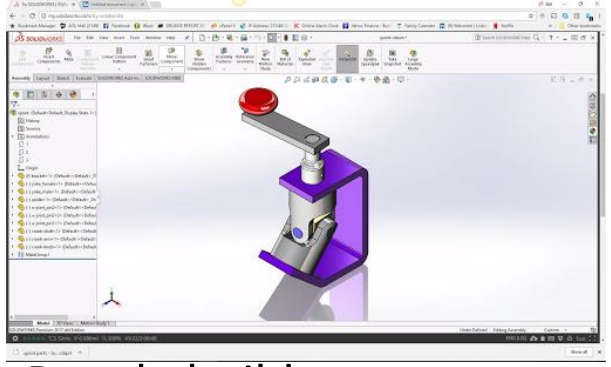
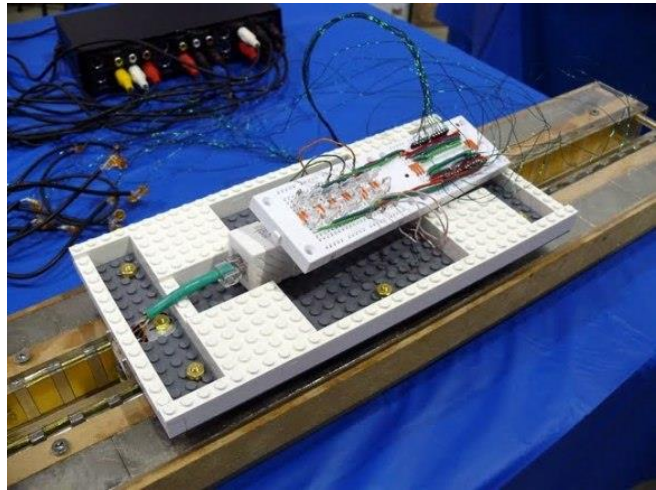


Some thoughts on Prototyping

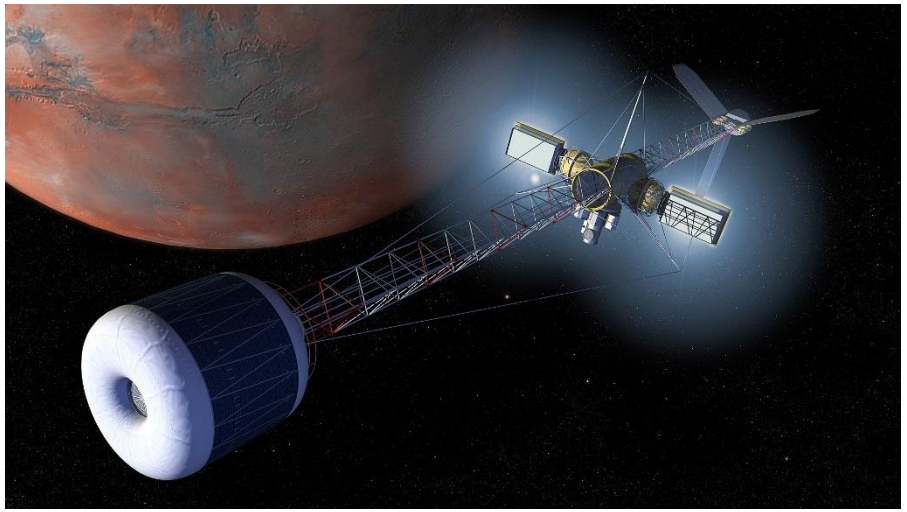
Glenn Johnson

People build prototypes to express their idea—both for themselves and for other people. First they build a prototype for themselves to see if their idea works the way they think it should, then they can use their working prototype to show their idea to other people to demonstrate how their idea fits together and solves the problem that it is intended for. The prototype also gives the inventor a method of testing to see what kind of improvements can be made to make it better. Sometimes it allows people to expand on what all it could be used for. There are many ways to build prototypes and many materials to build them out of. The method and materials you choose for your prototype will be different for each project. The only thing that determines the right materials is whether it allows you to express the idea and convince other people it is worth pursuing more.



Research

- Designing new hardware or software always starts with some research, some you know and some you don't. Make sure you understand the problem and have researched the environment and the problem that you are designing for. The Moon, Mars and zero-g are very different from where you live. Not everything you will deal with in these locations will have relevance here on Earth. People in space suits have different needs than those in heavy work clothes. Dust on the moon is much more abrasive than sand on the beach. Getting rid of trash on a space craft is much more dangerous than going out to the curb at home.



