MISSION POSSIBLE

1. **DESCRIPTION:** Prior to the competition teams will design, build, test and document a Rube Goldberg®-like device that incorporates simple machines connected in series to complete a required task.

   A TEAM OF UP TO: 3 **TIME:** Set-up: 30 min, Operation Time see Section 9

   IMPOUND: **No** (National-Yes) **EQUIPMENT:** event supervisors need meter sticks and stopwatches

2. **SAFETY:** Judges will inspect devices for potential safety hazards that may be cause for disqualification as determined by the event supervisor. Uncontrolled projectiles, uncontained spills, hazardous materials, electricity and flammable substances are not permitted (e.g., unshielded razor blades, rat traps, model rocket engines, cigarette lighters, fireworks, gunpowder, gasoline, acetone). Participants who do not properly wear approved Chemical/Splash Protection Goggles during setup and operation will not be allowed to compete. See: http://www.soinc.org/general/protection.
3. **DEFINITION OF TERMS:** A Simple Machine is a device that multiplies, divides or changes the direction of an applied force for the purpose of moving a load. The 8 types of simple machines listed below may earn points. Each of the 3 classes of levers is considered a different type of machine for scoring in this event.

   Note: A lever is a rigid bar that pivots to exert a force. All levers must have an identifiable fulcrum, load and effort. The load and the effort cannot be one and the same.

   a) **Class 1 Lever** – the fulcrum is between the load and the effort.
   b) **Class 2 Lever** – the load is between the fulcrum and the effort.
   c) **Class 3 Lever** – the effort is between the fulcrum and the load.
   d) **Inclined Plane** – a slope that reduces the effort required to move a load. To earn points the load must be moved upward along a slope at least 10 cm and must not descend back down the slope.

   e) **Wedge** – a wedge-shaped moving **object** that is driven under a load to lift it or into a load to split or separate it. **To earn points, the load must be lifted up or separated a distance of at least 1 cm.**
   f) **Screw** – a rotating spiral-shaped inclined plane. To earn points the screw must rotate at least 360 degrees and the load must be moved at least 1 cm in a linear direction.
   g) **Wheel & Axle** – a rotating device that exerts a rotational force at its center (axle) when its outer part (wheel) is turned or vice versa. If the input force is applied to the axle then the output force must come from the wheel or vice versa. A set of gears connected by teeth and a set of wheels connected by a continuous drive belt are each considered a valid *Wheel & Axle*. To earn points **both** the wheel and axle must rotate at least 360 degrees. A wheel used simply to reduce friction is not a *Wheel & Axle,* so a rolling car earns no points.
   h) **Pulley** – a wheel or set of wheels around which a single length (not a continuous loop) of rope or string passes to move a load. The direction of force must be changed by at least 90 degrees to earn points.
4. **START TASK**: At the judge's prompt, a team member will provide and **pour a container of marbles (any size, material, or number) into the Device** to activate a paddlewheel **which functions as a *Wheel & Axle*. The paddlewheel may have any number of "paddles" (e.g., Popsicle sticks, plastic spoons). All "paddles" must be the same color except for one, which will be used to determine whether the paddlewheel rotates at least 360 degrees.**
5. **COMPLETION TASK: Use a can of food and one or more simple machines of the same type, as defined in section 3, to lift a heavier can of food at least 5 cm. The cans must be unopened, unmodified, the manufacturer's label intact, and easily removed from the Device for inspection. Only the weight of the lighter can of food may provide the lifting force. Counterweights or stored energy devices (other than the lighter can) may not be used. Time stops when the heavier can stops moving and comes to rest in its raised position.** Times will be recorded to the tenth of a second, but rounded to the nearest second for determining scores. Task Completion points will not be awarded if ANY requirements in this paragraph are not met.
6. **BONUS**: A bonus will be awarded for the time the Device takes to load sand into a container attached to one end of *any class Lever* and **activate** the next simple machine in the sequence. **The time used to load the sand into the container is part of the Device's total operating time.**
7. **DETAILS:**
   a) The Device may contain up to sixteen (16) **numbered** simple machines. **The simple machines used for both the start and the completion task must each be a numbered simple machine. Additional un-numbered machines as described in paragraph 8d may be included.** There is no requirement for unique simple machines, however machines of the same type used in series will be counted as one machine (e.g., 3 *Pulleys* in a row only count as 1 *Pulley*). ALL simple machines must operate sequentially such that the output of one simple machine activates the next simple machine and contributes toward task completion – there can be no "dead ends".
   b) The first numbered machine **must** be a *Wheel & Axle* **as described under "START TASK".**
   c) All parts of the Device must fit within an imaginary box (80 cm x 50 cm x 50 cm in any orientation) before, during and after the Device's operation.
   d) Simple machines **may** be used to activate stored energy devices, which **may** then be used to operate other sequential simple machines. Stored energy sources (they may or may not be simple machines themselves)

