May the Force be with You

Lesson Overview

In this lesson, students will conduct a hands-on investigation to explore how varying forces and mass impact the motion of an object.

Alignment

Standard/Indicator Addressed

8.P.2A.1	Plan and conduct controlled scientific investigations to test how varying the amount of force or mas of an object affects the motion (speed and direction), shape, or orientation of an object.
8.P.2A.2	Develop and use models to compare and predict the resulting effect of balanced and unbalanced forces on an objects's motion in terms of magnitude and direction.
8.P.2A.5	Analyze and interpret data to describe and predict the effects of force (including gravitational and friction) on the speed and direction of an object.
8.P.2A.6	Use mathematical and computational thinking to generate graphs that represent the motion of an object's position and speed as a function of time.
8.P.2A.7	Use mathematical and computational thinking to describe the relationship between the speed and velocity (including positive and negative expression of direction) of an object in determining average speed (v=d/t).

Science and Engineering Practices

S.1A.1	Ask questions and define problems
S.1A.2	Develop and use models
S.1A.3	Plan and carry out investigations
S.1A.4	Analyze and interpret data.
S.1A.5	Use mathematical and computational thinking.
S.1A.6	Construct explanations.
S.1A.8	Obtain, evaluate, and communicate information.

S.1A.9 Construct devices or design solutions.

Standards for Mathematical Practice

Standard 1. Make sense of problems and persevere in solving them.
Standard 2. Reason both contextually and abstractly.
Standard 4. Connect mathematical ideas and real-world situations through modeling.
Standard 7. Identify and utilize structure and patterns.

ELA Inquiry Standards (as appropriate)

Standard 3 Construct knowledge, applying disciplinary concepts and tools, to build deeper understanding of the world through exploration, collaboration, and analysis.

Standard 6 Read, write, and communicate using knowledge of a particular discipline.

Standard 7 Integrate the Reading, Writing, and Communication Standards and the Inquiry-Based Literacy Standards to communicate and create understanding within content areas.

Standard 8 Extend and deepen understanding of content through purposeful, authentic, real-world tasks to show understanding and integration of content within and across disciplines.

Connections

Disciplinary Literacy Strategies (for Purposeful Reading, Meaningful Writing, and Productive Dialogue)

- Question Formulation Technique (QFT)
- Gallery walk
- Exit slips
- Making Thinking Visible (MTV)

Computational Thinking:

- Logically organizing and analyzing data by completing the data table on the data collection sheet.
- Representing data through abstractions such as models and simulations by setting up the ramps at different heights and changing the amount of mass on the matchbox cars.

- Automating solutions through algorithmic thinking (a series of ordered steps) by following the steps to assemble and carry out the simulations.

Lesson Plan

Time Required – Three 60-minute class periods

Disciplinary Vocabulary –

- Inertia
- Momentum
- Speed
- Velocity
- Slope
- Dependent/independent variable

Materials Needed:

For each group of 3 students:

- BluTrack
- Metric ruler
- Scale
- Toy cars (matchbox)
- Weights (washers)
- Tape (to attach weights)
- Timer/stopwatch
- Graph chart paper
- calculator

Formative Assessment Strategies:

- Student dialogue
- Exit Slips
- Discussion Questions
- Graphic Organizers

Misconceptions:

- Students often think that mass and weight are interchangeable.
- Students may think the more weight you add to the car, the faster the car's speed.

- Students may not understand the relationship between the height of the ramp and the speed of the car.

Lesson 3, Part A

Engage

- Today you will construct a "racetrack" for a toy car and perform two experiments to determine: the effect of the track height on the speed of the toy car and the effect of varying the toy car's mass on the speed of the car. You will use your creativity, problem solving skills, and physics knowledge to design a unique "racetrack" where the car will perform efficiently.
- Begin by posting review terms and concepts previously taught. Have the students work to answer the questions individually or in pairs. Call on selected students to share their responses.
- Groups students using the "counting off" method.
    - You will want to have groups of three for these activities.
    - Depending on how many people you have in your class, count off the students so you have groups of three. For instance, if you have 27 students in your class then you will have 9 groups. So you will count off your students by 9's.
    - Have all the 1's get together to form a group, all the 2's, all the 3's etc.

Explore

- The students will choose a location to set up the BluTrack.
- Ask one person from each group to come up and collect the materials to set up the track .
    - BluTrack
    - Stabilizer bars
    - Metric ruler
    - Matchbox car
    - Timer/stopwatch

https://www.rainbowresource.com
Search: blutrack

- The students set up the BluTrack using the stabilizer bars at an initial height of **92 centimeters**. One student will place the car at the top of the track and release while another student measures the time it takes the car as it travels to the end of the track using the timer/stopwatch. The third student will record the time on the data collection sheet.
- The students will repeat this trial 3 more times recording the data each time.
- The students will then find the average time of the trials and record on the data collection sheet.
- The students will find the speed of the car using the formula s=d/t and record that data on the data collection sheet as well.
- The students will then raise the BluTrack to a height of **112 centimeters** and repeat the previous steps recording the data for this height on the data collection sheet.
- The students will then raise the BluTrack to a height of **132 centimeters** and repeat the previous steps recording the data for this height on the data collection sheet.

