



A Sustainable Approach to FIRST Tech Challenge

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Introduction

Recently, while cleaning out our team's robotics garage, we threw out a lot of garbage. We found drawers packed with candy, broken parts, and a plethora of random items. Over the course of just our last season, we had accumulated a lot of waste. This got us thinking, "how can we reduce the amount of garbage our team produces, and make FIRST altogether more sustainable? Thus, we came up with a list of small steps that every team can make to help preserve this amazing planet we live on. We hope that together, we can make a difference.

-The Green Girls FTC team 7190

When Should I 3D Print?

3D printing has become a HUGE phenomenon in the last few years. The ability to design and create custom parts from scratch is both immensely popular amongst teams and the judges. Yes, it does look really cool when a team seems to 3D print their entire robot, but at what cost?

We need to take a step back. What are most 3D printed parts actually made of? Plastic. We produce an insane amount of plastic waste every year, with 185 pounds of plastic thrown away in America annually and 3D printing isn't exactly helping with that problem.

Now, don't get us wrong, we're not saying "don't use a 3D printer ever!" We are simply asking that, before you 3D print, you think "is there a better, more sustainable way to make this part?" 3D printing is not the only way to impress the judges! Using things like living hinges cut on a laser cutter, milled parts, or even pre-made extrusions can still be very impressive. Here are a few basic questions you should ask before 3D printing:

1. Does the part utilize the x, y, and z axis? If you are making something that is flat, don't 3D print it! Try using subtractive manufacturing instead.
2. Is it complex? If so, 3D printing is probably the right route. But, keep your filament size in mind. On FDM printers, overly complex parts might actually be too hard for the printer to handle.
3. Does it need to be strong? If so, don't print it. In order to make a part stronger, you often have to change the fill from a honeycomb to a solid one, making it much more wasteful. Stick with metal.
4. How big is it? If your part is over 12 inches, it may not be the best to 3D print. Most household printers can't even print a part that big anyways! Yes, you can split the part up, but in doing so, you are compromising the structural integrity of the part.

Alongside asking those questions, consider if the part can be reused (see: re-useable parts) or if it's a one-time print.

Here are some examples of parts that should, and shouldn't be printed.



Don't print this.

This is a claw that we made for Relic Recovery. It is mainly flat, and needed to be much stronger than it **actually was.**

Do print this.

This is a hex shaft converter. Because it can be used for many years, it is a worthwhile print.



Competition Handouts

Each year at the World Championships, we run out of pins on the second day. That's 700 pins in 2 days. Holy cow! Along with pins, in circulation are candies, wristbands, and brochures. We admit it, it's exciting to get all of the handouts, but what happens to them? At the end of the day, you have about 100 pins and wristbands that you don't know what exactly to do with. There are even people who choose to make chainmail out of all their pins. So, what can we do to make these handouts more practical and **eco-friendlier?**

Get your pins and stickers made by companies that have made a green pledge and use environmentally friendly **recycled materials**. That way, you are creating a closed manufacturing loop that doesn't rely on raw materials.

Or, try **using** stickers (sustainable ones of course!). Our team LOVES getting stickers from various teams, companies, and organizations. You can stick them on water bottles, notebooks **and** binders, skateboards, laptops, posters, and more. Plus, they take up much less space, which means less fossil fuels are created in transportation. Trust us, **stickers are awesome.**



Please, don't hand out pamphlets. Our team is definitely guilty of this ourselves, as it is such a nice resource to have. Unfortunately, they usually end up in the trash or recycling **though**. If you have to do paper handouts, reserve them for **the judges**.

Paperless Scouting

We live in a digital age where paper is “going out of fashion.” Or so that’s what people say. While it may not be totally true, that is a philosophy that we really should embrace when it comes to scouting. Our team has thrown out countless binders, stuffed full with scouting sheets. This is really wasteful. There are two ways to solve this, depending on what your resources look like. Our team is very fortunate and thankful to have iPads issued by our school district, and we understand that is not the case for everyone. Nevertheless, we hope one of these two solutions can solve the problem.

1. **Use wet** erase markers and laminated sheets of paper, or paper sleeves. This solution allows you to still have your scouting binder and forms, but makes them re-useable. The wet erase (not to be mixed up with dry erase) markers are great because you can write down the info, without smudges, and then wipe it off with a little water for a brand-new sheet of paper at the next tournament!
2. **Using a tablet or iPad.** **This** is the method our team uses. You can design a scouting form, and import it into a drawing or notetaking app on the iPad to write on. We recommend using a stylus for ease and more legible **handwriting.** This option is nice, because you are going totally paperless, and it means no big binder to lug around. When you are done scouting, you can email or airdrop the scouting forms to the rest of the team so everyone has access (while still being cautious of WIFI's impacts on the robots). Or, better yet, use a cloud-based app for your notes.

