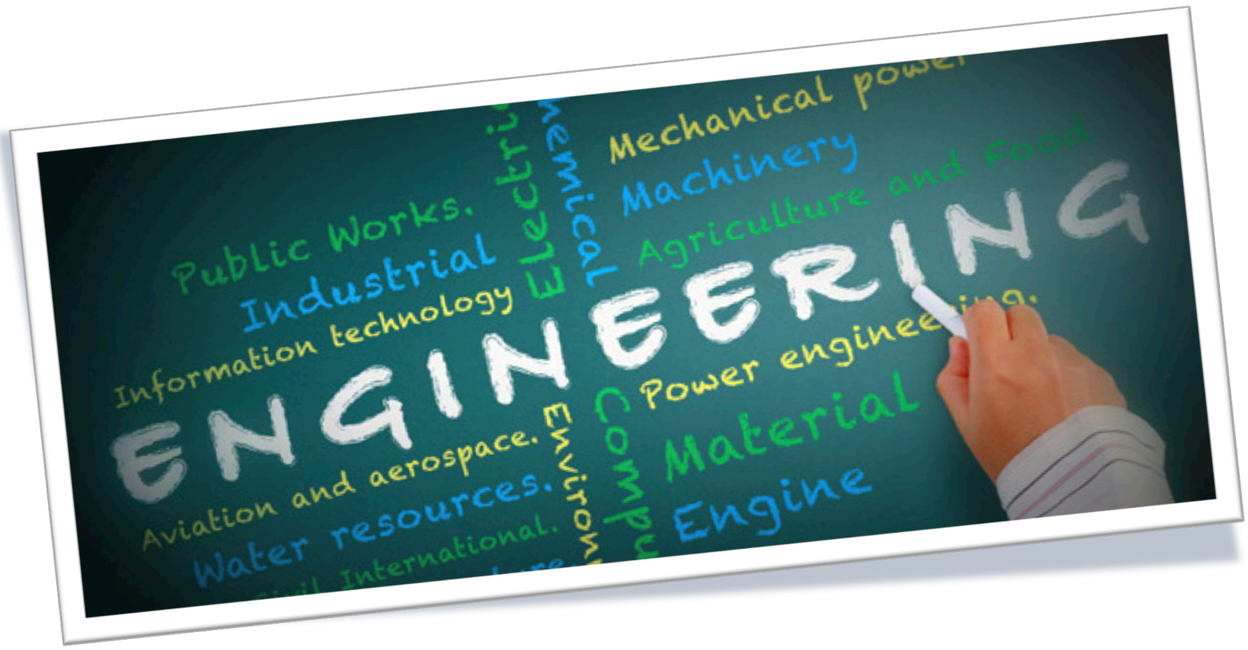
# STEM Olympics

**Summer**Camp 2015



## Balaji Temple Summer Camp
STEM Olympics: Intro to Design

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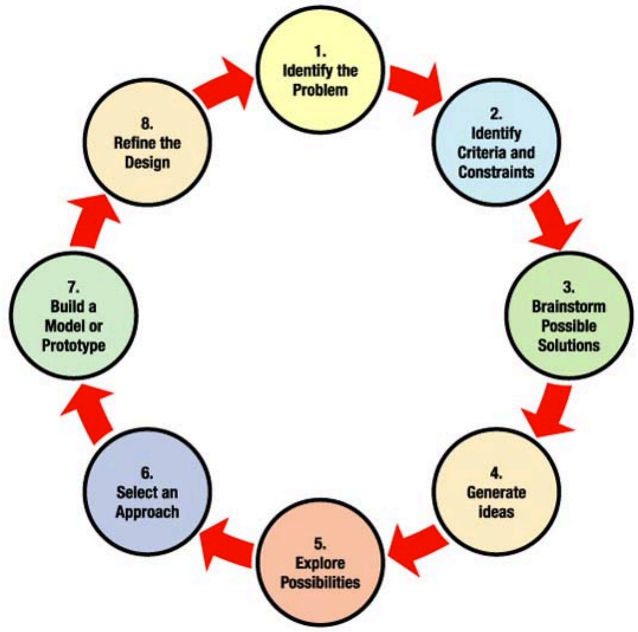
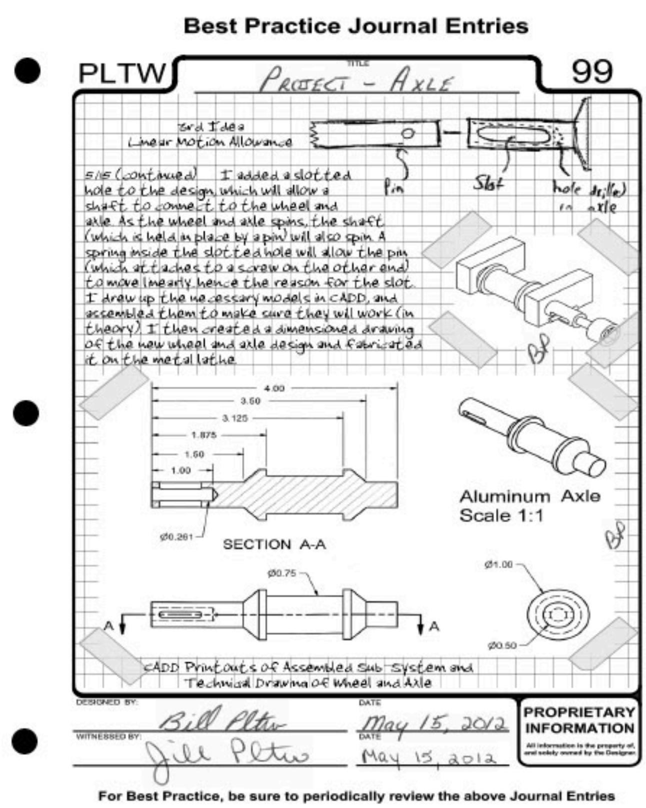
**Welcome to STEM Olympics!** In this activity, you will be completing with your team to complete a variety of engineering and science related activities. Before we start, here's an introduction to how engineers design their products.

It is important for engineers, architects, and scientists to layout their problems before beginning to work on a solution. We will adopt a system called a "design process." A **design process** is defined as a systematic way of solving a problem. We will use the **seven-step design process** in this outline. Here are the steps, followed by a short description of each.




1. **Define the Problem:** What is the problem at hand? What must the new product do?
2. **Research the Problem:** Research new terms, look up products that already exist, etc.
3. **Brainstorm Possible Solutions:** Sketch possible solutions in your notebook. *Do not discount any ideas.*
4. **Select an Approach:** Pick what you think is the best of the possible designs. This is usually done with a design matrix.
5. **Build a Model:** Just do it! Get your hands dirty.
6. **Test the Model**
7. **Revise the Model:** Does the model do everything it should? Are there any problems? How should we fix those problems?
   *The design process is repetitive. Once we identify a problem with our model, we begin the design process again to solve this new problem.*

Each time you solve a problem this week, you should think of these steps. Your group will be given point based on how well your team does in each event. Teams will also be awarded points for keeping good **engineering notebook-esq** enteries**.** An engineer keeps track of the above steps in an engineering notebook. For each event, you will go through each of the above steps and document them in your notebook. You'll also answer the post event questions in notebook style.



