

Unit 1: Design and Problem Solving (11 Weeks)

Content Area: **STEM**
Course(s):
Time Period: **Full Year**
Length: **11 Weeks**
Status: **Published**

UNIT RATIONALE

In this unit, students will learn and apply an engineering design process to collaboratively design a carnival game. As part of the design process, they will practice the art of brainstorming and begin to develop skills in graphically representing ideas through concept sketching. They will develop and test a solution and improve the design through iteration. In addition, they will apply statistical techniques to evaluate design solutions and apply those techniques to inform design decisions related to your game design. They will use isometric and orthographic technical sketching as a means to model and communicate ideas, designs, and problem solutions. Students will develop basic 3D solid models of simple designs and produce technical drawings using CAD. Students will learn the importance of precision measurement. They will use dial calipers to make precise measurements as they come to understand the concepts of precision and accuracy and their implication on engineering design and manufacturing. Students will apply statistics to quantify the precision and accuracy of measurements and of measuring tools. Students will individually apply the design process and the skills and knowledge gained in this unit to evaluate and improve the design of a consumer product to meet stakeholder needs. Students will learn effective presentation techniques and present their solutions to an audience.

ESSENTIAL QUESTIONS

1. What are the steps of the engineering design process and how can they be used to solve problems?
2. How can we evaluate data to determine the precision and accuracy of our solutions?
3. How can we model effectively through concept sketching?
4. How can we model effectively through technically drawing isometric pictorials?
5. How can we model effectively through technically drawing orthographic projections?
6. How do we properly dimension Multiview drawings?
7. How can we model effectively through CAD design?
8. How can we appropriately measure objects to appropriate levels of accuracy and precision?
9. How can we appropriately document design intent using detailed views and title blocks?

STANDARDS

New Jersey Student Learning Standards: 21st Century

CRP.K-12.CRP2.1	Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation.
CRP.K-12.CRP5.1	Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact and/or mitigate negative impact on other people, organization, and the environment. They are aware of and utilize new technologies, understandings, procedures, materials, and regulations affecting the nature of their work as it relates to the impact on the social condition, the environment and the profitability of the organization.
CRP.K-12.CRP11.1	Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks-personal and organizational-of technology applications, and they take actions to prevent or mitigate these risks.
CRP.K-12.CRP12.1	Career-ready individuals positively contribute to every team, whether formal or informal. They apply an awareness of cultural difference to avoid barriers to productive and positive interaction. They find ways to increase the engagement and contribution of all team members. They plan and facilitate effective team meetings.

NEW JERSEY STUDENT LEARNING STANDARDS: Technology

New Jersey Core Curriculum - Grade 9 - Technology

8.1.12.A.4

Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.

8.1.12.D.1

Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.

8.2.12.C.5

Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.

TECH.8.1.12.A.4	Construct a spreadsheet workbook with multiple worksheets, rename tabs to reflect the data on the worksheet, and use mathematical or logical functions, charts and data from all worksheets to convey the results.
TECH.8.1.12.D.1	Demonstrate appropriate application of copyright, fair use and/or Creative Commons to an original work.
TECH.8.2.12.C.5	Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.

NEW JERSEY STUDENT LEARNING STANDARDS: CAREER READINESS, LIFE LITERACIES AND KEY SKILLS

TECH.9.4.12.CI.1	Demonstrate the ability to reflect, analyze, and use creative skills and ideas (e.g., 1.1.12prof.CR3a).
TECH.9.4.12.CI.2	Identify career pathways that highlight personal talents, skills, and abilities (e.g., 1.4.12prof.CR2b, 2.2.12.LF.8).
TECH.9.4.12.CI.3	Investigate new challenges and opportunities for personal growth, advancement, and transition (e.g., 2.1.12.PGD.1).

