



Design/Build: Team Instructions

DO NOT BEGIN UNTIL INSTRUCTED TO DO SO

Instructions

This packet contains instructions for the Design/Build portion of the 2020 TEAMS competition.

1. Complete the SCHOOL/TEAMS INFORMATION at the top of the datasheets provided.

NOTE: Any datasheets submitted without identifying school/team information will NOT be scored.

2. Teams will have **5 minutes** to brainstorm and sketch their design. **Teams may not build any component of their device during this portion of the competition.** All team members should contribute to the process of designing the solution.
3. Teams then have **60 minutes** to build (and test) their final prototype made only with the allowed materials. Teams may test up to two times during the first **50 minutes**: teams that have not already tested twice may test one time during the final **10 minutes**. The better of the testing scores will be used as their final score.
4. At the end of this **60-minute time period**, no more construction may be done. Teams that have not yet tested must be in line in order to test one time.
5. Teams are responsible to record accurate information on height, cost, and capacity. Adult volunteer signatures verifying accurate scoring information are required.
6. Datasheets must be returned by hosts to the national TSA office for scoring.

NOTE: Failure to adhere to these directions may disqualify your team from the competition

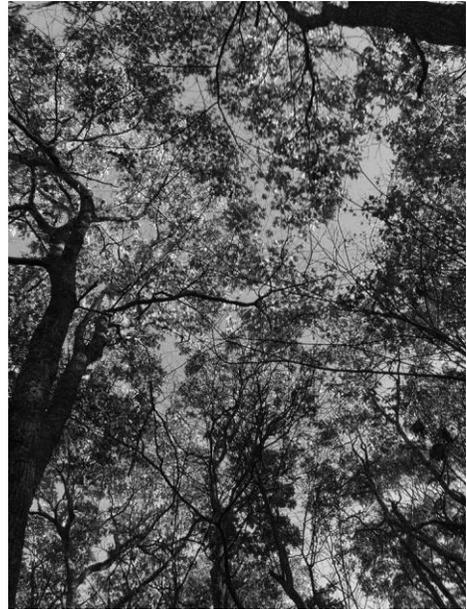


Design/Build: Team Instructions

Research in the Forest Canopy

Rainforests are vital to the ecosystem of Earth. Today, rainforests cover only 6-8% of the land surface of the Earth, but they support half of the plant and animal species inhabiting the globe. Although they are exceptionally important, they are also difficult to study. Research into the canopy of the forest – the layer formed by the top of the trees and other plants – has proven to be difficult. Currently, researchers chop down trees or branches, or climb trees with ropes to gain access to plant and animal life in the canopy.

Canopy cranes are a recent introduction to the study of the canopy layer. While we are used to seeing cranes at construction sites, lifting steel beams or other huge loads high in construction efforts, scientists are interested in using this technology to allow them to reach high into and above the canopy layer of the rainforest.



Your team has been hired to develop a tall, sturdy crane-like device (herein after referred to as crane) that will reach into the canopy layer in order to study the effects of diminishing rainforest on wildlife. This is a time-sensitive effort due to a recent increase in destroying rainforest to create farmland. Your task is to design and build a crane in the shortest time possible, while sticking to a tight budget with limited materials. Your team is required to begin with a prototype: a smaller-scale model of a full scale design. You should evaluate multiple designs before building a prototype. Since iteration is a key aspect of engineering, you will have to keep ahead of the project schedule to be able to design, build, and test your device more than once.





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Challenge

Your team has been tasked to design and build a crane which will be used to lift heavy material (for the purpose of this challenge, represented by pennies) high into the forest canopy. The crane must include a take-up mechanism to lift a bucket (or similar part to hold the load). The take-up mechanism must be capable of being locked in order to support the load without operator assistance.

The crane should:

- have a high range of motion (measured by maximum height of the load when lifted),
- be as inexpensively built as possible, measured by the total weight of the apparatus (lower weight = lower material cost),
- have a high maximum capacity (measured by holding the most weight in the bucket without an operator [while locked] and without the device failing).



Terms:

- **Crane, crane-like device:** This refers to your prototype. The device must lift the bucket (or part of the crane holding the load) using a take-up mechanism of some type.
- **Take-up mechanism:** The load must be lifted by a mechanism that is a component of the crane.
- **Bucket:** The part of the crane that holds the load.
- **Device failure:** When under test, the device may fail for a variety of reasons including but not limited to: the heaviness of the load, the structural integrity of the crane or any of its parts, and/or mishandling of the crane by the operators.

