Kyky's Guide to Ping Pong Parachute

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Introduction

Hi! My name is Kyky and I competed in my 2nd year of SciOly this year. This season, I was placed on the event Ping Pong Parachute (PPP) in Division B and it became one of my favorite events. In this guide, I'll be sharing some basic tips and advice about the event to help you get started. PPP is an event that calls for lots of experimenting and testing since there are so many variables that could affect your results… therefore you should definitely play around with the things mentioned in here and find new things to test. Please adapt these tips for it to fit your team as not all will apply to you.

Note: This guide will contain diagrams/drawings that will represent my partner and I's PPP with very few actual pictures since I don't have access to the builds currently.

Also Note: I competed in Division B this year but the rules for Division B/C are the same. However, expect Division C to be more competitive than Division B.

Rules

Like all events, the rules for PPP can be found in the rules manual on Science Olympiad's official site (https://www.soinc.org/). In this section, I'll explain some notable points in the rules that I've seen brought up in confusion on the SciOly Forums frequently. Keep in mind that what I'm about to say is merely one interpretation of the rules and by no means anything official. Anything said in this section should not be interpreted as an extension of the rules.

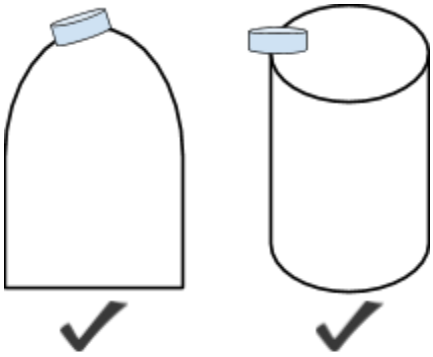


Figure 1a - legal designs, rocket does not touch inside of cap.

- SAFETY: Make sure you and your partner bring the correct type of eye protection and practice safe habits when launching. This should be common sense but the launchers are very dangerous when pumped with psi! This event requires impact goggles and I always recommend putting you and your partner's goggles in your PPP box to ensure that it will definitely be with you whenever you test. Get into a good habit by always wearing your goggles when practice launching.
- Construction Parameters 3c: Make sure that the tip of your rocket does not fit inside of a bottle cap. If it does, your rocket nose is too pointy and poses a safety hazard. An easy way to remedy this, is by putting a mini easter egg on top. Or if you are doing the popular tube design for your rocket, that fits within the rules just fine. See Figure 1a and 1b for what's legal and not legal. See section 3.c. in the rules manual.

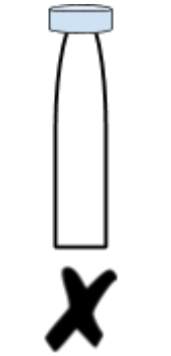


Figure 1b - illegal design, rocket touches inside of bottle cap

- Construction Parameters 3d: No glue allowed on the pressure vessel and no metal anywhere on the rocket! I will discuss parachute material later in this guide, but be very careful…some surface research will tell you that mylar is a good material for parachutes but typical mylar found in balloon material is *covered in a thin layer of aluminum* which means it's illegal! Also make sure that you are not using glue on the pressure vessel! This includes attaching fins and the nose/rest of the rocket. See section 3.d. in the rules manual.
- Practice Log: I'll talk more about the practice log in another section. However, it is critical that you have a complete practice log and that it's filled in properly in order to launch.

PLEASE PLEASE PLEASE observe that this is not all of the rules…these are just some notable ones that are constantly broken. Make sure to read the rules thoroughly (can be found using the link above) and I would strongly suggest printing out a copy and keeping it in your PPP box. This way, the night before a competition, you and your partner can go over the rules closely and inspect your rocket and parachute to make sure everything is good to go. It's also handy to have a copy of the rules in your PPP box in case you need to appeal a rules decision at competition. Also make sure to frequently check the FAQ page and the rules clarification page on https://www.soinc.org/ to make sure you stay up to date on any changes in the rules.

Getting Started/Research

After looking at the rules, you may be a bit lost as to where to start. That certainly was how my partner and I felt! I would suggest starting by doing some research on parachute designs because the parachute aspect is arguably much more important than the rocket part of this event. What my partner and I did was start a shared Google Doc and spent about a week reading different articles, watching different videos, and looking at different designs, then depositing all that we learned into the Doc. After that, it's time to take what you've learned and start experimenting with it. Something that might make sense theoretically on paper might not work well in reality due to unideal circumstances.

The Box, *The* Parachute Box, and *The* Folder: I *highly* recommend that you and your partner have a designated PPP box. This box will contain all of your building materials and will also be a home for *the* folder. *The* folder will contain important documents like your flight/practice log, a copy of the rules, and the label to your pressure vessel if you chose to take it off. *The* parachute box will be a separate box/storage area for your parachutes. If you don't store your parachutes well, the lines can get tangled pretty badly with other parachutes. Our storage solution wasn't very ideal but it was better than just chucking them all into the main box. We used a shoebox and laid our parachutes flat on top of each other like a stack of flat pancakes… the lines were definitely less tangled but sometimes we were careless in packing our parachutes. Also, the way you store your parachutes depends on your parachute material and what works well. We originally kept our parachutes folded but our material creased pretty easily and when we stored our chutes like that, it was very hard to get the chute open in launch. So it all depends. If you'd like to know what was in our boxes and what we brought to every practice and competition, you can find a list here.