NEW JERSEY STUDENT LEARNING STANDARDS: COMPUTER SCIENCE AND DESIGN THINKING

CS.9-12.8.1.12.DA.6	Create and refine computational models to better represent the relationships among different elements of data collected from a phenomenon or process.
CS.9-12.8.2.12.ED.1	Use research to design and create a product or system that addresses a problem and make modifications based on input from potential consumers.
CS.9-12.8.2.12.ED.2	Create scaled engineering drawings for a new product or system and make modification to increase optimization based on feedback.

PRE-ASSESSMENTS

Catapult design using given materials and measuring out mass using a gram scale and rice.

INSTRUCTIONAL PLAN

MODULE 1

LESSON 1.1

Activity 1.1.1

Activity 1.1.1: Design as a Process: Students will apply the engineering design process to design and build a device to launch a small beanbag and send it as far as possible. They are then to test their devices and represent their data using box plots.

<p>Student Learning Intentions (SLI) WALT: (We are learning to...)</p>	<ul style="list-style-type: none"> - Work in small groups and communicate. - Define Design Process - Sketch - Use a digital scale properly - Identify Criteria and Constraints - Develop Solutions using given materials
<p>Student Learning Strategies</p>	<p>Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Game</p>
<p>Success Criteria</p>	<ul style="list-style-type: none"> - Properly weighted bags of rice - Ability to throw a bag using designed device
<p>Formative Assessment (drives instructional decisions)</p>	<ul style="list-style-type: none"> - Measured Distance - Box Plot
<p>Activities and Resources</p>	<ul style="list-style-type: none"> - See Above
<p>Suggested Modifications</p>	<p>English Language Learners Adjusted Speech: The teacher changes speech patterns to increase student comprehension. This could include facing the students, paraphrasing, clearly indicating the most important ideas, and speaking more slowly.</p> <p>Visuals: The teacher uses graphics, pictures, visuals, and manipulatives. This helps ELL students better understand and comprehend the subjects at hand.</p> <p>Front-Loading Vocabulary: The teacher front loads vocabulary. This means providing students with a list of important vocabulary words they will need to know for a book, lesson, etc. prior to the lesson being taught. Including pictures to go with the vocabulary words is also very beneficial for the students.</p> <p>Students with Individualized Education Plans/504s Chunking: The teacher presents information in a way that makes it easy for students to understand and remember. Chunking is based on the presumption that our working memory is easily overloaded by excessive detail. The best way to deliver information is to organize it into meaningful units. Because students with special needs get overloaded easily, chunking is an effective strategy to use with them.</p> <p>Checking for Understanding: It is important to constantly check for understanding, especially for students who have accommodations. Teachers want to make sure students understand the concepts being covered in a way that makes</p>

sense to them.

Extra time: The teacher provides students with special needs extra time to complete work or answer questions. It is important to give students enough time to process their thoughts.

Oral Reading: The teacher will read work orally to students. Class work such as tests and literature circles may need to be read aloud to the student.

Gifted & Talented Strategies

Extensions/Enrichments: Teachers will provide gifted and talented students with extension/enrichment projects. Students will be challenged to further their understanding, to apply acquired knowledge, and/or to produce something in reference to acquired knowledge.

Modify/Change Activities: Teachers will monitor and modify activities to accommodate those students who need to be challenged further. Additional reading, problem-solving, writing, or project work is necessary for those students who are ready to move on at a rate more accelerated than their peers. In this way G & T students are provided the same opportunity for support as special needs students.

Students at Risk of School Failure

Directions or Instructions: Make sure directions and/or instructions are given in limited numbers. Give directions/instructions verbally and in simple written format. Ask students to repeat the instructions or directions to ensure understanding occurs. Check back with the student to ensure he/she hasn't forgotten.

Peer Support: Peers can help build confidence in other student by assisting in peer learning. Many teachers use the 'ask 3 before me' approach. This is fine, however, a student at risk may have to have a specific student or two to ask. Set this up for the student so he/she knows who to ask for clarification before going to you.