- When all data has been collected from each height, have the student who collected the materials take it back for storage until tomorrows lesson.
- Students will go back to their seats and complete the exit ticket for the day.

Exit Ticket for **Lesson 3, Part A**

- What is the independent variable in this experiment? How do you know?
- What is the dependent variable? How do you know?
- What did you control?

END Lesson 3, Part A

BEGIN Lesson 3, Part B

- Begin the day by going over some of the responses from yesterday's exit ticket. Talk about some of the trends that the different groups saw on their data collection sheet.
- Have students get back with their groups from yesterday.
- Have one student collect the BluTrack, stabilizer and other materials for today:
  - Metric ruler
  - Matchbox car
  - scale
  - Timer/stopwatch
  - Weights (washers)
  - Tape (to attach weights)
  - Graph chart paper

Explore (continued from Lesson 3, Part A)

- The students will set up the BluTrack in the same spot as yesterday. They may choose **either** 92 cm, 112 cm, or 132 cm. Once a height is chosen the students will use this height for the entire experiment.
- Today's experiment will focus on changing the mass of the matchbox car.
- Using the scale, find the mass of the car you will be using. Record this on the data collection sheet.
- Roll the car down the track without any weight. Record the time it takes to complete the track. Repeat this step 3 more times. Fill in all the columns of the data collection sheet.
- Tape one weight to the car. Using the scale, measure the mass of the car plus one weight and record on the data sheet.
- Roll the car down the track with the one weight. Record the time it takes to complete the track. Repeat this step 3 more times. Fill in all the columns of the data collection sheet.

- Tape two weight to the car. Using the scale, measure the mass of the car plus two weight and record on the data sheet.
- Roll the car down the track with two weights. Record the time it takes to complete the track. Repeat this step 3 more times. Fill in all the columns of the data collection sheet.
- When all data has been collected and the sheet is filled in with today's information, have the student who collected the materials take it back for storage.
- Students will go back to their seats and complete the exit ticket for the day.

Exit Ticket for **Lesson 3, Part B**

- What is the independent variable in this experiment? How do you know?
- What is the dependent variable? How do you know?
- What did you control?

END Lesson 3, Part B

BEGIN Lesson 3, Part C

- Begin the day by going over some of the responses from yesterday's exit ticket.
- Have students get back with their groups from yesterday.
- The teacher will use the Question Formulation Technique (QFT):
    - Provide a focus/topic based on the experiments that have been conducted.
    - Students work in their group to ask as many questions as they can for 2 minutes. Have a recorder from each group write down every question exactly as it was stated.
    - Ask students to review their questions and sort them into two types: open and closed.
    - Students work together to change closed-ended questions to open-ended questions. *This process will help students think about how the phrasing of a question can affect the depth, quality, and value of the information they will obtain.*
- The groups will hold these new formulated questions to use later in the class period.
- Today we will be analyzing and making some conclusions from the data we have collected.
- Look at the charts from each experiment and notice some trends. To make this more scientifically correct, you will need to graph your information.

- Look at the average speed of your car for the different track heights and record them in this chart:

Average the speed of the car for each track height.

Track Height	Average Speed (for the 4 trials)
92 cm	
112 cm	
132 cm	

- Look at the average speed for each mass of your car and record them in this chart:

Average the speed for each mass of the toy car.

Mass of Car =Weight	Average Speed (for the 4 trials)

- Now, graph each set of data on a sheet of chart paper. Draw conclusions on the chart paper based on the graphs you made. What effect did each variable have on the motion of the car?
- Each group will post their graphs around the room and the students will conduct a "gallery walk" adding questions or conclusions on sticky notes and posting them on the chart.
- One student from each group will then collect the BluTrack and a matchbox car. The group will use what they have learned to design and create a track with one loop (using the ramps to make the loop) where the car will go to the end. They are to show the teacher when they are successful.
- Each group should draw a picture of their design describing their thinking while designing the track and why the car was successful completing the track.

Explain

- The teacher will circulate through the classroom and ask questions as students conduct the experiments and record the data.
- The students will write the questions they formulated at the beginning of day three on chart paper and post them around the room.
- The teacher will choose an open-ended question from each group and the students will answer them independently.
- The groups will take turns presenting their racetrack design to the class.

- Pass out the exit ticket for the day and have the students fill it out, collect the exit ticket as the students leave the classroom.