# STEM OLYMPICS

## Event #1: Instant Challenge: Cable Car

**Introduction:** There are many ways to solve a problem. Sometimes it is as simple as applying a piece of duct tape. Other times it takes months or years for a product to progress from an idea into full-scale production. Often engineers and designers use a specific set of steps (sometimes called a design process) to find the best solution to a problem. In this activity your team will quickly design the solution to a problem using a design process that progresses from brainstorming to presenting a final design.

**The Design Process:** Engineers use a "design process" to come up with solutions to problems. We'll be using the 7-step design process in this activity.

1. **Defining the Problem:** To find a solution to a problem, we obviously need to be given an actual problem. This usually comes from the company.
2. **Design Constraints:** What are the things that the design needs to do? What does it need to be made of, and what are the max and min dimensions?
3. **Brainstorm Particular Solutions:** Come up a couple of solutions that you sketch out. Be wild! It's just brainstorming!
4. **Selecting an Approach:** After coming up with lots of ideas, we have to choose one, so pick your favorite.
5. **Design a Prototype:** Engineers usually come up with a computer model of their idea. Here, we'll let you go straight to building
6. **Test the Prototype:** Make the prototype do what it should be doing. Analyze the results
7. **Draw Conclusions and Fix Problems:** After testing, we fix things that went wrong and redo our design. We then go back to step 3 to fix these new issues.