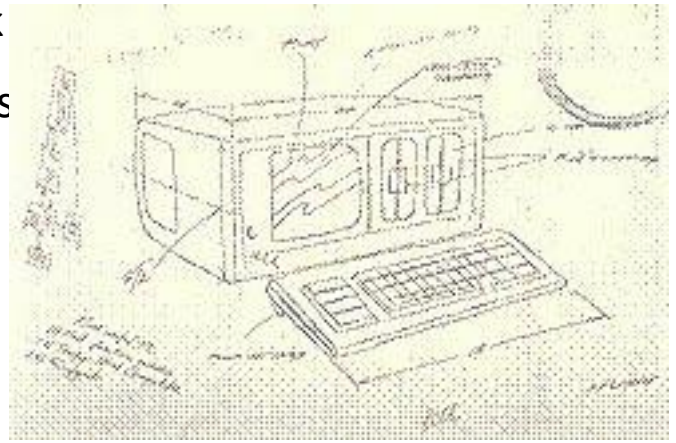
Sketching out ideas

Whether you start off on a napkin, the back of an envelope, engineering paper or you like to start with CAD, the picture and words you put down helps you talk with other people about your idea and their ideas can work with yours. **A picture is worth a thousand words.** The more detail you put into your pictures, the more it describes your project and people can have better conversations about what you are thinking.

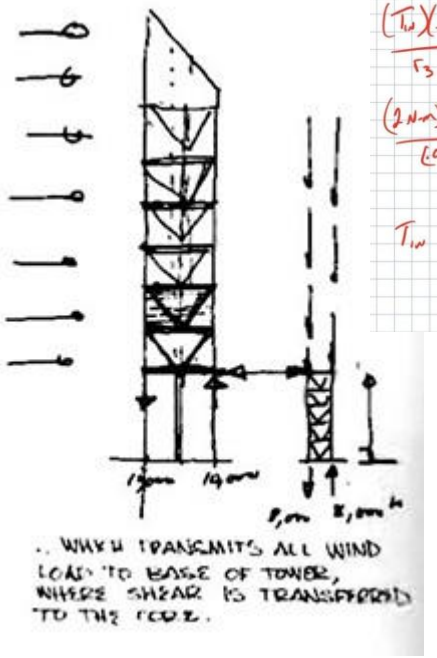
Some people start with drawing, others think with objects in their hands then sketching out what they are thinking of. Sometimes you can start with junk in the garage or bottles in the recycle bin but at some point you will need to sketch out the more full picture.

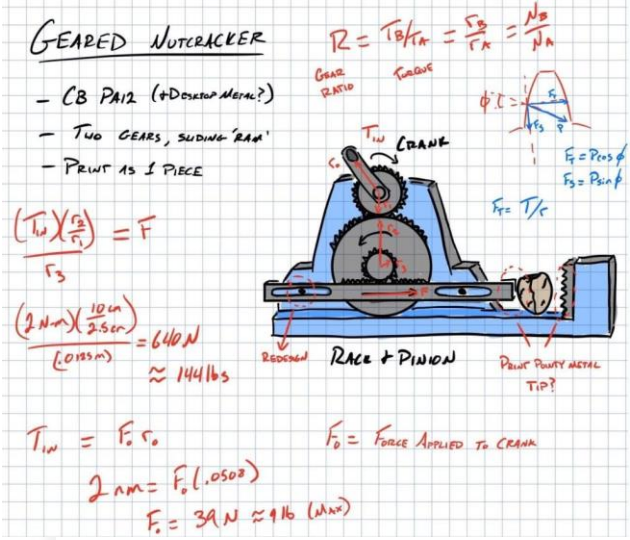
Once you are ready to flesh out your idea, there are many ways to turn your thoughts into 3 dimensional prototypes. Expect you will be making more than one prototype. The first will be very simple and your team will help you make it better and figure out what the next one will look like.

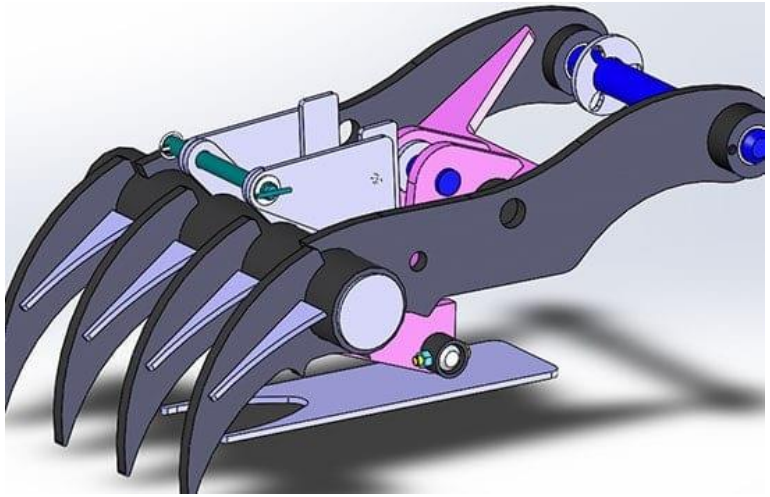
There are lots of materials to start with and all of them are valuable to consider.

