Theme

"Drawing is vision on paper."- Andrew Loomis

STEM Innovation Academy Unit 1

Subject: Introduction to Engineering Design Unit Title: Design and Problem Solving Grade: 9th	Teacher: Mrs. Allison Braizer-Martin Duration: 9 weeks; September - November

Summary of Unit

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.

Stage 1 – Essential Questions

Standards/Outcomes:

New Jersey Student Learning Standards for English Language Arts

AS.W.4 - Writing
Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

SL.1 - Speaking and Listening Initiate and participate effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grades 9–10 topics, texts, and issues

AS.L.6 - Language
Acquire and use accurately a range of general academic and domain-specific words and phrases sufficient for reading, writing, speaking, and listening at the college and career readiness level; demonstrate independence in gathering vocabulary knowledge when considering a word or phrase important to comprehension or expression.

Science and Engineering Practice - Developing and Using Models

Develop and/or use a model (including mathematical and computational) to generate data to support explanations, predict phenomena, analyze systems, and/or solve problems.

New Jersey Student Learning Standards for Mathematics

N.Q.1 - Quantities
Use units as a way to understand problems and to guide the solution of multistep problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.

N.Q.2 - Quantities
Define appropriate quantities for the purpose of descriptive modeling.

N.Q.3 - Quantities
Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

G.MG.1 - Modeling with Geometry
Use geometric shapes, their measures, and their properties to describe objects (e.g., modeling a tree trunk or a human torso as a cylinder).

S.ID.1 - Interpreting Categorical and Quantitative Data
Represent data with plots on the real number line (dot plots, histograms, and box plots).

G.GMD.3 - Geometric Measurement and Dimension
Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.

S.ID.4 - Interpreting Categorical and Quantitative Data
Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

2020 New Jersey Student Learning Standards – Career Readiness, Life Literacies, and Key Skills

9.4.12.CI.1: Demonstrate the ability to reflect, analyze, and use creative skills and ideas

9.4.12.CI.2: Identify career pathways that highlight personal talents, skills, and abilities

9.4.12.CI.3: Investigate new challenges and opportunities for personal growth, advancement, and transition

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?

Enduring Understandings: *Students will understand that…*

- The design process is applied to creatively solve problems.
- Collaboration is necessary to contribute to the efforts of a team to develop ideas.
- Practicing the art of brainstorming and spatial visualization will develop skills in graphically representing ideas through concept sketching and isometric sketching.
- Models are developed to represent a design idea.
- Using hand sketches, isometric views of a simple object or part at a given scale using the actual object, a detailed verbal description of the object, Orthographic projections of objects effectively communicates design intent.
- Giving and receiving effective feedback influences personal and professional development.
- As part of a design process, you develop conceptual models, graphical models, computer models, and physical models.
- Skills in producing basic 3D solid modeling of simple designs and technical drawings using CAD are gained.
- Applying an iterative design process, including developing appropriate models and/or simulations, creatively addresses a need or solve a problem.
- Creating technical drawings using 3D computer-aided design (CAD) software documents a design according to standard engineering practices.
- Demonstrating independent thinking and self-direction leads to accomplishing a goal.
- To communicate effectively with an audience is based on the characteristics of the intended audience.

Stage 2 – Assessment Evidence

Formative, Summative and Authentic Assessments:

- Design Process
- Bean Bag Toss Project
- Engineering Notebook Documentation
- Unit Conversion and Dimensional Analysis
- Descriptive Statistics: Mean, Median, Mode, Range
- Problem-solving Scenarios
- Technical Drawings
- Precision and Accuracy
- Measuring with a Dial Caliper
- Modelling of 3D Objects with CAD software
- Charmed Project
- Sweet Improvement Project
- Quizzes and Tests
- Unit Test

Presentations:

- Students will formally present all design challenge work through their engineering notebook documentation
- Students will orally present their solution to their projects and problem-solving scenarios as if they were pitching their idea to their client

Performance Task(s):

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.

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.

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.

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.

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.

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.

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.

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.

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.

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.

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

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

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.

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.

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

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

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.

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.

Problem 1.4.1: Sweet Improvement: Students will design and model an improvement to bakery packaging.

National Hispanic Heritage Month: September 15th - October 15th

1) Design a Poster or Travel Brochure

Let's get our passport ready! Students will take part in Virtual Trips to different Hispanic Countries. Students will watch videos on the different Hispanic countries and design a poster or travel brochure. Poster will include historical information and pictures of food, culture, musical instruments, national flag, clothing, historical artifacts, tourist attractions etc. Students will also include 1 thing that stood out to them about their visit to that country or that they liked most about the country.

