## Course Title:
Exemplary Engineering

## Length:
One Quarter
Grade 6

## Primary Content:
Gifted & Talented

## School:
Pierrepont

## Embedded Content:
English Language Arts, Math, Science, Visual and Performing Arts, Career Readiness, Life Literacies and Key Skills

## Initial BOE Approval Date (Born on):
June 24, 2024

**RUTHERFORD PUBLIC SCHOOLS**
**Rutherford, New Jersey**

**GIFTED AND TALENTED DEPARTMENT**

**EXEMPLARY ENGINEERING - GRADE 6**

## 1. Introduction/Overview/Philosophy

Engineering design is a vehicle for the integration of science, technology, engineering and mathematics (STEM) into classroom settings, as well as an outlet for creative problem solving and design-thinking. Engineering actively engages students through design-based projects while deepening their understanding of fundamental concepts; improves student learning through hands-on, project-based experiences; raises the level of technological literacy through practical skills and a deeper comprehension of our dynamic modern world and broadens participation in STEM fields through emphasizing that diverse teams result in the most innovative designs to improve our world; and introduces exciting career paths by opening students' eyes to how our lives are enriched by the work of engineers.

### Course Outline

Designing and building is essential to engineering. Engineers follow the steps of the design process to help them create the best possible solutions to real-world problems. These challenges may be simple or complex and the wide variety of solutions can also cover a range of effort for the user. In general, complex designs require more effort to develop than simple ones.

This course will showcase a few different applications of engineering. Starting with simple machines students learn about the six simple machines and how combining them creates a compound machine. Then we will learn about the classic "Rube Goldberg Machine" where students will design a complex machine to do a seemingly simple task. They will participate in the brainstorming process and work with their team to design their own Rube Goldberg (chain reaction) machine following specific requirements (constraints). Next students are introduced to some basic civil engineering concepts in an exciting and interactive manner via bridges and skyscrapers. After learning about skyscrapers, tower design principles and how materials absorb different types of forces, students compete to build their own towers to meet specific design criteria. Lastly, students are introduced to the world of creative engineering product design.Teams work through the steps of the engineering design process by completing an actual design challenge presented. Problems may include packaging challenges; designing a passenger compartment design/feature so that it better withstands front-end collisions; creating a helpful crutch system to bring belongings around school with them, etc.

The variety of enriching and thought-provoking learning experiences offered in the Gifted and Talented Program incorporates three levels of enrichment intended to promote critical thinking.

Type I—General Exploratory Activities (Content)- Exposure to disciplines, authors or events not covered in the regular curriculum. Children can be exposed to such areas long enough to be attracted to some of them for individual study.

Type II—Group Process Activities (Operations)- Students are taught skills for expanding their thinking and feeling processes. Among these activities are: brainstorming, analysis, classification, general inquiry, observation and evaluation.

Type III—Real Problem Solving (Products)- This type of enrichment involves children in thinking, feeling and doing in the manner of the practicing professional. Children are encouraged to focus on solvable problems so that they might become empowered to create products that influence outcomes and make a difference in the world.

In addition, a goal of the Gifted and Talented Program is to include activities aimed at developing the affective domain of our students, such as: valuing, responding, receiving/attending. It is through both thinking and feeling that our students will develop into thoughtful, contributing, valuable members of society.

## 2. Objectives

**Rube Goldberg Machine:**

1. Identify and describe the 6 basic simple machines.
2. Explain the mechanical advantage of simple machines.
3. Analyze and explain the relationship between potential, kinetic, and mechanical energy present in a compound machine.
4. Apply understanding of simple machines and energy transfer to design and build a compound machine to complete a predetermined task.
5. Write a Rube Goldberg machine explanation to describe the machine's actions.

**Civil Engineering:**

1. Be able to find a point in space given the X, Y and Z coordinates.
2. Be able to give the X, Y and Z coordinates, given a point in space relative to a specified coordinate system and origin.
3. Identify several different structural engineering principles relating to skyscrapers.
4. Match design principles with famous skyscrapers.
5. Explain and appreciate the challenges and difficulties in building tall structures.
6. Identify which designs can and cannot withstand the self-weight of the newspaper tower as well as a lateral wind load.
7. Explain how their towers worked to withstand the lateral wind load using terms learned in other lessons within this curricular unit if applicable or general engineering terms.

