaction with expert on student roller coaster
 3. Relationship to roller coaster safety

4. Example of real roller coaster applying the same principle
5. Questions for students and expert from participating students

III. Summary and Closing—In this segment we summarize what we've learned, thank everyone who participated, and close the show.

Featured National Standards:

Next Generation Science Standards

Middle School Physical Science

- 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-PS3-5. 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.

Next Generation Science Standards

Grades 9-12

Performance Expectations – Forces and Interactions •

- HS-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

Performance Expectations – Energy •

- HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

Disciplinary Core Ideas – Motion and Stability: Forces and Interactions •

- HS-PS2.A.i Newton's Second Law accurately predicts changes in the motion of macroscopic objects. •
- HS-PS2.A.ii Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.

Disciplinary Core Ideas – Energy: Conservation of Energy and Energy Transfer •

- HS-PS3.B.i Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. •
- HSPS3.B.iii Mathematical expressions, which quantify how the stored energy in a system depends on its configuration and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior

Energy and Matter • High School: Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

- High School: Energy cannot be created or destroyed – it only moves between one place and another place, between objects and/or fields, or between systems.

Structure and Function

- High School: Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different compounds, and connections of components to reveal its function and/or solve a problem.

Science Standards

Unifying Concepts and Processes - Unifying concepts and processes help students think about and integrate a range of basic ideas which builds an understanding of the natural world

1. Systems, order, and organization
2. Evidence, models, and explanation

Science as Inquiry - Science as inquiry requires students to combine processes and scientific knowledge with scientific reasoning and critical thinking to develop their understanding of science.

1. Abilities necessary to do scientific inquiry
2. Understandings about scientific inquiry

The following **Common Core Standards for English/Language Arts and Literacy in History/Social Studies, Science and Technical Subjects** are referenced in this program:

College and Career Readiness Anchor Standards for Reading

7. Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.

College and Career Readiness Anchor Standards for Writing

6. Use technology, including the Internet, to produce and publish writing and to interact and collaborate with others.
7. Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.

College and Career Readiness Anchor Standards for Speaking and Listening

1. Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.
2. Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.
3. Evaluate a speaker's point of view, reasoning, and use of evidence and rhetoric.
4. Present information, findings, and supporting evidence such that listeners can follow the line of reasoning and the organization, development, and style are appropriate to task, purpose, and audience.
5. Make strategic use of digital media and visual displays of data to express information and enhance understanding of presentations.

College and Career Readiness Anchor Standards for Language

6. Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when encountering an unknown term important to comprehension or expression.

Featured State Standards (Missouri):

Schools from across the country are invited to join in the program. Missouri state standards are provided for Missouri schools since partial funding for this program comes from various Missouri organizations.

Missouri Grade Level Expectations

Strand 7: Scientific Inquiry

Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking

Participant Preparation:

1. Participants should come to the program with an interest in energy, roller coasters, engineering and/or science.
2. Participants should utilize preparatory materials provided for the program and other resources of their own to better understand the context of the program's subject and to think in advance of questions they wish to ask the experts. If you want your students to be able to ask interactive questions during the program, please make sure to complete Pre-Program Activity 3 and send us their questions no later than Friday, April 13.
3. Participants should have pencil and paper ready to use during the program to jot down ideas and additional questions as they come to mind.

Pre-Program Activity Suggestions:

Please consider having your students do any or all of the activity suggestions below to determine the specific areas of focus for each program as well as questions they'd like to ask the program guests during the program they participate in. We really want each program's conversation to be driven by the student questions we receive in advance.

1. Learn More about Energy and Roller Coasters—Share the web resources below with your students so they can learn more about energy and roller coasters. Consider showing the video to your entire class with discussion or have students work in small groups and share what they learn with each other.

As students view the videos and share their learning, see if any questions develop that they'd like to ask the experts during the live program. If they do, consider including them in the advance questions you send us per the instructions provided in activity #3 below.

https://www.youtube.com/watch?time_continue=17&v=LlM1pIefpBM

https://www.youtube.com/watch?time_continue=3&v=Jnj8mc04r9E

<https://www.youtube.com/watch?v=J8pJiV44hVM>

<https://www.youtube.com/watch?v=3sS4nT5odP4>

<https://www.youtube.com/watch?v=06jLTR6NVrM>

<https://www.youtube.com/watch?v=0JMIWMiObrw>

2. Do a Roller Coaster Lab—Use the materials provided in Student Tool 60: Conservation of Energy (Roller Coaster Lab) to give student the opportunity to work in simulations dealing with roller coasters, potential energy and kinetic energy. The student tool is available on our Educate.Today website at <https://educate.today/videos/5566> and will also be e-mailed to you once you have registered for the program.

As students view the videos and share their learning, see if any questions develop that they'd like to ask the experts during the live program. If they do, consider including them in the advance questions you send us per the instructions provided in activity #3 below.

3. Send Us Your Advance Questions—Based on your students' research and conversation while doing pre-program activities #1 and #2, please help facilitate the most effective discussion possible during the program by e-mailing us no more than five "burning questions" your students have developed in advance to

ask our guests during the program. We will go through the questions submitted by all schools enrolled for the program to develop the final agenda for the videoconference. We will then e-mail you that final agenda no later than April 17 with the questions included that we have selected from each school. Please send us these “burning questions” no later than Friday, April 13 in the following way:

E-mail the questions to us at live@hectv.org or info@educate.today by sending us your completed Teacher Tool 272: Roller Coaster Program Worksheet available on our Educate.Today website at <https://educate.today/videos/5566>. That document will also be e-mailed to you once we receive your program enrollment information. Please be sure your completed worksheet also includes the names of each student who will ask those questions. If you choose this method, your students’ selected questions will be read by the program moderator with student name and school included.

PLEASE NOTE: We welcome advance questions from all groups, whether you are connecting to the program via VC, Skype, Zoom, by watching online at hectv.org, or by watching on HEC-TV in the St. Louis area. Please remember, the deadline for sending us your advance questions is April 13.

Program Keywords:

Science, STEM, Engineering, Roller Coasters, Physics, Energy, Law of Conservation of Energy, Potential Energy, Kinetic Energy

Vocabulary:

Law of Conservation of Energy
Dissipating Energy
Kinetic Energy
Potential Energy

Supplemental Resources:

For students interested in learning more about the topics explored in this program, consider sharing the following web resources with them.

https://www.youtube.com/watch?time_continue=17&v=LIM1pIefpBM

https://www.youtube.com/watch?time_continue=3&v=Jnj8mc04r9E

<https://www.youtube.com/watch?v=J8pJiV44hVM>

<https://www.youtube.com/watch?v=3sS4nT5odP4>

<https://www.youtube.com/watch?v=06jLTR6NVrM>

<https://www.youtube.com/watch?v=0JMIWMiObrw>

Cancellation Policy:

Since there may well be a waiting list for interactive participation, we ask that you let us know of your need to cancel as soon as you know.

Technology Specifications:

This program’s videoconference connections will be bridged through our state bridging agency, MOREnet. When you register, please include the IP address of the VC unit you’ll be using to connect to the program. A validation test call MUST be made with MOREnet no less than one week prior to the program date. As part of the confirmation you’ll receive after we get your registration and IP information, we’ll send you the details for the test call with MOREnet.