Tinkering with Tops

Lesson Focus

In this lesson, students build spinning tops out of everyday materials. Their challenge is to design a spinning top that can spin for at least 10 seconds within a circle 30 cm in diameter.

Lesson Synopsis

The "Tinkering with Tops" lesson explores the history, design and motion of spinning tops. Students work in teams of "engineers" to design and build their own tops out of everyday items. They test their tops, evaluate their results, and present to the class.

Age Levels

8-18

Objectives

During this lesson, students will:

- Design and build a spinning top
- Test and refine their designs
- Communicate their design process and results

Anticipated Learner Outcomes

As a result of this lesson students will have:

- Designed and built a spinning top
- Tested and refined their designs
- Communicated their design process and results

Lesson Activities

Students work in teams to design and build their own spinning top out of everyday materials. Their top must be able to spin for at least 10 seconds within an area 30 cm in diameter. Student teams review their own designs, the designs of other teams, and present their findings to the class.

Resources/Materials

- Teacher Resource Documents (attached)
- Student Worksheets (attached)
- Student Resource Sheets (attached)

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Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- TryEngineering (www.tryengineering.org)
- Wikipedia Gyroscopic Effect (https://en.wikipedia.org/wiki/Gyroscope)
- Spinning Top & Yo-Yo Museum (http://www.topmuseum.org/)

Recommended Reading

- Tops: Making the Universal Toy (ISBN: 978-1933502175)
- The Top-Universal Toy, Enduring Pastime (ISBN: 978-0517504161)
- The Little Book of Tops: Tricks, Lore, and More/Book and Top (ISBN 978-1561383108)

Optional Writing Activity

- Write a paragraph or essay describing how engineering is applied in the toy industry.

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For Teachers: Teacher Resource

Lesson Goal

The goal of this lesson is for students to design their own spinning top that can spin for at least 10 seconds within a circle 30 cm in diameter. Student teams design their spinning tops out of everyday materials and then test their designs. Students then evaluate the effectiveness of their spinning tops and those of other teams, and present their findings to the class.

Lesson Objectives

During this lesson students will:

- Design and build a spinning top
- Test and refine their designs
- Communicate their design process and results

Materials

One set of materials for each group of students:

- sharpened pencils
- pens
- toothpicks
- cds
- coffee stirrers
- marbles
- paper plates
- plastic lids
- pennies
- metal washers
- tape
- string
- clay
- scissors
- stopwatches
- ruler

Procedure

1. Show students the various Student Reference Sheets. These may be read in class, or provided as reading material for the prior night's homework. Have students visit Wikipedia Gyroscopic Effect (https://en.wikipedia.org/wiki/Gyroscope) to learn about gyroscopes.
2. Divide students into groups of 2-3 students, providing a set of materials per group.
3. Explain that students must develop a spinning top from everyday items. The top needs to spin for at least 10 seconds within a circle that is 30 cm in diameter. Students can mark this area with tape or string on the floor. The top that can spin the longest within the circle is the winner.
4. Students meet and develop a plan for their spinning top. They agree on materials they will need, write or draw their plan, and then present their plan to the class.
5. Student teams may also trade unlimited materials with other teams to develop their ideal parts list.
6. Student groups next execute their plans. They may need to rethink their plan, request other materials, trade with other teams, or start over.
7. Next….teams will test their spinning tops. Their object is to design a spinning top that can spin for at least 10 seconds within a 30 cm circle.
8. Teams then complete an evaluation/reflection worksheet, and present findings.

Time Needed

One to two 45 minute class periods

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Student Resource: All about Tops

◆ History of the Top

Tops have been in existence for thousands of years. The first top was most likely a rock or acorn spun by a child. Tops have been used for entertainment, gambling, or even spiritual purposes. Tops have been discovered throughout history all over the world. Clay tops have been found dating back to 3500 BC in the Middle East. Wooden tops found in Egypt are believed to date back to 2000 – 1400 BC. Tops have been found in Greece from as early as 500 BC. In Rome, tops made of bone dating from 27 BC have been discovered.

◆ Anatomy of a Top

A top is made up of four basic elements, the tip or point, the shoulder, the crown and the body. The top spins on its tip or point. At the opposite end of the top is what is known as the crown. The crown is sometimes used to spin the top using one's fingers. Below the crown is what is known as the shoulder. Between the shoulder and the point is the body of the top. Tops can be made out of all different kinds of materials such as clay, wood, ceramic, or plastic.

◆ Types of Tops

There are many different varieties of tops.

Twirling top - A twirling top is spun by manually twisting the crown. A dreidel is a common example of a twirling top.


Twirling top

Supported top – A top which is spun with a string while the top is held upright by a support.

Whip top - A whip top is set into motion and kept spinning by whipping it with a whip.


Throwing top

Throwing top - A throwing top has a string wrapped around its body which is attached to a stick. When the top is thrown causing the string to be rapidly released from its body, the top spins.

Pump top - A pump top has a crown that is pushed down or pumped several times to create the spin.


Pump top

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Student Worksheet: Design a Spinning Top

You are a team of engineers who have been given the challenge to design a spinning top out of everyday items. The top needs to be able to spin for at least 10 seconds within a circle that is 30 cm in diameter. The top that can spin the longest in the circle is the winner.

◆ Planning Stage
Meet as a team and discuss the problem you need to solve. Then develop and agree on a design for your spinning top. You'll need to determine what materials you want to use.

Draw your design in the box below, and be sure to indicate the description and number of parts you plan to use. Present your design to the class.

Design:

Materials Needed:

You may choose to revise your teams' plan after you receive feedback from class.

◆ Construction Phase
Build your top. Tips: You may want to experiment with different quantities of weights and the placement of those weights, as well as the distance between the body of the top and the point. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

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Student Worksheet: Design a Spinning Top (continued)

◆ Testing Phase
Each team will test their top. You'll need to time your test to make sure your top can spin for at least 10 seconds within a circle that is 30 cm in diameter. Be sure to watch the tests of the other teams and observe how their different designs worked.

	Time Spun within 30 cm Circle	Total Time Spun
Test 1		
Test 2		
Test 3		
Test 4		
Average		

◆ Evaluation Phase
Evaluate your teams' results, complete the evaluation worksheet, and present your findings to the class.

Use this worksheet to evaluate your team's results in the Tinkering with Tops lesson:

1. Did you succeed in creating a top that spun for at least 10 seconds within the 30 cm circle? If so, what was the maximum time it spun? If not, why did it fail?

2. Did you decide to revise your original design or request additional materials while in the construction phase? Why?

3. Did you negotiate any material trades with other teams? How did that process work for you?

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Student Worksheet:
Design a Spinning Top (continued)

4. If you could have had access to materials that were different than those provided, what would your team have requested? Why?

5. Do you think that engineers have to adapt their original plans during the construction of systems or products? Why might they?

6. If you had to do it all over again, how would your planned design change? Why?

7. What designs or methods did you see other teams try that you thought worked well?

8. Do you think you would have been able to complete this project easier if you were working alone? Explain…

9. Can you devise a way to calculate the number of rotations your top made in 10 seconds? If so how?

10. Why do you think the spinning top has been such a universal toy?

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For Teachers: Alignment to Curriculum Frameworks

Note: Lesson plans in this series are aligned to one or more of the following sets of standards:

- U.S. Science Education Standards (http://www.nap.edu/catalog.php?record_id=4962)
- U.S. Next Generation Science Standards (http://www.nextgenscience.org/)
- International Technology Education Association's Standards for Technological Literacy (http://www.iteea.org/TAA/PDFs/xstnd.pdf)
- U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics (http://www.nctm.org/standards/content.aspx?id=16909)
- U.S. Common Core State Standards for Mathematics (http://www.corestandards.org/Math)
- Computer Science Teachers Association K-12 Computer Science Standards (http://csta.acm.org/Curriculum/sub/K12Standards.html)

◆**National Science Education Standards Grades K-4 (ages 4 - 9)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of the activities, all students should develop an understanding of

- Properties of objects and materials

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Science as a human endeavor

◆**National Science Education Standards Grades 5-8 (ages 10 - 14)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop an understanding of

- Motions and forces

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- History of science

◆**National Science Education Standards Grades 9-12 (ages 14-18)**

CONTENT STANDARD A: Science as Inquiry

As a result of activities, all students should develop

- Abilities necessary to do scientific inquiry

CONTENT STANDARD B: Physical Science

As a result of their activities, all students should develop understanding of

- Motions and forces

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

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For Teachers: Alignment to Curriculum Frameworks

◆National Science Education Standards Grades 9-12 (ages 14-18)

CONTENT STANDARD F: Science in Personal and Social Perspectives

As a result of activities, all students should develop understanding of

- Science and technology in local, national, and global challenges

CONTENT STANDARD G: History and Nature of Science

As a result of activities, all students should develop understanding of

- Historical perspectives

◆Next Generation Science Standards Grades 2-5 (Ages 7-11)

Matter and its Interactions

- 2-PS1-2. Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

- 3-PS2-1. Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

Engineering Design

Students who demonstrate understanding can:

- 3-5-ETS1-1.Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2.Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

◆Next Generation Science Standards Grades 6-8 (Ages 11-14)

Engineering Design

Students who demonstrate understanding can:

- MS-ETS1-2 Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

◆Principles and Standards for School Mathematics (ages 11 - 14)

Measurement Standard

-Apply appropriate techniques, tools, and formulas to determine measurements.

- solve simple problems involving rates and derived measurements for such attributes as velocity and density.

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For Teachers: Alignment to Curriculum Frameworks

◆Principles and Standards for School Mathematics (ages 14 - 18)

Measurement Standard

- Apply appropriate techniques, tools, and formulas to determine measurements.
  - analyze precision, accuracy, and approximate error in measurement situations.

◆ Common Core State Standards for School Mathematics Grades 3-8 (ages 8-14)

Measurement and data

- Measure and estimate lengths in standard units.
  - CCSS.Math.Content.2.MD.A.1 Measure the length of an object by selecting and using appropriate tools such as rulers, yardsticks, meter sticks, and measuring tapes.
  - CCSS.Math.Content.2.MD.A.3 Estimate lengths using units of inches, feet, centimeters, and meters.

◆Standards for Technological Literacy - All Ages

Design

- Standard 8: Students will develop an understanding of the attributes of design.
- Standard 9: Students will develop an understanding of engineering design.
- Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

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