Materials: Teams may use only the materials as specified on the materials list:

(5) 5-ounce paper cups	(1) roll of scotch tape
(1) spool of thread	(2) metal flat washers
(1) sewing bobbin	(6) binder clips
(20) rubber bands	(6) unsharpened pencils
(5) wooden dowel rods	(6) paper/biodegradable drinking straws
(10) craft sticks / popsicle sticks	(12) toothpicks (unwrapped)
(20) standard paperclips	(1) pair scissors

Notes:

- Materials may be modified (for example, sticks may be broken; paperclips may be bent).
- Scissors, Ziploc storage bag, or any other packaging may not be used as any part of the structure.



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Process

Phase 1: Brainstorm / Sketch / Design

Each team is allowed **5 minutes** for brainstorming and sketching design ideas using the sketch paper provided to them.

Materials must remain sealed and under the table during this phase. (Note: opening materials before being instructed to do so will result in disqualification).

Phase 2: Build and Test

After 5 minutes, the bag of materials may be opened and building may begin.

Teams then have 60 minutes to build and test their final prototype.

Each team is allowed a maximum of two tests. Teams who are able to test twice will receive the better of the two testing scores. Since the maximum capacity test may be destructive and repairs or changes are likely needed afterward, teams should plan accordingly. Once a team tests twice, their testing is complete.

After 50 minutes (10 minutes remaining), teams may **test only one time, even if they have not yet tested.**

- **Teams that have tested twice:** no more testing
- **Teams that have tested once:** may test once more
- **Teams that have not tested:** may test once

At 60 minutes, all building is to stop. Teams that are (a) in line to test and (b) have not tested yet are allowed one test. This means that teams that are not in line and/or have not finished their build will not be able to test their device.

- **Teams that have tested twice:** no more testing
- **Teams that have tested once:** no more testing
- **Teams standing in line that have not yet tested:** may test once
- **Teams that have not yet tested and are not in line:** may not test

Data collection: Each team is responsible for recording the height, cost, and capacity results on the datasheets. An adult volunteer will sign and return the completed datasheets to TSA.

5 min	Brainstorm / Sketch / Design (5 minutes)
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Teams may begin using materials

50 min	Build and Test (60 minutes)	Teams may test up to 2 times (50 minutes)
10 min		Teams that have tested once or not at all may only test one time
	Final Test	No building: teams that are standing in line and have not yet tested may test once

Hint: Plan a strategy and pay attention to time

Teams can test twice, but the capacity test can destroy the structure and you may have to repair or replace your crane after the first test.



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Testing and Evaluation

Testing will require three team members to serve as operators:

Operator	Role
Base operator	Holds the base of the crane to the table during the height and capacity tests.
Take-up mechanism operator	Operates the take-up mechanism of the crane during the height test.
Load operator	Adds the load (i.e., pennies) to the bucket or similar part during the capacity test.

Testing Rules:

- The three operators (as assigned by teams) are the only individuals on the team allowed to assist with the testing of the crane.
- The three operators must adhere to their assigned role. If the operators or other team members assist with a role to which they are not assigned, then penalty will result.
- The crane must use a take-up mechanism to lift the bucket (or similar part) during the height test. The crane must also be capable of being locked for the capacity test.
- Once the base of the crane is placed on the table and the device is ready to test, it may not move.
- The capacity test will likely be destructive, so it must be done last.

Note: In the event of possible rule violation or questionable event, adult volunteers must include a detailed description of the violation on the team's datasheet.

Category and Evaluation Criteria	Unit	Percent of Total Score
Maximum height The height that the crane can lift the bucket: measured from the bottom of the bucket as it rests on the tabletop to the maximum height of the bucket. If the bucket does not touch the tabletop (because of its height at resting position), then height is measured from the lowest part of the bucket to the highest point reached.	Centimeters (rounded to the nearest ½ cm)	40% (higher is better)
Lower 'cost' The cost of production is always a factor when designing a product. Keeping your material cost low helps reduce production costs, therefore using only the materials needed to produce the most efficient design is best. The total cost will be represented by the final weight.	Grams	20% (lower is better)
Maximum capacity The final test is the maximum capacity as measured by the weight of the load (i.e., pennies) held within a one-minute time period without the device failing.	Grams	40% (higher is better)



