

Objective

Build a device that “rescues” a Lego minifigure from a toy tower and places the minifigure in a toy stretcher. The device is assembled from repurposed parts from a disassembled ink-jet printer, a motor controller supplied by the MME department, and any additional parts the team chooses to purchase or fabricate.

Playing Field

Figure 1 is a top view of the playing field, which rests on the competition table. Figure 2 is a solid model of the playing field. The playing field is a 48 inch wide by 30-inch long of plywood that is $\frac{1}{2}$ inch thick. The width of the playing field matches the width of the competition table. The toy tower and stretcher are fabricated from ABS pipe and 3D printed parts. The tower assembly is held together by hot glue. Both the tower assembly and the stretcher are secured to the plywood board by screws. The competition table has a starting line a distance $d = 8$ inches from the tower that limits how close the rescue device can be located relative to the tower at the start of a run.

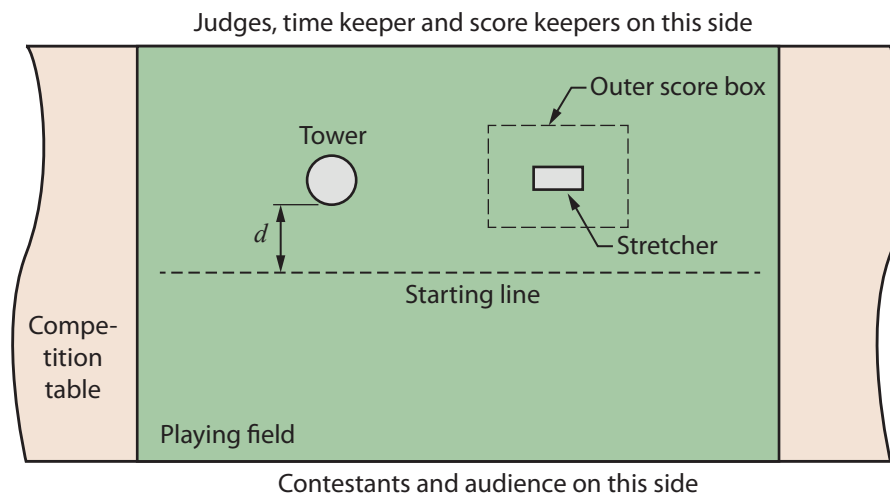


Figure 1 Top view of the playing field for the Lego rescue game.

Game Procedure

At the start of each round in the game, the team places their device on the playing field behind the starting line. In its initial configuration, the device must be completely behind the starting line, i.e., no part of the device can overhang the starting line boundary. After the starting judge gives the start signal, the device can move beyond the starting line.

The device can be anchored to the competition table with clamps, weights or other removable materials. No adhesive, tape or any material leaving a residue on the competition table or playing field can be used to anchor the device to the competition table or playing field. Any anchoring material is included as part of the device when the device is weighed to determine part of the team’s score for each run.

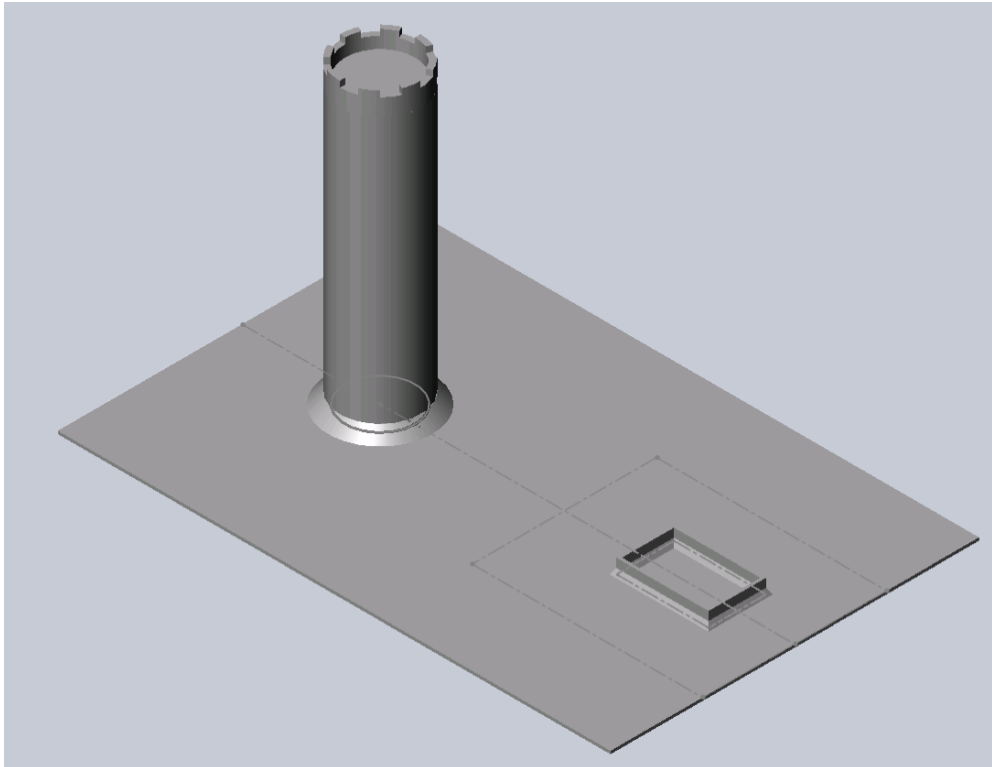


Figure 2 Solid model of the playing field for the game.

The competition will be held in the atrium of the Engineering Building. A pit area, consisting of plain tables and power strips, will be provided near the competition area. On the day of the competition, the order of teams will be chosen at random. Each team will get two runs, which will require the team to move their device from the pit area to the competition table. Teams should expect to move their device from the pit and set it in the starting position quickly. At a future date, the rules may specify a scoring penalty for exceeding a prescribed maximum set-up time.

Sequence of a Run

1. Team name is called by the starting judge.
2. Mass of the device, including attachment materials, but not including a detachable power supply, is measured by the weighing judge.
3. Team places device behind the starting line on the playing field and indicates that it is ready to begin the run.
4. Starting judge verifies that the device is completely behind the starting line.
5. One and only one member of the team is in position to operate the device to rescue the Lego minifigure. The starting judge verbally confirms that the operator is ready.
6. The starting judge counts down outloud: “3, 2, 1, go”. At “go” the timer is started.
7. The operator indicates completion of the run by raising both hands and saying “done”.
8. Starting judge stops the timer.

9. Scoring judge assesses the final position of the Lego minifigure.
10. The weighing judge records the mass of any debris left on the playing field.
11. When the scoring judge gives the team an “all clear” signal, the team removes its device from the competition table and playing field.
12. Judges re-set the playing field to prepare for the next run.

Scoring

A final score will be computed from the points gained by the team in the following categories.

- 20 points Time to complete the rescue operation
- 20 points Accuracy of landing Lego minifigure in the stretcher.
- 15 points Cost of parts in the BOM
- 15 points Automation
- 15 points Total weight
- 15 points Judges score for craftsmanship, innovation and aesthetics

Teams can have points deducted from their score according to the following categories.

- 2 points per gram of debris left on the playing field at the end of the run. This includes parts of the rescue device or any material attached to the minifigure that was not part of the minifigure at the start of the run. If any part of the rescue device touches the playing field on the tower-side of the starting line, then the entire mass of the rescue device will be counted as debris.
- 10 points for residue, e.g. adhesive or tape, left on the competition table
- 10 points for any non-destructive separation of the minifigure into distinct parts
- 50 points for destructive damage to the Lego minifigure

The penalty values are maximum and the scoring judge may choose to deduct less than the maximum for a minor infraction of any category in the preceding list.

