

# Science Olympiad Summer Institute

## MYSTERY ARCHITECTURE

### Sample List of Materials

This list of Materials

20 - #32 Rubber Bands, Brown

20 - Small Rubber Bands, assorted size/colors

1 - Roll Scotch Tape

4 - 5 oz. Plastic Cups

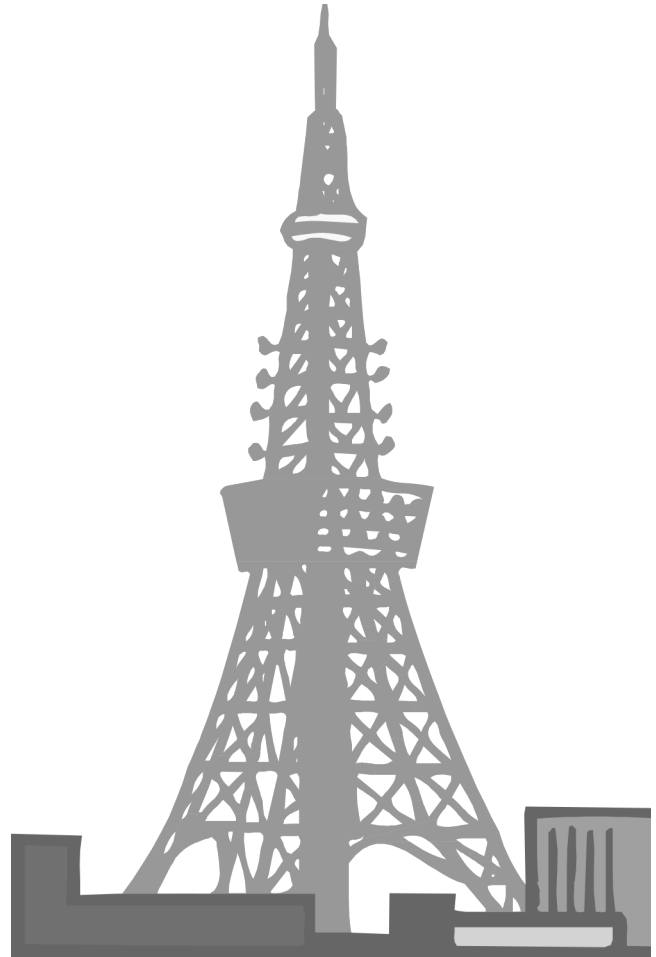
20 - Pipe Cleaners, assorted colors

10 - 10 inch Bamboo Skewers

10 - 12 inch Bamboo Skewers

20 - Drinking Straws

5 - 5 x 8 index cards



By

*Ervin E. Zimmerman*



# Mystery Architecture 2003



## **Object**

To build a device that can be tested in performing a given task.

## **Example Devices**

Tower – Support a given load at the greatest possible height above its base.

Bridge – Support a given load between two supports the greatest possible Distance (span) apart..

Cantilever – Support a given load the greatest possible distance beyond a support.

## **Testing**

Support a load for the specified time

If a load is required it will be available to each contestant while building the device.

The load may consist of only the mass of the device. (No load supplied)

This is a Pass / Fail measurement. All devices that support the load will be ranked above those that do not.

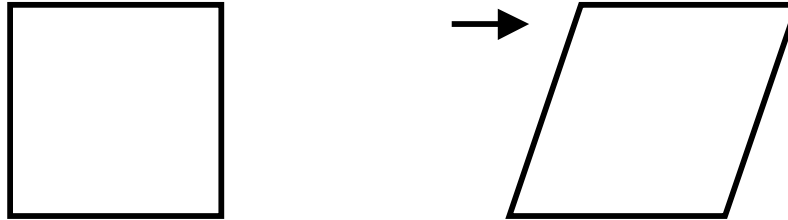
Measurement of device

Primary Dimension – Used to determine score as specified in task definition. Devices with larger dimension are ranked above those with smaller dimension.

Secondary Dimension – Used to break ties if two devices have the same Pertinent Dimension. Smallest dimension wins tie.

