

ASME
Student Design Competition

**The Robot Pentathlon:
Citius, Altius, Ingenious**

2017 Contest

Design Problem Description

The Olympic Summer Games test the abilities of people throughout the world in a wide variety of athletic challenges. The athlete that wins the Olympic decathlon or heptathlon is referred to as the world's greatest male or female athlete. The 2017 Student Design Competition challenges your technical design skills to create a robot that is fast, strong, and agile. Your team must build a remotely controlled device to compete against others in five different events – a robot pentathlon. Scores from each of the events will be combined to determine the overall champion.

The constraints and evaluation procedures for all device are as follows:

Spatial and Energy Constraints and General Rules

1. At the start of the competition, your system must fit within a sizing box that is no more than 50 cm x 50 cm x 50 cm (internal dimensions). A sizing box must be provided by your team.
2. Any dimension of the sizing box may be smaller than 50 cm, and your device may be placed in the box in any orientation.
3. Your device will be sequestered in the sizing box throughout the entire competition. It must be ready to operate for all five events upon removal from the box. For each event, teams will be given one minute to remove their device and be prepared to start.
4. Device controls must also fit within the sizing box.
5. All energy for the device must be provided by rechargeable batteries. Other forms of stored energy (compressed springs or gas) are allowed as long as the energy of this component is returned to the initial state (for example an initially compressed spring must be re-compressed using the energy from the battery).
6. Teams may replace batteries between events, however replacement batteries must be identical to the original and mounted in the same way to the device; all batteries must also fit in the sizing box. Battery specification documentation (in English) must be provided to the judges.
7. Devices may be controlled via remote control through a transmitter/receiver radio link or through an umbilical cord. As an exception to the rechargeable battery rule, a radio transmitter may have its own batteries and these batteries do not have to be rechargeable. The transmitter/receiver radio link may be any commercially available model controller. All radio controllers will be impounded and shut off at the competition, except during the team's attempt.

8. An umbilical cord controller may not contain any batteries. Mechanical forces on the umbilical cord may not be used to help propel or control the device. The umbilical cord must be easily detachable from the vehicle using a commercial connector. The umbilical cord may not be a part of the supporting structure of the device. The umbilical cord may only be used to transmit the commands from the controller. Teams will receive a last place score for any event where the umbilical cord is used to apply mechanical force to the device.
9. Flying devices are not allowed.
10. The competition location ceiling heights are uncertain. Devices should be designed to account for this potential uncertainty.

Event 1: The Sprint

1. Devices will be placed behind a start/finish line and must travel 10 meters in a straight line, touch a fixed wall (that will be at least 8 cm high) and return to the start finish line.
2. The course will be 1 meter wide.
3. Devices touching the side line incur a 5 second penalty (for each touch) added to the finish time; if the entire device crosses the side line the team will receive a last place score for the event.
4. Teams will be ranked from 1st to last, based on the fastest time. Teams only compete once and will have a maximum time of one minute to complete the event.

Event 2: The Lift

1. Devices must lift a weight as high as possible. When the weight has reached the maximum height, the weight must remain stationary with no controlling action performed by the team to allow the judges to measure the lift height.
2. Teams will provide their own weight and may select any desired mass and dimensions. The weight must be in the shape of a regular rectangular prism.
3. The weight must fit within the sizing box, it cannot fold or be deformed at any time.
4. The weight must have smooth sides, and cannot have any gripping or holding features. The team's device must be able to hold this weight.
5. Before the competition the judges will determine the mass of the lift object for each team.
6. The height lifted will be measured from the floor to the lowest part of the weight at maximum elevation **and then 50 cm will be subtracted.**
7. Teams will be ranked from 1st to last based on the height*mass score. Teams will get two attempts to lift their weight; and will have a maximum time of one minute to complete each lift and be ready for measurement.
 - Example calculation: a team lifts a 3.1 kg weight, the lowest part of weight is 88 cm above the ground, yielding a Lift Score of $(3.1 \text{ kg}) \cdot (88 - 50 \text{ cm}) = 117.8 \text{ kg} \cdot \text{cm}$

Event 3: The Throw

1. Devices must throw a tennis ball as far as possible. Devices must remain within a 1 m x 1 m throwing area at all times during this event. One edge of this area will be designated the throw measurement line.
2. Teams may place their tennis ball onto their device for throwing, and then will operate their device remotely to throw the ball. Teams will have a maximum time of one minute to complete the throw.
3. The tennis ball may not be modified in any way, competition judges will provide the ball for each team to use.
4. The device may move while throwing, or may remain stationary.
5. The distance of the throw will be measured from the throwing area boundary identified as the throw measurement line, to the spot where the tennis ball first hits the ground. A measuring tape will be placed on the floor extending in the throwing direction.
6. Tennis balls that land to either side of the measuring tape will receive a distance score determined by extending a perpendicular line back to the measuring tape.
7. Teams will be ranked from 1st to last, based on the distance thrown. Teams will get two attempts to throw the tennis ball.

Event 4: The Climb

1. Devices will be placed in a 1 m x 1 m marked starting area on the ground in front of a set of three steps. The height of each step will be no less than 8 cm, and no more than 15 cm. The steps may be of differing or the same heights. The horizontal landing area of each step will be at least 50 cm x 50 cm.
2. The steps will be made of wood, either unfinished or painted, and may or may not be smooth.
3. Devices must climb all three steps and then return to the starting area on the ground. Teams will have a maximum time of two minutes to complete each attempt.
4. A device has reached the top of the stairs when all of the device weight is supported by the horizontal surface of the top step. The attempt is completed when the entire device returns to the starting area and is not touching the steps.
5. If a device is touched by a team member, or if a device falls off the side or back of the steps the team will receive a last place score for the event.
6. Teams will be ranked from 1st to last, based on the fastest time. Teams will get two attempts to climb the steps.

Event 5: The Hit

1. Devices must hit a golf ball initially resting on the ground, making it fly as far as possible. Devices will remain in a fixed location during the attempt.
2. The golf ball may not be modified in any way, judges will provide the ball. It can either be placed on the ground, or the team may provide a stand to elevate the ball (a "tee"). The ball may be elevated no more than 0.2 cm above the ground.

3. Teams will have a maximum time of one minute to prepare their device and ball for each attempt; teams must operate their device remotely to hit the ball.
4. The ball should be aimed to land as close as possible to a measuring tape placed on the floor extending in the direction the ball is hit.
5. The distance score of the attempt will be measured from the spot where the ball first hits the ground. The perpendicular distance from the landing spot to the measuring tape will be determined, and subtracted from the travel measurement along the tape.
6. Teams will be ranked from 1st to last, based on the distance hit. Teams will get two attempts to hit the ball.
 - Example calculation: a team hits a ball 150 cm in the distance of the measuring tape but the ball lands 10 cm (measured perpendicular) to the side of the tape, yielding a Distance Score of 150 – 10 cm = 140 cm

The Overall Scoring of the Competition

- Each device is awarded a place for each of the five events in the pentathlon. Ties are permitted within the five individual events.
- For events where multiple attempts are allowed, the best score is used to determine the place.
- The overall champion will be determined from the sum of all five places from the five events. The lowest total is the winner.
- In the event of an overall tie score, the tiebreaker is determined by the lowest score of:

$$\textit{Tiebreaker} = \frac{\textit{Best Stair Climb Time}}{\textit{Best Tennis Ball Distance}}$$

There will be awards for the following:

- 1st place: Minimum Total Places from the Five Events
- Best Use of Advanced Manufacturing (optional for competitors; will be awarded at conference judges' discretion)
 - A one page report is to be submitted by the team prior to the Student Professional Development Conference. Judges at each competition will provide specifics regarding submittal timing. The report will explain how the team used Advanced Manufacturing in the design of their system.
 - Judges will ask teams who have submitted reports any necessary clarifying questions during normal pre-judging period at the competition.
- Best Use of Predictive Design and Simulation Tools (optional for competitors; will be awarded at conference judges' discretion)
 - A one page report is to be submitted by the team prior to the Student Professional Development Conference. Judges at each competition will provide specifics regarding submittal timing. The report will explain how the team used Predictive Design and Simulation Tools in the design of their system.
 - Judges will ask teams who have submitted reports any necessary clarifying questions during normal pre-judging period at the competition.