

TRAJECTORY

1. **DESCRIPTION:** Teams will design, construct, and calibrate a device capable of launching a projectile into a target area and collect data to develop a series of graphs relating launch configuration to target distance and height.

A TEAM OF UP TO: 2

IMPOUND: YES

APPROXIMATE TIME: 15 Minutes

2. **EVENT PARAMETERS:**

- a. Prior to competition students are to develop and use performance data and calibration charts to assist in determining the best launch parameters.
- b. Launch devices, **copies of graphs, and all materials the teams will use (other than the goggles)** must be impounded prior to the beginning of competition. Target distance and heights will not be announced until all devices have been impounded.
- c. **High Impact Goggles** must be brought and worn by participants during building, testing, and launching. (See <http://www.soinc.org>)
- d. Event supervisors may disqualify any apparatus that is operated in an unsafe manner.

3. **CONSTRUCTION:**

- a. The launching force must be supplied by non-metallic elastic solids such as rubber, wood, plastic, rubber bands, bungee cords, rubber tubing, etc.
- b. The launching device must fit within an 80 cm cube **prior to the first launch**. Any weights used to stabilize the device must be within the 80 cm cube.
- c. **Teams must make provisions to trigger the device in a limited space behind the launch area (50 cm minimum).**
- d. The triggering device **is not considered part of the device**. It must extend out of the launch area and does not need to return to the launch area after launch. Battery triggered devices are allowed; however radio controlled triggering devices may not be used. Students must be outside the launch area while triggering the device and may touch only the part of the triggering device that extends outside of the launch area.
- e. Teams will **provide** unmodified (labeling is permitted) tennis ball, racquetball, ping-pong ball or Hackie Sacks **to be used as projectiles**. They are not required to use the same projectile for every launch.

4. **COMPETITION:**

- a. When instructed by the event supervisor(s), the students will place their device anywhere in a **rectangular** launch area 1 meter wide (**perpendicular to the launch direction**) and 1.5 meters long. **The launch area will be designated by tape on the floor.**
- b. Students may not touch or hold the device, or be in the launch area **or the area in front of the line that marks the front edge of the launch area** during a launch.
- c. No part of the device may extend outside of the **launch area** before or after a shot. If part of the device extends beyond the launch area during the launching action, it must return to and remain in the **launch area** immediately after the launch without assistance of the participants.
- d. Two target areas will be placed in front of the launch area. **They will be centered on an imaginary line that bisects the launch area.** The target areas will be either circular (approximately 1 meter in diameter) or square (approximately 1 meter on each side). The impact area of each target will contain sand or cat litter approximately 1 cm deep. The center of the target areas will be marked so that the distance between the center of the initial projectile impact location and the center of the target area may be measured. **If the target area has a rim it shall be no higher than 3 cm.**
- e. The center of the target areas will be placed between 2 and 8 meters **for Division B; between 2 and 10 meters for Division C** (in 1 m intervals for Regional, ½ meter intervals for State, and 10 cm intervals for National) in front of the launch area. A distance of at least 2 meters must separate the centers of the targets. Once placed by the event supervisor(s), the targets will not be moved. The target areas will be at two different levels with the highest target located nearest to the launch area. **The highest target will be measured** in 10 cm intervals above the floor, up to one meter **for Division B; up to two meters for Division C**. The furthest target shall be at floor level. **Height of the target shall be measured from the floor to the top surface of the 1 cm deep impact area.** (Room ceiling height should be considered in establishing the target distance and heights.)
- f. Each team will have 10 minutes **at Regionals and States, 8 minutes at Nationals** to place the launching device in the launch area, check the launch distances and complete 2 **shots** at each of the target areas. The

time for measurement of the device or projectile impact will not be included in the allotted minutes. No practice shots will be allowed but adjustments may be made to the launching device between shots.

- g. The students must **inform** the event supervisor **before each launch** and **indicate which** target they are aiming to hit.
- h. **After each launch the event supervisor will indicate to the students when they may approach the target to make measurements to calibrate their device. Students may not touch either target.**
5. **PENALTIES:** A 100 point penalty will be added each time any of the following occurs:
 - a. A participant is warned by the supervisor(s) for not correctly wearing the safety spectacle/goggles.
 - b. The participant is in the launch area **or in front of the line that marks the front edge of the launch area** when a launch occurs.
 - c. The participant does not give a warning prior to a launch. Such launch, even if unintended, shall count as one of the four launches allowed to a team.
 - d. Any part of a team's device is outside the 1 m x 1.5 m launch area **prior to or after a launch.**
6. **SCORING:**
 - a. The **winner will be the team with the lowest Final Score** = lower **Close** Target Area Score + lower **Far** Target Area Score + Graph Score + Penalties (if any).
 - b. Target Area Scores
 - i. The **Close** Target Area Score shall be the distance in mm, from the center of the initial projectile impact location to the center of the target area. Teams who miss the target area **or if the device fails to launch**, will receive a score of **800 mm** for that shot.
 - ii. The **Far** Target Area Score shall be measured similarly for a hit in the target **area** but measured to the impact location if outside the target **area**. Event supervisor(s) will visually note and mark the observed impact location outside the target area, then measure the distance in mm. **If the device fails to launch due to breakdown or other reason the score will be the distance from the front of the launch area to the center of far target in mm.**
 - iii. A team who's announced target area is the farther target but whose projectile hits the nearer target will receive a score of the straight line measured distance between the impact location and the center of the farther target.
 - c. Graph Score - Each team starts with 400 graph points, which they can reduce by turning in graphs, notes, and other data at impound, as determined by the event supervisor(s). Each of four selected graphs may reduce the Graph Score by 100 points. **See sample graphs at <http://www.soinc.org>**
 - i. Any number of graphs may be impounded but the students must indicate which four will be used to determine the graph score. Failure to indicate this will **result in the 1st four graphs being scored.**
 - ii. Graphs and tables may be computer generated or drawn by hand. **Each graph-table pair** must be on a separate sheet of paper **and each pair must be on the same side of the paper.** If drawn by hand, they must be drawn on graph paper. Graphs and tables must be properly labeled. All variables and units must be identified. Each **sheet of paper** must be identified with the team name.
 - iii. Each of the four selected graphs will be scored as follows:
 - (1)20 point reduction for completed data table,
 - (2)20 point reduction for graph,
 - (3)20 point reduction **if graph matches data table and are on same page,**
 - (4)40 point reduction for graph being properly labeled (title, team name, x & y axis variables, & increments with units)
 - iv. Partial credit may be given.
 - d. Teams will be ranked in tiers based upon:
 - i. **Teams whose devices meet all specifications will be ranked, by score, in Tier 1.**
 - ii. Teams whose devices do not meet specifications listed in 3.a.b.c.d.e. will be ranked in the **second** tier.
 - e. Example: Lower Close Target Area Score = 10 mm, Lower Far Target Area Score = 1487 mm, Graph Score = 150, Penalties = 100
$$\text{Final Score} = 10 + 1487 + 150 + 100 = 1747$$
 - f. The first tiebreaker shall **be the lower total of the sum of the two scored shots** (to reward consistency) and the second tiebreaker by the **closest shot**. Third tiebreaker will be the non-scored shot at the far target; fourth tiebreaker will be non-scored shot at the close target.