Alternate or Modified Assignments: Always ask yourself, "How can I modify this assignment to ensure the students at risk are able to complete it?" Sometimes you'll simplify the task, reduce the length of the assignment or allow for a different mode of delivery. For instance, many students may hand something in the at-risk student may jot notes and give you the information verbally. Or, it just may be that you will need to assign an alternate assignment.

Increase One to One Time: When other students are working, always touch base with your students at risk and find out if they're on track or needing some additional support. A few minutes here and there will go a long way to intervene as the need presents itself.

Contracts: It helps to have a working contract between you and your students at risk. This helps prioritize the tasks that need to be done and ensure completion happens. Each day write down what needs to be completed, as the tasks are done, provide a checkmark or happy face. The goal of using contracts is to eventually have the student come to you for completion sign-offs

Hands On: As much as possible, think in concrete terms and provide hands-on tasks. This means a child doing math may require a calculator or counters. The child may need to tape record comprehension activities instead of writing them. A child may have to listen to a story being read instead of reading it

	<p>him/herself.</p> <p>Tests/Assessments: Tests can be done orally if need be. Break tests down in smaller increments by having a portion of the test in the morning, another portion after lunch and the final part the next day.</p> <p>Seating: Seat students near a helping peer or with quick access to the teacher. Those with hearing or sight issues need to be close to the instruction which often means near the front.</p>
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Activity 1.1.2

Activity 1.1.2: Iterate and Redesign: Students will iterate and redesign their designs based on new criteria decided on by the class. They will then use summary statistics to determine the success of their solutions and make predictions about device performance.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Definition of Redesign - Work in small groups and communicate. - Infer and analyze from recorded information - predict outcomes
Student Learning Strategies	<p>Journaling</p> <p>Collaboration</p> <p>Cooperative Learning</p> <p>APB Approach (Activities, Projects, Problems)</p> <p>Class Discussions</p> <p>Game</p>
Success Criteria	<ul style="list-style-type: none"> - Excel Sheet with Properly Formatted Data - Farther and more consistent throw
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none"> - Distance Prediction
Activities and Resources	<ul style="list-style-type: none"> - See Above
Suggested Modifications	<p>See Activity 1.1.1</p>

Activity 1.1.3

Activity 1.1.3: Concept Sketching: Students will develop realistic concept sketches to effectively document design ideas. They will then give and receive feedback to influence personal and professional development.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Properly sketch and add labels- Communicate Ideas- Receive and deliver criticism- Create a Google Form
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Game
Success Criteria	<ul style="list-style-type: none">- Labeled Sketch- Google Form Responses
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none">- Analysis of feedback
Activities and Resources	<ul style="list-style-type: none">- See above
Suggested Modifications	See Activity 1.1.1

Activity 1.1.4

Activity 1.1.4: Targeting Success Using Data: Students will collect, represent and evaluate the accuracy and precision of their solutions. They will then iterate their design, with new criteria regarding the accuracy and precision of their device.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Define and determine differences in Accuracy and Precision
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	- Increase design success according to testing results
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Game
Success Criteria	- Accuracy Precision Charts - Increased Accuracy and Precision
Formative Assessment (drives instructional decisions)	- Re-Designed Thrower
Activities and Resources	- See above
Suggested Modifications	See Activity 1.1.1

Activity 1.1.5

Activity 1.1.5: Design a Game: Students will apply everything they learned in lesson 1 to design a carnival game that meets specified criteria and constraints

Student Learning Intentions (SLI) WALT: (We are learning to...)	- Apply rules and goals to a game - Use Tools
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Game
Success Criteria	- Carnival Game
Formative Assessment (drives instructional	- Game and Rules

decisions)	
Activities and Resources	See above.
Suggested Modifications	See Activity 1.1.1

