Force, Mass, and Demolition Derby

Strand Force, Motion, and Energy
Topic Investigating motion
Primary SOL 4.2 The student will investigate and understand characteristics and interactions of moving objects. Key concepts include
b) changes in motion are related to force and mass.
Related SOL 4.1 The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which
a) distinctions are made among observations, conclusions, inferences, and predictions;
c) appropriate instruments are selected and used to measure length, mass, volume, and temperature in metric units;
e) predictions and inferences are made, and conclusions are drawn based on data from a variety of sources;
i) data are collected, recorded, analyzed, and displayed using bar and basic line graphs;
j) numerical data that are contradictory or unusual in experimental results are recognized;
k) data are communicated with simple graphs, pictures, written statements, and numbers;
l) models are constructed to clarify explanations, demonstrate relationships, and solve needs.

4.2 The student will investigate and understand characteristics and interactions of moving objects. Key concepts include
a) motion is described by an object's direction and speed;
c) friction is a force that opposes motion;
d) moving objects have kinetic energy.

Background Information

A force is a push or pull that causes an object to move, stop, or change speed or direction. The greater the force, the greater the change in motion. The more massive an object, the less effect the same force will have on the object.

There are many examples in daily life that demonstrate the relationship of force and mass with changes in motion. For example, most children could predict what would happen if a large football player and a small football player ran straight at each other at the same speed. The collision would send the smaller player backward while the larger player would continue to move forward. Students usually understand that the more massive object will cause a change in motion of the less massive object. Another example is how much more difficult it is to pick up a car than it is to pick up a paperclip. The car, due to its greater mass, requires much more force to move.

Materials

For each student:

- Copies of attached "Smash, Crash, Motion" Packet
- Half sheet of construction paper

For each small group:

- 2 toy cars
- Balance with gram weights
- Toy car track pieces (straight)
- 2 meter sticks
- Books
- Small amount of tape

Vocabulary

meter stick, mass, motion, transfer of energy, force, friction, independent variable, dependent variable, constant

Student/Teacher Actions (what students and teachers should be doing to facilitate learning)

Introduction

1. Begin the lesson by showing a video about, or discussing, spacewalking. What are some of the experiences astronauts have that relate to force and/or the absence of it when walking in space? Have students discuss why an astronaut would float away in space. Students should keep in mind that in space, without matter and air, friction does not exist. Discuss what would happen if you threw a baseball or if someone spun you around in space.
2. Students should come to understand that only another force could change their direction or stop them from spinning.
3. Let students know that today they will learn how force and mass relate to motion.

Procedure

1. Place students into groups of three or four students based on ability level.
2. Distribute materials for each group and the "Smash, Crash, Motion" Packet to each student according to the high leveled group or the medium and low leveled group. The packets are labeled accordingly.
3. Go over the "Smash, Crash, Motion" activities with the students. Be sure to discuss with the students the vocabulary terms independent variable, dependent variable and constant when describing the tests.
4. Students should work in their groups to complete the tests.
5. The teacher should pay close attention to the fairness of the tests. Many students make the mistake of making the tests competitive while trying to push the cars instead of merely releasing. It is important that children see unusual results in data and try to explain why these results may have occurred.
6. Throughout the experiment students will discuss data. The conclusion section of "Smash, Crash, Motion" can be completed as a class or as a group. The students should

be encouraged to use words and phrases such as force, mass, friction, transfer of energy, motion, independent variable, dependent variable, and constant.

Conclusion

1. Discuss with students how the experiments illustrate how changes in motion are related to force and mass.
2. Ask students to draw and label a picture on the half sheet of construction paper illustrating the same relationships that were evident in the experiment.
3. Have them write a paragraph explaining what is happening using scientific vocabulary.

Assessment

- **Questions**
  - How does mass affect motion?
  - In what ways can force affect motion?
- **Journal/writing prompts**
  - Imagine playing your favorite sport in space. Explain the difficulties with this idea.
  - You are designing a Bumper Car ride for your own amusement park. You want to be able to bump cars harder than everyone else every time you are on the ride. What could you do while you are designing the ride to assure that you will be the hardest hitter? Explain.
- **Other**
  - Give students a KWL Chart (listed in Differentiation Strategies) and evaluate the L section.
  - Grade the paragraph on their experiment.

Extensions and Connections (for all students)

- Complete another test adding more mass and/or more height to the ramp.
- Have students play a game of marbles with two sizes of marbles to hold a discussion about the transfer of energy, force, mass, and the change of motion.

Strategies for Differentiation

- Have your students create a KWL Chart.
  - In the K column have your students write down or draw pictures about a few things they already know about Force, Motion, and Mass.
  - In the W column have your students write down a few things they want to know. Give your students a few guiding questions such as “What would happen if you had an object with a greater mass, will it have a greater force?”
  - In the L column you will come back to this when your lesson is done. Ask your students what they learned from this activity. This can be done as a whole group activity.
- Students may use adding machine tape or yarn to measure trials.

Smash, Crash, Motion

Setup - Using a straight track for toy cars, books to create height, and tape to keep the track in place, construct a ramp 20 cm from the ground. During testing, you will release (without pushing) the car from the top of the ramp. Car two will be placed at the base of the ramp. Place a meter stick parallel to the track beginning at the starting point of Car 2.

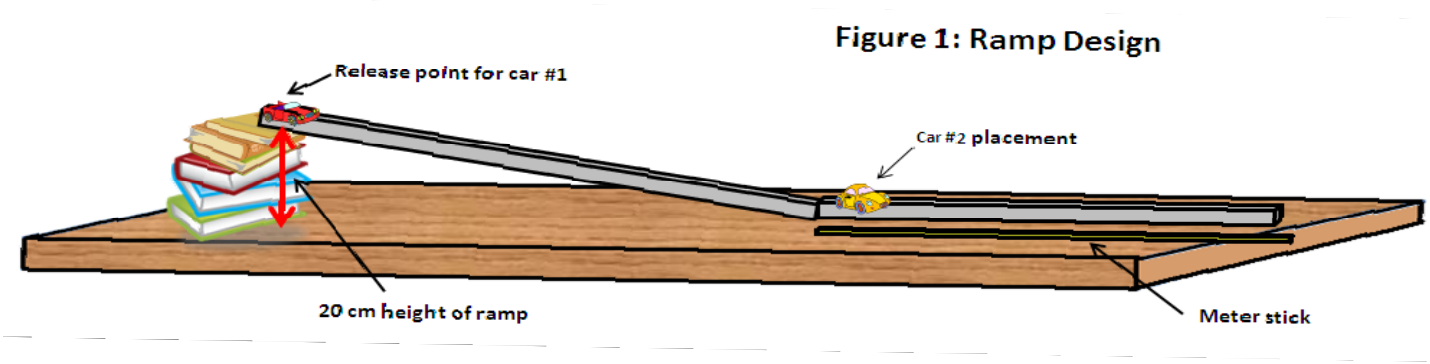


Figure 1: Ramp Design

Step One - Designate Your Vehicles

Measure the mass of both toy cars you have using a balance. The one with the larger mass should be designated Car 1 while the car with the smaller mass should be designated Car 2. If they happen to have the same mass, just choose which one you would like to be Car 1 and the other can be Car 2.

Car 1 _____grams

Description _____

Car 2 _____grams

Description _____

Step Two - Testing and Recording (High Group Worksheet)

It's time for Demolition Derby. You will be crashing your cars several times to see what affect force and mass have on motion.

Predictions

Before each test, be sure to make a prediction of how far Car 2 will travel after Car 1 applies force to it. (The teacher needs to decide on possible choices for predictions.)

Tests 1 and 2

For the first two tests, set your ramp height at 20 cm. In Table 1 you will see in the second column Car 2 will have to add 20 grams to its mass. The easiest way to do this is use tape to tape 20 grams onto your car. Make sure not to tape the wheels of the car or to add to its friction in any way. You will have to be very careful while adding mass to your car.

Tests 3 and 4

For tests 3 and 4, your ramp must be raised to 30 cm. Changing the height of the ramp will change where you place Car 2. Make sure to place Car 2 at the base of the ramp and to mark the spot to make sure you keep this placement constant for each trial. Complete all trials in the same manner as tests 1 and 2.

Record all trials for all tests in the table below. Calculate the average length traveled for each test to place in the last row.

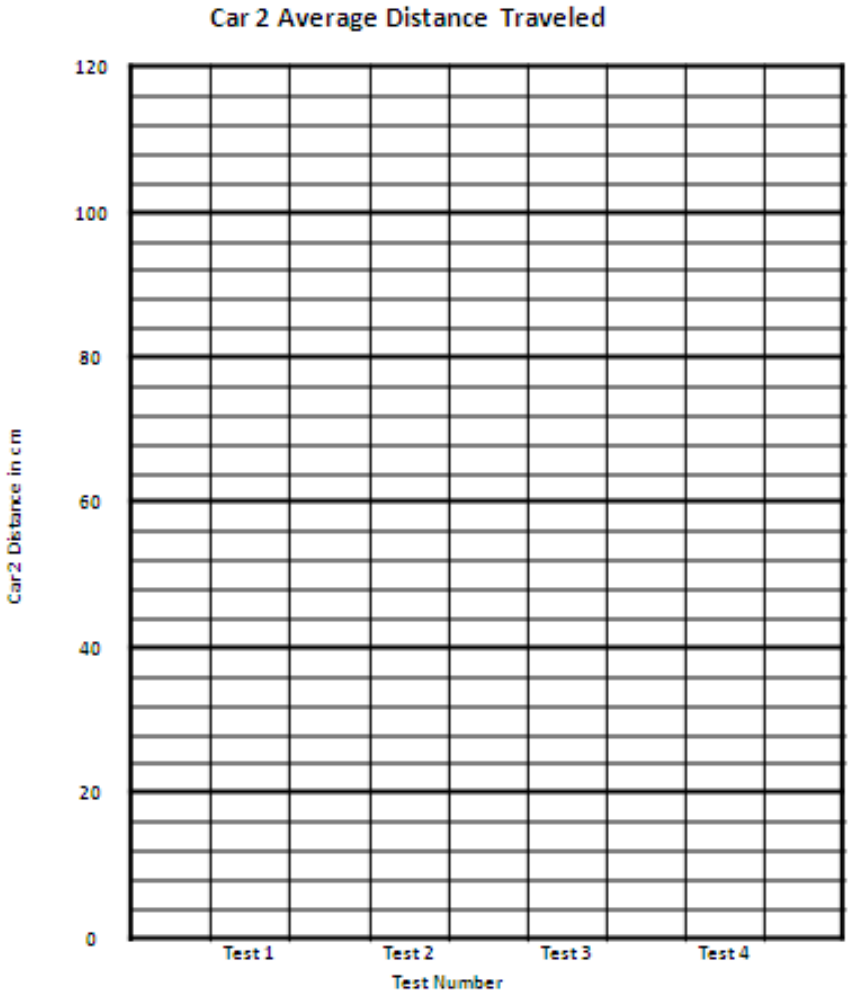
Table 1- ***Force and Mass Affecting Motion***

	20 cm Ramp - Distance Traveled of Car 2		**30 cm Ramp - Distance Traveled of Car 2**	
	Test 1	**Test 2**	**Test 3**	**Test 4**
Trials	Car 2	Car 2 + 20 grams	Car 2	Car 2 + 20 grams
1				
2				
3				
4				
5				
Average				

To find the average for all Trials (1, 2, 3, 4, and 5) together, get the sum. Then divide the sum by 5 to find the average.

