Montague Township School
Curriculum Guide
Engineering and Robotics- STEM Course
(Middle School: Mixed Grade Levels)

Course Description: Middle School is the perfect time for students to explore the numerous opportunities open to them. It is also a very appropriate time to learn how to solve problems, and that there is often more than one way to reach a solution to a problem. This STEM course of study is designed to introduce the Middle School student to various ways to think critically, work collaboratively, and employ the Engineering Design Process. Several design challenges will offer students the opportunity to develop these skills. In addition, students will be introduced to Computer Aided Drafting (CAD), a valuable tool in the Engineering field. A student-centered, hands-on approach, which has been developed in conjunction with the scientific research that proves that students learn best by active participation in their learning, will be the basis for instruction. All of these lessons will be applied through hands-on projects that address limitations and constraints in the engineering design process. This is achieved through building and collaborating with classmates to best construct a multitude of projects. Separately we assess students to gauge progress and inform instruction. Benchmark assessments for students in grades 6 through 8 are administered throughout the course.

Rationale: This trimester course will provide students with multiple opportunities to expand their critical thinking and problem solving abilities. The course will also introduce new subject matters and possible future careers in the various fields of engineering. The course incorporates basic physics concepts (gravity, load, structure, beams, force, tension, compression) into designing varying structures. This course is aligned with the New Jersey Student Learning Standards for Science, New Jersey Career Readiness, Life Literacies, and Key Skills and the New Jersey Student Learning Standards for Technological Literacy (NJSLS for Technological Literacy).

Format/Mapping/Sequence: The format in which the curriculum is written follows the parameters of Understanding by Design. Each course curriculum document is written as a series of units containing established goals, enduring understandings, essential questions, and the necessary skills and knowledge a student must attain in a school year. In addition, each document stipulates mentor/anchor texts and resources, required tasks, and assessments. Teachers are expected to design lessons that will meet the requirements stipulated in this document; however, they are provided flexibility in how they choose to meet these demands. As well, the order of the units is a suggestion and a teacher may introduce the units as he/she feels best meets the needs of the class, keeping in mind the scaffolding of skill development suggested.

Pacing: Engineering and Robotics is a choice elective course that meets every other day over the course of a trimester, 40-minutes per session, and is currently open to students in grades 5-8. There are 3 student-centered units, each designated to focus on a specific program or skill. Each of the units provides a suggested time frame, taking into consideration the time needed to differentiate for a variety of learners.

Resources: In each unit, both electronic and print resources are provided. It is the intention that teachers will be able to access the curriculum document on the district website as well as be able to add to the resources lists periodically throughout the school year. A valuable site that should be referenced in planning https://www.nj.gov/education/standards/

Student Outcomes: (Link to New Jersey Student Learning Standards)
In accordance with district policy as mandated by the New Jersey Administrative Code and the New Student Learning Standards, the following are proficiencies required for the successful completion of the above named course.

The student will:
1. Identify and apply safe practices as is required in the world of work.
2. Demonstrate proper and safe use of hand tools used in the classroom.
3. Explain the meaning of engineering and how it fits into STEM education.
4. Explain how engineers have contributed to the development of a major technology.
5. List and explain the steps involved in the engineering design process.
6. Produce a graphic design using basic mechanical drawing techniques or a computer aided design program.
7. Apply the engineering design process to a problem with constraints determined by the instructor.

Link to NJSLS:
English Language Arts
Mathematics
Science
Computer Science and Design Thinking
Career Readiness, Life Literacies, and Key Skills

Interdisciplinary Connections

Science:
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

ELA:
Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others' ideas and expressing their own clearly and persuasively.

