

Air 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 relate to the capabilities of the device.
A TEAM OF UP TO: 2 EYE PROTECTION #5 IMPOUND: YES APPROX. 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 **eye protection and calculators**) must be impounded prior to the beginning of competition. Target distance and heights will not be announced until all devices have been impounded.
 - c. **Competitors must wear eye protection during set-up and testing of their device. Teams without proper eye protection must be immediately informed and given a chance to obtain it if time allows.**
 - d. Event supervisors may disqualify any apparatus that is operated in an unsafe manner.
3. **CONSTRUCTION:**
 - a. The launching force must be **entirely** supplied by **the gravitational energy from a falling mass ≤ 5.000 kg. At some point during each launch, the gravitational energy must be converted to air pressure or movement, which is then utilized to launch the projectile, either directly (e.g. pop gun style, etc.) or indirectly (e.g. using a pneumatic cylinder to swing an arm, etc.).**
 - b. **All parts of the device must start each launch at and automatically return to ambient air pressure.**
 - c. The launching device must fit within a **1.00 m x 1.00 m x 1.00 m** cube prior to all launches. Any weights used to stabilize the device must be within the cube.
 - d. The triggering device is not considered part of the device. It must extend out of the launch area, **allow for the competitors to remain at least 1.00 m away from the launch area**, and does not need to return to the launch area after launch. Battery triggered devices are allowed; radio controlled ones are not. The triggering device must not pose a danger to anyone due to flying parts or excessive movement outside of launch area.
 - e. Teams will provide unmodified (labeling is permitted) tennis balls, racquetballs, ping-pong balls, or plastic practice golf balls to be used as projectiles. Different projectiles may be used for each launch.
4. **COMPETITION:**
 - a. When instructed by the event supervisor(s), teams will place their device anywhere in a rectangular launch area 1.00 m wide by 1.50 m long (parallel to the launch direction), designated by tape on the floor. **Tape will also be used to indicate a larger area that is 1.00m away from the sides & back of the launch area.**
 - b. Students may not touch or hold the device, or be **within 1.00 m** of the launch area or **in** the area in front of the line that marks the front edge of the launch area during a launch. They may touch only the part of the triggering device that extends **at least 1.00 m** outside of the launch area.
 - 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, centered on an imaginary line that bisects it. The target areas will be either circular (~1 m in diameter) or square (~1 m on each side), with a rim no higher than 3.0 cm. The impact area of each target will contain sand or cat litter ~1 cm deep. The center of the areas will be marked so that the distance between them and the center of the initial projectile impact location may be measured.
 - e. The centers of the target areas will be placed in front of the launch area between 2.00 m and 10.00 m (in intervals of 1.00 m for Regionals, 0.50 m for States, and 10.0 cm for Nationals). A distance of at least 2.00 m must separate the centers of the targets. Once placed, the targets will not be moved. The nearest target will be elevated above the floor, up to 2.00 m, in 1.0 cm intervals, measured from the floor to the top surface of the impact area. The furthest target shall be at floor level. Room ceiling height should be considered when setting the distances and height.
 - f. If requested, a bucket (~1 to ~5 gallon size) will be placed on the course between 2.00 m and 10.00 m and up to 2.00 m to the right or left of the center line. After impound these distances and the size of the bucket will be announced and will be the same for all teams. The bucket should only be on the course when

requested so as not to become an obstacle.

- g. Each team will have 10 mins. at Regionals and States, 8 mins. 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.
 - h. The students must inform the supervisor before each launch and indicate which target they are aiming to hit.
 - i. 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.
 - j. If the first shot at a target hits in the target area, a bucket shot may be requested in place of the second shot. Hitting, but not staying in, the bucket at first impact is worth 50 deduction points. Landing in and staying in the bucket is worth 100 deduction points. Teams with bucket shot attempt(s) will not have a third and/or fourth tie breaker and are scored behind those that do.
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 eye protection.
 - b. The participant is **within 1.00 m** of 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 1.00 m x 1.50 m launch area prior to or after a launch.
 - e. Students will be informed of a penalty they have received before the next launch.
6. **SCORING:** The winner will be the team with the lowest Final Score = Lower Close Target Area Score + Lower Far Target Area Score + Graph Score + Penalties – Bucket Shot Deductions (if any).
- a. 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. 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 hits the nearer target will receive a score of the straight line distance between the impact location and the center of the farther target.
 - b. Graph Score - Each team starts with 400 graph points, which they can reduce by turning in four different graphs and data tables. Each of the four selected graphs may reduce the Graph Score by 100 points.
 - 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 (on graph paper). Each graph-table pair must be on a separate sheet of paper and on the same side of the paper. Graphs and tables must be properly labeled. All variables and units must be identified. Each page must have the team name.
 - iii. One of the four graphs, selected by the event supervisor, will be scored as follows: 20 point reduction for each of the following: completed data table, graph, graph matches data table (on same page). 40 point reduction for proper labeling (title, team name, x & y axis variables, increments with units)
 - iv. Partial credit may be given.
 - v. The score of the scored graph will be multiplied by the number of graphs turned in (up to four).
 - c. 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 section 3 will be ranked in the second tier.
 - d. Example: Lower Close Target Score = 10 mm, Lower Far Target Score = 1487 mm, Graph Score = 150, Penalties = 100, Bucket Shot Deduction(s) = 50 -> Final Score = 10 + 1487 + 150 + 100 - 50 = 1697
 - e. Tiebreakers are: 1st: lower total of the sum of the two scored shots (to reward consistency); 2nd: closest shot overall; 3rd: non-scored shot at the far target; 4th: non-scored shot at the close target.