### A. Curriculum Objectives for Inquiry

Students will be able to refine and broaden

1. Divergent thinking

a. Creative thinking
b. Inventive thinking

2. Convergent thinking
    a. Deductive thinking
    b. Analytical thinking
    c. Evaluative thinking
3. Interpretive thinking
4. Research skills

1. In the area of **divergent thinking** students will:
    a. use **creative thinking** to:

        1. use fluent and flexible thinking to brainstorm ideas/solutions
        2. develop, produce, and dramatize
        3. adapt story versions
        4. illustrate interpretations
        5. use the five-step writing process to write original pieces
        6. create and construct original designs with a variety of manipulatives and art supplies

    b. use **inventive thinking** to:
        1. use fluent and flexible thinking to brainstorm ideas/solutions
        2. adapt items to be used for an alternate purpose

2. In the area of **convergent thinking** students will:
    a. use **deductive thinking** to:
        1. formulate predictions/hypothesis
    b. use **analytical thinking** to:
        1. analyze story elements
        2. compare and contrast story elements/manipulatives/interpretations
        3. interpret visual representations
    c. use **evaluative thinking** to:
        1. judge character traits and motivation
        2. compare, rate, rank, revise, and eliminate information
        3. determine cause and effect
        4. make conclusions about given information
        5. self-assess using set criteria

3. In the area of **interpretive thinking** students will:
    a. use shared inquiry to:
        1. build awareness of interpretive issues in a story
        2. analyze character motivation and development

4. In the area of **research skills** students will:
    a. access and select meaningful information using the Internet, books, videos, and other media
    b. use the five-step writing process of prewriting, drafting, editing, conferencing, and publishing for a variety of audiences and purposes
    c. use a variety of computer software to record research
    d. synthesize knowledge of a topic into self-selected culminating activities
    e. cite references
    f. Present to/share research with others

a. **Skills**
    i. Improvement of reasoning ability
    ii. Development of creativity and personal development

## B. New Jersey Core Curriculum Content Standards

SL.PE.6.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.
SL.II.6.2. Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.
SL.PI.6.4. Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate speaking behaviors (e.g., eye contact, adequate volume, and clear pronunciation)
SL.AS.6.6. Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.
MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

9.4.5.CI.3: Participate in a brainstorming session with individuals with diverse perspectives to expand one's thinking about a topic of curiosity
9.4.5.CT.4: Apply critical thinking and problem-solving strategies to different types of problems such as personal, academic, community and global
9.4.5.TL.5: Collaborate digitally to produce an artifact

Career Readiness, Life Literacies, and Key Skills Practices

Career Readiness, Life Literacies, and Key Skills Practices describe the habits of the mind 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. These practices should be taught and reinforced in all content areas with increasingly higher levels of complexity and expectation as a student advances through a program of study.

| Practice | Description |
|---|---|
| Act as a responsible and contributing community members and employee. | Students understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams, families, community and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good. |
| Attend to financial well-being. | Students take regular action to contribute to their personal financial well-being, understanding that personal financial security provides the peace of mind required to contribute more fully to their own career success. |
| Consider the environmental, social and economic impacts of decisions. | Students 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. |
| Demonstrate creativity and innovation. | Students regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization. |
| Utilize critical thinking to make sense of problems and persevere in solving them. | Students readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem. They are aware of problems when they occur and take action quickly to address the problem; they thoughtfully investigate the root cause of the problem prior to introducing solutions. They carefully consider the options to solve the problem. Once a solution is agreed upon, they follow through to ensure the problem is solved, whether through their own actions or the actions of others. |

| Practice | Description |
|---|---|
| Model integrity, ethical leadership and effective management. | Students consistently act in ways that align personal and community-held ideals and principles while employing strategies to positively influence others in the workplace. They have a clear understanding of integrity and act on this understanding in every decision. They use a variety of means to positively impact the directions and actions of a team or organization, and they apply insights into human behavior to change others' action, attitudes and/or beliefs. They recognize the near-term and long-term effects that management's actions and attitudes can have on productivity, morals and organizational culture. |
| Plan education and career paths aligned to personal goals. | Students take personal ownership of their own education and career goals, and they regularly act on a plan to attain these goals. They understand their own career interests, preferences, goals, and requirements. They have perspective regarding the pathways available to them and the time, effort, experience and other requirements to pursue each, including a path of entrepreneurship. They recognize the value of each step in the education and experiential process, and they recognize that nearly all career paths require ongoing education and experience. They seek counselors, mentors, and other experts to assist in the planning and execution of career and personal goals. |
| Use technology to enhance productivity increase collaboration and communicate effectively. | Students 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. |
| Work productively in teams while using cultural/global competence. | Students 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. |

## 3. Proficiency Levels

Students in grades six are identified as "Gifted and Talented." Students that have received 2 points on the Gifted and Talented screening will be offered all 4 available grade level courses.