**Materials:** You will be given the following [and only the following] materials to use.

- 1 sheet of cardstock
- 2 tongue depressors
- 2 paper clips
- 2 rubber bands
- 1 straw
- 1 balloon: choice of either long and skinny (balloon animal) or round 9" diameter (or similar) balloon
- 12 inches of string
- 6 inches of masking tape
- Small figure (such as a Lego man or similar) or other small object to transport
- Scissors (tool only – cannot be consumed in design)

### Procedure

Using only the materials provided, design and build a device or vehicle to move a small figure (or other object) as far as possible across the room on the fishing line cable. A team member may initiate the motion of the vehicle or device but may not provide forward momentum.

**BRAINSTORM IDEAS:** Draw some of your ideas here. Circle your final design. You'll get some points for doing this step.

**CONCLUSION QUESTIONS:**

1. Why do you think brainstorming is helpful when solving a problem?

2. How did testing improve your design?

3. With respect to designing the solution of a problem, what are some important characteristics of a successful team?

**Balaji Temple Summer Camp**
STEM Olympics: Structural Engineering

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**Introduction:** Town and city planners often try to keep plots of land as small as possible so that the city can accommodate as many buildings as possible. As a result, architects must design buildings that can be as tall as possible with as small of a base as possible.

**Problem Statement:** Build a tall device out of paper and tape that is (a) as tall as possible and (b) can withstand a wind load.

**Design Constraints:**
The following constraints must be followed:

- ✓ Base must be smaller than 8.5" x 11"
- ✓ Device must be at least 1' tall
- ✓ The device stand for at least 15 seconds while your team blows on it.
- ✓ The device is made of ONLY newspaper (3 sheets) and tape (3 feet). Glue, plastic, and cardboard MAY NOT be used.
- ✓ The entire device must be made within 15 minutes.
- ✓ The device CANNOT be attached to the table in any way.

**Pre-Event Questions:**

1. Research: What shape will you use as a base? Explain your choice.

2. Select an Approach: What strategy will you use to make your structure as tall as possible?

**Post-Event Questions (Answer these AFTER your device has been tested):**

1. Other than height and base shape, what factors do you think Civil Engineers and Architects must consider before choosing a design? One example is changing temperatures, which can cause materials to expand and contract.

2. What is the surface area of the base you created? Show all calculations below. If your shape involves pi, you may leave your answer in terms of pi.

**Scoring:**
The following scoring rubric will be used:

<u>Design Constraints Check</u>

| | | |
|---|---|---|
| The device is at least 1' tall | **Y** | **N** |
| The device's footprint is less than a standard sheet of paper | **Y** | **N** |
| The device is made of only the allowed materials | **Y** | **N** |
| Proper planning was used (pre-event questions) | **Y** | **N** |

If "N" is selected for any of the above, the device must be scored in Tier 2.

***A.*** *Device's Height (to nearest inch):* ______________________
***B.*** *Device's Base SA (to nearest inch):* ______________________
***C.*** *Calculated SA:* ______________________
***D.*** *10* - |B-C| ______________________
***E.*** *Pre and Post-Event Questions (+10 max)* ______________________

**The device's total score is the addition of the scores from part A, D, and E.**

**TOTAL SCORE: ______________________**

**Place: ________________________________**

**Judge's Initials: ______________________**

# Paper Airplane Toss

**Group Name:________________________________________**

**Introduction:** The majority of young kids have made and flown a paper airplane in their homes. However, have you ever wondered what causes these planes to fly farther and stay in the air longer? In this activity, through many attempts, students will figure out what factors affect the flight of a paper airplane.

**Materials:**

- ✓ 5 Standard sheets of copy paper (8.5" x 11")
- ✓ Tape
- ✓ Scissors
- ✓ Ruler

**Procedure:**
Students will be placed in groups of 2-3. Each group will design 3 *different* paper airplanes that will compete in a distance and hang-time competition.