## Simple Structures

Square

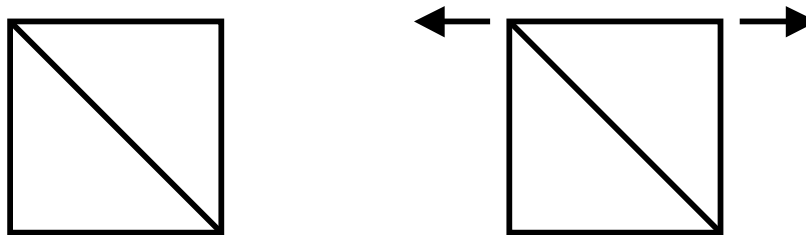


Use 4 pipe cleaners and 4 drinking straws to form a square. Insert the pipe cleaners through the straws and twist them together at the corners. Stand the square on edge and apply a downward force to the top of it. The square deforms easily due to the weakness (in rotation) of the corner joints.

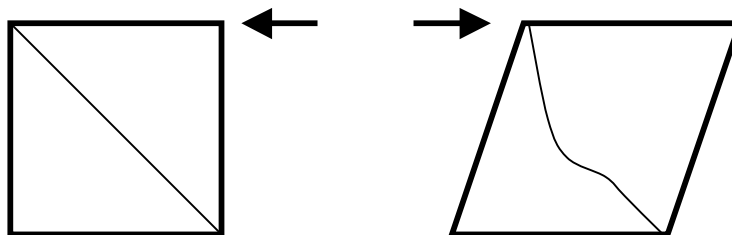
Triangle



Make a triangle in the same manner using 3 pipe cleaners and straws and test it as you did the square. The triangle won't change shape unless you push hard enough for either a joint or one of the straws to break.



Fortunately a 4-sided figure can be changed into 2 triangles by connecting 2 opposite corners together. Add a rigid cross brace to the square and test it again. Now it is much stronger.



Remove the rigid cross brace and replace it with a piece of string. Now you can deform the square in one direction easily but not the other. If you connect the remaining 2 corners with another string the square will be rigid in both directions again. By using these principles you can build a larger structure that is strong and rigid.

## Analysis of Structures

### Definitions

Joint – The place where 2 or more members are connected together.

Member – A part of a structure that connects 2 joints.

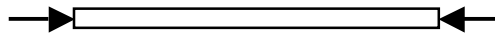
Strain – The deformation or change of shape that is the result of applied stress.

Stress – The force applied to an object that tries to change its shape. There are 5 different forms of stress.

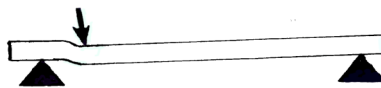
Bending – Stress that tends to deform an object from a straight line.



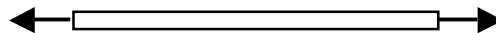
Compression – Stress that tends to compress an object together.



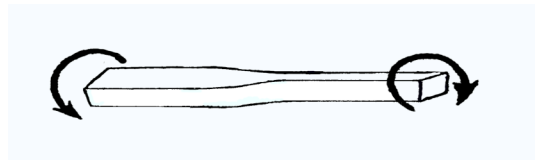
Shear – Stress that tends to make two parts of an object slide past each other.



Tension – Stress that tends to pull an object apart.



Torsion – Stress that tends to twist an object around an axis.



For our simplified analysis we will only consider bending, compression, and tension.

## Towers

The object is to support a load at some height above the base.

A tower is made up of:

Legs or Columns – Vertical members

Extend from the base to the top of the tower

Support the load

Need to be strong in compression.

Bend easily because they are long and slender.

