611-1725 (45-010)
Gravity Investigations Kit

Quantity	Description
6	Graduated cylinders, plastic
6	Aluminum specimens
6	Brass specimens
6	Copper specimens
6	Steel specimens
6	PVC specimens
6	Graphite specimens
6	Metal cylinders w/hooks
6	Hanging rods (suction cups)
6	100G spring scales
6	Styrofoam peanuts
1	Spool of string

Exploring Density: Student Instructions, Journal Page,Teacher Edition
Exploring Weight: Student Instructions, Journal Page, Teacher Edition
Exploring Acceleration Due to Gravity: Student Instructions, Journal Page, Teacher Edition

Warranty and Parts:

We replace all defective or missing parts free of charge. Additional replacement parts may be ordered toll-free. We accept MasterCard, Visa, checks and School P.O.s. All products warranted to be free from defect for 90 days. Does not apply to accident, misuse or normal wear and tear. Intended for children 13 years of age and up. This item is not a toy. It may contain small parts that can be choking hazards. Adult supervision is required.

P/N 24-45010

Exploring Acceleration Due to Gravity

Objectives

- To experimentally determine acceleration due to gravity.

Materials

- Hanging rod
- Bob (metal cylinder with hook)
- String (110 cm)
- Stopwatch or watch with a second hand (not included)
- Meterstick (not included)

Background

Balance a pencil on the edge of your desk or tabletop. Push the end just enough for it to teeter on the edge and then push it just a little more. What happened? An attractive force—gravity—pulled the pencil to the floor. In fact, falling objects have fascinated scientists and mathematicians for thousands of years.

By the late 1600s, most people accepted that a force exerted by Earth caused objects to fall. Although they had the 'why,' early scientists did not really have the 'how.' Two thousand years earlier, Aristotle concluded that heavy objects fall faster than light objects. This belief stood until Galileo (1563-1642) reexamined the question of how things fell. After a series of clever experiments, he proved that objects fell at the same rate in spite of their differences in mass. Aristotle had been wrong all along! Not content to stop there, Galileo took it a step further. He also proved that falling objects did not fall at a constant rate. His results showed that objects gain speed—accelerate—as they fall.

There is a bit more to this idea of acceleration than increasing speed. **Acceleration** measures how *speed* and *direction* change with time. Acceleration is actually a two-way street. Of course, an object that speeds up is accelerating. However, an object that slows down is also accelerating! If you drop a bouncy ball out of a fourth story window, the speed of the ball continues increasing until it hits the ground. Because it is moving toward the ground and its speed changes during the entire trip, it is said to be accelerating. And then what happens? The ball hits the ground. It bounces away from Earth's surface moving very fast…at first. However, from the moment the ball begins moving away from the surface, gravity slows the speed of the ball. Because its speed changes during the time it is moving away from the surface, this is also acceleration. How does gravity affect an object's acceleration? Do the investigation to find out.

Procedure

1. Tie one end of the string to the hook on the bob.

2. Attach the hanging rod to a metal cabinet or locker at least 1.5 meters above the floor.

3. To make your pendulum, attach the string to the hanging rod. Measure the pendulum length as the distance from the end of the string at the hanging rod to the center of the bob. Adjust the length of string until this distance equals **1 meter**.

4. Practice pulling the bob back about 30 degrees from the perpendicular position and letting it drop. The pendulum should swing freely without bumping into the locker.

5. With your partner timing, drop the bob and time how long it takes for the bob to complete 10 swing cycles. The bob completes a swing cycle when it returns to the starting position.

6. Record the time it took to complete 10 swing cycles in your table on your Journal Page.

7. Use the equation shown below to calculate and record the period of the pendulum for trial number 1.

$$\frac{\textit{Time (s)}}{\textit{Number of Complete Swing Cycles}} = \textit{Period}$$

8. Repeat steps 5 through 7 for the remaining trials recording your results on your Journal Page.

9. Calculate average length, time, and period. Record your averages.

10. Calculate the acceleration of gravity (***g***) using the equation shown below. Use your averaged calculations for length of pendulum (***l***) and period (***T***). **Hint**: Don't forget to square the values indicated in the equation. Record your calculation on your Journal Page.

$$\frac{4\pi^2 l}{T^2} = \textit{Acceleration of Gravity (g)}$$

11. Complete the questions on your Journal Page.

Name ______________________ Date ______________________

Class ______________________

Exploring Acceleration Due To Gravity

Journal Page

Trial	Pendulum Length (l)	Number of Complete Swing Cycles	Time(s)	Period (T) (time/number of complete swing cycles)
1	1.0m	10		
2	1.0m	10		
3	1.0m	10		
4	1.0m	10		
Average				

Experimental Results

Acceleration Due to Gravity (g) = ______________________

____Think It Over

1. The standard value of acceleration due to gravity (g) is 9.8 m/s^2 or 980 cm/sec^2.
   How does the acceleration due to gravity (g) that you determined compare to the standard value?