Parachute

So I'll start by going over with some things to consider when building your parachutes. The parachute is arguably the much more important part of this event. The parachute's job is to deliver the ping pong ball to the ground as slow as possible. An ideal parachute would deploy and open up quickly and at the highest point from the rocket, and then descend slowly… almost as if it's drifting. If you have a good deployment but a fast falling parachute or a great, slow parachute but it takes forever for it to open up fully, you'd probably be unsatisfied with the time that you got. In the next few sections, I'll explain and present some of the variables you can change on your parachute. Make sure to experiment with each variable and see what combination of them gives you the best result.

Parachute Shape + Size

You probably noticed that most parachutes are a circular shape and rightfully so! Circular shapes are able to catch more air molecules and produce more drag than other shapes. They also tend to open faster than other shapes. However, feel free to try other shapes and play around with it. Some of our parachutes were octagons and we also had one that looked like a star. It all depends and the only way to find out is through trial.

As for size, the more surface area your parachute has, the more drag it will produce, which means your chute will fall slower. However, as your parachute gets bigger, it will take longer to open up, and if it gets *too* big, the parachute will cave in on itself and not be able to hold its open state. Therefore, you should try to make your parachute as large as you can while it is still holding its shape. For us, this was about 2.5 ft in diameter.

Another thing that my partner and I saw discussions about on Discord but didn't get a chance to experiment with was the dome vs sheet designs. So theoretically, a domed parachute will create more drag than a parachute that was created from a sheet. By sheet, I mean that you start off with a flat piece of material and that when you attach lines on it, it will pull the chute into a shape that looks pretty round/hemispherical. However, it is impossible for a true dome to be completely flattened into a single sheet (for example, projecting the Earth onto a map always creates some distortion). Therefore, you need to create several panels or gores and then attach them together by a central point in order to create a true dome. My partner and I were planning on experimenting with this design after regionals, but since states was cancelled and practices were too, we never got around to it. However, it's definitely an interesting idea to explore and I'll provide links and a diagram below that explain the dome design better.

Dome shape- perfect half sphere

Made from a sheet- close to a half sphere but a bit distorted

Dome Parachute Links:
https://www.nakka-rocketry.net/paracon.html#Design
https://www.youtube.com/watch?v=2KzF8yHFnMM

Parachute Material

So you might be wondering, "All of this is great... but what do I use to create my parachute?" Well, parachute material is probably one of the most important variables to play around with. You want a material that's lightweight so that it can stay up longer but it needs to be able to withstand rocket launch and be able to support itself. We've gone through dozens and dozens of different materials before we found one that works relatively well for us. I definitely think that a thin plastic material works the best… any other material besides plastic and you're going to run into lots of problems. Below I'll list some common choices for materials and some materials that might look good but you should stay away from. I did some messy experimenting with materials that completely flopped so you don't have to watch a piece of paper crash epically into a wall.

- Aluminum foil: Please don't use aluminum foil. It's against the rules (3d: no metal) and rips super easily. I'm mentioning it simply because I've witnessed it being used once. Just use some common sense…
- Cling wrap/seran wrap: Again… would not advise you to use this material. Yes, it is a thin plastic material but just like the name suggests… IT CLINGS TO ITSELF! There's no way your parachute can open up if all it wants to do is cling to itself. Yes, there are "hacks" to make cling wrap not clingy, like freezing it or putting a TON of powder on it, but they are not guaranteed to work. Again, use some common sense.
- Grocery/retail bags: This is a good material to start off with. It's a thin plastic material that's easy to obtain and easy to work with. However, your limitation comes with the sizes of these bags. Most typical grocery bags aren't that big and the thick seam at the bottom of the bag prevents you from using both sides connected. If you go to bigger retail stores and ask for larger bags, you can make bigger chutes from those but from my experience, you're still limited by the seams and the area you have. Still a good material to play around with—one of our first rounds of testing parachutes was comparing bags from different stores. We found out that Dollar Tree bags worked the best (probably since the bags looked the thinnest and cheapest out of all the stores.)
- Trashbags: There's a huge spectrum of trash bags on the market. Our final parachute utilized some cheap off-brand trash bag. However some trash bags we experimented with were just plain horrible.
    - Kitchen trash bags: Did not have a great experience with these. These were advertised as "ultra strong" so we decided to give it a try. However, the "strength" and "toughness" comes from the plastic being texturized. It also became staticy really quickly and started clinging to itself. Would not recommend it. See Figure 2a for an example of what I'm talking about.

Figure 2a - Not something I would recommend for you to use.