Re-using Parts

Each year, a new challenge is announced, new parts are bought, and robots are built. At the end of the season, the robot is torn apart, and the parts are filed away into a location where they will never be used again.

As a veteran team, we have accumulated many parts over the years. Sadly, those parts are neglected, or thrown away once they are no longer of use. To solve this problem, teams need to start re-using parts. And, in order to re-use parts, we need to be conscious of the parts we are making and buying in the first place.

When buying parts, go for the higher quality ones. Yes, they often cost a bit more, but they will often last longer in return. Read the reviews because there are multiple kinds of the same part. If there aren't reviews, ask the robotics community! Social media is a great way to reach out to teams that are not in your area. Many teams have probably worked with the same part that you are looking at. Also, take the part's material into account. Buying metal gears instead of plastic ones is more expensive, but there is less of a chance that they will grind.

When making parts for your robot, try to aim for a more modular design. This allows you to make new attachments without impacting the others, or your robot's base. This is what our team does. Last year, when we rebuilt our robot, we benefited greatly from our modular attachments, because we were able to reuse our entire base and drive train.

Lastly, try to make parts that can be used for multiple years. Yes, 3D printing a phone holder isn't as cool as a specific mechanism for an attachment, but it can be reused for multiple years to come.

Also, take care of your parts! You can't use them if they're broken.

Recycled Organization

Let's take a step back from the robot, and talk a little about your team's meeting place. If you are like us, it is probably always in desperate need of a little organization. When the time comes to clean, resist the urge to go and buy storage solutions. Buying bins, organizers, and boxes can not only add up in cost **really** quickly, but is also not very environmentally friendly. Instead, start collecting your recyclables for reuse. Shoeboxes, candy jars, cereal boxes, canned food jars, and even toilet paper rolls are great for organization. If you need a little inspiration, check Pinterest! Even small snack and cosmetic boxes are great when taped together to make a **drawer divider**.



What to Do with the Old Field Elements

The FIRST game designers do a great job coming up with cool field designs and concepts each year, but at the end of the season, teams are left with large game elements that just take up space. This is where we **call you to be** creative!

Some things are simple to re-use, like the whiffle balls, **exercise ball**, and small game elements, while others are a bit trickier. Here's a few ideas on what you can do with your old field.



Make a chandelier.

This is one that our team member Grace made out of some LEDs and the center goal from Velocity Vortex. This is a cool way to repurpose the larger center structures from over the years.

Make a jewelry holder.

Most of the games involve PVC pipe of some sort, and it's really easy to cut up and re-use. Our team member Zoe used some old PVC to make herself a bracelet holder.





Dress up your relics.

Our team is obsessed with decorating our relics. They're so cute and can be made into lots of cool things. We first noticed this trend at Minnesota FTC tournaments when the volunteers made a ref relic, Olympic relic, and 2 relics going to prom. The one in the picture is one that we made. We wanted to dress up our relic like Jerry, the MC at North Super Regionals because Jerry was just that awesome!

Re-purpose your relics.

This is our relic lamp. Our team used to use a tent in our pit, and at MN state last year, we realized it was way too dark. Thus, we decided to make a relic lamp. The lamp was really easy to make. All you need is a large step drill bit, a screw in lightbulb kit that plugs into a wall (ours is from a craft store), hot glue, a wooden base, a relic, and a really cool light bulb.



Sustainable Shopping

So, this is a bit more loosely related to robotics, but it is still important to



keep in mind. Every time that you make a run to the store to buy tools, parts, and snacks bring a reusable bag with you. Plastic bags are awful for the environment, and do not degrade easily (it takes over 500 years for a plastic bag to degrade in a landfill). Plus, they are super impractical due to how flimsy they are. So, simple solution: bring your own. Reusable bags are

often given out for free at events, so they're pretty easy to get ahold of. If you don't have any though, they are quick to make with a little fabric and ribbon. All you have to do is sew down the tops of 2 square pieces of fabric, and then sew them together on 3 of the sides. Also, if you want to keep the edges of your ribbon from fraying, burn them. Be careful though!



Keeping Inventory

One of the easiest yet hardest things to do is keeping inventory. In order to do it, you don't need running lists of what your team has and doesn't have. It can be as simple as knowing where things are, and checking to see if you have something before you buy. This will help you save money, and prevent duplicates. If you are using recycled organization (which we hope you **now are!**) than labels are great for when your containers are not see through.

Also, keep track of what is working properly, and what is not. If something breaks, get **rid of it!** If anything, keep labels on your components that aren't running quite right. This will help you know if that pile of servos is actually sufficient, or if you need to order new ones.