Exit Ticket for **Lesson 3, Part C.**

3 – 2 – 1

- 3 ideas from these lessons that were new to me that I think I understand now.
- 2 ideas from these lessons that were a review of something I already knew.
- 1 question I have about the work we did with these lessons.

Extend

- Have the students have fun with this new learning by designing a roller coaster with the BluTrack and the ramps. Draw your design. Test it out!

HANDOUTS FOR THE LESSON BEGIN ON THE FOLLOWING PAGE

MAY THE FORCE BE WITH YOU!
BluTrack Investigation

Name _____

Date _____ Block/Pd _____

Today you will construct a "racetrack" for a toy car and perform two experiments to investigate the following:

- the effect of track height on the speed of the toy car, and
- the effect of varying the toy car's mass on the speed of the car.

You will also use your creativity, problem solving skills, and physics knowledge to design a unique "racetrack" where the car will perform efficiently.

Review/Discussion:

1. Define:

   inertia _____

   momentum _____

   speed _____

   velocity _____

   slope _____

2. Describe variables that may have an effect on a toy car rolling down a track.

3. List the 3 variables involved in any scientific investigation.

4. If you change the mass of the toy car for each trial, what type of variable will that be:

   When you measure the time the car spent on the track, you are measuring the _____ variable.

   Write a testable hypothesis: _____

5. What things will you keep constant each time you experiment with the cars and the BluTrack?

Experiment #1

1. Start the **BluTrack** at **92 centimeters**. Do not use any loops or twists. Use the stopwatch to time how long it takes the car to travel to the end of the track. Calculate the speed. Repeat this trial 3 times.
2. Raise the **BluTrack to 112 centimeters**. Do not use any loops or twists. Use the stopwatch to time how long it takes the car to travel to the end of the track. Calculate the speed. Repeat this trial 3 times.
3. Raise the **BluTrack to 132 centimeters**. Do not use any loops or twists. Use the stopwatch to time how long it takes the car to travel to the end of the track. Calculate the speed. Repeat this trial 3 times.

Record your data in the chart: (Note: The BluTrack is 5.4864 meters long.)

TRIAL	HEIGHT (cm)	TIME (seconds)	SPEED (s=d/t)
1	92 cm		
2	92 cm		
3	92 cm		
4	92 cm		
Average			

TRIAL	HEIGHT (cm)	TIME (seconds)	SPEED (s=d/t)
1	112 cm		
2	112 cm		
3	112 cm		
4	112 cm		
Average			

TRIAL	HEIGHT (cm)	TIME (seconds)	SPEED (s=d/t)
1	132 cm		
2	132 cm		
3	132 cm		
4	132 cm		
Average			

Identify:

- independent variable _____
- dependent variable _____
- control variable _____

Experiment #2

In this experiment, you will change the mass of the toy car by adding the weights. The height for each trial will be the same.

1. Using the scale, determine the mass of the toy car.
2. Choose one height and attach the BluTrack. Roll the car down the track without any weight. Record the time it takes to complete the track. Repeat this step 3 times and record your data.
3. Tape one weight onto the car. Using the scale, determine the mass of the car and one weight. Roll the car down the track and record the time it takes to complete the track. Repeat this step 3 times and record your data.
4. Tape 2 weights onto the car. Using the scale, determine the mass of the car and two weights. Record the time it takes to complete the track. Repeat this step 3 times and record your data.

Record your data in the chart: (Note: The BluTrack is 5.4864 meters long.)

TRIAL	MASS of car	TIME (seconds)	SPEED (s=d/t)
1			
2			
3			
4			
Average			

TRIAL	MASS of car (1 weight)	TIME (seconds)	SPEED (s=d/t)
1			
2			
3			
4			
Average			

TRIAL	MASS of car (2 weights)	TIME (seconds)	SPEED (s=d/t)
1			
2			
3			
4			
Average			

Identify:

- independent variable _____
- dependent variable _____
- control variable _____

Analyze/Conclude:

1. Look at each chart and notice the trend. Hey, wait …. is this easy to do by "eyeballing it"? To make this more scientifically correct, you will need to graph your information. So, do the following:

Average the speed of the car for each track height.

Track Height	Average Speed (for the 4 trials)
92 cm	
112 cm	
132 cm	

Now, graph this data on the chart paper

Average the speed for each mass of the toy car.

Mass of Car =Weight	Average Speed (for the 4 trials)

Now, graph this data on the chart paper

2. Finally, draw conclusions on the chart paper based on the graphs you made. What effect did each variable have on the motion of the car?

Experiment #3: Loopy

Using what you learned, design and create a track with one loop (use the ramps to make the loops) where the car will go to the end. Show your teacher.

Teacher check _____

Experiment #4: Now you get to have some fun with the track – Roller Coaster Thrills!

Design something new. Draw your design on a separate sheet of paper. Test it out!