    - Outside trash bags/any other large trash bag besides the textured ones mentioned above: These are generally good. Some common types you see are the black or white ones. The only issue I had with these trash bags is that they tend to be very clingy/staticy. I'll talk about some ways to reduce cling and optimize the likelihood of the parachute opening in a section below.
    - Bathroom bags: These are the trash bags used to line the trash cans in your bathroom or maybe in your room… they're the small bins in your house. I highly recommend this material

because it's usually thinner than kitchen trash bags or the trash bags used for the outside trash. The only downside is that they might be a bit small depending on what type you get. But unlike grocery bags, bathroom bags and trash bags in general don't typically have weird seams, which means you can open up the bag and combine both sides.
    - Janitor Bags: We've noticed that the bags our school uses in the cafeteria for the big garbage cans were thin but also very very big. We also figured that these bags can hold pounds of trash created by a bunch of middle schoolers so they looked very strong and durable. We were able to get an entire roll of these bags from our school janitors which became a lifesaver! Each bag could create three very large parachutes and if there's something we wanted to try out, we would start by trying it out on these janitor bags since we had so much of this material. It didn't produce the best time out of all our material but it did give us a very high time so all our backup chutes used this material. Since this material was more durable than the material our main chutes were made of, it was perfect as a backup, just in case our main chutes ripped in transportation. I definitely would try asking your school for some or you could probably find these large industrial trash bags online.
    - Other random trash bags: Our final material that we were happy with was just some random off brand plastic bag that was on the bottom shelf of a store that I forgot the name of. That just shows that any material has the potential to be *the* material that you'll find success with. This is why experimentation is so, so, so important!!!
- Painter's plastic: I heard a lot of good things about painter's plastic or painting cloth. Like trash bags, this material is a thin plastic. However, there's definitely different types of painter's plastic like trash bags. The hardware store closest to us only had 3 types of painter's plastic. We tried the thinnest two but they were both heavier than the trash bags. We tried going to Home Depot to find a thinner type but all the thinner ones were out of stock. However, very thin painter's plastic does work because I've seen it used at competition. When we tested our painter's plastic, it worked but had a less optimal time than the trash bags so we ultimately went back to the trash bags. However, I think that if we were able to get our hands on thinner painter's plastic it would've definitely worked.
- My thoughts on mylar: Don't use it. A rocketry book that my partner found said that the material balloons use is mylar and that it's a very good material to use for hobby rocketry. However, this type of mylar in products is coated on both sides with a coat of aluminum to make it shiny. This makes this type of mylar illegal according to rule 3d, no metal. The actual mylar without the aluminum coating is not easy to acquire and not easy to work with. It's too fragile and thin and will not survive a rocket launch. Even if you get it to work, there are many other easier to acquire materials that are just as effective, if not more so, than mylar.

An example of a mylar/aluminum balloon. Thin material but not legal.

Other notes regarding parachute material: The reason why a plastic parachute works better than say a cloth or paper parachute in this context, is because the only load you have to carry is a ping pong ball! Both cloth and paper are so much more heavy or stiff compared to plastic. Cloth is just way too heavy and falls super quick. It also doesn't do a good job of catching the air since most of the air can pass through it. And yes there are thin light paper like tissue paper, but the reason why this doesn't work is because paper isn't flexible enough. It doesn't bend into a nice curved shape like plastic does…this is another one of the materials I played around with so you don't have to. Tissue paper was an epic flop… straight up flipped upside down (paper heavier than ball) and crashed. So the takeaway in this section is to find any thin plastic material and just play around with everything you find. But be sensible in what you're testing out otherwise you're just wasting your time. ;)

Shroud Lines

Shroud lines are the strings on your chute that connects the canopy (parachute material stuff) to the load (the ping pong ball). I'd say the type of string matters as well because certain types of strings are easier to tangle than others. The number of lines also matters. The bigger your parachute, the more lines you will need to support the canopy so keep that in mind. Less lines means less tangling, but it's better to have your lines tangle than for your entire chute to collapse. Some common numbers of lines include 6, 8, 12, 16, 24, and 32. Too many lines means that there's a greater chance that one of the lines will snag the rocket during deployment which means the chute might not detach from the rocket or it will be a less than optimal deployment placement. Too many lines will also add unnecessary weight to your chute. Below I'll share some good line material and some not so good line material.

Good Lines

- Embroidery thread: This very thin thread is ideal for parachute lines. It's thin and easy to work with and was a favorite line for us to use.
- Regular thread: Regular thread works very well too. I think we preferred the embroidery thread since the kind we chose was a bit glossier and had less fraying.
- Fishing line: Thin fishing line is a durable line that also works.
- There's definitely more good lines out there. We found new types of line material every time we went to the store and it was fun to experiment with what worked and what didn't.

Bad Lines

- Yarn: Please do not use yarn. The fraying is insane and gets tangled super easily!
- Friendship Bracelet Cord: We tried this material because the cords were bright and colorful… but they were super heavy. I think the one parachute that has the friendship bracelet cord on it is the prettiest though. (ფ﹏ფ)
- Regular String: Not a fan of this line material at all. Tangles and frays almost as bad as the yarn. By regular string I mean the white string that comes in the ball that is neither thick or thin.
- Hemp Cord: We tried it just for giggles and kicks… too stiff of a material.
- Floss: Bad, bad, bad material! Tangles super badly and the waxy floss is just a nightmare.

Spill Hole?