Computer Science & Design Thinking:
Recommend improvements to computing devices in order to improve the ways users interact with the devices.
Identify the steps in the design process that could be used to solve a problem.
Evaluate the impact of sustainability on the development of a designed product or system.
Design a product to address a real-world problem and document the iterative design process, including decisions made as a result of specific constraints and trade-offs.
Explain how the development and use of technology influences economic, political, social, and cultural issues.
Compare how technologies have influenced society over time.
Evaluate the impact of sustainability on the development of a designed product or system.
Examine a malfunctioning tool, product, or system and propose solutions to the problem.
Analyze an existing technological product that has been repurposed for a different function.
Examine a system, consider how each part relates to other parts, and redesign it for another purpose.
Explain how a product designed for a specific demand was modified to meet a new demand and led to a new product.
Analyze the impact of modifying resources in a product or system.

Analyze the design of a product that negatively impacts the environment or society and develop possible solutions to lessen its impact.
Explain ethical issues that may arise from the use of new technologies.
Examine the effects of ethical and unethical practices in product design and development.

Career Ready Practices
Assess data gathered on varying perspectives on causes of climate change (e.g., cross cultural, gender-specific, generational), and determine how the data can best be used to design multiple potential solutions.
Repurpose an existing resource in an innovative way.
Examine challenges that may exist in the adoption of new ideas.
Evaluate diverse solutions proposed by a variety of individuals, organizations, and/or agencies to a local or global problem, such as climate change, and use critical thinking skills to predict which one(s) are likely to be effective.
Develop multiple solutions to a problem and evaluate short- and long-term effects to determine the most plausible option.
Compare past problem-solving solutions to local, national, or global issues and analyze the factors that led to a positive or negative outcome.
Analyze the resource citations in online materials for proper use.
Provide appropriate citation and attribution elements when creating media products.
Explain how communities use data and technology to develop measures to respond to effects of climate change.
Demonstrate openness to diverse ideas and perspectives through active discussions to achieve a group goal.
Create a digital visualization that effectively communicates a data set using formatting techniques such as form, position, size, color, movement, and spatial grouping.
Identify the impact of the creator on the content, production, and delivery of information.
Select appropriate tools to organize and present information digitally.
Collaborate to develop and publish work that provides perspectives on a real-world problem.
Compare the process and effectiveness of synchronous collaboration and asynchronous collaboration.

Math:
Make sense of problems and persevere in solving them.
Reason abstractly and quantitatively.
Construct viable arguments and critique the reasoning of others.
Model with mathematics.
Use appropriate tools strategically.
Attend to precision.
Understand congruence and similarity using physical models, transparencies, or geometry software.

Essential Questions and Content
Overarching Essential Questions:
a) What safety precautions are critical to follow?
b) What is the function and use of tools in the lab?
c) What is engineering?
d) What criterias should be completed to become an engineer?
e) What are the different disciplines of engineering?
f) What are the necessary steps to efficiently solve a problem?
g) What is the purpose of redesigning a product?

h) What is CAD?
i) How does CAD improve engineering?
j) How is the solution going to be influenced by the design constraints?
k) What are the benefits and drawbacks of the various building materials that engineers use to construct structures?
l) How can decisions be made collaboratively and fairly?
m) What is structure and how does structure relate to function?
n) Why do engineers need to keep outside effects in mind when designing?
o) What are the effects of gravity load or force?

Strategies
Student projects
Group discussion
Team/group work
Individual conferencing
Scaffolding of work
Peer to Peer Leaders/Support

Evaluation:
Forms of Assessment: This course will utilize formative, summative, alternative and benchmark assessments.
Projects: 50% : This grading component includes in-class projects that direct the students attention to major objectives of the unit. These projects are often focused on group planning, problem solving issues, addressing and reacting to artificial limitations and criteria, and creating a product that reflects a solution to the problem.
Classwork/HW: 25% : This grading component assesses the students ability to complete daily tasks within the classroom that addresses basic skills necessary for complete understanding of the units. Students use homework for elaboration of in-class techniques and themes in order to better prepare them for future projects and assignments.
Assessment/Quiz: - 25% This grading component assesses student understanding of in-class subjects and lessons. Assessments can range from mini-projects and challenges to presentations, google forms, or graded exit tickets

Resources
Hardware
Engineering Fundamentals by: Ryan A. Brown, Joshua W. Brown, Michael Berkeihiser; ISBN: 978-1-61960-220-5 Copyright: 2014
Software
TinkerCAD

Other Resources
Engineering Fundamentals Student Companion Website
What is Engineering?
The Engineering Design Process
Teach Engineering Editors Pick

Scope and Sequence

Unit 1: Lab Safety/What is Engineering? (2 Weeks)
Content Objectives:
Lab Safety/What is Engineering:
1. Identify and apply safe practices as is required in the world of work.
2. Demonstrate proper and safe use of hand and power tools used in the lab.
3. Explain the meaning of Engineering and how it fits into STEM/STEAM education.
4. Explain how Engineers have contributed to the development of a major technology.
5. Explain the importance of differing engineering disciplines and how they have positively impacted society.
6. What is civil engineering and what type of prototypes and designs are involved in this specialty?

Standards Covered:
Science: MS-ETS1.B
ELA: NJSLSA: SL1, SL.8.1, SL.8.5
Career Readiness, Life Literacies, and Key Skills: 9.4.8.CI.1, 9.4.8.CI.2, 9.4.8.CI.3, 9.4.8.CT.1, 9.4.8.CT.2, 9.4.8.CT3, 9.4.8.DC.1, 9.4.8.DC.2, 9.4.8.DC.8, 9.4.GCA.2, 9.4.8.IML.3, 9.4.8.TL3, 9.4.8.TL.6
Math: MP1, MP3, MP5
Computer Design Thinking: 8.1.8.IC.1, 8.2.8.ED.2, 8.2.8.ED.3, 8.2.8.ED.7, 8.2.8.ITH.1, 8.2.8.ITH.2, 8.2.8.ITH.3, 8.2.8.NT.1, 8.2.8.NT.2, 8.2.8.NT.3, 8.2.8.NT.4, 8.2.8.ETW.2, 8.2.8.ETW.3

Suggested Activities:
a. Participate in a class discussion of engineering and engineering as a profession.
b. Design Activity: Work in teams to solve a day 1 teacher assigned design challenge such as longest line of paper built from one piece of construction paper or creating a boat out of a piece of tin-foil that can float with the most pennies.
c. Participate in internet research of historical Engineering achievements in the eight main engineering disciplines.
d. Develop a Google Slide of engineers that have made major engineering developments in history.
e. EdPuzzles: Engineering Safety and Engineering Ethics

Teacher's Notes
➢ Use the internet for research.
➢ Allow students to research all of the disciplines of engineering before picking on achievements.
➢ SWBAT create and present what is important about the engineering discipline and why it is needed in modern society.
➢ Explain what is a simple machine and provide examples in everyday life.
➢ What is Engineering?
➢ Safety Lessons (glue gun use and equipment use is important to address)
➢ When reviewing the different branches of engineering, put more focus on civil engineering as this will be the branch focused on in this course.

Unit 2: The Engineering Design Process: (3 Weeks)
Content Objectives:
1. List and explain the steps involved in the engineering design process.
2. Understand how to use CAD programs in order to facilitate accurate design and creation.

3. Produce a digitally created design using basic mechanical drawing techniques or a computer design program.

Standards Covered:
Science: MS-ETS1.A
ELA: NJSLSA.SL1
Career Readiness, Life Literacies, and Key Skills: 9.4.8.CI.2, 9.4.8.CI.3, 9.4.8.CI.4, 9.4.8.CT.1, 9.4.8.CT.2, 9.4.8.CT3, 9.4.GCA.2, 9.4.8.IML.3, 9.4.8.IML.4, 9.4.8.IML.13, 9.4.8.TL3
Math: 8.G.A.1, 8.G.A. 2, 8.G.A, 3, 8.G.A.4, MP1, MP4, MP5
Computer Design Thinking: 8.1.8.CS.1, 8.1.8.IC.1, 8.2.8.ED.2, 8.2.8.ED.3, 8.2.8.ED.5, 8.2.8.ED.6, 8.2.8.ED.7, 8.2.8.ITH.1, 8.2.8.ITH.2, 8.2.8.ITH.3, 8.2.8.NT.1, 8.2.8.NT.2, 8.2.8.NT.3, 8.2.8.NT.4, 8.2.8.ETW.2, 8.2.8.EC.1, 8.2.8.EC.2