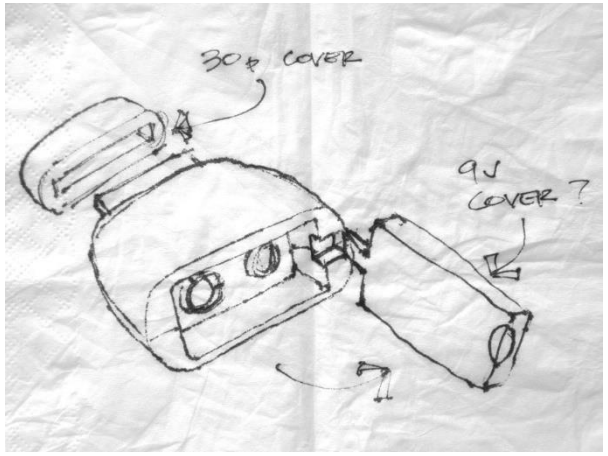


My friend in college had a Compaq computer just like this sketch.









Clay Modeling

If a picture is worth a thousand words a fully dimensioned object is worth a thousand pictures.
Clay Modeling has been used for a long time to shape and mold ideas. It has been used in the car industry to bring the ideas on a flat paper into 3 dimensions so the full idea can be evaluated and measured before a final product is made. Although it may not be used for the final product, it can be a great method of finding the outer shape that is desired and can be modeled in great detail.

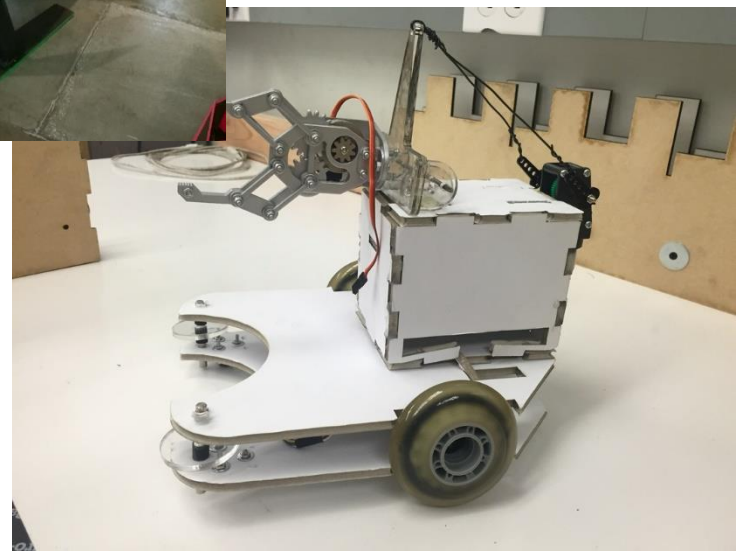
Cardboard

Cardboard is something everyone has available at home, school or the office. It can be glued and taped into many shapes. It is a great starting material because it is so easy to work with.

At some point you will need to move on from cardboard. It is cheap and versatile but it also looks cheap, it isn't very strong and you can only do so much testing with it. Start cheap, plan for better.

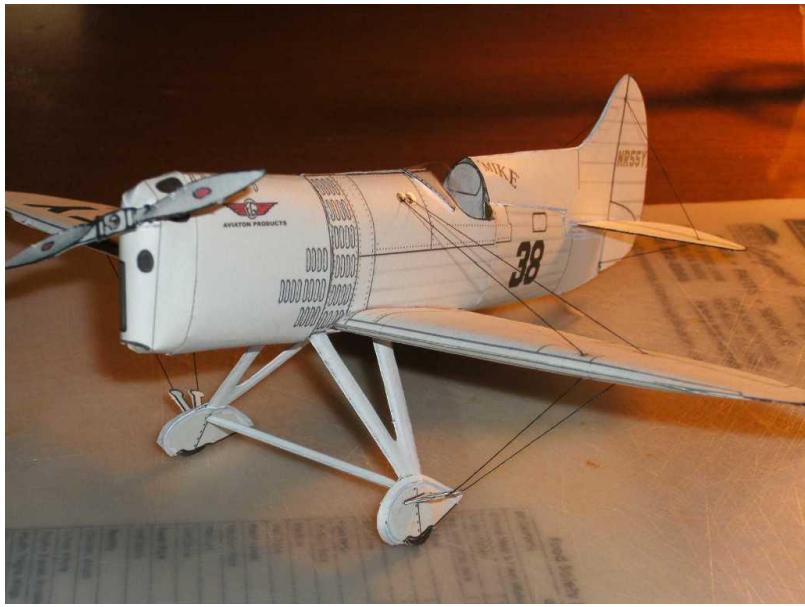
Foam Core

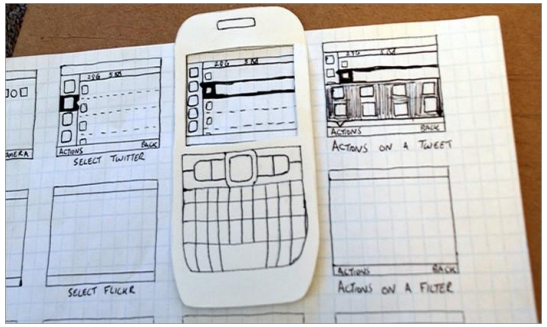
Foam core is not much different from cardboard. It is more rigid, looks more clean, comes in many colors and has a more professional look but is still not very durable. It won't last through much testing. This can be a great material for showing size and dimensions. It is easy to write and draw on to show other components and features that you want to add.