2) Hispanic Influencers/Contributors in STEM and Engineering

Students will research different Hispanic Influencers and Contributors in the STEM and Engineering field. In this activity students will use the researched information to write a short autobiography on their chosen person. Students will share their autobiographies in class.

3) Trivia

Students will take part in a Hispanic History/Culture trivia game. Students will be placed in groups. Each group will take turns asking questions. Points will be given for each correct answer. Points gained during activity will be used as extra credit.

4) Design a Ponce Mask

Students will take part in a virtual visit of The National Museum of American History and explore the Hispanic Heritage artifacts, specifically the Puerto Rican Ponce Mask. Students will design and make their own Ponce mask.

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<tr>
<td>Extensions (Tier I):
More Design Challenges to foster mastery.
More Complicated objects to draw and model on CAD
Additional criteria and/or constraints in design challenges
Career Profiles- Give students insight into what jobs in certain engineering careers would look like through PLTW provided career profiles
CAD Challenges will be provided to challenge students who are excelling
Office Hour Appointments</td>
<td>Differentiation (Tier II):
Group work will allow high-tier students to support low-tier students in design challenges
Open-ended design challenges will allow students to create solutions that are appropriate for their design and modeling skills
Peer Tutoring
One on one discussions
Office Hour Appointments
Differentiation Tier (III):
CAD Tutorial Videos will be provided to aid in student’s mastery.
Provide students with Frame worksheet to scaffold design challenges https://drive.google.com/file/d/1nP_ZMx_E5YzeiXBqXmU79Fow9xSnpJze/view?usp=sharing
Peer Tutoring
One on one discussions
Office Hour Appointments</td>
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<tr><td colspan="2">Stage 3 – Learning Plan</td></tr>
<tr><td colspan="2">Project Lead the Way (PLTW)

Introduction to Engineering Design Digital Textbook (password required): https://pltw.read.inkling.com/a/b/c9ddcf5dc84f4dca98e9dda94d41c727/p/c0fc8676465f4e15bd4602a84390092b

The IED Digital Textbook linked above includes informational text, videos procedures, project requirements, presentations, and technical drawings used in the design of the learning tasks described in the stage 2 section of this unit plan.</td></tr>
<tr><td colspan="2">Vocabulary</td></tr>
<tr><td colspan="2">Accuracy / Additive Modeling / Annotation / Blind Hole / Bottom-Up Modeling / Box Plot / Brainstorming / Cabinet Oblique / Calibrate / Cavalier Oblique / Center Line / Collaboration / Computer Aided Design / Concept Sketch / Constraint / Construction Line / Conversion Factor / Criteria / Decision Matrix / Deliverable / Design Brief / Design Process /Design Statement / Detail View / Dial Caliper /Dot Plot / Empirical Rule / Hidden Line / Histogram / Inter quartile range / Isometric / Iterative / Mean / Measure of center / Measure of spread / Median / Mode / Model / Multi-view Drawing / Normal Distribution / Object line / Oblique Sketch / Orthographic Projection / Outlier / Perspective Sketch / Pictorial Sketch / Piling On / Precision / Problem Solving / Problem Statement / Proportion / Range / Scale / Sectional view / Section Lines / Standard Deviation / Subtractive Modeling / Through Hole / Title Block / Top Down Modeling / Validate/ Variation</td></tr>
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Expert/Field Experience(s)

- Field Trips: Architectural Company/Drafting and Design Company
- Potential Guest Speakers: CAD Drafter, Architect, Bakery owner

Literacy Connections/Research

- Students will incorporate research into their design work for their Sweet Improvement Project, to learn about bakery packaging
- Interesting Engineering articles will give students the opportunity to read about technical engineering advancements and make decisions regarding its ethical implications, which can then be discussed and debated as a class