Suggested Activities:
a. Participate in a poster/multimedia project highlighting the parts of the design process.
b. Using TinkerCAD, have the students design and create items on the software program (city, vehicle, bridge, the next iPhone, other structure pieces).
c. Research Report: Building structure including information about success and failures.
d. Research Report: Bridge structure including information about success and failures.

Teacher's Notes :
➢ Provide students with examples of different problem statements. Students read each statement and rank them. In groups, students develop criteria for a "good" problem statement.
➢ Discuss ways in which designs are evaluated.
➢ Discuss the difference between an English and a metric ruler.
➢ The Engineering Design Process

Unit 3: Design Challenges and Problem Solving: Civil Engineering (5 Weeks)
Content Objectives:
1. Solve a problem with constraints determined by the instructor within the civil engineering branch using the EDP.
2. Creating a structure that can survive multiple challenges and issues.

Standards Covered
Science: MS-ETS1.A
ELA: NJSLSA.SL1
Career Readiness, Life Literacies, and Key Skills: 9.4.8.CI.2, 9.4.8.CI.3, 9.4.8.CI.4, 9.4.8.CT.1, 9.4.8.CT.2, 9.4.8.CT3, 9.4.GCA.2, 9.4.8.IML.3, 9.4.8.IML.4, 9.4.8.IML.13, 9.4.8.TL.3. 9.4.8.TL.5, 9.4.8.TL.6
Math: MP1, MP2, MP3, MP4, MP5, MP6
Computer Design Thinking: 8.2.8.ED.2, 8.2.8.ED.3, 8.2.8.ED.5, 8.2.8.ED.6, 8.2.8.ED.7, 8.2.8.NT.1, 8.2.8.NT.2, 8.2.8.NT.3, 8.2.8.NT.4, 8.2.8.ETW.1, 8.2.8.ETW.2, 8.2.8.EC.1, 8.2.8.EC.2
Suggested Activities:
a. Working with teammates, use the design process to design and construct a solution to a design challenge.
b. Use TinkerCAD programs in their design processes before they build.
c. Possible projects include: Wooden Bridge, Paper Tower, Straw Suspension Bridge, Book Support Challenge. All with different constraints (materials, weight, distance, budget, size, time).

Teacher's Notes

- ➢ Safety Lessons (glue gun use and equipment)
- ➢ Use internet for research
- ➢ Use CAD software for design drawings
- ➢ Activities should fall under Civil Engineering as this is the branch of focus in this course.

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Appendix

Standards in Action

Montague Township School District believes in offering an interdisciplinary approach to teaching and learning because students are able to make connections and relationships by bringing together separate content disciplines, skills and knowledge around common themes, issues, or problems. The NJ Department of Education mandates the following be identified as areas of study beneficial to integration into all grade levels and content areas.

Please click the hyperlink for further information on each area:

Career Readiness, Life Literacies, and Key Skills
Climate Change Education
Contributions of Disabled and LGBT Individuals
Holocaust Education
Amistad Commission
Social and Emotional Learning
Diversity, Equity and Inclusion
Asian American Pacific Islander

Types of Assessments

Students will be assessed across the units and year in a variety of ways. The link below indicates resources for developing assessments and general examples of assessments that teachers may utilize across all of the content areas.

Formative, Summative, Alternative, and Benchmark Assessments

Accommodations & Modifications for Special Education, ELL, G&T, 504 Plans and At Risk:

Modifications and Accommodations