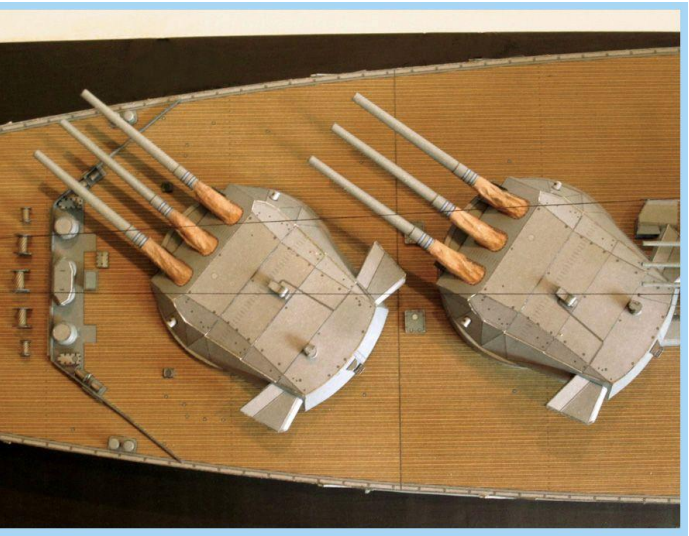


Paper

Paper bends and folds similar to cloth but is much easier work with as you are developing your thoughts and ideas. It can also be shaped to be more rigid than cloth to get the shape you are looking for. These shapes can then be used as the pattern for what comes next.





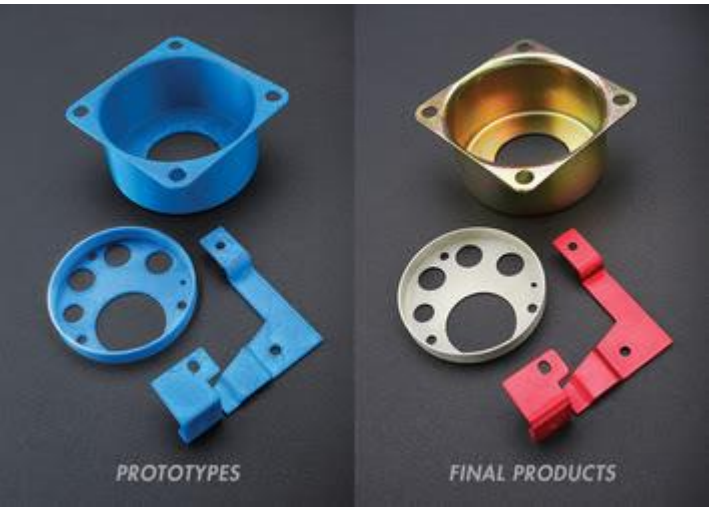


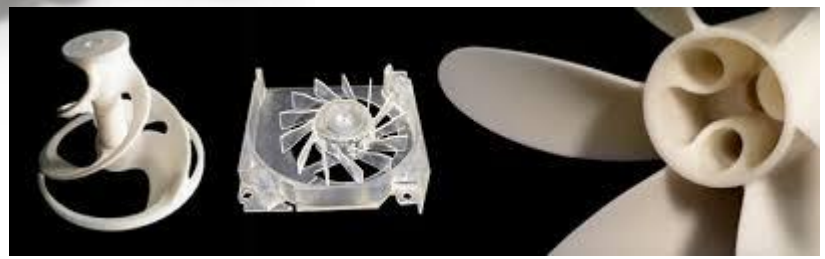
Plywood

Plywood is an excellent material that is cheap and can be made into many different shapes. It is much more durable than cardboard and paper and can handle going through many testing cycles. Some of these prototypes were built using saws, drills and sanders where others were made using laser cutters.

Fig. 4 An early wooden prototype of the 'X1 Experimental Vehicle'.