> **Distance Competition:** The distance competition will take place on level ground. Students will throw their aircrafts from the same height with a force that they believe is appropriate. The horizontal, perpendicular distance the aircraft travels will be measured, from the start line to the place where the airplane FIRST LANDS. If the plane lands and slides a distance *D,* the distance (*D)* the airplane slides will not be counted. All three airplanes will be tested. The plane with the highest distance will be used to calculate scores.

> **Hang time Competition:** The hang time competition will take place on the upper level of the Temple. Students will throw their airplanes from the same height with a force that they believe is appropriate. The amount of *time* the aircraft is airborne will be recorded. All three airplanes will be tested. The plane with the highest distance will be used to calculate scores.

Students will be given 30 minutes to design and build 3 airplanes. On the back of this sheet, each student in the group must sketch an idea of a good airplane, then proceed to build it using the materials provided.

**Scoring:** The airplane with the highest distance will win the distance competition. The airplane with the highest time will win the hang time competition.

**FOR JUDGE USE ONLY**

1. Distance Competition (In feet)
   - Aircraft #1Distance Traveled ____________________
   - Aircraft #2Distance Traveled ____________________
   - Aircraft #3Distance Traveled ____________________
   - **Highest Distance** ____________________
2. Hang Time Competition (In seconds)
   - Aircraft #1 Hang Time ____________________
   - Aircraft #2 Hang Time ____________________
   - Aircraft #3 Hang Time ____________________
   - **Highest Time** ____________________

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**Introduction:** Cylindrical cans are a common sight in most markets and superstores. However, have you ever wondered how the contents of these identical can effects the way they roll? In this activity, competitors will identify how different contents change the way a can rolls.

**Some Science:**

If we slide a box down a ramp and then let it continue to slide down the floor, you can probably imagine that it wouldn't go very far. However, if we roll a can (with the same mass) down the ramp, it would probably go a lot farther. If we look at the physics of the situation, we can see that the fact the can *rolls* down the ramp allows it to better use its **energy.**

When a box slides across the floor, there is a frictional force in the direction opposite of its motion that causes it to stop. However, in a rolling object, the friction actually *causes* the object to rotate allowing it to move farther across the floor. Note, however, that the contents of the can changes the distance a can moves. In this activity, you will figure out what factors affect how a can moves.

**How it Works:** Tomorrow, each of your team members should bring in a can that you believe will roll the farthest when we roll it down an incline. On the day of the competition your team must select one of the cans from the ones you bring in that you will actually compete with. The team with the can that rolls the farthest will win.

**When you are testing your can at home, please make sure it rolls in a straight line.**

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Of the cans your team brought, which one are you going to select to compete?

**Post-Event Questions:**

1. What causes different cans to move farther? What about the contents of the cans cause them to move farther? Does the weight of the can play a factor in how far it rolls?

2. The following cans are rolled down a ramp. Given that all of the cans have same radius and mass, which one will roll the farthest?

- Diced Pineapple
- Crushed Tomatoes
- Tomato Paste

3. The experiment is repeated with cans of condensed milk. Can A has a mass of 3, can B has a mass of 4, and can C has a mass of 5. Given that dimensions of each are unchanged, which can do you think will roll the farthest?

Suppose a box and a can of equal weight are pushed off of the same ramp at the same time. Which one do you think will move farther?

**Balaji Temple Summer Camp**
STEM Olympics: Structural Engineering

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**Introduction:** Structural and mechanical engineers work together to design large structures. It is their job to analyze the structure after the architects design it to make sure that it can withstand various dead and live loads. Before we move on, we must define a few important terms:

**Mechanical Vocabulary**

*Force:* Energy associated with physical movement. *F=ma.*
*Load:* A force applied to a structure.
*Dead Load:* The weight of the building itself
*Live Load:* A changing load, usually that of people or cars.
*Shear Forces:* Two forces, in opposite directions, applied on the same part.
*Compression Forces:* Pushing forces *into* the part.
*Tension Forces:* Pulling forces *away* from the part.
*Buckling:* When a member begins to bend under a tension force.

