The study of various structures and how they impact our daily lives.

Understanding the attributes of structures including shapes, strengths and weaknesses, and applications.

Developing a basic understanding of how structures are used in complex applications to solve specific problems.

Develop an understanding of how simple geometric shapes are integrated into common structures.

Understanding and applying basic design concepts of form and function.

Introduction
This STEM-Maker project is appropriate for middle and senior high school levels and is recommended for students working in pairs or small teams up to four students. This project is designed to promote creative thinking, problem solving, innovation, invention, and provides an excellent applied learning experience for all STEM students.
Welcome

Activity Information
This activity will require students to use the process that designers and engineers use to solve problems. Students will walk through each step of the design and engineering process as they develop their own solution to a problem.

Classroom Management
This activity packet should serve as a guide for students as they develop creative solutions to problems. Students can work in groups of up to four to research, design, and engineer their own solution to a thematic problem.

Resources Needed
Rokenbok Advanced Projects Lab

Activity Time
120-180 Minutes

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Project Based Integrated STEM: Civil Engineering

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**Design Brief: Scenario**

The ROK-Works Construction Company has been asked to submit a contract bid for a new, four story hotel and convention center in downtown ROK City.

In order to compete for the bid, the company will need to design and build a custom tower crane that will be able to lift beams and equipment up to the top of the new building. The success of the bid is dependent upon the design and capability of the new tower crane.

**Design Project**

Your design and engineering team has been assigned the task of building a scale model of a tower crane. The tower crane must be able to operate in confined spaces and should be designed to be erected and disassembled in prefab sections. It should have a 360 degree rotation capability.

Time is of the essence and your team must work through the design process to prepare your scale model for presentation to ROK-Works Construction Company executives at their next board meeting.
The layout and design of your tower crane model should be determined by your design team, based on strength requirements and aesthetic appeal.

The crane must be designed to fit into a footprint that is 50cm long x 50cm deep x 140cm tall. The crane must be able to reach the load receiving zone at each level of the building.

The crane must be designed to safety standards and properly constructed with necessary bracing, counterweights, and appropriate structural geometric shapes.

The crane must be equipped with a controllable motor system that will allow the hoist cable to extend and retract as needed.

The structure must be structurally sound and include reinforcement components such as beams, cantilevers, braces, and girders.

Your team should prepare to deliver a presentation to the ROK-Works Construction Company executives about the merits of your tower crane model and design.

**Evaluation**

Students will be evaluated on the following criteria:

- Creativity and design
- Functionality of structure
- Time management and teamwork
- Successful completion of the challenge
- Adherence to constraints/criteria

Use the Rokenbok Universal Performance Rubric for evaluation. Available for download at RokenbokEducation.org
Using the Design and Engineering Process
Use the steps in the design and engineering process to develop a high quality design.

Step 1: What is the Problem/Opportunity?
A tower crane needs to be designed and built. The tower crane will be used in the development of city structures and buildings.

Step 2: Research and Discovery
Check out availability of materials and how to build a new tower crane that meets certain specifications.

Step 3: Brainstorm Ideas
List all the ideas that you have found then look at the pros and cons for each idea, considering each one carefully before making a final decision.

Step 4: Select a Solution
Identify the best solution and move forward with your design.

Step 5: Develop a Plan
Once you have made a decision on which solution you think is best, then put together a good plan for designing and building a custom tower crane.

Step 6: Build a Prototype/Model
Build a model of your design.

Step 7: Test the Design
Once you build your prototype or model, test your design to make sure it meets all constraints and specifications.

Step 8: Fix and Redesign
If you have identified any problems or design issues, then go back through the design process to make any needed changes or redesigns.
Writing Your Story

After you have completed the design of the tower crane, it is important to tell others what you have learned and experienced. One good way to share is to write your story down on paper or on the computer. Some things you might include are:

1. What were the ideas that your team brainstormed?
2. Why did you choose the designs that were built?
3. What was the most difficult part of your designs?
4. What did you enjoy the most about this project? The least?
5. What did you learn about design and engineering by completing this project?

Telling Your Story

An important part to design and engineering is the ability to communicate the design to someone else. Prepare a short presentation to explain the tower crane that was built and the process of building it. Make sure you speak loudly and clearly so everyone can hear and understand you. Be enthusiastic and ready to answer any questions that might be asked.

Presenting the Design

When your team has completed the project, it should be presented to your teacher and classmates for evaluation.

Your grade will be determined by how well you do on all grading criteria. These include:

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Were all design constraints met?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Quality</td>
<td>Are the space tools built well? Are they highly functional?</td>
</tr>
<tr>
<td>Time Management</td>
<td>Did you get your project done on time? Did you use your time wisely?</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>Do the tools look good?</td>
</tr>
<tr>
<td>Story</td>
<td>Were you able to clearly communicate the design by writing a story?</td>
</tr>
<tr>
<td>Presentation</td>
<td>Did you make a good presentation? Were you interesting and engaging?</td>
</tr>
</tbody>
</table>
**Science**
Students will use and reinforce these science concepts:
- Principles of static and dynamic loads
- Structural forces including compression, tension, shear, bending, and torsion
- Structural components including beams, columns, girders, struts, and braces
- Structural materials

**Technology and Engineering**
Students will use and reinforce these technology and engineering concepts:
- Prototyping and modeling
- Invention and innovation
- Structural integrity/strength
- Brainstorming and problem solving
- Trial and error engineering concepts

**Math**
Students will use and reinforce these math concepts:
- Calculating the structural stability of a truss
- Structural analysis using trigonometric functions
- Linear measurement and scaling techniques

**Standards**
This design project is based on the following national standards:
- The Next Generation Science Standards
- Common Core standards
- Standards for Technological Literacy
- Endorsed by the International STEM Education Association