Differentiating Instruction for Students with Special Needs: Students with Disabilities, English Language Learners, and Gifted & Talented Students

Differentiating instruction is a flexible process that includes the planning and design of instruction, how that instruction is delivered, and how student progress is measured. Teachers recognize that students can learn in multiple ways as they celebrate students' prior knowledge. By providing appropriately challenging learning, teachers can maximize success for all students.
Examples of Strategies and Practices that Support
Students with Disabilities and Students with 504 plans

- Use of visual and multi-sensory formats
- Use of assisted technology
- Use of prompts
- Modification of content and student products
- Testing accommodations
- Authentic assessments

Gifted & Talented Students

- Adjusting the pace of lessons
- Curriculum compacting
- Inquiry-based instruction
- Independent study
- Higher-order thinking skills
- Interest-based content
- Student-driven
- Real-world problems and scenarios

English Language Learners

- Pre-teaching of vocabulary and concepts
- Visual learning, including graphic organizers
- Use of cognates to increase comprehension
- Teacher modeling
- Pairing students with beginning English language skills with students who have more advanced English language skills
- Scaffolding
- Word walls references
- Sentence frames
- Think-pair-share
- Cooperative learning groups
- Teacher think-alouds

**4. Methods of Assessment**

Participation
Completed products and performance
Teacher observation

## 5. Grouping

Small group pull-out for students identified as “Gifted and Talented” according to the Rutherford School District Gifted and Talented Policy 2464 (revised December 7, 2020) to be run as a grade 6 cycle course.

## 6. Articulation/Scope & Sequence

Course length is one quarter.

Major Products:

a. Group discussions and cooperative work
b. Completion of RG machine to specs of contest determined by year

## 7. Resources

a. References

https://orise.orau.gov/resources/k12/documents/lesson-plans/rube-goldberg-machines-complete-lesson-plan.pdf
http://media.rubegoldberg.com/site/wp-content/uploads/2017/10/Rube-Goldberg-Lesson-Plans.pdf
https://www.youtube.com/watch?v=qybUFnY7Y8w
https://youtu.be/dCMZe6FVbpc
https://sciencebysinai.com/how-to-create-a-structured-rube-goldberg-machines-unit/
https://www.youtube.com/playlist?list=PLjg0Q1jq354JJFy-ftCA--PMWlPShSuki
https://www.teachengineering.org/curricularunits/view/cub_simp_machines_curricularunit
https://www.youtube.com/playlist?list=PLjg0Q1jq354IpcJAw8pB_Wb1FrYMoPUnR
https://scientificteacher.com/2014/07/28/digital-notebooks-tutorial/
https://www.teachengineering.org/curricularunits/view/duk_tower_tech_unit
https://www.teachengineering.org/lessons/view/wst_environmental_lesson01
https://www.teachengineering.org/activities/view/wpi_crutches_activity

b. Technology

Chromebooks
Internet

c. Supplies/Materials

hot glue
construction paper
marbles
small paper cups (such as Dixie cups)
paper towel tubes
string
jumbo paper clips
rubber bands
PVC pipe
Tubing
LEGO bricks
Pulleys
Dominos
Duct Tape

Gears
Cardboard
Pipe cleaners
d. Texts
e. Supplemental Reading

## 8. Methodologies

Methods include, but are not limited to:
• Cooperative learning
• Individual and group research
• Individual and group problem solving
• Inquiry
• Class discussion
• Brainstorming
• Critical Thinking
• Experimenting
• Short lecture

## 9. Suggested Activities

• Skill-building activities
• Exploring multiple intelligences
• Researching
• Public Speaking
• Videos
• Shared Inquiry discussions

## 10. Interdisciplinary Connections

The scope of materials for this Rube Goldberg unit is broad and interdisciplinary. Rube Goldberg was both an engineer and a cartoonist. In theory all of his wacky inventions would work, but his main goal was to make you laugh! RGMs should work but they also need to capture attention. The most successful teams have diverse members from engineers to artists, mathematicians to comedians, all working together. Students are also encouraged in critical thinking as they brainstorm, problem solve, build, test and rebuild. As this is a team activity, Rube Goldberg Competition encourages individual responsibility and cooperation among class members.