   ____

   ____

2. Use the equation below to calculate how far off your experimental results were from the standard value.

$$\frac{g_{(student)} - g_{(standard)}}{g_{(standard)}} \times 100\% = \%\ Error$$

   What was your percent error? List three (3) factors that could have impacted your experimental results. In other words, what could have introduced error into your experiment?

   ____

   ____

3. Acceleration is a measure of how speed and direction change with time. Describe the acceleration of the bob through one complete swing cycle.

   ____

   ____

Challenge

1. Does pendulum length affect the acceleration due to gravity? Write your prediction in a complete sentence.

   ____

   ____

2. Design an experiment to test your prediction.

3. Perform your experiment.

4. Conclusion : ____

   ____

   ____

Exploring Density

Objectives

- To measure mass and volume of several material samples.
- To calculate density of each material sample.
- To identify material samples using student data.

Materials

- Graduated cylinder
- Material sample set
- Balance (not included)
- Water (not included)
- Paper towels (not included)

Background

Throw a baseball as hard as you can in any direction and what always happens? As long as it doesn't get stuck in a tree or lost on a roof, the baseball always lands on the ground. The force that pulls the baseball to the ground is the same force of attraction that keeps most objects, including you, firmly on the ground.

Gravity is a force of attraction between things that have mass. Remember, **mass** is a measure of how much matter an object contains. A pencil, desk, you, Earth, Moon, Sun, and stars are all made up of matter and therefore, all have mass. That means you are attracted to Earth and Earth is attracted to you. Similarly, a baseball falls to the ground because of the attraction between Earth and the baseball. However, the force of attraction between Earth and you and Earth and the baseball is not the same. In fact, the strength of the gravitational attraction between objects depends, in part, on the sizes of their masses. Gravitational force increases as the sizes of the masses increase.

Density is the amount of matter within a specific volume. Which has a higher density, a sandwich bag full of rice or a sandwich bag full of sand? The bags hold equal volumes of material but not equal amounts of matter. You can fit many, many more grains of sand into a sandwich bag than you can fit grains of rice. How do you determine the density of a substance when the particles are too small to count? Do the investigation to find out.

Procedure

1. Observe each material sample. Record your observations in the data table on your Journal Page.

2. Measure the mass of each sample. Record your measurements in your data table.

3. Add six milliliters or more of water to the graduated cylinder. Remember, one cubic centimeter (cc) or (cm^3) is the same as one milliliter (mL). For the purpose of calculating the density of a solid, use cubic centimeter (cm^3). Record water volume on a sheet of scrap paper. This is your *starting volume*.

4. Carefully slide Material Sample #1 into the graduated cylinder. Tap the graduated cylinder to remove air bubbles. Record the new water volume on your scrap paper. This is your *ending volume*.
5. Use the equation shown below to calculate the volume of material sample #1. Record your calculation in your data table.

Ending Volume – Starting Volume = ***Volume of Material Sample***

6. Repeat steps 3-6 calculating and recording volumes of each remaining sample.

7. Use the equation shown below to calculate the density of material sample #1.

$$\frac{\textit{Mass of Sample (g)}}{\textit{Volume of Sample (cm}^3\textit{)}} = \textit{Density of Sample (g/ cm}^3\textit{)}$$

8. To identify each sample, compare your results to the known densities of common materials shown in the table below. Record your identifications in your data table.

Copper	brown-reddish color, shiny, smooth	8.9
Brass	yellow color, shiny, smooth	8.0
Steel	gray/silver color, rough	7.6
Aluminum	silver color, shiny, smooth	2.7
Glass	clear, solid	2.3
Graphite	gray color, rough, marks paper	2.2
Vinyl Plastic	gray color, smooth, dull	1.4
Water	clear, liquid	1.0

9. Complete the questions on your Journal Page.

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Exploring Density

Journal Page

Sample	Observations	Mass of Sample (g)	Volume of Sample (cm^3)	Density of Sample (g/cm^3)	Sample Name
1					
2					
3					
4					
5					
6					

Think It Over

1. Explain how your steel and aluminum samples are alike. How are they different? Use evidence from your investigation to support your answer.

2. Several material samples have the same shape and volume but vary widely in mass. How is this possible?

3. Gravity is a force of attraction between things that have mass. Which of your material samples exerts the greatest force on Earth's surface? Explain your answer.

Challenge

Obtain a cup and a mystery sample from your teacher. Fill a cup half full with water. Drop the mystery sample in water and observe what happens.

1. What can you infer about the density of your mystery sample? Use evidence from your investigation and the chart in your student instructions to support your answer.