A spill hole is the little hole at the top of a parachute's canopy (see figure 3a). The purpose of the spill hole is to allow air to escape in order to make your parachute fall straighter and open faster. The downside to having a spill hole is that your chute will fall faster since there's less surface area and your chute is catching less air. Based on our tests, it is beneficial to have a small spill hole since a parachute that opens quickly but falls faster is better than a slower falling chute that opens closer to the ground. I agree that a horizontally drifting chute is good since it produces more time if it is falling at an angle. However, you want your chute to be relatively reliable in where it's going to go. You don't want your chute drifting and hitting a wall or snagging a basketball hoop if testing in a gym. Therefore, because the spill hole reduces some of that drifting, it will make your chute more reliable overall. If you have a small enough spill hole, you can get the benefits of a spill hole as well as some of the beneficial drifting that will increase your time. It's all a delicate balance that you need to play around with! Spill hole or no spill hole could definitely be one of your variables on the flight log which is explained here.

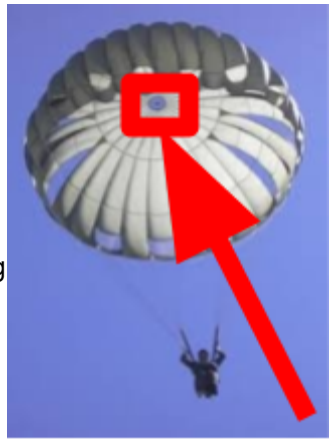


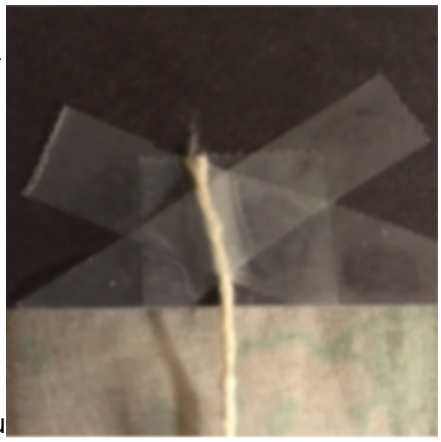
Figure 3a - Spill Hole

Attaching Lines to Chute

The way you attach the lines onto your parachute canopy is very important. There's been more than a few times when one of our lines would detach from the canopy during a test, making the entire parachute unstable

and plummet to the ground. There's two common ways to attach the lines to the chute - with tape or by tying. No matter what method you use, you need to make sure that the connection area is reinforced.

Tape: In order to reinforce a tape connection, I would recommend a cross connection or a double tape. I would also recommend taping on top of a layer of tape, so that the plastic does not rip if you should need to reposition your line. Use Scotch tape or a lighter tape - our experiences with packing tape produced a chute that kept sagging at the edges. See the diagrams off to the side on how you can reinforce a tape connection.



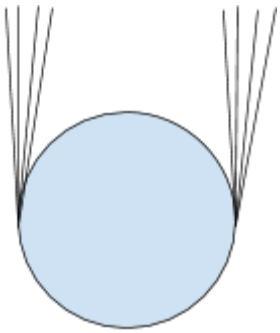
Cross Tape over a tape. Using bold materials so that it's easier to see.

Tying: For the tying method, you would poke a hole on the edge of your chute, pass the line through and tie it in place securely. However, if you launch and test your parachute too many times, the hole could get bigger and rip the edge of the chute. In order to prevent this, put down a layer of tape before you poke your hole through the tape area. The tape serves as a reinforcement. Hole reinforcements for binders is also a good reinforcer. Also, if you have clumsy fat fingers like me, I'd suggest using a needle with your line threaded on it and then poking a hole. See the diagrams off to the side on how you can reinforce your hole.

Tying over a reinforced hole. Using bold materials for the camera to capture it better

<u>Lines Tangling + Attaching Ping Pong Ball</u>

One of the biggest issues that you will encounter when testing parachutes is line tangling. When the parachute is deployed and the lines start to tangle with each other, it will drastically lower your time. Before every test, you should untangle your lines because testing with tangled lines will not work out well. There are a few common ways people use to reduce tangling… however, tangling will most likely still occur, just on a smaller scale. Tangling can be heavily reduced based on the way you attach your ping pong ball to the parachute. There's 2 configurations of attaching lines to the ball that seem to work out. The first configuration is attaching each line separately to the ball all evenly spaced out. This configuration takes a bit of time to put the ball on the chute and might not be ideal if you need to attach the ping pong ball to the chute under stressful conditions like competitions, especially if you have a lot of lines. The second configuration is separating your lines into 2 equal sections and attaching these two groups of lines on either side of the ping pong ball. (See diagram for a visualization.) My partner and I only used 2 groups on our chute attachments since it worked out for us when we were testing. However, I have seen teams split their lines into 4 sections and attach their lines in those equal sections on to the ball.



