W 420

ROLLER COASTER PHYSICS

An Introduction to Engineering Design

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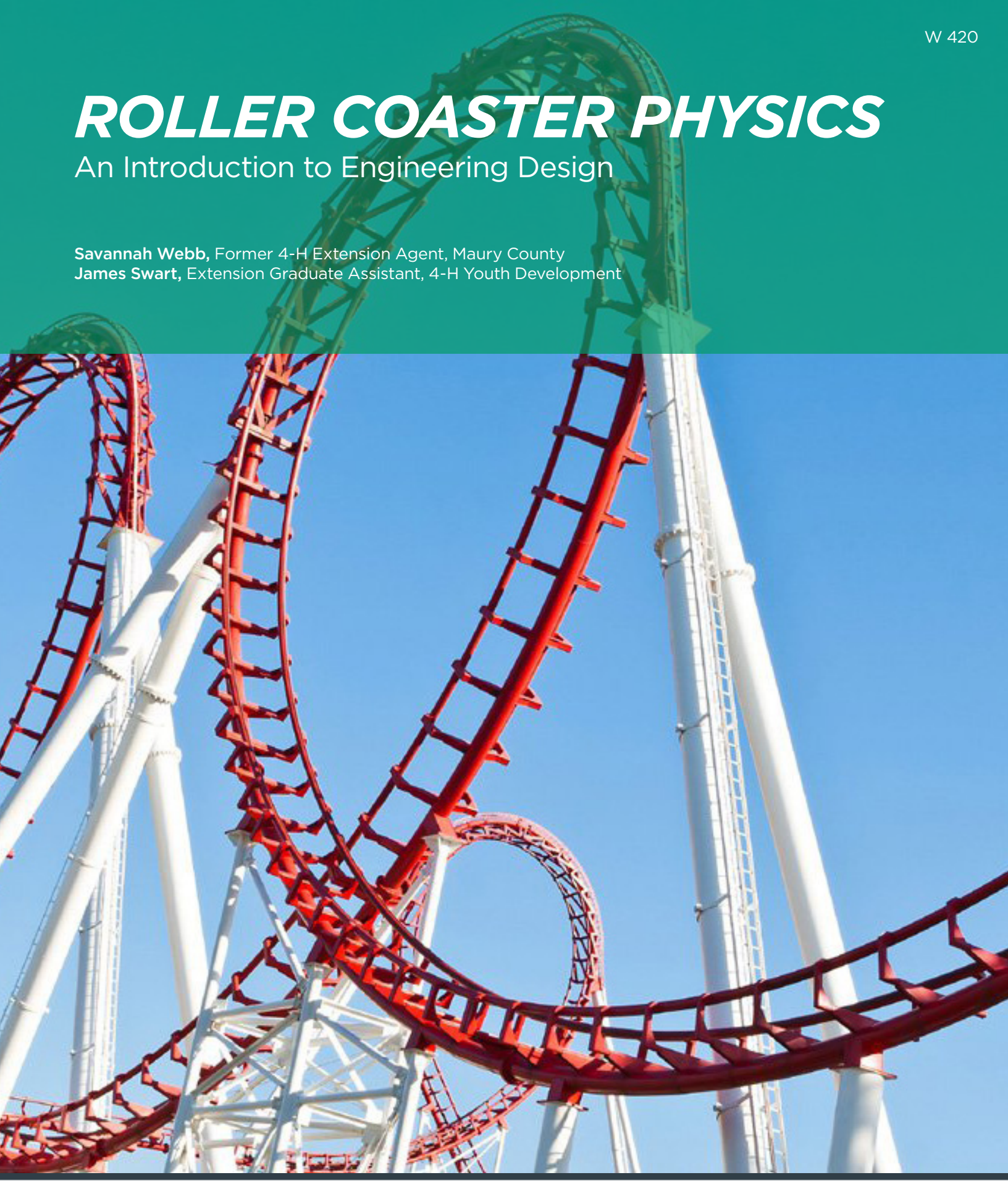

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Tennessee 4-H Youth Development

Roller Coaster Physics

An Introduction to Engineering Design

Skill Level
Beginner

Learner Outcomes
The learner will be able to:

- Work together to design and construct a roller coaster.
- Explain how the physical concepts of laws of physics work in their design.

Educational Standard(s) Supported
5.ETS2.1: Use appropriate measuring tools, simple hand tools, and fasteners to construct a prototype of a new or improved technology.

Success Indicator
Learners will be successful if they:

- Identify which roller coaster will cause the marbles to travel the fastest.
- Explain how each roller coaster affects the marble speed.

Time Needed
30-45 Minutes

Materials List
Foam pipe insulation (cut in half), glass marbles, wooden marbles, masking tape, Styrofoam or plastic cup, stopwatch, ruler.

Introduction to Content

Roller coasters are fun, especially for children. In this lesson, students will learn about the physics of roller coasters. They will design a roller coaster out of pipe insulation and duct tape that a marble will roll down continuously once released. Students will be responsible for designing, constructing, testing, and analyzing their structures.

Introduction to Methodology

Students will understand the Law of Conservation of Energy. They will understand that all energy can be considered to be either kinetic energy or potential energy. Students also will learn that friction affects the motion of their marbles.

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Terms and Concepts Introduction

- **Potential Energy —** The energy stored in an object ready to be used.
- **Kinetic Energy —** The energy of an object in motion, which is related to its mass and velocity.
- **Friction —** A force caused by rubbing two objects together.
- **Gravity —** Force that draws two objects closer together.
- **Momentum —** The strength or force something has when it's moving.
- **Law of Conservation of Energy —** Statement that energy cannot be created or destroyed.