may be used as interfaces between the simple machines. For example, the output work of one machine causes stored energy to be released that provides the work input to the next machine.

e) Batteries, voltage sources, electric motors or electronics may be used for mechanical or other uses but may not be used for electrical purposes.

f) Each machine to be scored must have a clearly visible and legible number on it indicating its correct sequence in the operation of the Device. The number on the machine within the Device must correspond to the number on the Simple Machine List.

g) Energy storage units (e.g., springs, mouse traps) may be activated prior to starting the Device (except for task completion).

8. **SIMPLE MACHINE LIST (*SML*):**

a) The ***SML*** must be submitted prior to the tournament (The tournament director will provide information specifying the time/date **and method** for submitting this list.)

b) Each line of this list will detail one simple machine in the sequence in which it occurs during operation of the Device. The ***SML*** must be an accurate indication of the Device's operation.

c) The list must use the exact format below, including the total points **(actions/sequence used may differ)**:

No.	Action	Simple Machine Type Or Bonus	Points	1st or 2nd Use Pts.	Total Points
1	Marbles activate paddlewheel	Wheel & Axle	10	20	30
2	Paddlewheel activates lever and string	Class 2 Lever	10	20	30
3	String through a series of pulleys lowers weight	Pulleys	10	20	30
4	Weight activates a series of levers & string	Class 2 Levers	10	10	20
5	String attached to pulley raises weight	Pulley	10	10	20
	Weight activates lever & string	Class 2 Lever			
6	String attached to pulley lowers weight	Pulley	10		10
7	Weight pushes food can onto lever lifting heavier food can	Class 1 Lever	10	20	30
	Heavy can is lifted at least 5 cm and stops	Task Complete	100		100
	Load / Effort = 32 oz. / 12 oz. = 2.7		3		3
	Set-up in less than 30 minutes		30		30
	Met all requirements		200		200
	Total points expected to be earned		403	100	503

d) The ***SML*** should be legible, well organized and neatly done. The machine number and the points expected to be earned for each machine and bonus must be shown on the list. Only points documented on the *SML* will be awarded. If the Device includes extra simple machines that do not count for points, then they must be documented in the list, but they shall not be numbered. The list must be accurate to earn the "requirements satisfaction" points detailed **in paragraph 10.a) vii) of** the scoring section.

9. **OPERATION OF DEVICE:**

a) The Optimum Operating Time (*OOT*) is 60 seconds for Regional & State tournaments. An *OOT* between 90 and 150 seconds will be selected and announced after impound by the event supervisor at the National tournament. **The judges will start their stopwatches when the first marble enters the Device**. Time stops **when the last action listed on the *SML* has either been completed or fails to operate or when the *MOT* is reached**.

b) Use of a remote timer will result in disqualification.

c) The Maximum Operating Time (*MOT*) is 180 seconds at Regional & State tournaments. The *MOT* at the National tournament will be 150-210 seconds (*OOT*+60 sec.) If the Device is running when the time limit expires, the points earned up to that point determine the score. No completion points can be awarded in this case. Example: If the national *OOT* is 96 seconds, the Device will be allowed to run up to 156 seconds. If the task has not been completed within 60 seconds after the *OOT*, points and penalties earned up to that time will be awarded.

d) **Once the Device has been started, penalty points will be deducted each time a team member touches the Device.**

e) If the Device stops, jams or fails, the team will be allowed to "adjust" the Device to continue operation, but penalty points will be deducted. Timing does not stop.

f) For the last step prior to Task Completion or for Task Completion, the team will not be allowed to complete the task themselves or make an adjustment that leads directly to task completion in the very next action. Any obvious stalling during "adjustments" to gain a time advantage can result in disqualification.