## 11. Professional Development

As per the PDP/100 Hours statement: the teacher will continue to improve expertise through participation in a variety of professional development opportunities. Specialized professional development for teachers in the Gifted and Talented Department is offered through the Bergen County Consortium of Teachers of the Gifted (BCCTG) and the New Jersey Association for Gifted Children (NJAGC). Teacher will continue to read professional journals and books.

## 12. Curriculum Map

| Unit Topic | Time Allocated | Differentiating Instruction for Students with Disabilities, Students at Risk, Students with 504 Plans, English Language Learners, & Gifted & Talented Students | Standards | Assessments |
|---|---|---|---|---|
| Part 1: Understand Rube Goldberg and the specifications of the competition, work and the mechanical advantages of six simple machines that make work easier, introduction to compound machines, energy transfers | Number of weeks<br><br>(This course meets for approx. 10 weeks)<br><br>Time allocated is approx. 2 weeks/5 sessions | For Support:<br><br>Computer-Based Instruction: Use of chromebooks/computers, use of YouTube, TedEd and other sites as deemed useful to enhance and modify learning<br>Multi-media approach to accommodating various learning styles<br>Use of visual and multi-sensory formats<br>For Enhancement:<br><br>Interest driven<br>Peer tutoring<br>Higher order thinking skills | MS-ETS1-1<br>MS-ETS1-2.<br>MS-ETS1-4<br>MS-PS3-5<br>9.4.5.CI.3<br>9.4.5.CT.4<br>9.4.5.TL.5<br>NJSLSA.SL1.<br>NJSLSA.SL2.<br>NJSLSA.SL4.<br>NJSLSA.SL5.<br>NJSLSA.SL6.<br>MS-ETS1-1 | Formative Assessment:<br><br>Oral participation in activities (class discussion)<br>Teacher observation of student progress<br>Classwork<br>Self-assessment<br>Group and individual critique |
| Part 2: Bridges and Skyscrapers | Number of weeks<br><br>(This course meets for approx. 10 weeks)<br><br>Time allocated is approx. 2 weeks/5 sessions | For Support:<br><br>Computer-Based Instruction: Use of chromebooks/computers, use of YouTube, TedEd and other sites as deemed useful to enhance and modify learning<br>Multi-media approach to accommodating various learning styles<br>Use of visual and multi-sensory formats<br>For Enhancement:<br><br>Interest driven<br>Peer tutoring<br>Higher order thinking skills | NJSLSA.SL1.<br>NJSLSA.SL2.<br>NJSLSA.SL4.<br>NJSLSA.SL5.<br>NJSLSA.SL6.<br>MS-ETS1-1<br>MS-ETS1-2.<br>MS-ETS1-4<br>MS-PS3-5<br>9.4.5.CI.3<br>9.4.5.CT.4<br>9.4.5.TL.5 | Formative Assessment:<br><br>Oral participation in activities (class discussion)<br>Teacher observation of student progress<br>Classwork<br>Self-assessment<br>Group and individual critique |

| | | | | |
|---|---|---|---|---|
| Part 3: Final Design Challenge (Problems may include packaging challenges; designing a passenger compartment design/feature so that it better withstands front-end collisions; creating a helpful crutch system to bring belongings around school with them) | Number of weeks<br><br>(This course meets for approx. 10 weeks)<br><br>Time allocated is approx. 3-4 week/5 sessions | For Support:<br><br>Computer-Based Instruction: Use of chromebooks/computers, use of YouTube, TedEd and other sites as deemed useful to enhance and modify learning<br>Multi-media approach to accommodating various learning styles<br>Use of visual and multi-sensory formats<br>For Enhancement:<br><br>Interest driven<br>Peer tutoring<br>Higher order thinking skills | NJSLSA.SL1.<br>NJSLSA.SL2.<br>NJSLSA.SL4.<br>NJSLSA.SL5.<br>NJSLSA.SL6.<br>MS-ETS1-1<br>MS-ETS1-2.<br>MS-ETS1-4<br>MS-PS3-5<br>9.4.5.CI.3<br>9.4.5.CT.4<br>9.4.5.TL.5 | Formative Assessment:<br><br>Oral participation in activities (class discussion)<br>Teacher observation of student progress<br>Classwork<br>Self-assessment<br>Group and individual critique<br><br>Summative Assessment of project |