Eco-friendly Cleaning

This may sound obvious, but use the recycling, trash, and compost when you clean. Many times, people can get caught up in the moment and just end up throwing everything in the trash. This is **really** wasteful. Keep at least a recycling bin and a trash can on hand where you meet, so recycling can occur just as easily as throwing away trash. Not sure what goes where? Here's a guide from wm.com:



**RECYCLE OFTEN.
RECYCLE RIGHT.**



RECYCLE OFTEN.



Metal Cans

Steel, tin & aluminum soda, vegetable, fruit & tuna cans



Plastic Bottles & Containers



Paper

Brown paper bags, non-confidential office paper, newspaper, magazines



Paper Cardboard, Dairy & Juice Containers



Flattened Cardboard & Paperboard



Glass Bottles & Jars

RECYCLE RIGHT. Things you can do to ensure quality material is recycled:



DO NOT INCLUDE: Food waste, plastic bags, polystyrene foam cups & containers, hangers or hazardous waste

- Paper and cardboard must be dry and free of food debris.
- Tissues, paper towels or other paper that has been in contact with food is not acceptable.
- Make sure food contamination and caps are removed from cans and plastics and all containers are empty.
- Separate plastic lids from plastic bottles (often made from different materials).
- Do not place medical waste (needles, catheters or lancets) into the recycling containers.

Water Bottle Waste

Staying hydrated at competitions is really important in order to keep your team members healthy and to do your best. So, when drinking water, keep this simple, but impactful tip in mind: use a re-useable water bottle at competitions. At each competition, our pit seems to fill up with empty and half-drunk plastic water bottles. This not only makes the pit look bad, but is also pretty bad for the environment. To save yourselves some money, invest in a re-useable water bottle. Our team has some awesome custom ones that one of the moms made and decorated with our initials.



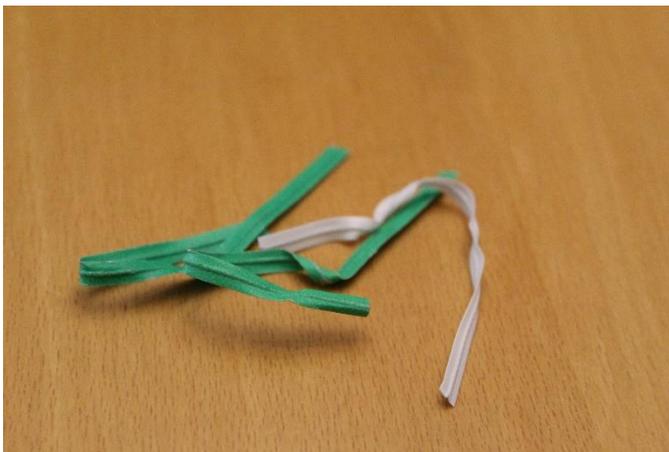
Zip Tie Elimination



Yeah, zip ties are iconic, but they're also less practical than they seem. We waste a ton of zip ties each year, **because once they're on, they can't be undone.** Because of this, we are stuck trying to hack our way into cutting them with some wire cutters every time we need to make a change, and then reaching for a new one when done. In the end, there's a giant pile of used zip ties that just get thrown away.



Instead of zip ties, use something else. For bundling wires together, use **conduit.** We recommend sticking to the bigger conduit though, as the little stuff can be pretty tricky to open. For other things, use bread ties (the little twisty ones) or Velcro ties. These can be reused over and over again, and are easy to undo.



Sustainable Fundraising

You can not only make an impact on the FIRST world, but also amongst people who are not in FIRST by encouraging good behavior when fundraising. This doesn't necessarily mean chastising people for using plastic bags during a bagging event, or throwing away recyclable materials from your team bake sale. Here are a few small steps to make your fundraising more sustainable.

1. Encourage the use of paper over plastic bags when doing grocery store bagging fundraisers.
2. If you are selling baked goods or food, try to use paper over plastic wrapping
3. Try having a QR code that people can scan that will lead them to your website instead of passing out business cards, or business plans
4. Stay away from handing out candy. Though it looks like the wrappers are recyclable, they're often not.
5. Opt for emails over mailed letters when contacting potential sponsors.



Cardboard Prototyping

One thing that we recommend due to both its functional and sustainable benefits is cardboard prototyping. This means re-using boxes and cardboard sheets to prototype your robot.

This is practical, because it is super-fast and easy. You can make holes with a screwdriver instead of a drill, and make cuts with scissors instead of a saw. It's also really simple to remove.

On the sustainability side, using cardboard to prototype is a great way to reuse those old boxes. It is also much more environmentally friendly than 3D printing or using plastic.

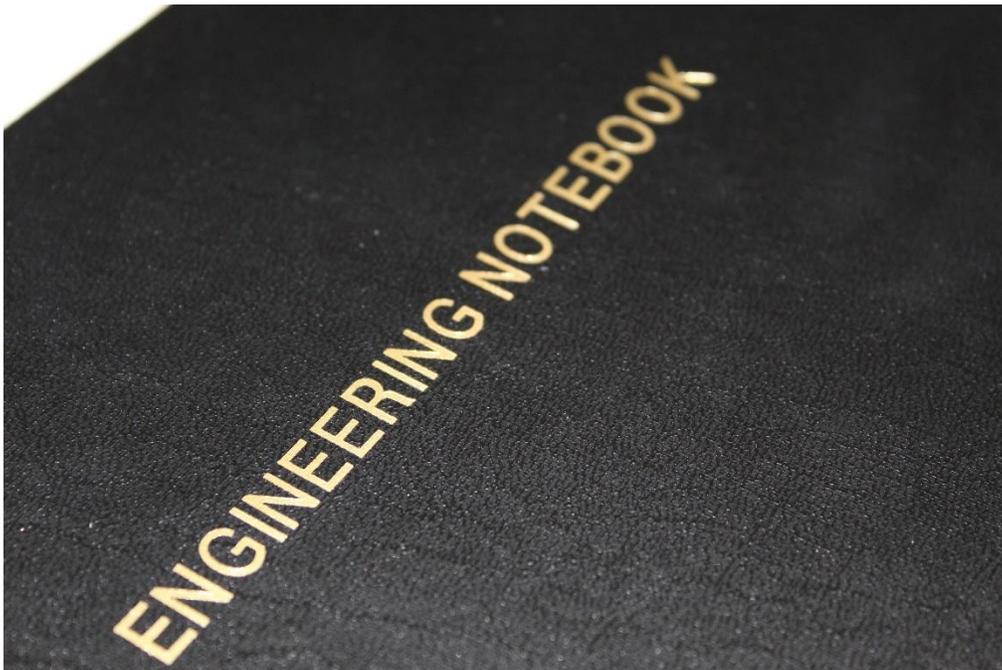
Make sure that when you are done, you remove all non-recyclable materials from the cardboard before recycling. Things like duct tape are not recyclable!



Engineering Notebook Paper Waste

This one is for teams that do online engineering notebooks. There are many ways to cut down on the amount of paper that you use for your engineering notebook while still maintaining its integrity and aesthetics.

1. Format your notebook in multiple documents. This means splitting up your engineering sections, team sections, and even individual outreach events. That way, when you make updates before tournaments, you don't have to re-print the entire thing.
2. Print your notebook double sided. This sounds obvious, but can really help cut down on paper waste.
3. If you are going to keep an extra notebook in your pit, make it a virtual one. You can save your notebook as a pdf and display it on a tablet or laptop. This allows you to bookmark those special pages for when judges come around. If you have a handwritten notebook (like us) then scan it!



A New Life for Old 3D Printed Parts

By now, we've talked a lot about 3D printing waste. So, to build on it even further, we're going to briefly go over what to do when your 3D printed parts are no longer useable by your team. If the part is still in useable shape, then you can give it a new life!

The first way to do this is by donating your old (non-damaged) parts to another team that will benefit from them. Things like old controller mounts, wire organizers, and wheel modifiers are great for donation! You can even count this as community outreach. But, please keep gracious professionalism in mind. If your team receives a part from another (whether that is via an opensource website or a physical part donation) make sure to ALWAYS give them credit. FIRST is a family, and sharing can make a big difference.

Preventable Damage

We'd like to finish off by touching on the easiest way to keep your parts working for as long as possible: by preventing damage to them in the first place. Things like the phones, joysticks, controllers, and even custom parts should be able to last for a long time. Try not to drop, throw, or rough them up. Here's a few tips on how you can protect your phones and joysticks specifically.

1. Use **phone cases**. There are lots to pick from on Amazon, and they are pretty low in cost. It's way cheaper to buy a case than to replace a screen or buy a new phone altogether.
2. Store your things in a safe place. Computer bags with lots of pockets are great for robot driving supplies. You don't want to just toss everything in one pocket, because it's bound to get damaged.
3. Create a driver control plate. We got the idea for this from FixIt when we

were in China. Our team uses a lanyard attached to a clipboard for ours. Then, we attach the phone, joysticks, and hub to the plate with Velcro. Our coach wears the plate during matches. Make sure to check with



the referees at tournaments before doing this. Sometimes they will ask to take it off or not touch it during a match to keep things legal.

A Path to a Better Future

Thank you for taking the time to read this. We hope that by following these little steps, we can make a big impact towards a more sustainable future. Make sure to share this book with other teams, as that is the only way we can truly spark a change.

We'd love to see the steps that you are taking to make FIRST more sustainable, as well as hear feedback on this informative short book. Make sure to mention us on Twitter, Instagram, and Facebook!



Instagram: @ggrobotics



Twitter: @ggrobotics



Facebook: Greengirlsrobotics