Cross Braces – Horizontal/Diagonal members

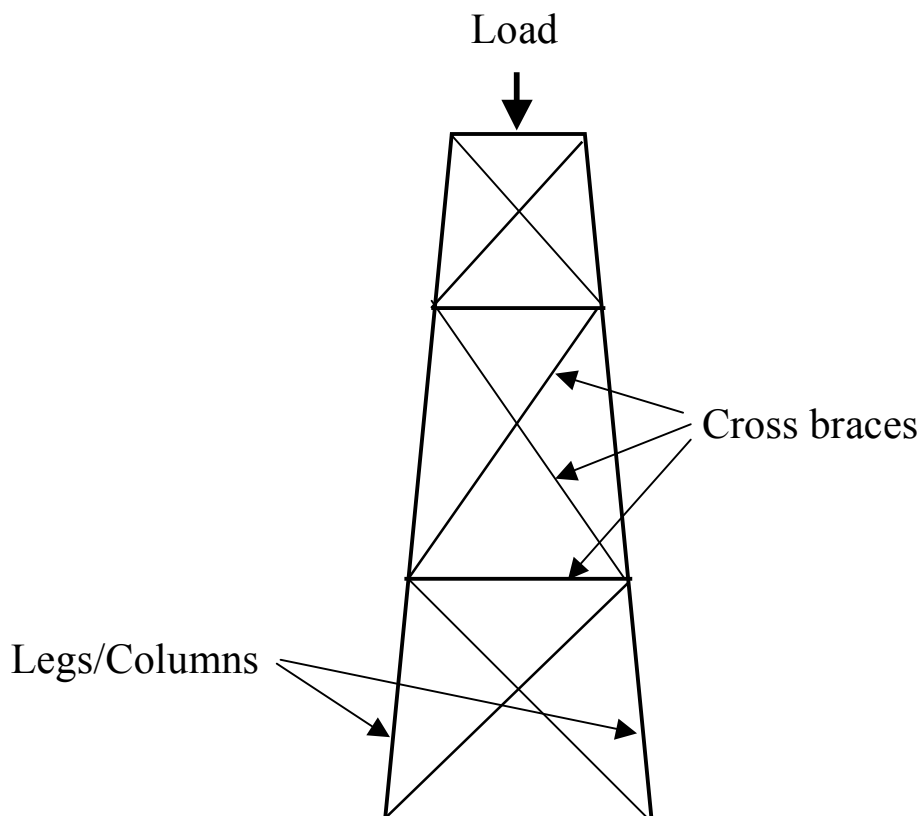
Connect one leg to another

“Break” the legs up into shorter/stiffer members

Prevent the legs from bending

May be under compression or tension

Have very little stress as long as the legs remain straight.

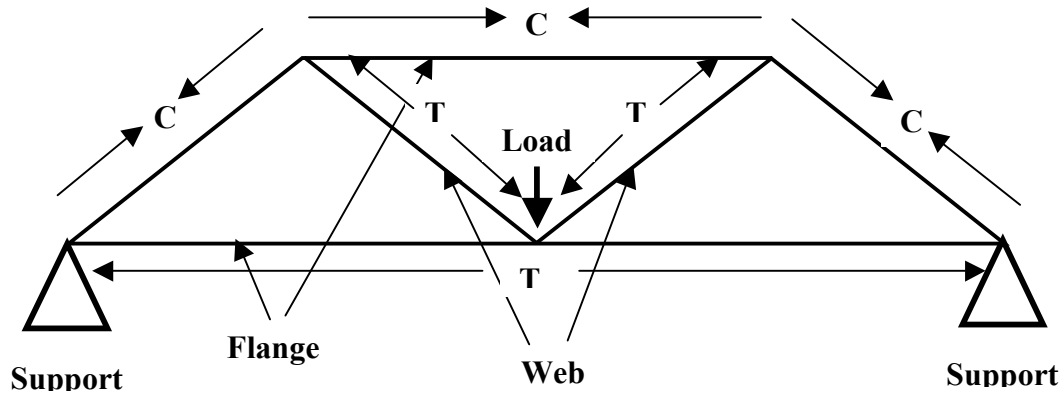


## Bridges

The object is to support a load between two supports.

T = Tension

C = Compression



A Bridge is usually made up of two or more trusses which contain:

**Flanges – Horizontal /Diagonal members**

Transfer the force generated by the load to the supports

Top flange is under compression

The bottom flange is under tension

Need to be strong in compression/tension

Bend easily because they are long and slender

**Web – Vertical/Diagonal members**

Help carry the load to the supports

Hold the flanges apart

Need to be strong in compression/tension

“Break” the flanges into shorter/stiffer members

Keep the flanges from bending

**Cross Bracing – Connects the trusses together**

Keep the trusses from bending sideways (laterally)

Have very little stress as long as the flanges are straight

## Cantilever

The object is to support a load at a horizontal distance from a support.

A Cantilever is similar to a bridge except:

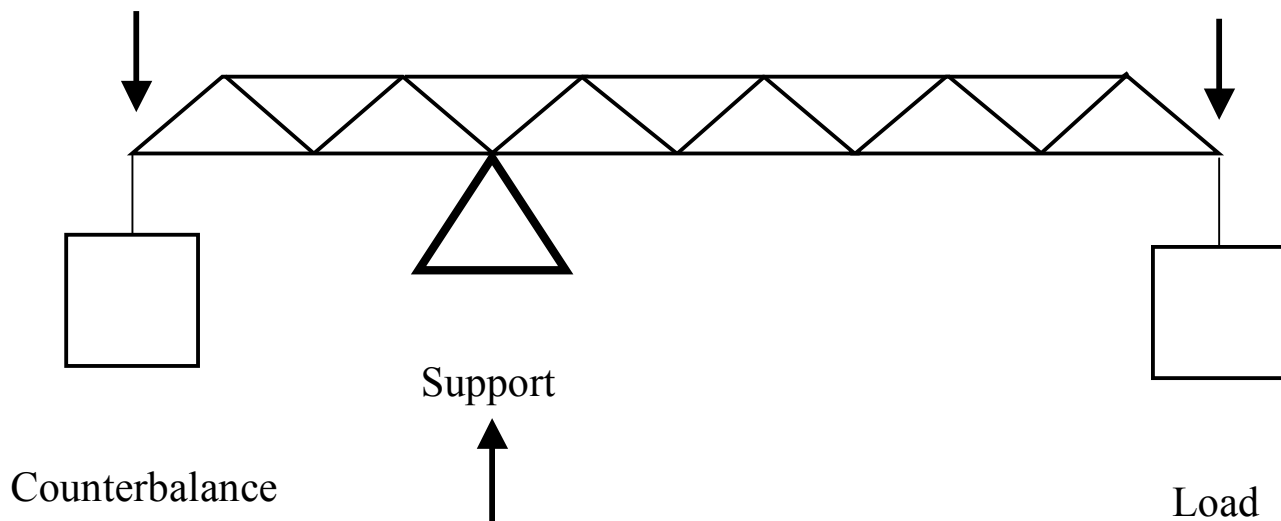
The support is in the center of the lever.

There is a load at one end of the lever

The counterbalance is at the other end of the cantilever

The top flange is in tension

The bottom flange is in compression



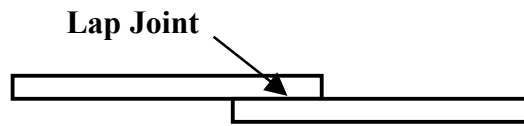
## Joints

A joint is where 2 or more members are joined together

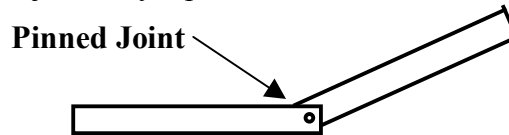
Butt Joint – pieces are joined end to end



Lap Joint – Pieces are overlapped



Pinned/Hinge Joint – Pieces joined by a pin



The strength depends on the type of joint and material used to hold it together.

You can use Tape to hold butt and lap joints together. When you wrap a butt joint with tape it technically becomes a lap joint.

A lap joint can be held together with string or tape used as glue.

## Strength of Joints

### Butt Joint

- Bending – Weak
- Compression – Strong
- Tension – Weak

### Lap Joint

- Bending – Strong
- Compression – Medium
- Tension – Medium

### Pinned Joint

- Bending – Weak
- Compression – Medium
- Tension – Medium



## Materials

Before you start building, inspect the materials provided. Try to match their properties to those required where it will be used.

## Properties

### Drinking Straws

- Bending – Strong
- Compression – Medium
- Tension – Strong

### Bamboo Skewers

- Bending – Strong
- Compression – Strong
- Tension – Strong

### Index cards

- Bending – Weak
- Compression – Weak
- Tension – Strong

### String

- Bending – Weak
- Compression – Weak
- Tension – Strong

Tape – Its stickiness is good for holding joints together.

- Bending – Weak
- Compression – Weak
- Tension – Medium

Rubber Bands – Elasticity makes them useful for holding joints together

- Bending – Weak
- Compression – Weak
- Tension – Elastic

## **Sources of information**

Great Buildings of the World - Bridges, Derrick Beckett, 1969, Hamlin Publishing Group Ltd., SBN 600 01640 4

Engineering For Young Scientists, Peter H. Goodwin, 1987, Peter H. Goodwin, ISBN 0-531-10339-0

Messing Around With Drinking Straw Construction, Bernie Zubrowski

Structures, The Way Things Are Built, Nigel Hawkes



# Mystery Architecture 2003



## MYSTERY ARCHITECTURE

Team #: \_\_\_\_\_

School: \_\_\_\_\_

District: \_\_\_\_\_

Name: \_\_\_\_\_

Name: \_\_\_\_\_

Scheduled Time: \_\_\_\_\_

----- Do Not Write Below this line -----

Start Time: \_\_\_\_\_ Stop Time: \_\_\_\_\_

Primary Dimension:	Secondary Dimension:	Place:	Points: