

Mousetrap and Gravity Vehicle Design Tips

A Note on Plagiarism

Plagiarism is easier to accidentally do than you might think. We absolutely encourage you to talk at length with teammates, coaches, and any other advisors about design ideas or how to revise your proposal, but it is very important that the words you put to the page are your own. You should not have any identical wording to another team from your school. You should not have uncited images from the internet. You may, however, use the Vehicle Design, Mousetrap Vehicle, or Gravity Vehicle rules without citation.

Meeting the Construction Check

Meeting the construction check should be much easier in Vehicle Design than when actually constructing a vehicle, because you don't have the difficulty of fabricating your design precisely, rather you can just tell the ES what the specifications of your vehicle are. The burden of proof is on you, though. It is not enough to simply list what construction parameters must be met; you must show the ES how your design meets them. Go through the Construction Parameters section of the rules line by line to be sure you have specified all required details.

What if you already built a vehicle last year?

It is not simply enough to write about what you did in years past. First of all, the Mousetrap and Gravity Vehicle rules have changed in some significant ways since last year, so your previous designs will not be appropriate without modification. But even more than that, we really just aren't interested in hearing a book report about what you did last year. We want you to use this year where you don't have the burden of fabrication to go through a thorough design process from scratch and learn how to write about it well. Of course use your past experience to inform your design, but simply stating that you used a design last year is not justification. You may use labeled photos of past devices to help illustrate components of your new design, but we encourage you not to rely solely on this to make your figures.

Requirements for a High-Scoring Proposal

1. Identifying Information

Each proposal should contain the school/team name, team number, student name(s), and a reasonable title.

2. Evaluation of the Problem

This section is your chance to introduce the ideas that will be important throughout your proposal: scoring incentives, key construction parameters, and any specific implicit constraints that factored into your design (like budget or transportability). If your design rationale section is going to make tradeoffs around certain concepts like accuracy or repeatability, then you need to establish why those concepts matter here in the introduction. While those things might seem

obvious to you, the ES can't follow your reasoning unless you are explicit. This section does not need to be long, but it is crucial in setting up your proposal to make the most of the page limit.

The ES will be looking for not just the presence of some elements, but also the absence of incorrect or extraneous elements. The latter include mischaracterizing the objective (e.g., including run-time as a scoring element), adding unnecessary commentary (e.g., time constraints unrelated to the event like school work), or general comments on physics, engineering, construction, etc. not directly related to your design, construction, calibration, and operation. In short, if you will never mention an idea again, leave it out of this section too.

3. Background Research

We would like you to present at least two researched topics. Points are only awarded for relevant research topics that directly apply to your design. Simply explaining the fundamentals of friction or gravity won't cut it. We also are not looking for you to look up videos of other team's past vehicles and say you are wholesale using their design because it worked well for them. The most relevant concepts are probably engineering, applied physics, and systems design research that directly relates to the actual design of your vehicle or ramp. Since this section comes before your design specification, though, this is not the right place to begin your design justification. Just lay out what the ES will need to know to understand the details of your design justification later on in the proposal, while making it clear why your research is relevant to your design.

4. Design Specification

Describe the entire design so that the ES can easily see that the design parameters are met and that you understand how to set up the vehicle in the ready-to-run position. Every major element of the device must be mentioned and/or diagramed here. The method of fabricating and assembling the device must also be described here. The ES will not assume, for example, that the chassis of the vehicle is square or that the axles are level and perpendicular to the chassis unless you explain how you made the chassis square and the axles level and perpendicular. Figures will be very helpful in communicating your ideas in this section.

Make sure each construction parameter is clearly addressed. The quantitative specifications must be in either or both the text and the figures. The ES will not infer compliance from an incompletely labeled figure (e.g., an unlabeled dowel on a diagram of the vehicle will not be assumed to have the required dimensions). It is also not sufficient to simply state your device meets a rule – give the specific attributes that show it meets the rule. It should be obvious to the ES how to find all the necessary information to do the construction check. If they have to look for it, they might miss it.

You will also want a section that details your expected procedure for running the device in the competition setting. This might seem obvious to you, but it isn't to the ES. How will you divide the given time between all the tasks you need to do? How will you split responsibilities with your partner if you have one?

5. Design Rationale

The ES will score the team based on the design considerations you set up in your Evaluation of the Problem, the constraints you operated under, and the tradeoffs you considered in relation to the vehicle's accuracy, propulsion, braking, repeatability, calibration, stability, and ability to run in competition. Your rationale should reflect the saying "there are no solutions, only tradeoffs." Typical tradeoffs include your choice of the vehicle mass and distribution of the mass across the vehicle; the ramp shape, surface, and release height; the braking system; and the wheel diameter. How do your choices tie into the objectives you stated in your Evaluation of the Problem? What likely will be the most important point of failure during design, during construction, and during operation? How would you address these failure points?

For some teams, the device will already exist because they (or something very similar) were built in a previous year for a previous competition. That is fine but design rationale points are awarded for explaining why the design choices were made, not that the device exists independent of the design choices. No points are awarded for saying, for example, that Banebot T81 wheels were chosen because the school supplied Banebot T81 wheels or because T81 wheels were used on Battery Buggy the year before. The teams need to explain their designs as if they were built from scratch.

This section is worth the most points for a reason. This is the heart of your proposal, so treat it like that both in terms of the time you spend writing it and the pages you take up explaining it.