Accuracy Score

- 20 pts The minifigure is at rest completely inside the stretcher, not overhanging the vertical walls of the stretcher.
- 15 pts The minifigure is at rest inside the stretcher, but with part of its body touching a vertical section of stretcher wall, *while* the overhanging part does not touch the playing surface outside of the stretcher.
- 10 pts The minifigure is outside the stretcher, and completely inside the outer score box. This includes the case of the minifigure partially hanging over a vertical wall of the stretcher while any part of the minifigure touches the playing surface outside of the stretcher.
- 5 pts The minifigure is partially inside and partially outside of the outer box. This includes the case of any part of the minifigure body touching the line that defines the outer box.

- 20 pts BONUS The Lego minifigure comes to rest standing upright inside the stretcher. To receive the bonus for standing upright, the Lego minifigure cannot be touched by any part of the team's device at the completion of the run.

Automation Score

- 15 pts The only interaction with the device is by pushing a maximum of two buttons during the round. For example, a button press to start the device and a button press to stop the device would be considered fully autonomous. Wireless communication with the device is *not* considered fully autonomous.
- 5 pts The device is operated via a wired or wireless control panel. The control panel must be operated by a single team member while the control panel is completely behind the starting line.

Prizes

Prizes will be awarded according to a ranking by total score. Ties will be decided by a coin flip.

- 1st place \$30 cash
- 2nd place \$20 cash
- 3rd place \$10 cash

Detailed Rules

The following rules clarify the competition process and scoring described above. Teams are encouraged to read the rules and ask for clarification by 18 November 2017, when the rules will be finalized.

1. Safety is the most important criterion for conducting the competition. The ME 491 instructor may disqualify a team at any point if it appears that the device designed by the team or behavior of the team puts the team members, any bystanders, or the physical infrastructure of the PSU Campus at risk of harm. Teams should discuss any safety concerns with the instructor.
2. Electrical power to sensors, actuators and controls of the device must be DC with a maximum voltage of 12 VDC. An AC to DC power supply must be provided by the team, but is not counted in the Bill of Materials unless it is permanently attached. Hint: use a barrel jack connector.
3. Teams may purchase additional hardware. All costs must be accounted for in a detailed bill of materials, which is used in the scoring. Parts scavenged from the ink-jet printer supplied to the teams should be listed in the BOM, but those scavenged parts are considered to have zero cost. In other words, there is an incentive to use as many scavenged parts as possible.
4. The rescue device must incorporate a single point of attachment, e.g. a loop or hole in the structure, so that the entire apparatus can be picked up by a hook and weighed. During weighing, the electrical power supply can be detached *if and only if* it has a standard barrel jack connector. Any materials used to secure the device to the competition table

attached to the device when it is weighed. It is up to the team to make sure that the device and any attachment materials are held in place during weighing.

5. The Lego minifigure used in the competition will be supplied by the instructor. Several minifigures will be available in the capstone labs at least one month before the competition.
6. Teams may opt out of the public competition, with no effect on their grades in ME 491. Teams are required to complete group and individual assignments related to the project as part of ME 491 course curriculum. Teams who opt out of the public competition will need to demonstrate their device and have it scored in private by the instructor.
7. The rescue device must use at least one electrical motor that is powered and running during the rescue operation. A device that uses force or torque applied by a human during the run will be disqualified from winning any prizes.
8. The rescue operation cannot damage the Lego minifigure. Permanent damage to the minifigure will result in disqualification from the competition. If parts of the minifigure become detached during the rescue operation, the total number of parts is used as a multiplier to the rescued time used to compute the score. For example, if the team completes the rescue in 24 seconds, but the minifigure separates into two pieces during rescue, then the time for the run is 48 seconds.
9. Each team will get two chances (or runs) to perform the rescue. All competing teams will complete their first run before the second run. Final team ranking will be determined by the best score from a single run. The device can be manually re-set between runs. The weight and bill of materials are determined from the configuration for the best run time and automation score.
10. The initial position of the device must have all parts, including overhanging parts, on the audience side of the starting line. Consider the starting line to be a virtual wall, extending upward from the playing field. At the start of the run, the rescue device must be completely behind that wall. At the end of the run (after the rescue), the rescue device can be overhanging, but not touching, any part of the field.