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IEEE Lesson Plan:

# Statue Display Tower

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## Lesson Focus

Students design, build, test and redesign a display tower that will meet a specific set of criteria and constraints.

## Lesson Synopsis

Students apply the engineering design process to solve the Golden Book design challenge to make a low cost display tower that can hold a statue and can be taken apart and reassembled easily for transporting from one library to another.

## Age Levels

10-18

## Objectives

During this activity students will:

- Design a display tower that meets the set criteria and constraints.
- Build, test, and redesign a prototype.
- Disassemble and reassemble their prototype with minimal steps.
- Calculate total cost of final design.

## Anticipated Learner Outcomes

As a result of this activity, students will have:

- Designed a display tower that met the set criteria and constraints
- Built, tested, and redesigned their prototype.
- Disassembled and reassembled their prototype with minimal steps.
- Calculated total cost of their final design.

## Lesson Activities

Students will work in teams to design a statue display tower that meets set criteria and constraints. Teams will construct a prototype, test and redesign. Teams must keep track of materials and calculate total cost of their final design. The teacher will calculate each team's final score. The lesson closes with the final test, discussion of reflection questions, and announcement of the winning team.

## Resources/Materials

- Teacher Resource Document (attached)
- Student Worksheet (attached)

## Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

## Internet Connections

- TryEngineering (www.tryengineering.org)

## Recommended Reading

- Force & Motion (ISBN: 978-0789448828)
- The Art of Construction: Projects and Principles for Beginning Engineers & Architects (ISBN: 978-1556520808)

## Optional Writing Activity

- Write an advertisement for your display tower aimed at other libraries, galleries and museums.

## For Teachers: Teacher Resource

### Lesson Goal

The goal of this lesson is for students to design a statue display tower that meets set criteria and constraints. Teams will construct a prototype, test and redesign. Teams must keep track of materials and calculate the total cost of their final design. The teacher will calculate each team's final score. The lesson closes with the final test, discussion of reflection questions, and announcement of the winning team.

### Lesson Objectives

During this activity students will:

- Design a display tower that meets the set criteria and constraints.
- Build, test, and redesign a prototype.
- Disassemble and reassemble prototype with minimal steps.
- Calculate total cost of final design.

### Materials

Set up a table with all of the materials where students can choose what and how much they will use.

- Pieces of corrugated cardboard (put into small, medium, and large groups)
- Newspaper
- Index cards
- Paper
- Card stock
- Clay (cut into 1" sections)
- Straws
- Pipe cleaners
- Skewers
- Dowels
- Paper Clips
- Binder Clips
- Brass Fasteners
- Masking Tape (cut into 1 foot pieces)
- String (cut into 1 foot pieces)
- Aluminum Foil (cut into 6" pieces)
- Craft Wire (cut into 1 foot pieces)
- Scissors
- Hole Punches
- Rulers
- Markers
- Books (for testing) Consider wrapping 1 book in gold paper or spray paint it gold (for final test)
- Design Challenge worksheet (per student)
- Stop Watches

## For Teachers (continued):

- **Time Needed:** Three to four 45 minute sessions
  - Introduction (15 minutes)
  - Brainstorm, Choose Best, Sketch, Materials List (30 minutes)
  - Get materials, build, redesign up to 3 times (45 minutes)
  - Demonstrations, Final Testing, Discussion (30 – 60 minutes)

- **Procedure**
  1. Pass out the Engineering Design Challenge Worksheet and read the scenario.
  2. Discuss the criteria and constraints to make sure students understand each one. Clarify that the tower must be able to be easily taken apart and reassembled.
  3. Review the steps of the engineering design process.
  4. You may consider having a discussion on compression with the students. See the compression teacher resource.
  5. Break student into teams of 3-5.
  6. Give students 30 minutes to brainstorm solutions and choose best solution.
  7. They must draw a sketch of their solution, label it and fill in Trip 1 of the Materials List with how much of each item they want to purchase.
  8. Give students another 45 minutes to redesign and purchase more materials if necessary. They can only make 3 total trips to the store for materials.
  9. Have each team demonstrate their design. Students can test it with a book and time whether it can hold the book for 2 minutes (or to save time, have all teams at the same time put the book on their design use a stopwatch to time the 2 minutes.)
  10. Teams must demonstrate how they can take the tower apart and reassemble it. The number of steps to be reassembled must be added to the score sheet.
  11. Give teams time to complete reflection questions while you give each team an aesthetic score and calculate final score.
  12. Have a class discussion about the reflection questions.
  13. Hand back score sheets and announce winning team.
  14. Give winning team members a certificate.