2 groups of string attached to ball

Other ways of reducing tangling: (Most of which I do not recommend)

- Knot: An easy way to reduce tangling… as well as reduce your time. The knot method has you tying a knot right above the bottom of all your lines and then just taping the knot to the ball. I would strongly encourage you to use the methods listed above when attaching the chute to the ball, because this method here will definitely make your chute fall faster.
- Separator: I saw a few times at competition, teams that used a cardboard or balsa separator that they attached right above the ping pong ball and in which all the lines feed into. It significantly lessens tangling but the times were only in the middle of the pack. When experimenting with the cardboard separator ourselves, we concluded that it was very hard to work with since the lines would slide in the separator, therefore making the separator tilted. When the separator is tilted, the parachute will become unbalanced and you can say goodbye to a good time at this point.

- Carrier: Some teams have created a little carriage or basket for their ping pong ball in which they attach the lines to the carrier. This is very unnecessary and the carrier adds so much extra weight causing the chute to fall faster.

Overall, I'd recommend playing around with how you're attaching the lines to the ball in order to reduce tangling and maximize your time. Always remember that you can ***only use tape to attach your ball to the parachute*** as per rule 2b in the rules manual!

Rocket + Deployment

Having a good parachute means nothing if you can't deploy it into the air! The sole job of the rocket is to deploy your parachute at the highest point possible without violating any of the rules. Your parachute deployment is dependent on what type of rocket you create. I'll start off by explaining some general principles that apply to all rockets then explaining two common types of rockets.

Pressure Vessel/Bottles

The pressure vessel is a 1 liter bottle (or less) in which all the pressure will be pumped into via the launcher. This 1 liter bottle MUST come from a carbonated beverage! Beverages that are carbonated have bottles that are built stronger in order to handle the carbonation, and therefore can handle higher pressures like the pressure you're pumping into it. Non-carbonated beverages have weaker plastic bottles that might withstand the pressure you're putting into it the 1st or 5th launch, but might explode on the 6th launch. The proctor/ tournament staff *should* enforce this strictly and if you don't see it being followed, you should say something as this is a huge safety hazard.

The pressure vessel *can* be less than 1 liter but I would not recommend this. A smaller rocket is less predictable especially if you pump a lot of psi into it. Think of it as like giving a little kid too much sugar… they become less predictable and will be going crazy. You want your rocket launches to be as predictable as possible, ensuring that your parachute will deploy in the same fashion every time. Another reason to use a 1 liter bottle is because the Nerds Inc. launcher that most competitions use, does not have a tight fit on bottles that are less than 1 liter. We tried putting a regular sized (500 mL) Coca Cola bottle on our Nerds Inc. launcher and it kept tilting to one side since it was a loose fit. When we started pumping it with psi, some of it started leaking. Therefore, I recommend sticking with a 1 liter bottle.

Picking a bottle: There are many 1 liter bottles out there. When picking one out, make sure to check that it is in fact *carbonated*, and also consider the shape of the bottle. The shape of your bottle is something you should experiment with, but my partner and I found it easier to work with bottles that are more smooth and less curvy/bumpy. The only issue we had was that no one loved to drink the sparkling water so you might also want to consider the flavor of the drink. Before the Covid-19 pandemic, we set up a bottle drive in our cafeteria and the teacher's lounge for 1 liter bottles, but seeing that school is no longer in session and it's not very hygienic… you better get drinking! ʘ_ʘ

Fins?

Fins are placed on a rocket in order to stabilize it. There have been debates whether fins are necessary on these rockets. On one hand, fins do add weight onto the rocket and if you don't accurately place the fins on, they could do more harm than good. On the other hand, your rocket becomes less predictable with high psi or a strong draft in the room, so fins can help correct your rocket's paths in those scenarios. Based on our

experiences, fins have been really useful on our rockets especially when we were using the tube design. However, we did experience a time when I put on one fin slightly more tilted than the other fins which resulted in our rocket consistently launching where we didn't want it to go. So even though I recommend having fins, you need to be extra careful when putting them on.

Fin Material: Fin material doesn't matter a ton since it's only job is to help stabilize the rocket. Cardboard does the job although the fins tend to dent and bend easily. Foam is also a good option as well since it's lighter than cardboard. 3D printed fins are lightweight and durable, but they're very hard to secure onto the rocket since you can only use tape. You could 3D print a ring to slip around the bottle and have the fins attach to this ring however. Another common material used is plastic cut up from another bottle and flattened. We ended up using some folded thick cardstock for our fins. Remember to only use **tape** to attach the fins to the rocket or if you are using the 3D print, make sure the ring is secured tight to the pressure vessel and won't slip. Also, make sure that there is nothing in a 5 cm zone around the opening/neck of the pressure vessel as per rule 3e in the rules manual.

Nose Cone? Where Does the Parachute Go?

A lot of hobby rockets that you see online have a nose cone that goes on the top of the rocket and inside this nose cone is the parachute. When those rockets launch, the nose cone pops off and the parachute is deployed. However, in the context of SciOly, I would not recommend you to have the parachute located on the inside of the rocket, or at least not contained within a nose cone, since your deployment will be much MUCH slower which will definitely cut your time by a few seconds. Also, these hobby rockets are usually launched outside where there is no ceiling limit so you can have longer time for deployments. But if you are competing in any state except Northern California, you will be testing indoors with a ceiling height, and our rocket that used a nose cone wouldn't deploy until it was only a couple feet from hitting the ground.

So where does the parachute go if it doesn't go inside the rocket? The most popular option by far is to just balance or drape the parachute over the top of the rocket's blunted top. If you choose to use the tube design, people drape the parachute over the top of the tube, either with the ping pong ball on top of the tube or hanging to one side of the tube. If you choose to use the flip design, it is common to see the parachute placed upside down on top with the parachute canopy touching the blunt top and the ball balanced on top. These options provide a quick deployment since the parachute is already on the outside and it's also very consistent since the chute deploys when the rocket falls away due to gravity.

Flip Design

This design manipulates the rocket to flip/tilt in the air in order to deploy the parachute. The parachute is usually placed upside down on the top of the rocket with the ball on top. Since these rockets are manipulated to tilt, it will flip the parachute the right side up while it's deploying. (See the diagram off to the side for a visualization.)

There are two ways that I can think of in order to achieve this slight tilt in your rocket launch to get your chute to deploy. The first way does not involve a tube and is a relatively short stocky rocket compared to most others. When we first started off with PPP, we started off with this design; we used another 1L bottle and stacked it on top of the pressure vessel and cut out a little groove on top to hold the parachute steady. I'll explain in detail in the testing section, but the rocket wiggles and jolts a bit when you start pumping psi into it. SInce you placed the parachute just on top or draped it over the rocket, there's a great risk that the parachute will fall off the rocket during pressurizing which will technically give you a time of <1 sec. That's why we had a shallow groove to hold the ball steady on our rocket. These short rockets don't have a long tube to stabilize it, so they can become unstable and tilt enough to deploy the chute at a "golden psi". This design of rocket takes a lot of

experimentation to find that "golden psi" where your rocket tilts enough. If there's not enough psi, your rocket won't tilt enough to deploy the chute and one of the lines in your chute can get stuck on a fin and just not separate. On the other hand, if there's too much psi, your rocket could tilt too far and actually fall on top of your chute, causing your chute to plummet to the ground since it has the weight of the heavy rocket on top of it. (See diagrams.) This method also doesn't allow for much optimization of ceiling height. This "golden psi" to deploy the chute, could mean that the rocket doesn't have enough psi to get that close to the ceiling. At our school, the gym ceilings are 28 ish ft and our "golden psi" flipped the rocket around 26 ft, which is amazing since the parachute is deployed close to the ceiling, optimizing the time. However, when we brought this rocket to Cornell Invitational where the venue for PPP was 63 ft tall… our parachute deployed at around 25-30 feet which was what we expected but definitely did not optimize the ceiling height since our time could've doubled if the rocket got close to the ceiling. Another issue with the flip method is that you need to allow room for the flip to happen. You want to get as close as possible to the ceiling but if you get too close, there's no room for the flip to happen without touching the ceiling. If your rocket touches the ceiling when flipping, you will be placed in Tier 3 which is something you need to avoid at all costs.

The other way you can achieve a flip is to use the tube design but modify it to flip. In order to do this, all you have to do is add a bit more weight to one side of the rocket. I would add this weight in the form of extra tape or a little bit of paper stuck to one side where the tube meets the pressure vessel. The benefits to this form of flipping is that there's not really a "golden psi" so the rocket isn't limited at what height it can flip at. However, this design also has a higher likelihood of the rocket hitting the ceiling during the flip because the rocket is much longer.

Overall, I'd have to say that not many people use the flip design because it's hard to figure out the deployment and is very dependent on the conditions at the testing location. Few people during the season used the flip method, and instead opted for the tube design, which is a much simpler design that arguably does better.

Tube Design

The tube design is a lightweight, tall rocket whose goal is to launch as straight as possible and to fall back to the ground as straight as possible. When the rocket falls due to gravity, the parachute that's draped over the top will deploy. This tube is created using a fluorescent light tube guard which you can find at any hardware store. These tubes are super light and come in many different sizes and lengths. The longer the tube, the more stable your rocket will be. However, you don't want the rocket too tall or it'd be hard to place the parachute on top of the rocket and it also becomes less durable and easier for the tube to break. These light tubes are generally very strong but a strong impact to the floor or someone accidentally stepping on it can crack, bend, or dent the tube. It is imperative that you make the tube as straight as possible when building, otherwise your launches will always tilt and the parachute might not deploy if the launch is tilted since one of the lines can catch the tube.

Fluorescent light tube guard used on tube design rockets. They are a few dollars per tube and can be found at any hardware store. They also come in different lengths and widths and can be cut down to a smaller length.

Testing and Practicing

Now that you've constructed your parachute and your rocket, it is time to go test! Testing what you've made is the only way to know where you can improve your design. Make sure to test each rocket/parachute after you've made them so then the next rocket/parachute you make will address the problems you encounter when you test.

Parachute Testing

You will most likely make a lot more parachutes than you will rockets and sometimes you don't want to bring out the entire launcher and rocket just to test a new parachute. Anytime we finished making a new parachute, we would drop it off a balcony or at a wide stairwell just to see how it falls. If the parachute falls quickly when just dropped, it probably won't do that well when launched on the rocket, so instead of wasting time to launch with a parachute that's not that good, you can take that time to make another parachute. I would say to drop it off a stairwell/ high place at least 5 times before deeming whether it's a good or not so good parachute. By doing these parachute tests by themselves, you and your partner can have one day dedicated to just making and testing parachutes and you guys don't even need to touch the rocket or the launcher. Once you get faster at making parachutes, you will find that you can test out all the different variables you want to play around with.