3D printing

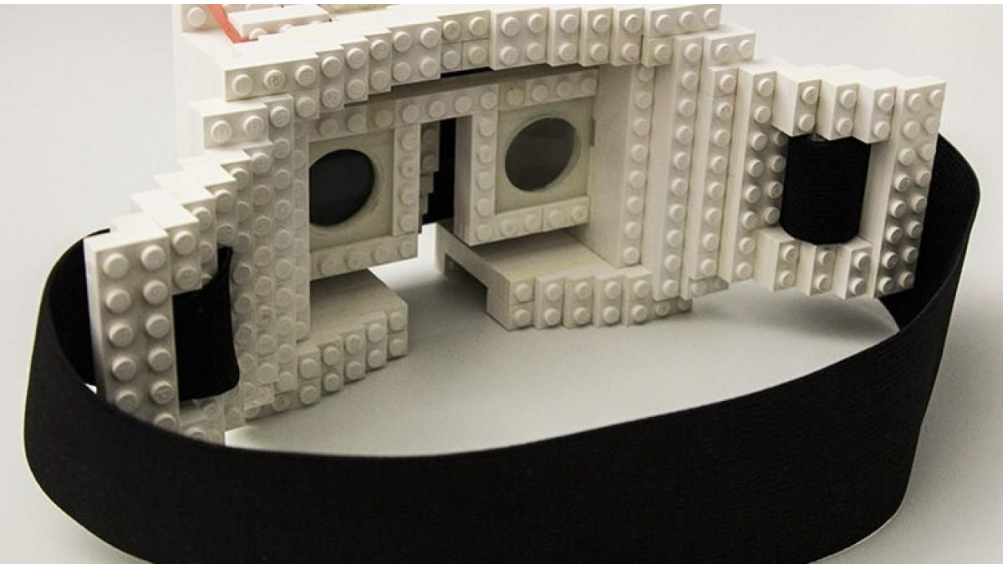


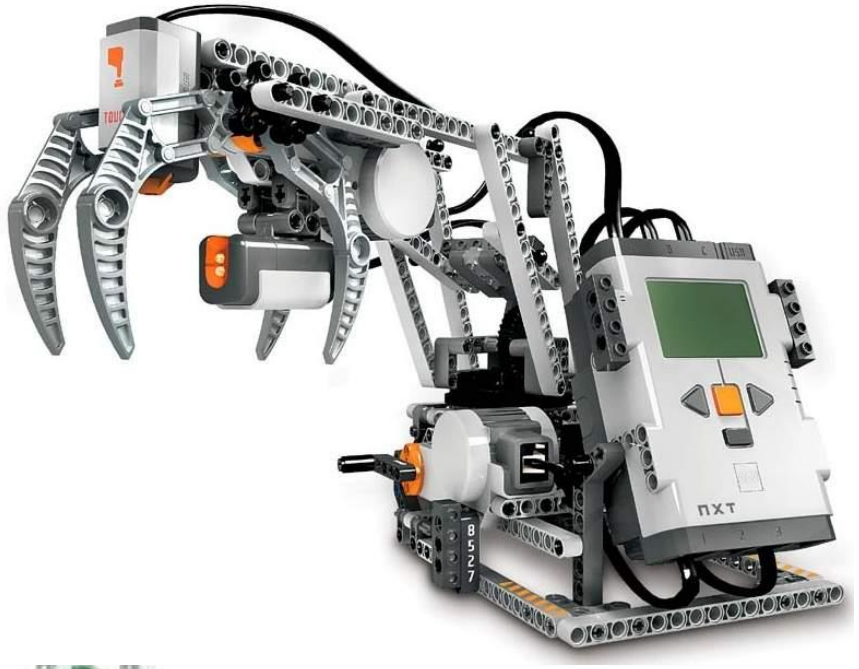


3D printing is all the rage right now and is a very powerful tool. You can make very intricate parts, sometimes very quickly, in many different colors. Unfortunately it isn't always available at all schools or from home or there are lots of people trying to use it at the same time. The CAD software for making the parts isn't always available at home on a slow school computer. PVC or PLA isn't always the best material to represent your idea if you are needing strength. Some people make the mistake of trying to make all of their idea from one print or only from plastic. Some materials like nuts and bolts are much better and easier to obtain from the hardware store. Print what is special and unique but save yourself time and effort by using what already exists.

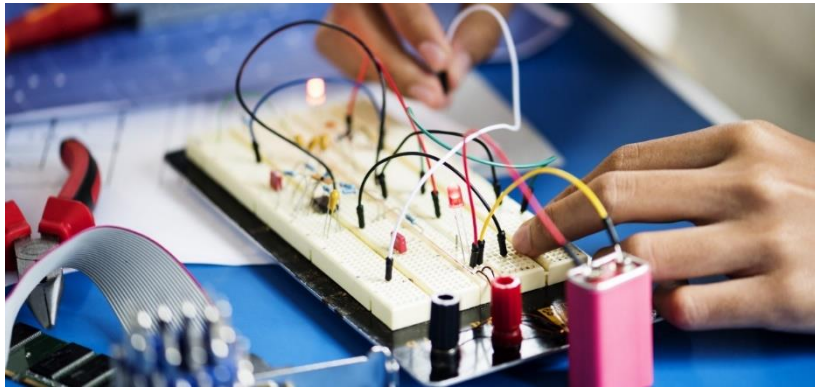
Robotics sets

Vex, Erector, Lego sets are all good kits to help your idea develop. Each of them can be used to help put life into your thoughts. Some are more durable and can handle forces better than others. I am sure there will be limits for what you can do with a kit but there may be parts you can use in conjunction with off the shelf parts and others.



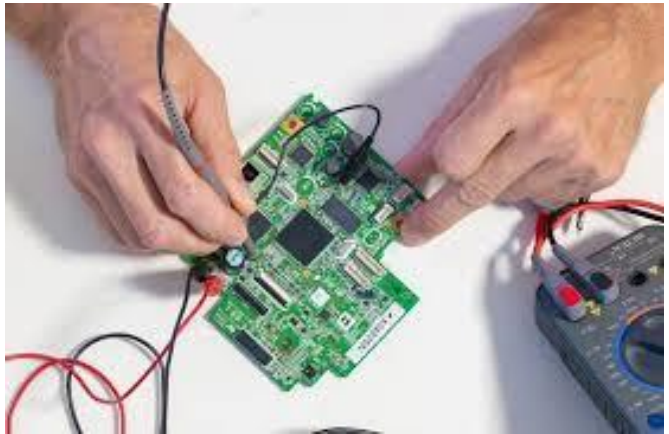


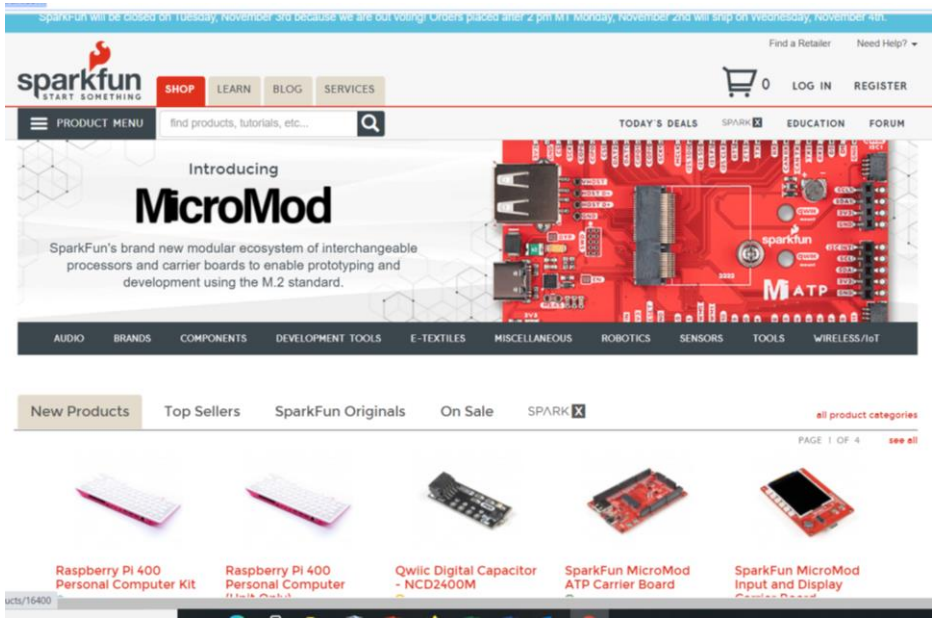
Bread Boards



Bread Boards are a great way to lay out and test electronic components and demonstrate what all is desired. This is what they were designed and built for. After you test everything to work correctly there will be a point when you can make it smaller by having a board built for your design—that is much later in the process.

Sparkfun kits come with breadboards and many components that can make it easier to design and build the initial ideas you have.
https://www.sparkfun.com/





Off the shelf parts

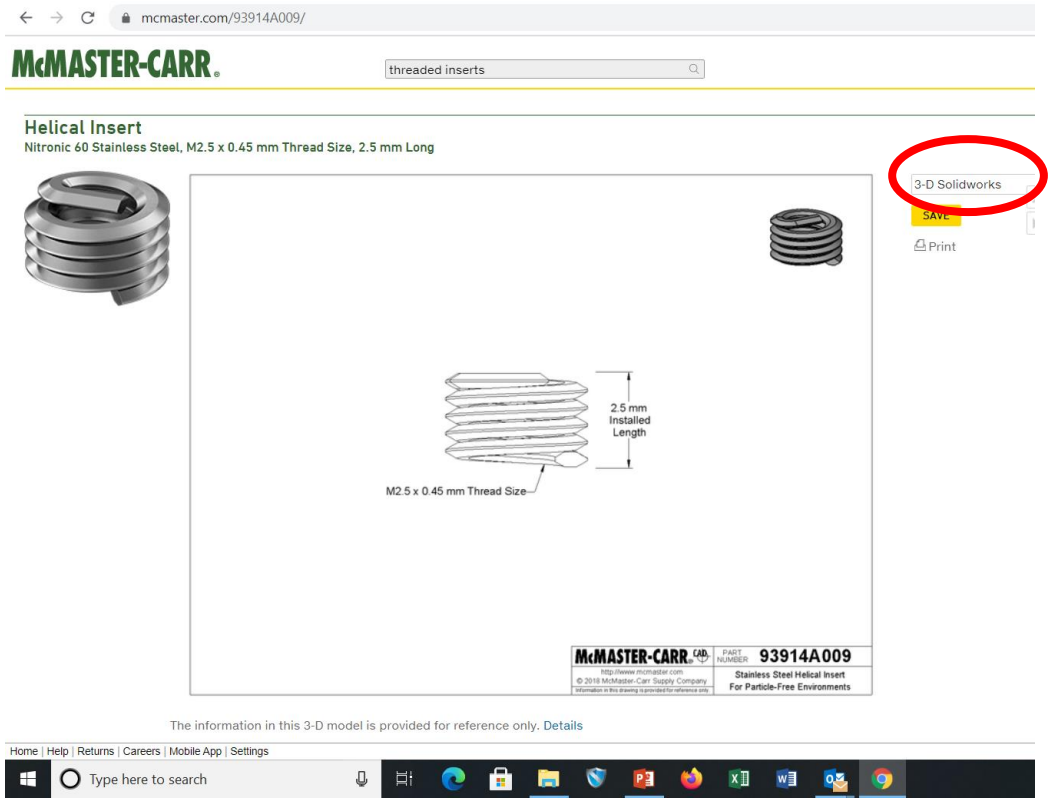
- McMaster-Car has lots of parts you can order and have delivered to your house or the school. Most of the parts are also available to be imported into solid works already.

https://www.mcmaster.com/

- Another option is Grainger.