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Specific Testing Procedures:

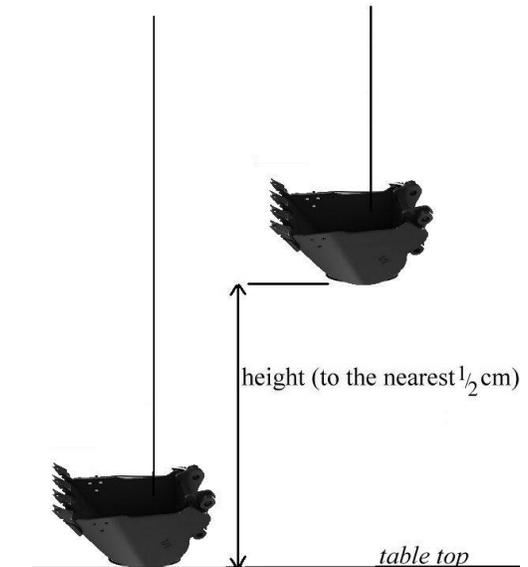
Height Test (as measured by bucket height, rounded to the nearest $\frac{1}{2}$ cm):

Operators: base operator, take-up mechanism operator

Instructions: The base operator places the base of the crane anywhere on the tabletop. The bottom of the bucket (or part to hold the load) should rest on the tabletop. It may not start lower than the tabletop.

While the base operator holds the base of the crane to the table, the take-up mechanism operator raises the bucket to the maximum height by operating only the take-up mechanism. The operator may not pull thread (if used).

The volunteer judge uses a tape measure to measure the maximum height from the tabletop (or bottom of the bucket/part that carries the load) to the maximum height reached (see image to the right). Teams record the maximum height reached (rounded to the nearest $\frac{1}{2}$ cm) on the datasheet.



Notes:

- If the bottom of the bucket does not touch the tabletop (because of its height at resting position), then height is measured from the lowest point of the bucket to the highest point reached.
- The bucket should not be lifting the load (i.e., pennies) during this test.

Height Test Rules:

- The base operator may only touch the base of the crane.
- The crane must use a take-up mechanism to lift the bucket (or similar part).
- The take-up mechanism operator may only touch the take-up mechanism to demonstrate movement. The take-up operator may not touch the thread (if thread is used).

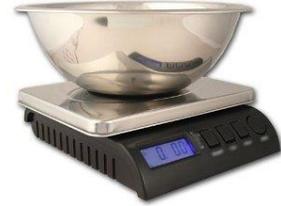


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'Cost' Test (as measured by crane weight, rounded to the nearest gram):

Operators: Any one of the three operators places the crane on the scale and removes it once the weight is recorded.

Instructions: The designated operator places the crane (without the load; i.e., pennies) on the scale. Teams record the weight of the crane (rounded to the nearest gram) on the datasheet.





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Capacity Test (as measured by load weight, rounded to the nearest gram):

Note: The maximum capacity test must be done last.

Operators: base operator, load operator

Instructions: The base operator holds the base of the crane to the table. The crane must remain locked: the operators may not touch the crane. The bucket (or part that holds the pennies) may be suspended at any height as long as it is suspended above the table.

Teams are given one-minute to load as many pennies as possible into the bucket without the device failing. The load operator will use his/her discretion in deciding how many pennies to add at once. While the volunteer judge keeps track of time, the load operator will continue adding pennies until maximum load is reached, the device fails, or time runs out. (Note: teams may wish to stop adding pennies before the device fails or the time limit is reached).

The weight should be recorded as the weight of the pennies in the bucket when maximum load is reached or the time limit is reached, or before the device fails. Teams record the weight of the pennies (rounded to the nearest gram) on the datasheet. If the device fails, teams record the weight of the pennies in the bucket before failure as well as the time at which this happened.

Capacity Test Rules:

- The base operator may only touch the base of the crane.
- The load operator adds pennies to the bucket (or part of that holds the pennies) but cannot touch any part of the crane.
- The crane must remain locked with the load suspended above the table: the base of crane may not move.
- There is a maximum time of 1 minute per test.

Examples of device failure: include but not limited to: pennies spilling from the bucket, the bucket load dropping, the bucket load detaching from the crane, the crane tipping over, the operators directly touching the load or thread, etc.