

# Laws of Motion

Materials: Station 1

**Consumable**

none

**Nonconsumable**

1 large, heavy book

1 bear counter

1 toy truck

Materials: Station 2

**Consumable**

none

**Nonconsumable**

sealable plastic bag

sand

1 spring scale (250g/2.5N)

1 toy truck

Materials: Station 3

**Consumable**

none

**Nonconsumable**

sealable plastic bag

sand

2 similar toy trucks

Additional materials to set up the Stations

masking tape (Stations 1, 2, and 3)

metric ruler (Stations 1 and 3)

# How to Set Up

## Station 1

### Materials

- 1 toy truck
- 1 large, heavy book
- 1 bear counter
- metric ruler
- masking tape

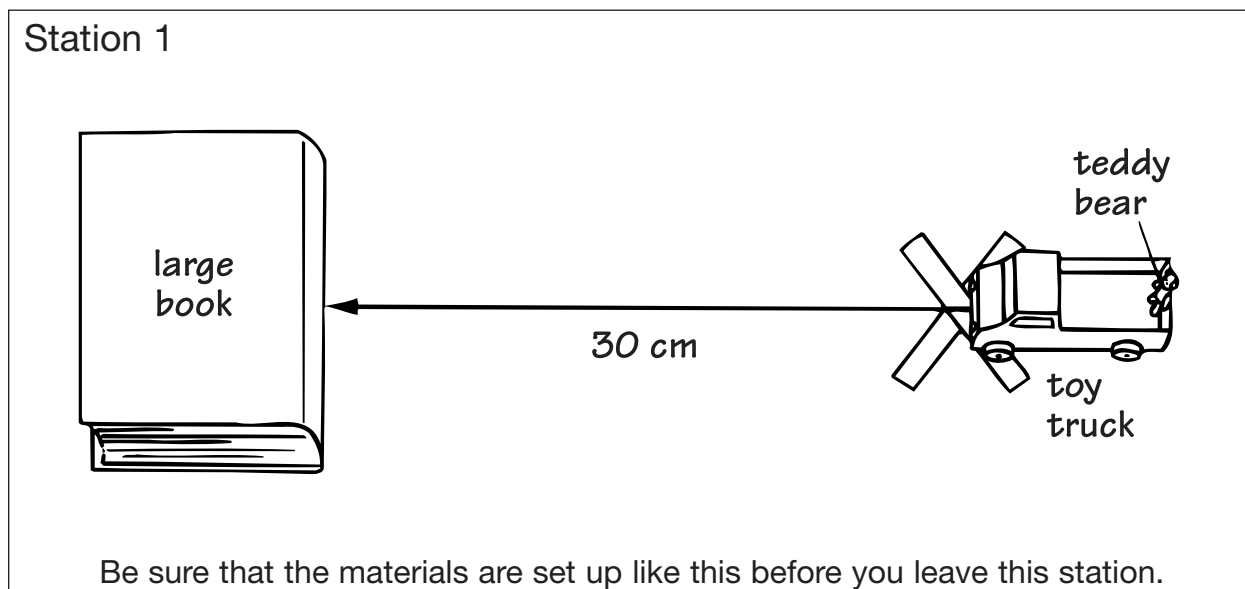
### Preparation

1. Because the book will be used as a crash barrier, it should be large and heavy. Place the book with its spine facing toward the truck.
2. Be sure that the bear “passenger” is placed upright in the rear of the truck bed.
3. Position the truck so that it is facing the spine of the book. A distance of 30 cm should separate the book and the truck.

### Helpful Information

- The truck will stop at the book and the bear will continue to move forward.
- This activity illustrates Newton’s first law of motion—an object in motion (the truck and the bear) remains in motion unless acted on by a force (the book).

### Setup



# How to Set Up

## Station 2

### Materials

- 1 toy truck
- 1 spring scale (250g/2.5N)
- sealable plastic bag
- sand
- masking tape

### Preparation

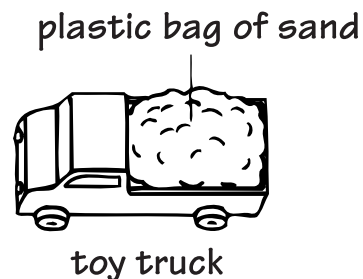
1. Place enough sand in the plastic bag to completely fill the bed of the truck. Remove all the air from the bag and seal it.
2. Fold the bag so that it will fit in the bed of the truck. Use masking tape to ensure that the bag stays folded.
3. Make certain the spring scale is properly calibrated.
4. For your own reference, perform the activity several times, recording the force needed for each trial.

### Helpful Information

- Students might find that it takes 0.05 N of force to move the empty truck and 0.15 N of force to move the full truck.
- This activity illustrates Newton's second law of motion—an object's acceleration depends on the mass of the object and the size and direction of the force acting on it.

### Setup

#### Station 2



Be sure that the materials are set up like this before you leave this station.