2. Most rivers, ponds, and lakes never freeze solid during the winter. Ice forms at the surface of these bodies of water. What can you infer about the density of water, a liquid, compared to the density of ice, a solid? Explain your answer.

Exploring Weight

Objectives

- To observe the effect of gravity acting on matter producing weight.
- To observe the effect of buoyancy on the apparent weight of an object.
- To deduce the relationship between density of a fluid and buoyancy.

Materials

- Foam peanut
- Spring scale
- Metal cylinder with hook
- String
- Large cup or beaker (not included)
- Water (not included)
- Corn syrup (not included)

Background

Fill a cup or beaker with water. Place the foam peanut in the beaker. What happens? Using one finger, slowly push the peanut below the water's surface. What do you feel? Carefully drop the metal cylinder into the water. What happened? Why did the two materials behave differently?

The quick answer is that these materials behaved differently because they have different weights. Weight is a *product* of gravity acting on mass. The metal cylinder feels heavier than the foam peanut because the metal cylinder contains more matter for gravity to act on. The metal cylinder has a higher density than the foam peanut. That brings up **Newton's Third Law of Motion –** for every action there is an equal and opposite reaction. Now you may be thinking, "What does Newton have to do with this weight business?" Earth exerts a gravitational force on an object such as you and you exert an equal and opposite force back on the Earth. This force is weight. **Weight** is the force of gravity acting on the mass of something. In the English system of measurement, this force is measured in **pounds**. But this is science, right? And in science, all measurements are metric measurements. Therefore, force exerted by an object on Earth's surface is measured in **newtons (N)**.

Does gravity and weight explain why the metal sinks and foam peanuts float? Not completely. Gravity acts on the mass of the metal cylinder and the mass of the foam peanut AND the mass of the water! All three substances have weight. Push the foam peanut below the water's surface and you feel a force pushing back or lifting the peanut towards the surface. The lifting force exerted by a fluid—in this case the fluid is water—back on the peanut is called **buoyancy**. You know that placing a solid in water *displaces* or pushes out of the way a volume of water equal to the volume of the solid. This volume of water is displaced vertically. You know this because placing the metal cylinder in water causes the water level in the container to rise. Like the solid, this displaced volume or parcel of water is acted on by gravity. The parcel of water has weight. The weight of the parcel of water as it is displaced vertically provides the lifting or buoyant force.

Procedure

1. Tie one end of a string to the hook on the metal cylinder.

2. Make a loop on the other end of the string. Attach the loop to the hook of the spring scale. Measure the weight of the metal cylinder suspended in mid-air. Record the weight in newtons on your Journal Page.

3. Fill a large beaker with water. Using the spring scale, submerge and suspend the metal cylinder completely in water. Do not allow the cylinder to touch the bottom or sides of the container. Record the weight of the metal cylinder in water on your Journal Page.

4. Dry the metal cylinder.

5. Fill a large beaker with corn syrup. Using the spring scale, submerge and suspend the metal cylinder completely in corn syrup. Do not allow the cylinder to touch the bottom or sides of the container. Record the weight of the metal cylinder.

6. Complete the questions on your Journal Page.

Name ______________________ Date ______________________

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Exploring Weight

Journal Page

Observations

Weight of metal cylinder in air (*N*) = ______________________

Weight of metal cylinder in water (*N*) = ______________________

Weight of metal cylinder in corn syrup (*N*) = ______________________

Think It Over

1. Air, water, and corn syrup are all fluids, substances that flow. How did submerging the cylinder in these fluids affect the *actual* weight of the cylinder? How did it affect the *apparent* weight of the object?

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2. Use the equation shown below to calculate the buoyant force exerted by each fluid.

$$\textit{Weight of Object(N)}_{(air)} - \textit{Weight of Object(N)}_{(liquid)} = \textit{Buoyant Force of Fluid(N)}$$

Buoyant force of water = ______________________

Buoyant force of corn syrup = ______________________

3. How does the buoyant force exerted by each fluid compare to the weight of the metal cylinder? Use data from your investigation to explain your answer.

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4. Why do you think the cylinder appeared to lose more weight when suspended in corn syrup than in water?

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5. What do you think would happen if the buoyant force of the fluid were greater than the weight of the object? Explain your answer.

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The table shows several common materials and their densities including substances used in this investigation.

Common Materials	**Physical State**	**Density (g/cm^3)**
Air	Gas	0.0
Copper	Solid	8.9
Corn oil	Liquid	0.9
Corn syrup	Liquid	1.4
Glycerine	Liquid	1.3
Foam peanut	Solid	0.05
Water	Liquid	1.0
Wood	Solid	0.8

6. How does density of a fluid affect buoyancy? Use evidence from your investigation to explain your answer.

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7. Saltwater is different from fresh water. Salt water contains higher amounts of dissolved minerals. How do you think the buoyancy of saltwater compares to the buoyancy of fresh water? Explain your answer.

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