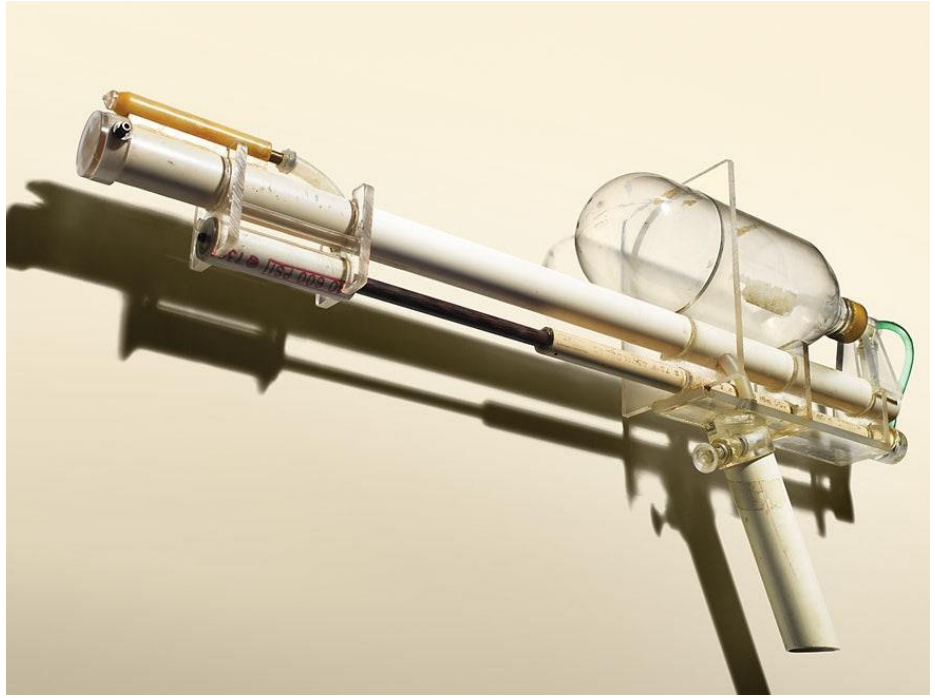
https://www.grainger.com/

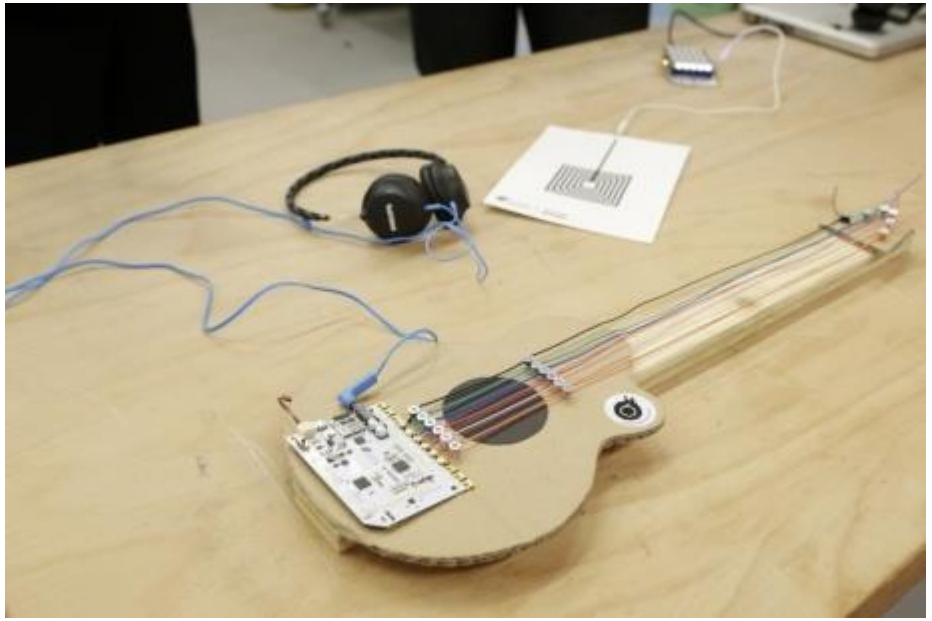
I’m sure there are many others.



There are lots of cool prototypes on the internet.