Special Education/ 504:	**English Language Learners:**
-Adhere to all modifications and health concerns stated in each IEP. -Give students a MENU options, allowing students to pick assignments from different levels based on difficulty. -Accommodate Instructional Strategies: reading aloud text, graphic organizers, one-on-one instruction, class website (Google Classroom), handouts, definition list with visuals, extended time -Allow students to demonstrate understanding of a problem by drawing the picture of the answer and then explaining the reasoning orally and/or writing , such as Read-Draw-Write -Provide breaks between tasks, use positive reinforcement, use proximity -Assure students have experiences that are on the Concrete- Pictorial- Abstract spectrum by using manipulatives -Implement supports for students with disabilities (click here) - Make use of strategies imbedded within lessons -Common Core Approach to Differentiate Instruction: Students with Disabilities (pg 17-18)	- Use manipulatives to promote conceptual understanding and enhance vocabulary usage - Provide graphic representations, gestures, drawings, equations, realia, and pictures during all segments of instruction - During i-Ready lessons, click on “Español” to hear specific words in Spanish - Utilize graphic organizers which are concrete, pictorial ways of constructing knowledge and organizing information - Use sentence frames and questioning strategies so that students will explain their thinking/ process of how to solve word problems - Utilize program translations (if available) for L1/ L2 students - Reword questions in simpler language - Make use of the ELL Mathematical Language Routines (click here for additional information) -Scaffolding instruction for ELL Learners -Common Core Approach to Differentiate Instruction: Students with Disabilities (pg 16-17)
Gifted and Talented:	**Students at Risk for Failure:**
- Elevated contextual complexity - Inquiry based or open ended assignments and projects - More time to study concepts with greater depth - Promote the synthesis of concepts and making real world connections - Provide students with enrichment practice that are imbedded in the curriculum such as:	- Assure students have experiences that are on the Concrete- Pictorial- Abstract spectrum - Modify Instructional Strategies, reading aloud text, graphic organizers, one-on-one instruction, class website (Google Classroom), inclusion of more visuals and manipulatives, Peer Support - Constant parental/ guardian contact

● Application / Conceptual Development ● Are you ready for more? - Provide opportunities for math competitions - Alternative instruction pathways available - Common Core Approach to Differentiate Instruction: Students with Disabilities (pg. 20)	- Provide academic contracts to students & guardians - Create an interactive notebook with samples, key vocabulary words, student goals/ objectives. - Plan to address students at risk in your learning tasks, instructions, and directions. Anticipate where the needs will be, then address them prior to lessons. -Common Core Approach to Differentiate Instruction: Students with Disabilities (pg 19)

21st Century Life and Career Skills:

Career Ready Practices describe the career-ready skills that all educators in all content areas should seek to develop in their students. They are practices that have been linked to increase college, career, and life success. Career Ready Practices should be taught and reinforced in all career exploration and preparation programs with increasingly higher levels of complexity and expectation as a student advances through a program of study.

https://www.state.nj.us/education/cccs/2014/career/9.pdf

● CRP1. Act as a responsible and contributing citizen and employee. ● CRP2. Apply appropriate academic and technical skills. ● CRP3. Attend to personal health and financial well-being. ● CRP4. Communicate clearly and effectively and with reason. ● CRP5. Consider the environmental, social and economic impacts of decisions. ● CRP6. Demonstrate creativity and innovation.	● CRP7. Employ valid and reliable research strategies. ● CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. ● CRP9. Model integrity, ethical leadership and effective management. ● CRP10. Plan education and career paths aligned to personal goals. ● CRP11. Use technology to enhance productivity. ● CRP12. Work productively in teams while using cultural global competence.

Students are given an opportunity to communicate with peers effectively, clearly, and with the use of technical language. They are encouraged to reason through experiences that promote critical thinking and emphasize the importance of perseverance. Students are exposed to various mediums of technology, such as digital learning, calculators, and educational websites.

Technology Standards:
All students will be prepared to meet the challenge of a dynamic global society in which they participate, contribute, achieve, and flourish through universal access to people, information, and ideas.
https://www.state.nj.us/education/cccs/2014/tech/

8.1 Educational Technology: All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge. A. Technology Operations and Concepts: Students demonstrate a sound understanding of technology concepts, systems and operations. B. Creativity and Innovation: Students demonstrate creative thinking, construct knowledge and develop innovative products and process using C. technology.Communication and Collaboration: Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. D. Digital Citizenship: Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. E. Research and Information Fluency: Students apply digital tools to gather, evaluate, and use of information. F. Critical thinking, problem solving, and decision making: Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources.	Technology Education, Engineering, Design, and Computational Thinking - Programming: All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment. A. The Nature of Technology: Creativity and Innovation- Technology systems impact every aspect of the world in which we live. B. Technology and Society: Knowledge and understanding of human, cultural, and societal values are fundamental when designing technological systems and products in the global society. C. Design: The design process is a systematic approach to solving problems. D. Abilities in a Technological World: The designed world in a product of a design process that provides the means to convert resources into products and systems. E. Computational Thinking: Programming- Computational thinking builds and enhances problem solving, allowing students to move beyond using knowledge to creating knowledge.