6. Testing and Calibration

What data will you collect, how will you collect it, and how will you calibrate your vehicle based on it? This requires keeping the practice log mentioned in the Mousetrap or Gravity Vehicle rules showing target distance and vehicle distance from the target plus a third optional parameter, e.g., wheel rotations, distance of wingnut travel along an axle, variable release height, variable vehicle mass, variable vehicle mass distribution, etc. There is also much more than what would be in a typical practice log that needs testing, though. You need to think in terms of the same tradeoffs you thought about for the design. What do you adjust if the vehicle consistently goes off-axis, skids, and comes up short? What do you adjust if the vehicle is inconsistent in distance or lateral movement? What exactly needs calibrating: the wheels, the bearings, the axle, the chassis, the ramp surface, the ramp angle, etc? Any of these off-specification actions could require calibrations in potentially all three axes (yaw, pitch, roll). If you have design components that you think you would need to test out in a physical device like vehicle mass or wheel diameter, also include a testing plan for those design components.

Also consider how would you test and calibrate your vehicle on the fly if tournament conditions differ materially from test conditions. Rule 5.g. says teams may not roll the vehicle on the floor of the track at the tournament without permission of the ES. What would you do if the track surface was materially different from the test conditions (e.g., very slick or not flat) and the ES did not allow testing outside the 10-minute competition window?

7. Budget

The budget consists of three categories of items: materials used to build the device, tools to build the device, and tools to measure, test, and calibrate the device. Every element from all three of those categories should be itemized. Think about everything from the required dowel to the tape you will use to lay out a practice track to a protractor to help wind your wheels.

Realistic prices matter. A sheet of plywood does not cost \$40. A wingnut does not cost \$7. Items that you already own should still be listed, but you can give them an effective cost of \$0. There is no particular total budget that the ES will look for, but it should be reasonable, probably a few hundred dollars.

8. References

Cite what needs to be cited in a consistent and referenceable form. There is no specific requirement for reference style and there is no minimum required number of references; however, you should probably have citations for the information in your research section, where you got your base design ideas (you didn't invent the wingnut braking system), any figures you pulled from another source, and where your prices are from. All of these should probably have corresponding in-line citations. Remember that citations are not just a chore, they are actually a very useful tool to help back up your claims.

If a reference is provided it must be something the ES could check if they chose to. Instead of just mentioning physics class or generally citing Newton's Principia, you should give links to specific websites, texts, or videos.

9. Figures

Figures are very helpful for the ES's scoring, but they're also very helpful for the team's understanding of the problem and the design. If the device is too difficult to diagram, it's too difficult to build. Figures should include enough detail to make them easily understandable, including a title, the view (i.e., top, bottom, side, front, back), measurements (mm, cm, inches), and labels (release mechanism, wingnut stopper, bearings, etc). Figures must be identified in the text, eg. Figure 1 shows a side view of the vehicle. Do not have unidentified figures floating in the text. Make sure that when you shrink your figure down to fit on the page the ES will still be able to easily see all the features of the image.

10. Format

Any consistent, reasonable, easily readable format is sufficient. Standard formats are typically 11-12 point font, 1" margins all around, black text on white background, Times New Roman or Calibri font (or something similar), single space or 1.5 spacing, page numbering, consistent offset for section headings and paragraphs, and consistent titling of sections and figures. It is acceptable to put the figures in-line with the text or as a group at the end of the proposal, however, only the budget can go beyond the page limit. Remember that your proposal is likely being scored by someone much older than you, so they may not be able to read small text as well

as you can. Try asking your parents or grandparents if they can comfortably read your proposal, especially any small figure captions or labels.

Format is about more than just small editing details, though. You want the ordering and layout of information to actively aid in its understanding. For example, if the ES is trying to go back to a particular piece of information, there should be enough headings to point them close to it. For the same reason you also would not want to use long bulleted lists for the main body, since they don't distinguish which information is more important.

11. Scientific Writing Style

Scientific writing style begins with correct spelling, standard sentence and paragraph structure, and clear English. Vehicles have brakes and axles; they do not have breaks and axels. Spell-check is not sufficient to ensure (not insure) correct spelling and word usage.

The tone of the writing should be formal, neutral, and impersonal – “we built the vehicle on a 30cm long by 20cm wide chassis because we determined that 30cm x 20cm was the most stable length and width,” or (in the passive voice) “the vehicle was constructed on a 30cm x 20cm chassis because that is the most stable length and width,” not “we built the vehicle with a 30cm long by 20cm wide chassis because it seemed like a pretty good size” or “because that’s the size we cut the chassis frame to before designing the vehicle.” Scientific writing should also be declarative and expository rather than narrative – lay out the important elements of the build rather than telling a step by step story of how you built the vehicle.

A lack of necessary information, too much unnecessary information, or information presented in the wrong sections is also bad scientific writing, since these things make your proposal much harder for the ES to read, and might even cause them to miss important information if you put it in the wrong place or mix it into a paragraph of meaningless fluff. Your proposal needs to make sense to someone who doesn't already understand your thought process.

12. Review

Make sure you leave yourselves enough time to put your proposal through several rounds of proofreading before the due date. First, map the scoring elements in the rules to your proposal to be sure you have included everything you need to. Then, when you've completed your first draft, ask someone (probably a teacher, coach, or friend that is a scientist/engineer) to review it compared to the rules and these tips. This outside review will prove helpful in identifying errors, omissions, unclear ideas, and items that may seem obvious to you (the participants) that may not be obvious to the judges. Once you have settled on the content of your proposal, you will also want to have someone review your final draft for little mistakes like grammatical and spelling errors or inconsistent formatting.

Q&A

Since the proposal will be due about a week ahead of each tournament, use that week to practice for the Q&A. The Q&A shouldn't be an overly stressful or scary thing, but it's still worth

practicing to make sure you and your partner are comfortable answering together. Make sure to keep the scoring rubric in mind when constructing your answers. In particular, teams tend to forget to specifically reference rules when justifying their answers. Also remember that the Q&A is only five minutes, so practice giving reasonably succinct answers.