

*Geometry of the Karakuri box*

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| **Introduction** | |
| Japanese karakuri boxes from the Edo period are intricate, meticulous, and innovative. Mathematical precision is essential for the mechanisms of these trick boxes to work. This lesson can be taught in a geometry lesson to calculate the surface, area, volume, of many different two- and three-dimensional objects. The karakuri boxes illustrate that math is often used in way that may at first seem hidden, but as students design their own trick boxes, they will see the necessity and potential of math in the real world. This cross-curricular lesson will help students to see math all around them. | |
| **Indiana Standards Connections:**    G.TS.4. Solve real-world and other mathematical problems involving volume and surface area of prisms, cylinders, cones, spheres, and pyramids, including problems that involve composite solids and algebraic expressions.  G.TS.5 Apply geometric methods to create and solve design problems. (E)  8.GM.2 Solve real-world and other mathematical problems involving volume of cones, spheres, and pyramids and surface area of spheres. (E)  7.GM.3  Solve real-world and other mathematical problems involving volume of cylinders and three-dimensional objects composed of right rectangular prisms. (E) | **Compelling Question(s):**    How can we use geometry skills to solve real world problems?  How is math used in the design of toys and everyday objects? |
| **Lesson Objectives:**    Students will be able to:  Calculate volume of a variety of three-dimensional objects  Use geometry to design a karakuri box | |
| **Materials** | |
| 1. Projection Device  2. Videos of Karakuri boxes in use: <https://www.youtube.com/watch?v=V9ecL8yFwuI&t=56s>  3. Either pictures with dimensions OR sample karakuri boxes  4. Drawing supplies for students.    **For extension:**  <https://www.youtube.com/watch?v=8EbberPJy8I>  <https://www.youtube.com/watch?v=8EbberPJy8I>  These two videos can make the design process for students more intricate and complex, depending on the grade level or mastery of your students. | |
| **Learning Plan** | |
| **Activities**  This activity will help students to learn principles of geometry within a historical context. Students will see the real-world applications of math and precision in real-world goods.  1. Watch the video demonstrating the karakuri boxes. Talk about the history of the artifact with your students, using information from the Windows to the World project.  2. Model using geometry to solve equations for a karakuri box  The educator can decide how intricate to make this process based on the level of their students. Perhaps you will want them to account for the indentation needed for the parts of the box to slide. Perhaps they can solve for the depression in the top of the cylindrical cup. Model for students how to creatively find formulas and solutions of how to calculate the volume of these objects.  3. Provide students with paper and drawing materials for them to design their own karakuri box with a small group. Students can practice using measurements and formulas to solve the area, volume, and algebraic expressions for this object.  4. Discuss with students what they are noticing, what problems they are running into. As a class, brainstorm ways to work through these questions. | |
| **Assessment Suggestions**       The design and work of their own karakuri box | |
| **Extensions**    This assignment could be built out to a bigger project to have students work with 3D printing technology to design an object to be produced.    Watching these videos can help your students to see the level of precision required for this type of design:  <https://www.youtube.com/watch?v=8EbberPJy8I>  <https://www.youtube.com/watch?v=8EbberPJy8I> | |

**Art**

**Visual Arts – Presenting:**

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| VA:Cn11.1.6 | *(a) Analyze how art reflects changing times, traditions, resources, and cultural uses.* |
| VA:Cn11.1.7 | *Analyze how response to art is influenced by understanding the time and place in which it was created, the available resources, and cultural uses.* |

*Art can be practical and functional; it is more than just a painting or sculpture. Understanding everyday objects as creations of art can reveal important values of a culture and society. What does the art of the karakuri box demonstrate about art as entertainment?*

*Allow students to examine several different games as examples of art. Notice what materials are used, what are the fundamental features and uses of the objects. Consider what color, shape, mobility, material, and utility reveal about a culture.*

**Economics**

**Supply and demand**

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| E.2.2 | *Recognize that consumers ultimately determine what is produced in a market economy* |
| E.2.3 | *Illustrate how supply and demand determine equilibrium price and quantity.* |

*The intricacy of craft and quality of materials influences the price of karakuri boxes sold today. Examining costs of different toys and games based on their demand, quality, craft, design, and intricacy can help students to think about supply and demand.*

*An investigation into game production and costs can reveal what consumers desire and how the market fulfills those desires.*