LESSON 1.2

Activity 1.2.1

Activity 1.2.1: Isometric Sketching: Students will create isometric views of simple objects at a given scale given the actual object or a pictorial representation of the object. Students will then give and receive feedback on their drawings to improve performance.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Define Orthographic and Isometric - Properly sketch and dimension Isometric Views
Student Learning Strategies	<ul style="list-style-type: none"> Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	<ul style="list-style-type: none"> - Properly formatted Sketch - Sketch properly dimensioned
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none"> - Isometric Sketch of Given Block
Activities and Resources	<ul style="list-style-type: none"> - See Above
Suggested Modifications	See Activity 1.1.1

Activity 1.2.2

Activity: 1.2.2: Solid Modeling: Students will use a combination of additive and subtractive modeling methods to create 3D computer models to represent provided objects and design ideas.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Define CAD- Create login for OnShape- Identify parts and navigate the OnShape Screen- Create properly dimensioned sketches- Properly use the Extrude tool
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	<ul style="list-style-type: none">- Able to log into OnShape- 3D Document
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none">- Properly designed Block in 3D
Activities and Resources	<ul style="list-style-type: none">- See Above
Suggested Modifications	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: auto;">See Activity 1.1.1</div>

Activity 1.2.3

Activity 1.2.3: Multiview Drawings: Students will create multi-view drawings of objects by hand, with proper line conventions. Students will then create multi-view drawings of objects on CAD.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Define Engineering Drawings - Relate Multiview Drawings to Isometric - Identify Top, Front, and Side of Object
Student Learning Strategies	<ul style="list-style-type: none"> Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	<ul style="list-style-type: none"> - Properly formatted Drawing
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none"> - Engineering Drawing of Selected Part
Activities and Resources	<ul style="list-style-type: none"> - See Above
Suggested Modifications	<p>See Activity 1.1.1</p>

Activity 1.2.4

Activity 1.2.4: Fundamentals of Dimensioning: Students will apply proper dimensioning techniques to multi-view drawings, both by hand and using CAD. Students will then get and receive feedback on their dimensioning to improve performance.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Using a Ruler - identifying correct dimensional units - Using Dimension Tool - changing/inputting units in OnShape
Student Learning Strategies	<ul style="list-style-type: none"> Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	<ul style="list-style-type: none"> - Choosing Correct Dimensions

	- Accurately Measuring
Formative Assessment (drives instructional decisions)	- Recreation of Chosen Part in 3D
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Activity 1.2.5

Activity 1.2.5: Sketches, Extrusions and Revolutions, Oh My!: Students will begin to learn more complicated CAD tools, such as the use of parameters, revolve, fillet and chamfer.

Student Learning Intentions (SLI) WALT: (We are learning to...)	- Define and use: <ul style="list-style-type: none"> - Constraints - Revolve - Fillet - Chamfer
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Adaptations of previous activity design
Formative Assessment (drives instructional decisions)	- 3D file of chosen object
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Activity 1.2.6

Activity 1.2.6: Charmed, I'm Sure: Students will interview a partner and then design and model a charm based on their partner's interests and specifications. They will create isometric and multi-view technical drawings, as well as create a part file and multi-view drawing on CAD.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Listen to clients- Create drawings in CAD from 3D parts
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Print
Success Criteria	<ul style="list-style-type: none">- Charm Design- CAD Drawing
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none">- CAD Drawing
Activities and Resources	<ul style="list-style-type: none">- See above.
Suggested Modifications	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: auto;">See Activity 1.1.1</div>

LESSON 1.3

Activity 1.3.7

Activity 1.3.7: Design a Protective Case: Students will design and model a protective case for earbuds using identified criteria and constraints. Students will review detailed multi-view drawings of competing models to inform their decision making.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Define Top Down Design - Define Assembly - Insert Parts - Mate Parts
Student Learning Strategies	<p>Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Print</p>
Success Criteria	<ul style="list-style-type: none"> - Properly Mated Assembly
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none"> - 3D File of earbud case
Activities and Resources	<ul style="list-style-type: none"> - See Above
Suggested Modifications	<p>See Activity 1.1.1</p>

Activity 1.3.6

Activity 1.3.6: I Section That!: Students will use CAD to understand and create section views of objects.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Define Section View - Create and place Section Views
Student Learning Strategies	<p>Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Game</p>

Success Criteria	- Proper section view of given 3D file
Formative Assessment (drives instructional decisions)	- 3D File
Activities and Resources	- See Above.
Suggested Modifications	See Activity 1.1.1

Activity 1.3.5

Activity 1.3.5: Documenting a Design: Students will identify necessary/appropriate views to fully detail a part or assembly, including potentially detail views. Students will include title blocks, dimensions and notes into their CAD drawings.

