Unit 1: Mechanical Design

Content Area: **STEM**
Course(s):
Time Period: **Full Year**
Length: **10 Weeks**
Status: **Published**

Unit 1: Mechanical Design (10 Weeks)

Unit Rationale

In Unit 1, students explore the foundational elements that make up complex mechanical devices and systems. They work collaboratively to solve real-world problems using their understanding of mechanical designs and motion to develop complex mechanisms. Students end the unit by working collaboratively and applying their knowledge to solve a real-world agricultural problem. Students gain understanding of mechanical engineering concepts such as simple machines, energy, work, power, and mechanisms and apply them to solve engineering problems. Students continue to apply their project management, collaboration, communication, and additional key transportable skills throughout the unit. They continue to explore future career opportunities by conducting a professional interview of a professional of their choice.

Essential Questions

1.1 - 1 How do engineers quantify the mechanical advantage of a system?

1.1 - 2 How do engineers apply their knowledge of simple machines to solve problems?

1.1 - 3 How do engineers quantify energy, work, and power?

1.1 - 4 How do engineers apply their knowledge of energy, work, and power to solve problems?

1.2 - 1 How are mechanisms used to convert one type of motion to another?

1.2 - 2 How do engineers manipulate motion to solve design problems?

1.3 - 1 How can you apply your understanding of machines and mechanisms to solve an authentic problem?

Pre-Assessments

Shoe Design from Activity 0.1

Instructional Plan

MODULE 1

LESSON 1.1

Simple and Compound Machines In Lesson 1.1 students explore simple machines, where they are found, how they are used, and why they are the foundation of mechanical devices. They will explore the fundamentals of energy, work, and power then apply their understanding to maximize efficiency and power. Students then investigate the factors that impact pulley systems, how to maximize the efficiency of pulleys, and design their own pulley system in a simulation. Students discover the benefits and drawbacks of different gears and gear trains as well as how to optimize speed or torque through gear ratios. Finally, students use force and acceleration sensors as well as their understanding of simple machines to design a robot that can pull with the greatest force.

Activity 1.1.1

Over-Easy Engineering: In this challenge, students will create an expandable grabbing tool to help retrieve a small item from a hard-to-reach place on a farm.

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Apply a design process to creatively solve a problem. • Develop, test, and evaluate a potential solution to verify it meets constraints and criteria. • Contribute to the efforts of a team.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Properly able to retrieve designated object - Designated object not damaged beyond tolerance
Formative Assessment (drives instructional decisions)	- Design Sketch - Mass measurements
Activities and Resources	- See Above

Activity 1.1.2

What's Simple About a Combine?: In this activity, students will learn how the combine harvester uses several simple machines to complete its tasks. You also learn how to calculate the mechanical advantage of each simple machine. To expand your understanding, you end the activity using your VEX® V5 POE Kit to create some simple machines used in the combine harvester.

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Identify six types of simple machines. • Calculate mechanical advantage. • Replicate simple machines using VEX® components.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Excel Sheet with Properly Formatted Data - Lifting of Masses
Formative Assessment (drives instructional decisions)	- MA Calculations
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

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Student Learning Strategies	Journaling Collaboration Cooperative Learning

	APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Excel Sheet with Properly Formatted Data - Lifting of Masses
Formative Assessment (drives instructional decisions)	- MA Calculations
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Activity 1.1.4

Powerful Pulleys: Students will use a simulated pulley tool to explore how pulleys can be used to increase mechanical advantage and decrease the amount of effort force needed to lift objects.

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Design and validate a pulley system using CAD software. • Investigate the factors that impact a pulley system. • Understand the benefits and drawbacks of pulley systems.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Properly working 3D Pulley System - Lifting of given mass
Formative Assessment (drives instructional decisions)	- 3D File - MA Calculation Proof
Activities and Resources	- See above
Suggested Modifications	See Activity 1.1.1

Activity 1.1.5

Top Gear: In this activity, students will explore how gears are used to optimize either speed or torque. You'll

construct both simple drive trains, as well as more complicated assemblies. Ultimately, you will make a small vehicle. Your goal is to make the slowest car possible. Start your engines!

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Design, construct, and solve for simple and compound gear trains. • Apply knowledge of gears and gear ratios to design gear trains to optimize speed or torque.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Game
Success Criteria	- Working Gear Train
Formative Assessment (drives instructional decisions)	- Calculated Gear Ratio matches Output
Activities and Resources	See above.
Suggested Modifications	See Activity 1.1.1

Activity 1.1.6

Maximizing Power: In this activity, Students will learn how to take the measurements of a motor. You will also create characteristic curves that you can use to select a motor that delivers maximum power or maximum efficiency for a given task.

