SCIENCE OLYMPIAD
MISSION POSSIBLE

TIPS FOR DESIGNING, BUILDING, AND OPERATING A HIGH-SCORING DEVICE
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Plan Before You Build

Know the rules.

- Read the rules. Talk to your teammates about them.
- Look up technical or engineering terms that you don't understand. For example, scorable actions this year include terms like IMA, gear ratio, and 3rd class lever. If you don't understand, look it up.
- Read the clarifications.
- Only members of the team may build the device – no one else.

Design your device on paper.

- Outline your operational sequence and plan for building each part of the device. If your design is too hard to outline, too hard to put on paper, and too hard to explain, it's too hard to build.
- Think about tradeoffs. For example, consider whether you should sacrifice size points for additional scorable action elements or easier access.
- Incorporate a reliable and consistent non-electric, non-spring timing element. The value of timing is doubled this year.

Watch YouTube Videos

- Watch Mission Possible videos on YouTube and think about the structural and functional designs of the winning devices. Think about how those devices avoid the common design mistakes outlined below.

The Most Common Design Mistakes

Big box. Do not start with a box near the dimensional limit (60 cm + 60 cm + 60 cm) and fill it with things. Start with a functional design for the scorable actions and build a compact structure to accommodate the design, subject to a maximum score of 30 points per dimension (height, length, width each <=30 cm) for a maximum possible score of 90 points. A dimension less than 30 cm does not receive additional points. Protruding elements on the exterior of the structure are measured as part of the device dimensions.

Inefficient geometry. Inefficient geometry goes hand-in-hand with a big box. For example, linear elements (e.g., ramps, levers, screws) can often be positioned parallel to each other and in a single plane, often two sides of a single vertical surface rather than one side of two or more vertical surfaces and especially not one side of two maximum-size perpendicular vertical surfaces. Similarly, think of the device geometry in all three axes, not X and Y, with Z as an afterthought.

Large components, large spacing. Do not use unnecessarily large components and leave large gaps in-between them. Determine if smaller components and tighter spacing will do the same thing and be just as reliable, consistent, and accessible. A tube or ramp designed to contain a golf ball, for example, only needs to be large enough to contain a golf ball, nothing more.

Absence of a timing element. Timing is often the difference between medaling and not medaling at a tournament. There are numerous allowable timing mechanisms that are easy to implement and easy to adjust. Probably the biggest benefit of watching a few YouTube videos is to see how the devices incorporated simple and high-performing timing mechanisms.

Inaccessibility, reliability, and touches. Configure your device to be reliable but also so that you can access all scoring and non-scoring actions during the run, if necessary. If your device fails during operation, you may need to touch it to continue the run. You can minimize the loss of points by restarting the failed action so that it initiates the subsequent action rather than manually initiating the subsequent action. You may touch the same scoring or non-scoring action multiple times for which you will be assessed a single 25-point penalty but you may only touch three different actions in total for a maximum penalty of 75 points. If your device fails after three separate touches, scoring stops. No additional points will be awarded and no time points will be awarded for the run. Also, because 75 points are awarded for not touching the device at all, the first touch is effectively a 100-point penalty (25 points for the touch and the loss of 75 points for not touching at all). Reliability matters.

Unsuitable materials and unsuitable structural support. Use reliable and robust materials for your device. In decreasing order of robustness, for example,

Plywood → Peg board → Cardboard;
Wooden dowels → Balsa wood;
Two support points → One support point; and
Screws → Nails → Duct tape.

Use the right materials to attach components so you know exactly how things will move. Levers, for example, should only move along one axis, with no significant wobble. The heavier any component is, the more force it applies, or the more force is applied to it, the more attention you should pay to how and where it is attached to the device or other components. It is common to see, for example, golf balls or other relatively heavy objects rolling down flimsy cardboard ramps attached to the device with duct tape. This is generally not a good approach. Also, consider friction in moving parts. A pulley using thread or flexible fishing line will have less friction than one using twine. How does this affect the consistency and reliability of the pulley? This is one of the many tradeoffs to consider.