Step Three - Graphing

Use the average of each test to make a bar graph of your data in the chart below. Be careful using the increments on the chart. Make sure you know the value of each gridline.



Step Four - Analyzing Data

Analyze the difference between Test 1 and Test 3. When the height of the ramp was raised, what effect did it have on Car 1? Did this increase or decrease the force applied to Car 2?

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Analyze the difference between Test 1 and Test 2 and the difference between Test 3 and Test 4. When the mass of Car 2 was raised, what effect did it have on how far it traveled?

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Other Conclusions- _____

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Step Two - Testing and Recording *(Mid and Low Group Worksheet)*

It's time for Demolition Derby. You will be crashing your cars several times to see what effect force and mass have on motion.

Predictions

Before each test, be sure to make a prediction of how far Car 2 will travel after Car 1 applies force to it. (The teacher needs to decide on possible choices for predictions.)

Tests 1 and 2

For the first two tests, set your ramp height at 20 cm. In Table 1 you will see in the second column you will need to add 20 grams to the mass of Car 2. The easiest way to do this is use tape to tape 20 grams onto your car. Make sure not to tape the wheels of the car or to add to its friction in any way. You will have to be very careful while adding mass to your car.

Record all the trials for all the tests in the table below. Calculate the average length traveled for each test to place in the last row.

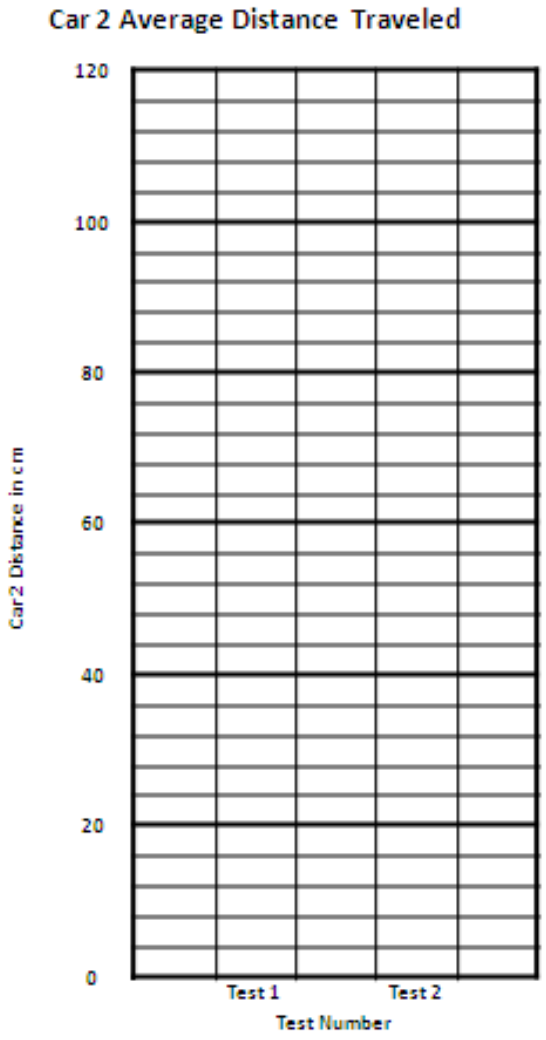
Table 1- *Force and Mass Affecting Motion*

	20 cm Ramp - Distance Traveled of Car 2	
	Test 1	Test 2
Trials	Car 2	Car 2 + 20 grams
1		
2		
3		
4		
5		
Average		

To find the average for all Trials (1, 2, 3, 4, and 5) together, get the sum. Then divide the sum by 5 to find the average.

Step Three - Graphing

Use the average of each test to make a bar graph of your data in the chart below. Be careful using the increments on the chart. Make sure you know the value of each gridline.



Step Four - Analyzing Data

Analyze the difference between Test 1 and Test 2 and the difference between Test 3 and Test 4. When the mass of Car 2 was raised, what effect did it have on how far it traveled?

_____

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_____

Other Conclusions- _____

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