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Take measurements of motors. • Create and interpret characteristic curves that provide data on maximum power and efficiency.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems)

	Class Discussions
Success Criteria	- Moving Robot - Properly setup rig for recording
Formative Assessment (drives instructional decisions)	- Data set from digital recorders
Activities and Resources	See above.
Suggested Modifications	See Activity 1.1.1

Activity 1.1.7

Tug-Of-War: In this project, students will apply engineering knowledge using your VEX® V5 POE Kit to design a machine that can pull with as much force as possible.

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Design and construct a prototype to solve an engineering design challenge. • Conduct quantitative tests to inform iteration throughout an engineering design challenge. • Differentiate between accuracy and precision in measurement. • Apply knowledge of mass, friction, and gearing to an engineering design problem.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions Game
Success Criteria	- Properly designed robot - hard point for hitch receiver
Formative Assessment (drives instructional decisions)	- Competition Results
Activities and Resources	See above.
Suggested Modifications	See Activity 1.1.1

LESSON 1.2

Mechanisms Students begin Lesson 1.2 by examining the four types of motion as well as their application in different mechanical devices. They apply their understanding of motion by designing and building a latch mechanism to fix a broken door. Students continue their understanding of motion by creating a variety of different mechanisms and explore how they convert one type of motion to another. The lesson ends with a motion conversion challenge where students work collaboratively to design, build, and test individual segments of a machine and combine their machines to make a large-scale device to solve a problem.

Activity 1.2.1

A-door-able Hens: Now that you know a little bit about the types of motion, it is time to design and build a simple latch mechanism to help keep the chickens safe.

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Differentiate between the four types of motion. • Identify input and output motion of everyday household devices. • Design a simple device that takes advantage of motion types.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Properly formatted Sketch - Sketch properly dimensioned and annotated
Formative Assessment (drives instructional decisions)	- Isometric Sketch of Device
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Activity 1.2.2

Converting Types of Motion: In this activity, students explore how mechanisms are used to convert between different types of motion.

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Apply your knowledge of simple machines to create complex mechanisms. • Understand how mechanisms are used to convert from one type of motion to another type of motion. • Create a physical prototype of a mechanism that converts one type of motion to another type of motion.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- 2 different types of motion - Working Button
Formative Assessment (drives instructional decisions)	- Mechanism results matches predictions of range
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Activity 1.2.3

Motion Conversion: In this project, students use their knowledge of simple machines and mechanisms to create a Rube Goldberg device with their classmates.

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Apply knowledge of simple machines and mechanisms to design, build, and test a solution that follows challenge criteria.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions

Success Criteria	- Device can integrate with driver and driven devices
Formative Assessment (drives instructional decisions)	- Last device in line activated by driver
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

LESSON 1.3

Agricultural Solutions In this unit problem, students apply their understanding of simple machines, compound machines, mechanisms, and motion to choose a real-world agricultural problem then design, test, and build a compound machine that solves the identified problem. They then pitch their solution to a team of potential investors in an informative and persuasive presentation.

Activity 1.3.1

Fix Fran's Farm: The goal of this project is to give students an opportunity to apply the knowledge and skills they developed in previous activities and projects. Through the context of developing a solution for one of the problems described in Fran's journal, students use their knowledge of key concepts in mechanical engineering to produce a working prototype.

Student Learning Intentions (SLI) WALT: (We are learning to…)	• Apply knowledge of mechanical design, simple machines, and mechanisms to an agricultural design context.
Student Learning Strategies	Journaling Collaboration Cooperative Learning APB Approach (Activities, Projects, Problems) Class Discussions
Success Criteria	- Assembled and working prototype - individually designed Python code
Formative Assessment (drives instructional decisions)	- Prototype successfully satisfies given scenario
Activities and Resources	- See Above
Suggested Modifications	See Activity 1.1.1

Modifications and/or Accommodations

Suggested Modifications (ELL, Sp. Ed, GIfted, At-risk of Failure)

English Language Learners

Native language support: The teacher provides auditory or written content to students in their native language.

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.

Visuals: The teacher uses graphics, pictures, visuals, and manipulatives. This helps ELL students better understand and comprehend the subjects at hand.

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.

Special Education Students

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.

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 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.

Timers: The teacher will use timers as an instructional tool. The use of timers is beneficial for students who have trouble completing tasks. Timers can be helpful so the student is aware of how much time they have to complete an assignment.

Students with 504 Plans

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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 students 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 him/herself.

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.

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.

Integration of Diversity, Equity and Inclusion, Climate Change, Informational and Media Literacy

New Jersey Student Learning Standards: Content Area

New Jersey Core Curriculum - Grade 10 - 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.

Integration of 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).

Integration of 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.

Interdisciplinary Connections: NJSLS for ELA, Social Studies, Science and/or Math

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.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).
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.HSS-ID.A.1	Represent data with plots on the real number line (dot plots, histograms, and box plots).

21st Century Life and Career

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.