10. **SCORING**: Up to 850 regular points plus 30 bonus points (Regional), 39 (State), or 69 (National) will be awarded based on the following criteria:

a) **Regular Points:**

i) 30 points for taking no more than 30 minutes to setup.

ii) 10 points for each successful operation of a machine, which includes activating the next machine of a different type in sequence or in the case of the last machine, activating the completion task. **Prior to**

operation a team member may be asked to verbally explain how each numbered simple machine satisfies the appropriate definition in section 3 to earn points for that machine. 160 pt. max

iii) 20 points for the first time each of the 8 machine types listed is **successfully** used. 160 pt. max

iv) 10 points for the second time a listed machine type is **successfully** used. 80 pt. max

v) **Zero points are awarded for "extra" unnumbered machines. These machines might resemble valid machines, but do not satisfy the definitions in section 3 or they might simply be required for other components to function correctly. All "extra" machines must be documented in the *SML* for it to be considered an accurate list, but verbal explanations will not be required.**

vi) 100 points for successful task completion within the *MOT*.

vii) 20 points each for satisfying the following 10 requirements: Wearing goggles properly without prompting from the judges; having valid Device dimensions; no batteries or electricity; using a **paddlewheel type of *Wheel & Axle*** starting mechanism; using only sequential simple machines; using the correct Simple Machine List format; having an accurate List; submitting the List properly and in time; limiting numbered simple machines to 16; and ending the Device with a **simple machine using a lighter can of food to lift a heavier food can.** 200 pt. max

viii) 2 points for each second or part of a second (up to 60 seconds even though National Tournament *OOT* will be greater than 60 seconds) that the Device operates before task completion**. These points will be awarded regardless of whether the completion task is accomplished**.120 pt. Max.

b) **Bonus Points**:

i) Regional and State Tournaments - Up to 30 points, one point for each second (up to 30 seconds) the Device takes to load the sand into the container.

ii) National Tournament - One point for each second (up to 60 seconds) the Device takes to load sand into the container. Devices may take longer than 60 seconds to load the sand but the bonus is limited to 60 points. **Teams must adjust only the flow rate of the sand timing device to compensate for the *OOT*. The quantity of sand and/or any counterweights associated with the sand timer may not be adjusted.** Teams must identify on their *SML* which numbered simple machine they will adjust to change the operating time. **Adjusting other parts of the Device to compensate for the additional time will result in a 200-point penalty.**

iii) State and National Tournaments - Up to 9 points for the **Load to Effort ratio, rounded to the nearest integer, of the completion task. (Ex. a ratio of 4.4 would receive 4 bonus points and 4.5 would receive 5 bonus points.)** If the cans do not use the same units of weight (ounces, pounds, grams etc.), the **unit conversion calculations must also be documented.** To earn these points the team must **document the Load to Effort ratio calculations somewhere on the *SML*.**

c) **Penalties**:

i) Regional & State Tournaments: 1 point for each second the Device operates over 60 seconds, up to the three-minute limit. Maximum 120 point deduction

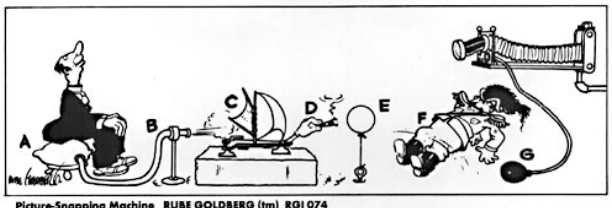
ii) National Tournament only: 2 points for each second or part of a second (up to 60 seconds) that the Actual Operating Time differs (longer or shorter) from the *OOT*. Devices will be allowed to run up to 60 seconds past the *OOT*. Maximum 120-point deduction.

iii) 50 points, one time, for any object (solid or liquid) that leaves the boundary of the Device

iv) 19 points for each time the Device is touched, adjusted, or restarted

v) National Tournament only: 200 points for adjusting something other than the flow rate of the sand delay timer.

d) **Tie-Breaking Criteria:** Fewest penalty points, best operating time to .1 seconds **(.1 second under will rank above .1 second over), the higher Load/Effort ratio for the completion task (calculated to the nearest tenth)** and finally the greatest variety of design.



Recommendation: Use simple components that obviously satisfy the rules and definitions and avoid questionable components that are too complex, too small, too heavily disguised or not clearly visible.

See: http://www.soinc.org/events/missposs/index.htm