- **Final Score (Lowest Score Wins Contract)**

Total Score = Cost + Number of Criteria NOT met + Aesthetic Score + Reassemble Steps

- **Extensions Ideas**
  - Limit how many times they can go to the store to just once.
  - Increase the weight the tower must hold and how long it must hold it.
  - Lead a discussion on compression and consider having students calculate stress.

## Teacher Resource: Compression

A force (f) is something that causes a body to change its speed, direction, or shape.

F= ma (mass x acceleration)

- Mass is the quantity of matter in a body. (m=w/g) (mass equals weight divided by gravity)
- Acceleration is the rate at which an object changes its velocity. (a= Δ velocity / time) (acceleration equals change in velocity divided by time)

The force can be one of three main types:

- Tension (Pull): a orce that stretches or elongates.
- Compression (Push): a force that shortens or squeezes something, decreasing its volume.
- Torque (Rotate): a force that causes rotation around a central point such as an axle.

This lesson will be focusing on compression. The display tower is under the compression force from the statue.

Examples of compression

Compressed Spine

Compressing an Injury

A compression force, or any force for that matter, will cause stress on the object. Stress is equal to force divided by area (cross-sectional).

Stress = F/A

You may consider having the teams calculate the stress on their display tower. The force will be 2 lbs. Students will need to calculate a specific cross-sectional area (where high stress is anticipated or where it failed in testing) of their display tower ($in^2$). The stress will be in psi or lbs of force per $in^2$.

## *Teacher Resource:*
## *TEAM FINAL SCORE SHEET & CERTIFICATE*

TEAM Members: _____

CRITERIA

| The display tower must be: | YES | NO |
|---|---|---|
| ◈ 4 feet tall | | |
| ◈ Able to support 2 lbs for 2 minutes (minimum) | | |
| ◈ Free standing (not attached to any surface) | | |
| ◈ Fits into 2 gallon bag when taken apart | | |

Total criteria NOT met: _____

Total Cost: _____

Aesthetic Score = 0 (Excellent), 5 (Okay), 10 (Needs Works) CIRCLE SCORE

Assembly Steps (total steps to be reassembled)=

FINAL Score = Cost + Number of Criteria NOT met + Aesthetic Score + Assembly Steps