Launcher

Once you've created several great parachutes and a rocket you want to try out, it's time to use the launcher. There's many different launcher options out there. Most competitions will use the Nerds Inc. Launcher which can be found here. This launcher is very easy to use and is the launcher we got to test our PPP. However, this launcher is pretty pricey and there are many tutorials on YouTube of how you can make a homemade launcher for much cheaper.

Note: The competition website should tell you the height of the testing venue and the launcher model a month in advance. It's good to practice with the same launcher as the model at competition if possible. However, due to the ongoing Covid-19 pandemic, some competitions in the 2020-2021 season might not be running PPP due to logistical constraints and the safety of everyone. In this case, get/build a launcher that fits in your budget, just so you can practice and fill out your flight log, in case situations clear up and the event will be run again at that competition.

Also note: The launchers used in the event Bottle Rockets a few years ago also work in PPP. Any water rocket launcher should have a nozzle that fits onto your indoor rocket. The only downside to these launchers is that they're located off the ground versus the Nerds Inc. launcher which lays flat on the floor. But if you can find your team's launcher for that event from a few years ago, you can save some money.

Flight Log

The flight log is another very important part of this event. The flight log proves that whatever rocket/parachute you plan on using for competition has been tested before. My partner and I also found that the flight log helps us keep track of what combination of variables works the best. We are able to take notes on each launch we do directly on the flight log. On the flight log, there are 5 total variables that you need to have—3 of them provided to you in the rules, and 2 of them that you need to think of yourself. The 3 variables provided in the rules that you must include is the pressure in psi, the estimated/recorded peak flight height in feet, and the time aloft in seconds.

1. Pressure (psi): Simply write down how much psi used per launch. Make sure that none of your launches uses a psi greater than 65 psi as per the rules clarification.
2. Estimated/recorded peak flight height (ft): This is simply you estimating the highest point your rocket/parachute was at. This is merely an estimate so there's no need to be exact. Some ways you can estimate is by launching next to a wall that has bricks or tiles. You can measure one brick's height and then multiply by how many bricks you saw the rocket/parachute go up. Another idea to estimate a semi-accurate height is to film your launch and then replay it afterwards. It might also be helpful to know the ceiling height of where you're practicing your launches. We asked the janitors the height of our gym since they had our school's original blueprints, but later on we got a laser pointer that measures distance so we could measure the heights at different testing locations.

3. Time aloft (sec): Start the timer when you or your partner presses the green launch button and end the timer whenever the ping pong ball hits the ground or whenever the rocket/parachute hits the ceiling or a fixture.

Some variables you can use for the 2 variables you pick can include but is not limited to:

- Number of fins on rocket
- Tube length on rocket
- Thickness of tube on rocket
- Parachute diameter
- Spill hole vs no spill hole
- Powder vs no powder
- Diameter of spill hole
- # of lines

Make sure that for every rocket you make, you have a separate flight log. Each flight log must have 15 or more trials for it to be complete. If you choose to use a variable concerning the rocket like "number of fins on rocket", you need two separate flight logs, each with 15 or more trials. Also make sure that you can justify everything that's happening on your flight log. The proctor at competition has the right to ask you questions regarding the flight log to make sure that you and your partner actually built and tested the rocket(s) and parachute(s) you bring to competition. Remember, you can bring up to two rockets and two parachutes at competition but both rockets must have separate flight logs.

I also think it is very helpful to have a "Notes" column on your flight log just for your own purposes. In the notes column, I keep track of what tier launch it was (tier 1, 2, or 3), when the parachute deployed, and anything odd the parachute did (drifting, tangling, etc.). This is not required on the flight log but it's helpful for you to go back and make changes later to your parachute and rocket.

Below is the template I used for my flight logs to make sure all the necessary information is located on the log. I would print out this template and fill out the data with a pen when testing. I only put 15 trials on the template but we usually end up doing much more trials than 15. Technically, you don't have to record your other trials past 15 and should focus more on the actual testing than the log but I liked to keep a good record of all our launches. I'd just keep adding rows to the bottom and our logs would have 45+ trials.
Flight Log Template

Miscellaneous Testing TIps

Below is a collection of random things that made testing more smooth for me and my partner.

- When using the Nerds Inc. Launcher, the first pump will always jolt the rocket a bit. I've also seen this in other launchers where the rocket moves around when you pressurize the vessel. Just be wary that this happens and to make sure your parachute is secured and won't fall down.
- When testing, it's good to have a parent, coach, or a supervisor videotape each launch. That way if a rocket launch went really crooked, you can play it back. I also recommend recording in slow motion since you can see the exact point when the parachute deploys from the rocket.
- If all the videos are taking up a lot of phone storage, it'd be good to upload the videos to a private Google Drive account for viewing later.
- I find it easier to have only one person to put the parachute onto the rocket since too many hands can get in the way or push the parachute to where it shouldn't be. Usually while I'm placing the parachute on the rocket, my partner is making sure that the rocket is straight on the launcher and that the parachute is positioned right from far away.