Setting the Stage and Opening Questions

Since this lesson is dependent on the students having a working knowledge of several different physics concepts, the background information to be used to set the stage has been included in the supplemental information section of this lesson plan.

After presenting the opening information, ask the students the following questions.

- **"How many of you have ever ridden on a roller coaster?"**
- **"Who loves roller coasters? Who hates them? Why?"**
- **"What is it about roller coasters that makes them fun/scary?"**

Tips for Engagement

During the experience portion of the lesson, rotate around the room and ensure that the students are engaged in the design and building process. Since the groups may be larger than normal, it may be beneficial to assign roles for the students in the groups.

Experience

Go over background information with all students, then divide the class into three engineering groups.

Explain that a glass marble demonstrates a roller coaster full of people and a wooden marble represents an empty coaster.

Designate to each group the coaster they must design: 1) At least one hill and no loops, 2) Only one loop and one hill, and 3) Two loops with no hills.

Have groups start designing their coasters, with the following constraints in place: 1)The marble must roll continuously when released, 2) The marble cannot leave the track at any time, 3) Coasters may not be taller than 36 inches at any place in the design, 4) Each group will only have 12 feet of insulation to use.

Give each group foam tube track, masking tape, ruler and cup to be used for construction. Explain that each group has 10 minutes for design and construction.

Have students test roller coasters and time each trip. Record the time for each trip on the board.

As a class, analyze the data:

A) Which marble moves faster? B) Why do you think the fastest coaster was the fastest? C) Could any changes be made to make the coasters run faster? D) Where does each coaster have the highest potential energy? Kinetic energy? E) How is friction affecting our trial runs?

Share

As a class, analyze the data by asking the following questions:

- **"Which marble moves faster?"**
- **"Why do you think the fastest coaster was the fastest?"**
- **"Could any changes be made to make the coasters run faster?"**
- **"Where does each coaster have the highest potential energy? Kinetic energy?"**
- **"How is friction affecting our trial runs?**

Process

- **"What types of marble moves faster?"**
- **"Explain the difference in potential and kinetic energy."**

Generalize

- **"How is friction affecting trial runs?"**
- **"How is potential energy being transferred into kinetic energy in this experiment?"**

Apply

- **"How could being a roller coaster designer be a stressful job?"**
- **"What are other jobs you can think of that would use the skills we gained today?"**

Life Skill(s) from TIPPs for 4-H

5th Grade:
Participate in 4-H club meetings by saying pledges, completing activities and being engaged. (Head)

Divide a team task by identifying contributions by each person. (Hands)

Speak clearly and effectively in group settings. (Hands)

Reference

Arizona Mathematics Engineering Science Achievement. *Middle School Lesson Plans.* Retrieved July 31, 2014. http://azmesa.arizona.edu/sites/azmesa.arizona.edu/files/Lesson%20Plans%20Master-MS_1.pdf

Supplemental Information

- *Ask students if they know what makes a roller coaster work. Guide students to an understanding that roller coasters are powered by gravity. Make sure students have a solid understanding of gravity [the force of attraction between two masses; on Earth, the force that pulls objects toward the center of the Earth].*
- *Ask students if they can think about what all roller coasters have in common at the beginning of the ride. [They are pulled up to the top of a big hill to start the ride; this hill is the biggest hill on the track.] Why do all roller coasters start this way? [Going to the top of the hill provides the roller coaster with enough potential energy to complete the rest of the track.]*
- *Ask students if they've ever learned about potential energy before, and if they can think of any examples (batteries store energy; energy is stored in springs when you compress them; energy is stored in a bow's string when you pull it back, etc.). When an object has potential energy, it has the potential to do something. In the case of something at the top of a hill, it has the potential to come down the hill. The higher up it is, the more potential energy it has.*
- *Have students think about whether they'd rather drop a penny into their hand from 2 feet up, or from 200 feet up! The penny at the greater height would have more potential energy, so it could potentially hurt you when it hit your hand. In the case of roller coasters, they have the potential to fall toward the ground when they are at the top of the hill. How much potential energy the roller coaster has depends on how high it is lifted at the beginning of the ride.*
- *Ask students what happens once the coaster is let go at the top of the hill. When the roller coaster starts moving, the potential energy is converted into kinetic energy, the energy associated with motion. Ask students to give example of objects that have kinetic energy (e.g., a moving car, a running person, a river, the wind, a watch hand, etc.). What would they expect has more kinetic energy, something moving fast or something moving slow (something moving fast)? The faster something is moving, the more kinetic energy it has. Also, the more mass something has, the more kinetic energy it has. Which would cause more damage, a mouse running into a wall or a car running into a wall? The car is more massive so would cause more damage, even if it and the mouse were moving at the same speed.*
- *Ask, "Why do they call them 'roller coasters'? What does it mean to coast?" Guide students to an understanding that all the energy for the ride comes from the potential energy of being at the top of the first hill, and that the coaster uses this energy to coast along the rest of the track. [Note: There are some roller coasters that use other sources of power at certain points of the ride, but true roller coasters simply coast.]*
- *Ask if anyone has heard of the Law of Conservation of Energy [energy cannot be created or destroyed; it can only be transformed (changed from one type to another) or transferred (exchanged between objects)]. Have students discuss this concept. Ask, "How does the Law of Conservation of Energy apply to roller coasters?" (The roller coaster's potential energy from being at the top of the first hill is transformed into kinetic energy as it falls down the hill; the energy is often transformed multiple times as the roller coaster goes over additional hills and loops.)*

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