**Drawing Forces:**

In addition to having a numerical value, Forces have a direction associated with them. When making bridges or towers, we will assume the forces to be pointing along the member. These members are called **two force members.**
We'll show you an example of this in class.

**Design Challenge**

Balaji and Associates has contracted your team to construct a tower for their company. Before the company will decide to hire you for sure, you will be required to follow the engineering process and build a miniature prototype of your tower. The Balaji and Associates manager will then load your tower with a live load. The team to hold the highest weight will get the contract.
The project manager has given you the following materials to work with:

- ✓ One (1) bag of craft sticks
- ✓ Hot Glue
- ✓ Tape
- ✓ Scissors (cannot be used in actual design)
- ✓ Ruler (cannot be used in actual design)

Your design must adhere to the following constraints:

- ✓ The tower's highest point must be 15" or higher from the ground.
- ✓ The center of the tower must be clear such that a loading chain can be put down the middle.
- ✓ A 4 inch square wood plate will be placed on tope of the tower to distribute the force evenly. Be sure the opening at the top of the tower is LESS than 4" x 4".
- ✓ Must provide horizontal support by at least 3 supports.
- ✓ The tower must be *free standing,* meaning it cannot be attached to the ground by any other means except the base.

Competition Rules:

1. Your team will be loading the tower. Instructors will *not* place the loading block, bucket, or sand on your tower for you.
2. There will be a 5-minute loading limit. Your time will begin once you start setting up your tower on the testing machine. Testing will be completed when your tower breaks **or** when the 5-minute time period has expired; whichever comes first.
3. Instructors will weigh the tower before testing and the load after testing. The sand you place in the bucket that physically breaks the tower *will not* be counted and will be removed.
4. The tower that has the greatest efficiency will win. The following equation will be used to calculate efficiency:

$$\text{Efficiency} = \frac{mass\ of\ load\ (g)}{mass\ of\ tower\ (g)}$$

Scoring:
Your entire project will be graded in the scoring of this event, meaning that you *must* follow the design process.
Your project will be graded using the following:

| Item Description | Total Points | Points Received |
|---|---|---|
| Defining the Problem | 10 | |
| Identifying Constraints | 10 | |
| Brainstorming/ Research | 10 | |
| Final Design Sketch | 20 | |
| Tower Placement | 40 | |
| Post Event Evaluation | 10 | |
| | **TOTAL (100)** | |

To earn the points above, answer the following questions.

**Defining the Problem:**

1. Who are you designing your project for?

2. What is the problem? What factors do you need to take into account?

**Identifying Constraints:**

3. What design constraints must you follow? Do not list materials given here.

**Brainstorming and Research:**

4. What shape do you think your truss members should be? Why do you think so?

5. Sketch some tower designs here. Draw at least 3.

**Final Design Sketch:** Use the grid to draw *one face of* your final design. Be sure to include dimensions. Additionally, choose one part of your tower to draw the forces on.

Date:

| Signature: | Judge Approval: |
| --- | --- |

**Evaluation:**

1. What parts of your design worked? What caused your tower to fail? Highlight the *failure member* on your tower design sheet.

2. Suppose your tower had to withstand a wind load in addition to the vertical applied load. What changes would you make to your design? Draw a rough sketch below.

______________________________**DO NOT WRITE BELOW THIS LINE**______________________________

**Tower Placement:**

| **No** | **Constraint** | | |
|---|---|---|---|
| 1 | Tower is at least 15" tall | Y | N |
| 2 | Center of the tower is clear. A loading chain can go through the middle. | Y | N |
| 3 | Top of tower is configured such that a 4" loading plate can be placed on it. | Y | N |
| 4 | The tower is supported by at least 3 supports | Y | N |
| 5 | The tower is free standing | Y | N |
| **6** | **"Y" is marked for all 1-5** | **Y** | **N** |
| | *If "N" is marked for 6, the tower must be placed in tier 2. | | |

Record the Mass of the Tower here: ____________________g

Record the Mass the Tower held here: ____________________lb

Record the total loading time here: ____________________

Efficiency: ________________________________________

Place: ______________

Judge's Initials: ________