Student Learning Intentions (SLI) WALT: (We are learning to...)	- Adding information to CAD Drawing File
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Cad Drawing File properly formatted
Formative Assessment (drives instructional decisions)	- CAD Drawing File
Activities and Resources	- See Above.
Suggested Modifications	See Activity 1.1.1

Activity 1.3.4

Activity 1.3.4: CAD Modeling Skills: Students will continue to learn more complicated CAD tools, such as loft, tapered extrusions, patterns, shell, measure, project geometry and emboss and engrave.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none">- Defining and Using:<ul style="list-style-type: none">- Loft- Taper- Pattern- Shell- sketch projections- Emboss and Engrave- Text Tool- Use Tool- Making Selections
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- 3D File with each tool represented
Formative Assessment (drives instructional decisions)	- Modified Charm from previous activity
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Activity 1.3.3

Activity 1.3.3: Constraining a Sketch: Students will apply geometric constraints to their CAD models to make them neater and more efficient.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Identify types of common constraints - Deleting/Removing/Editing Constraints
Student Learning Strategies	<p>Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions</p>
Success Criteria	<ul style="list-style-type: none"> - Constraining an incorrect sketch
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none"> - 3D File of Sketches
Activities and Resources	<ul style="list-style-type: none"> - See Above
Suggested Modifications	<p>See Activity 1.1.1</p>

Activity 1.3.2

Activity 1.3.2: Making Holes in CAD: Students will model different hole types and sizes using CAD.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Define Tolerance - Define and Identify Fit Types - Using Hole Tool - Determine when to use Hole tool or not
Student Learning Strategies	<p>Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Demonstration</p>
Success Criteria	<ul style="list-style-type: none"> - 3D file with properly sized holes with tolerances
Formative Assessment (drives instructional	<ul style="list-style-type: none"> - Re-Creation of holes and placement on 3D trammel

decisions)	toy block
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Activity 1.3.1

Activity 1.3.1: Measure It!: Students will measure objects with the appropriate measuring device to increase both the accuracy and precision of the measurement.

Student Learning Intentions (SLI) WALT: (We are learning to...)	<ul style="list-style-type: none"> - Identify Parts of Dial Caliper - Properly Use Dial Caliper
Student Learning Strategies	<ul style="list-style-type: none"> Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Game
Success Criteria	<ul style="list-style-type: none"> - Working with thousandths of an inch - Using a Dial Caliper Properly
Formative Assessment (drives instructional decisions)	<ul style="list-style-type: none"> - Properly Measured Item
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

LESSON 1.4

Activity 1.4.1: Sweet Improvement: Students will design and model an improvement to bakery

packaging.

Student Learning Intentions (SLI) WALT: (We are learning to...)	- Combine CAD Skills
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Using all tools at disposal
Formative Assessment (drives instructional decisions)	- 3D File and Drawings properly formatted according to given information.
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

REFLECTIONS

INTERDISCIPLINARY CONNECTIONS: NEW JERSEY STUDENT LEARNING STANDARDS FOR ELA, SOCIAL STUDIES, SCIENCE AND/OR MATHEMATICS

CCSS.Math.Content.HSS-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).
CCSS.Math.Content.HSF-IF.B.4	For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship.
CCSS.Math.Content.HSN-Q.A.2	Define appropriate quantities for the purpose of descriptive modeling.
CCSS.Math.Content.HSN-Q.A.3	Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
CCSS.Math.Content.HSG-MG.A.1	Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).