- Make sure to practice testing under a time constraint to simulate competition. You don't have to do this all the time but make sure you practice it a few times to make the loading and pressurizing processes quicker.
- In the ideal environment, there are no drafts in your testing location. However, you don't know whether the competition location will be just as ideal so make sure to try your parachute once or twice in a cold draft and a warm draft.
- Bring your build box when testing… you don't know if a fin will break or a shroud line will come undone. Be prepared!

Competition

Now that you've built and tested your rockets and parachutes, you are ready for competition! Make sure to check the competition's website beforehand so you know roughly the dimensions of the room. Staying calm during competition is imperative so that you can make quick logical decisions in a new environment.

Packing for Competition

Make sure you bring *everything* to competition. You might not need to bring the build box to the actual site of testing. However, you should bring this box and leave it in the team room just in case you need to fix something on your parachutes or rockets that broke during transportation.

We packed our parachutes in a parachute box with the chutes stacked on top of each other without the ball attached. We also got a large cardboard box to transport our rockets and to make sure rain/snow doesn't get on them when we moved them. Then we had our build box and our launcher box that contained the stuff we needed to launch. It is very helpful to create a checklist the night before competition and to just make sure everything is packed beforehand. I'd also recommend going over the rules the night before to make sure that your rocket and parachute conforms with the rules.

Before Launching

Since PPP is a self-scheduled event, you can go and test anytime in the time block. It takes around 15 minutes total to launch from unpacking your rocket/parachute and to putting away your rocket/parachute. When you get to the event, your rocket should be good to go already but your parachute will probably need more setting up. You will definitely avoid lots of tangles in your chute if you place the ball on right before you're going to launch so give yourselves a few minutes to tape the ball to your chute. Once you've got everything set up, you can go up to the proctor and the table to check in. The proctor will ask questions about your rocket and parachute to make sure you guys made it yourself and then the proctor will measure and inspect your rocket and parachute to make sure they fit within the rules. You will also present your flight log and your bottle label to your pressure vessel if you decide to take it off. After all of this is set, the proctor will start a timer for 5 minutes in which you have to do both launches.

Launching Under a Time Constraint

During competition, you have 5 minutes to do two launches. In order to maximize your efficiency, one of you should be in charge of pressurizing the vessel and the other partner should be in charge of putting the rocket on the launcher and putting the parachute on top. Both of you guys need to make sure that the rocket and parachute are straight. Make sure to work fast but also make sure you aren't rushing. If you rush placing the parachute on top, you risk your parachute falling off before launch. Make sure to keep calm and realize that 5 minutes is a lot longer than you think it is!

Scoring

The highest time aloft wins as long as that time is in Tier 1. In PPP there are three scoring tiers. In Tier 1, there are no violations and this is the tier you want to be in. A launch is categorized as Tier 2 if the parachute did not deploy from the rocket. A launch is placed in Tier 3 if any part of the rocket or parachute touches the ceiling or any fixture that's connected to the ceiling like basketball hoops or beams. Even if you had say a 9 second time but there's no violations, you'd do better than someone with a 20 second time but their rocket touched the ceiling.

What times will place at competitions? If you attend a not so competitive regionals, you can expect a time of 0.6 sec/ft - 1 sec/ft to win regionals. At states, expect a time of around 1 sec/ft in order to place. At nationals, expect a time of around 1.5 sec/ft - 2 sec/ft to win nationals. For invitationals, it depends on how competitive the invitational is. In order to calculate your sec/ft, divide your time by the ceiling height of the testing location. For example, 15 seconds in a 25 foot room will give you 0.6 sec/ft.

<u>What's in our Box/Folder?</u>
Here's just a rough breakdown of what we bring to practices and competitions.

The Folder:

- Flight Log(s) - you need a flight log for every rocket you bring as per rule 4.a. in the rules manual
- Label for the pressure vessel bottle
- A copy of the rules

Build Box:

- The folder
- Rulers and a protractor
- Baby powder and brushes to apply it
- String
- Tape (scotch, packing, and masking)
- Glue
- Sandpaper
- Extra parachute material
- Sewing needle
- Pens / scissors / pencils / markers

Launcher Box:

- Launcher
- Over 60 ping pong balls because we are extra :)
- Chapstick (our launcher's O-rings would get stuck but according to the official FAQs you are not allowed to lubricate the inside of your pressure vessel or the competition launcher - we just keep it to fix our own launcher)
- Bike pump
- Our rockets (Make sure you are only bringing up to 2 rockets for competitions)
- Goggles
- Another set of rules

The Parachute Box:

- All our parachutes
- Tape
- 2 extra ping pong balls

That about wraps up this Ping Pong Parachute guide! I hope this guide has gotten your brain thinking and has helped you start off on this event. If you have any questions, feel free to PM me on SciOly Forums, DM on Discord at Kyky#4674, or email me at yangster39@gmail.com. I wish you the best of luck and stay safe during these uncertain times!