= _____ + _____ + _____ + _____

**FINAL SCORE = _____**

# GOLDEN BOOK DESIGN CHALLENGE

Student

# Congratulations!

**For winning the**

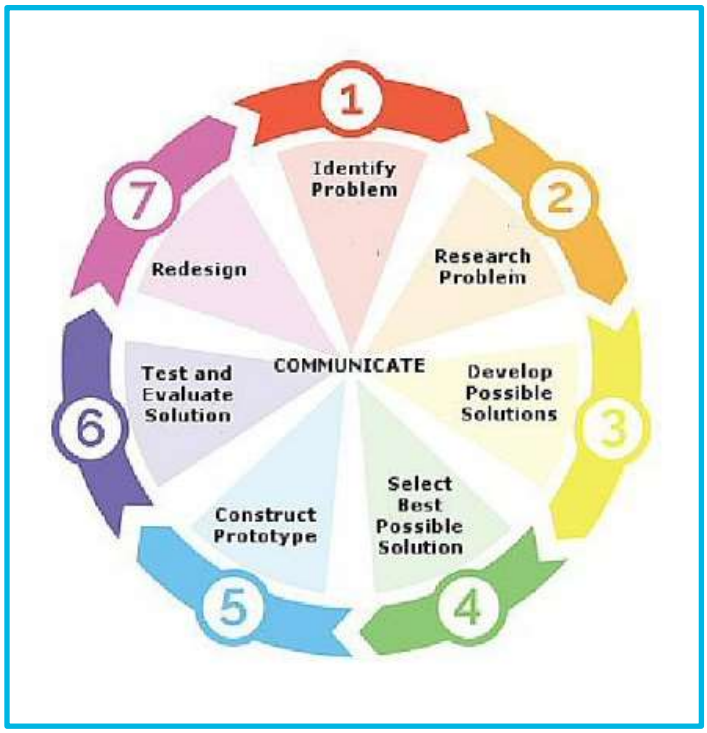
## Display Tower Contract

Teacher

Date

*Student Resource (continued):*

# The Engineering Design Process




## 1. Identify the Problem
What is the problem you want to solve?

## 2. Research Problem
What do you know about the problem? Find out as much about the problem as you can. What are the criteria (conditions that the design must satisfy—its overall size or weight, etc.) and constraints (limitations with material, time, size of team, etc.) of this problem?

## 3. Develop Possible Solutions
Brainstorm as many solutions as possible.

## 4. Select Best Possible Solution
Which of your designs do you think is the best possible solution?

## 5. Construct Prototype
Using the materials given, build a prototype (a working model) of your design. Don't forget about the criteria (conditions that the design must satisfy) and constraints (limitations that need to be designed around).

## 6. Test & Evaluate Solution
Test and evaluate your design. Did you satisfy the criteria and constraints?

## 7. Redesign
Did your design solve the problem? If not, brainstorm a new design, build and test it until you have successfully solved the problem.

## And, throughout….Communicate
At each step in the process you must communicate with your team members. You need to also communicate with others outside of your team to get feedback on your design. You need to communicate verbally as well as by describing your design thorough writing and drawings. Communication is at the core of the engineering design process.

## Student Worksheet: Golden Book Design Challenge

### Scenario

A gold statue of a book was created by one of America's top artists in celebration of America's first public library. The statue will sit in the main entrance of your local library for a week. It will continue to be moved from library to library throughout the year. A tower must be built to hold the statue so it can be on display for all to see and also be able to be taken apart and reassembled for each move. The engineering team that can design the lowest cost display tower that meets all of the criteria will be awarded the contract.

### Design Challenge

Design and construct a display tower for your local library that supports the golden book and is able to be taken apart and reassembled easily while still being low cost.

### Criteria

The display tower must be:

- 4 feet tall
- Able to support 2 lb for 2 minutes (minimum)
- Taken apart and fit into a 2-gallon bag
- Reassembled easily (least amount of steps)
- Low cost
- Aesthetically pleasing (unique shapes/patterns, construction is neat, nice color)
- Free standing (not attached to any surface)

### Constraints

- You can use only the material provided.
- You can only make a total of 3 trips to the store to purchase materials

### Final Score (Lowest Score Wins Contract)

Aesthetic Score = 0 (Excellent), 5 (Okay), 10 (Needs Works)
Assembly Steps (Total steps to be reassembled) =
Total Score = Cost + Number of Criteria NOT met + Aesthetic Score + Assembly Steps

## *Student Worksheet (continued): Golden Book Design Challenge*

### Material Costs

- Pieces of cardboard: $0.50 (small), $0.75 (med), and $1.00 (large)
- Newspaper: $0.01 (per sheet)
- Index cards: $0.05 (for 1)
- Paper: 0.05 (per sheet)
- Card stock: $0.50 (per sheet)
- Clay: $0.25 (per 1” piece)
- Straws: $0.10 (for 1)
- Pipe cleaners: $0.10 (for 1)
- Skewers: $2.00 (for 1)
- Dowels: $5.00 (for 1)
- Paper Clips: $0.15 (for 1)
- Binder Clips: $1.00 (for 1)
- Brass Fasteners: $0.25 (for 1)
- Masking Tape: $2.00 (per 1 foot)
- String: $0.25 (per foot)
- Aluminum Foil: $0.50 (per 6”)
- Craft Wire: $1:00 (per 1 foot)

### Planning Stage

Meet as a team and discuss the problem you need to solve. Then develop and agree on a design for your statue display tower. You'll need to determine what materials you want to use.

Draw your design below, and be sure to indicate the description and number of parts you plan to use.