Open pours. "Open pour" is used to describe actions occurring in an undefined space, e.g., water or sand being poured from one container to another, marbles rolling off a ramp, dominos falling down, or levers flipping things. Eliminate open pours by using components that confine and tightly constrain the action, e.g., funnels, closed tubes, and containers within containers. Open pours often lead to objects leaving the device (50-point penalty) or triggering actions out of sequence (leading to a loss of scorable actions and possible touch penalties).

Hair triggers. Ensure that each action is triggered by the preceding action rather than by inadvertent vibrations, touches, or out-of-sequence actions. Avoid precariously balancing items on levers or edges, allowing moving weights to create excessive vibrations, or combining or positioning objects intended to move in ways that can cause unexpected or out-of-sequence reactions.

Off-spec force. The Start Action involves dropping a golf ball into the device. A golf ball dropped from too high above the device or from an unexpected angle is very likely to cause some type of failure, either because the force is too great or the angle of the force is too far off-specification. This same issue applies to the force of a moving golf ball in this year's Final Action. Be particularly careful in designing and testing actions that involve a relatively high degree of force. Force equals Mass times Acceleration. Too much mass or too much acceleration usually ends badly.

Parallel actions. Only actions that are part of the sequence leading to the Final Action are scored. The most common parallel action is when a scorable action and a timing element are operating at the same time (i.e., in parallel). In this case only the sequence leading to the Final Action (either the scorable action or the timer but not both) will be part of the scorable sequence.

Misunderstanding the rules, especially the Start Action and Final Action. Dropping a golf ball from "completely above the device" means completely above the device, not near the top of the device or inside the device. On the other hand, "above the device" doesn't imply any minimum distance above the device, only "above." Also note that the golf ball in the Final Action is the same golf ball as in the Start Action. A different golf ball will not be scored.

Build and Test Your Device – Then Test It Again and Again

Walk through your device with other team members

- Explain how your device works (action by action) and its anticipated run-time.
- Describe the Final Action.

Test your device

- Plan and practice your set-up.
- If you notice variability between runs, adjust your device to improve consistency.
- Calibrate your timing element, if you have one.

Complete your Action Sequence List (ASL) and label your device.

- Your ASL must correspond to the actions labeled on your device, including non-scorable actions.
- Put your team name and number on the device and the ASLs.

Check your device against the rules and clarifications.

- Check construction parameters and operational requirements.
- Check for unallowable materials, e.g., flames, rat traps, lead weights, fuses, electrical or spring timers, over-voltage batteries/circuits, and unlabeled batteries.
- Check for the common design mistakes described earlier in this paper.

Make a Tournament Day checklist.

- Make a checklist of things you need to bring to the tournament (tools, tape, unmodified golf balls, golf tees, live batteries, dominos, goggles, etc.). The event supervisors do not supply these items.
- Make a checklist of your set-up plan, especially the order in which you set up the device. The rules this year have a high number of moving objects (golf balls, dominos, something floating on water, weights on pulleys, etc.) The first things to set up are fixed objects (like pulleys, gears, fans, levers, and a timing element) and the battery and connecting / switching / sequencing elements (like strings, ramps, mechanical switches). Make sure your device is stable on the table. Shortly before running, position objects that are liable to fail due to vibration, temperature, time, etc. Depending on your design, this may include the golf balls, dominos, floating object, mousetrap, etc. There is no requirement for a checklist but each year many devices fail for mistakes that would easily be identified on a formal written checklist. As operational cheat sheets go, this is the biggest recommendation of all.

Other Tournament Day Considerations

Interference. During impound and from the start of your session to the end of your run, you may not communicate with anyone about MP other than your MP partner. Coaches, parents, other teammates, and outsiders may not communicate with you. The event supervisors may assess an interference penalty without any warning.

Clean-up. Avoid penalties incurred for not cleaning up the competition area after your scored run. If you plan to leave your device for later retrieval or because you are protesting, return it to the impound area.