# How to Set Up

## Station 3

### Materials

- 2 toy trucks
- sealable plastic bag
- sand
- metric ruler
- masking tape

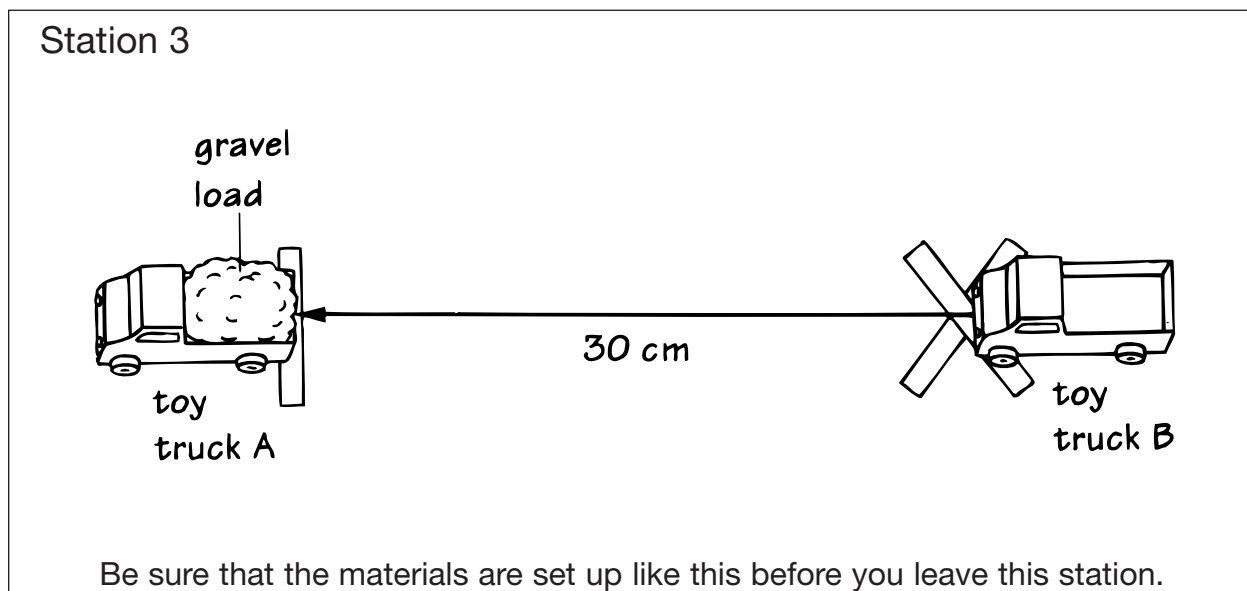
### Preparation

1. Place enough sand in the plastic bag to completely fill the bed of the truck. Remove all the air from the bag and seal it.
2. Fold the bag so that it will fit in the bed of the truck. Use masking tape to ensure that the bag stays folded.
3. Label the loaded truck “A” and mark a line with masking tape to indicate its position.
4. Label the empty truck “B” and position it at least 30 cm from the rear of truck A. Mark this location with a masking tape X.

### Helpful Hint

- This activity illustrates Newton’s third law of motion—when an object exerts a force upon a second object, the second object exerts an equal and opposite force upon the first object.

### Setup



# Evaluation Guide

## Station 1

### **Purpose**

To evaluate a student's ability to make careful observations of the motion of two objects.

### **Criteria**

3 points = Student records observations of the bear's motion as well as the truck's motion.

2 points = Student records observations of the bear's motion or the truck's motion.

1 point = Student does not record observations of either the bear's or the truck's motion.

## Station 2

### **Purpose**

To evaluate a student's ability to measure and compare the force needed to accelerate the truck.

### **Criteria**

3 points = Student accurately measures the force for the empty truck and the full truck.

2 points = Student accurately measures the force for the empty truck or the full truck.

1 point = Student is unable to measure the force needed to move either truck.

## Station 3

### **Purpose**

To evaluate a student's ability to make observations of two colliding trucks.

### **Criteria**

3 points = Student records two or more observations of the colliding trucks.

2 points = Student records one observation of the colliding trucks.

1 point = Student records no relevant observations of the colliding trucks.

# Data Analysis

## Purpose

To evaluate a student's ability to apply the data collected and knowledge of motion to a new situation.

Answers should reflect the ideas that during a crash or other sudden stop, an unrestrained object or person in a moving vehicle will continue to move forward, increasing the chance of injury.

## Criteria

- 3 points = Student describes the motion of the passenger in relation to the motion of the vehicle and relates the motion to Newton's Law(s).
- 2 points = Student describes the motion of the passenger in relation to the motion of the vehicle or relates the motion to Newton's Law(s).
- 1 point = Student does not describe the motion of the passenger in relation to the motion of the vehicle nor the relation of the motion to Newton's Law(s).

## Performance Activity Scoring Guide

| <b>Points</b> | <b>% equivalent</b> |
|---------------|---------------------|
| 12            | 100                 |
| 11            | 92                  |
| 10            | 83                  |
| 9             | 75                  |
| 8             | 67                  |
| 7             | 58                  |
| 6             | 50                  |
| 5             | 42                  |
| 4             | 33                  |
| 3             | 25                  |
| 2             | 16                  |
| 1             | 8                   |

*Imagine that you are a test crash engineer. Your assignment is to conduct tests on two toy trucks and report your observations.*

## My Data Collection

### Station 1

*Use the card at the station to correctly set up the equipment.*

#### Test 1

Apply a force to the rear of the truck so that the truck will quickly roll and crash into the book barrier. Observe what happens to the truck and to the bear when the truck hits the book barrier.

- Record your observations.

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### Station 2

*Use the card at the station to correctly set up the equipment.*

#### Test 2

Measure the force needed to accelerate the empty truck. Then measure the force needed to accelerate the full truck.

- Complete the chart.

| Load  | Force |
|-------|-------|
| Empty |       |
| Full  |       |

## Station 3

*Use the card at the station to correctly set up the equipment.*

### Test 3

Apply a force to empty truck B so that it will quickly roll and crash into the back of full truck A. Observe what happened to each truck.

- Record your observations.

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### My Data Analysis

You have now completed three toy truck tests. Use the data you've collected and what you know about motion to answer the following questions.

- Can an empty vehicle crash into a full vehicle and exert enough force to move a full vehicle? How do you know?

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- Why is it important to wear a safety belt when you travel in a moving vehicle? What observations support your answer?

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