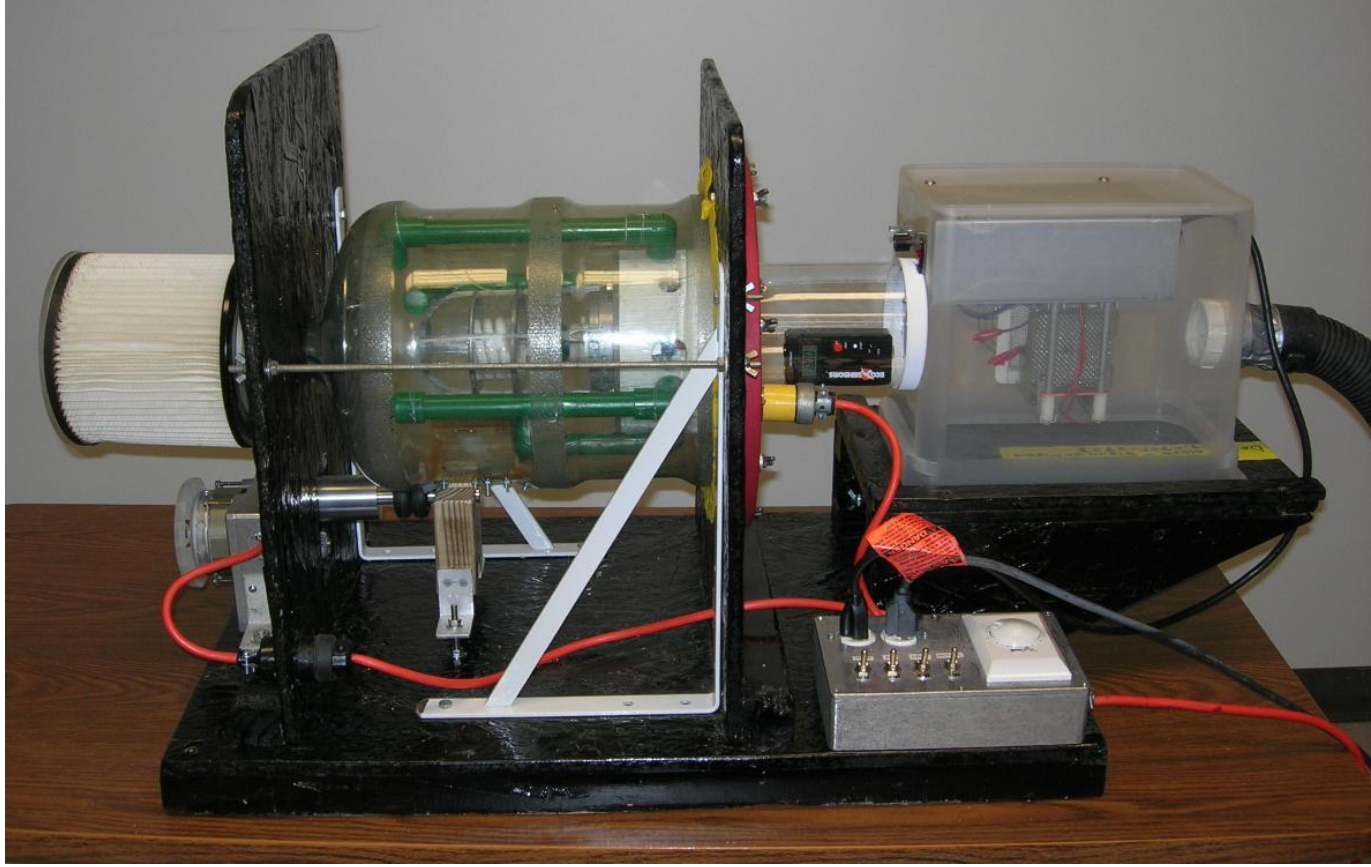
This Dyson vacuum cleaner started as a cardboard prototype





Mixed materials

For me, prototyping starts as soon as I have a plan of where I want to go with an idea. I start picking up objects around the house or office and start arranging them in my hands or desk to fit the need. Then I draw on paper how the parts would fit into positions that make sense. The more corrections I can do at the beginning, the fewer corrections I will make later on. I try to think in the life size at first and then scale it down as I need to. Many inventions are composed of many parts and components. I use off the shelf parts whenever I can. Don't 3D print nuts and bolts unless you have to, its way easier to find some in the garage or buy them at the hardware store. Steal wheels from broken toys or pull them off the broken wagon outside. Wooden dowel rods and PVC pipe are much better axels than something that comes off a printer.



This is a proof of concept prototype I built to demonstrate a washing machine for zero-g. Notice that I used many materials from around the house—5 gallon water jug, plywood, electrical extension cords, PVC pipe, off the shelf brackets, plastic containers, filter from a shop vac, felt from the sewing supplies,… I knew from the beginning that this wasn't what a flight unit would look like but it showed how many of the parts would interact with each other. It showed the flow of the cleaning process. It gave me many talking points so I could discuss the idea with who I presented to. And just like every other real life engineering project, not everything turns into a commercial or final product. However, it did give me the bigger back ground that I could move up to other jobs and to other things. The failures and lessons learned are sometimes more valuable than the successes.