Team members:_____

Brainstorm possible solutions:

## *Student Worksheet (continued): Golden Book Design Challenge*

Choose BEST solution and SKETCH it (make sure to LABEL your sketch):

## Student Worksheet (continued): Golden Book Design Challenge

MATERIAL LIST

| Materials and Cost | How Many Trip 1 | How Many Trip 2 | How Many Trip 3 | TOTAL Used | TOTAL Cost |
|---|---|---|---|---|---|
| Pieces of corrugated cardboard (different sizes): $0.50 (small), $0.75 (med), and $1.00 (large) | | | | | |
| Newspaper: $0.01 (per sheet) | | | | | |
| Index cards: $0.05 (for 1) | | | | | |
| Paper: 0.05 (per sheet) | | | | | |
| Card stock: $0.50 (per sheet) | | | | | |
| Clay: $0.25 (per 1" piece) | | | | | |
| Straws: $0.10 (for 1) | | | | | |
| Pipe cleaners: $0.10 (for 1) | | | | | |
| Skewers: $2.00 (for 1) | | | | | |
| Dowels: $5.00 (for 1) | | | | | |
| Paper Clips: $0.15 (for 1) | | | | | |
| Binder Clips: $1.00 (for 1) | | | | | |
| Brass Fasteners: $0.25 (for 1) | | | | | |
| Masking Tape: $2.00 (per foot) | | | | | |
| String: $0.25 (per foot) | | | | | |
| Aluminum Foil: $0.50 (per 6") | | | | | |
| Craft Wire: $1.00 (per foot) | | | | | |
| | | | | **TOTAL COST** | |

- Construction Phase

Build your statue display tower. During construction you may decide you need additional materials or that your design needs to change. This is ok – just make a new sketch and revise your materials list.

- Testing Phase

Each team will test their statue display tower. If your design is unsuccessful, redesign (purchase more materials if necessary- Round 2) and test again. Be sure to watch the tests of the other teams and observe how their different designs worked.

## *Student Worksheet (continued): Golden Book Design Challenge*

Sketch your final design (make sure to label your sketch):

| |
|---|
| |

◆ Evaluation Phase

Evaluate your team's results, complete the evaluation worksheet, and present your findings to the class.

Use this worksheet to evaluate your team's results in the Statue Display Tower Lesson:

Did your solution meet the criteria?

| The display tower must be: | YES | NO |
|---|---|---|
| ◈ 4 feet tall | | |
| ◈ Able to support 2 lbs for 2 minutes | | |
| ◈ Free standing (not attached to any surface) | | |
| ◈ Fit into a 2 gallon bag when taken apart | | |

Assembly Steps (Total steps to be reassembled) =

1. If you had time to redesign again, what changes would you make?

2. What went well?

## Student Worksheet (continued): Golden Book Design Challenge

3. What didn't go well?

4. Where there any trades-offs (an exchange that occurs as a compromise or concession) you had to make with your design? (For example: cost and performance) If so, explain:

5. What is your favorite step in the engineering design process and why?

6. What is your favorite element of your design and why?

Aesthetic Score = 0 (Excellent), 5 (Okay), 10 (Needs Works)
Total Score = Cost + Number of Criteria NOT met + Aesthetic Score + Assembly Steps

TOTAL SCORE: _____

## *For Teachers: Alignment to Curriculum Frameworks*

Note: All lesson plans in this series are aligned to the National Science Education Standards which were produced by the National Research Council and endorsed by the National Science Teachers Association, and if applicable, also to the International Technology Education Association's Standards for Technological Literacy or the National Council of Teachers of Mathematics' Principals and Standards for School Mathematics.

### ◆National Science Education Standards Grades 5-8 (ages 10 - 14)

**CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

### ◆National Science Education Standards Grades 9-12 (ages 14-18)

**CONTENT STANDARD E: Science and Technology**

As a result of activities, all students should develop

- Abilities of technological design
- Understandings about science and technology

### ◆Standards for Technological Literacy - All Ages

**Technology and Society**

- Standard 5: Students will develop an understanding of the effects of
  - technology on the environment.
- Standard 7: Students will develop an understanding of the influence of
  - technology on history.

**Design**

- Standard 10: Students will develop an understanding of the role of
  - troubleshooting, research and development, invention and innovation, and
  - experimentation in problem solving.