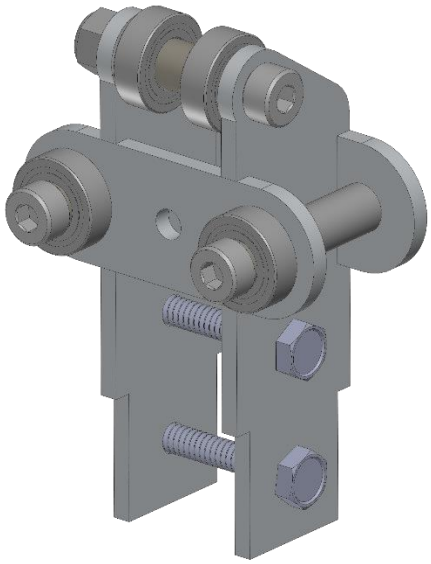
# S3 Linear Motion Kit (am-4136)

# Assembly Instructions & Usage Guide



## Additional Instructions Available

We encourage customers to seek product information at **AndyMark.com**, contact us via e-mail at **support@andymark.com**, or call Toll-Free **877-868-4770** with questions about any of our products.

## Revision History

First Release 9/3/19

Updated 6-32 Screw size to match what's needed in the real world 9/26/19

## Tools List

(Tools not included)

| Component | Part Number | Part Photo |
|---|---|---|
| 1/4" Nut Driver | am-3677 |  |
| 5/16" Nut Driver | am-1273 |  |
| 1/4" – 5/16" Combination Wrench | am-3174 |  |
| 3mm Hex Driver | am-3688 |  |
| 7mm Wrench | |  |

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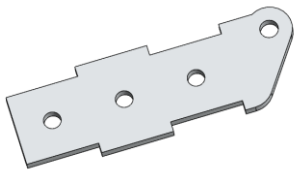
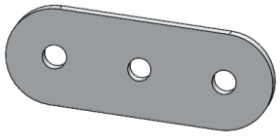
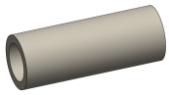
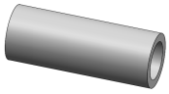
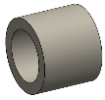
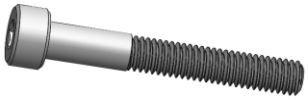
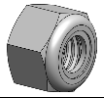
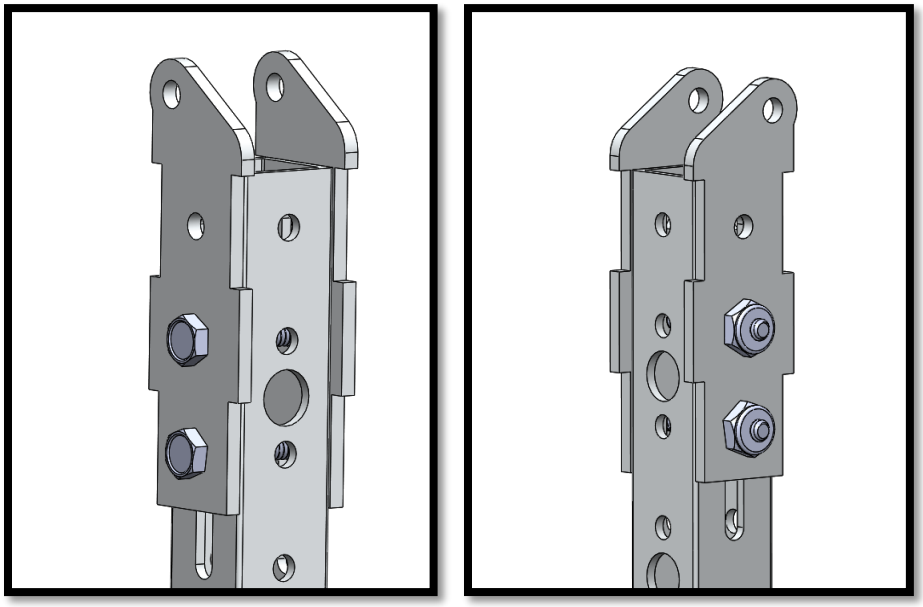
## Parts List

Parts list below is for 1 Bearing End Assembly. Each am-4136 kit comes with double the listed quantities

| Component | Part Number | QTY | Part Photo/Render |
|---|---|---|---|
| S3 Linear Motion – Main Plate | am-3968 | 2 |  |
| S3 Linear Motion – Bearing Holder | am-3971 | 2 |  |
| Bearing 6mm x 12mm x 4mm | am-3604 | 4 |  |
| Push in Rivet | am-1504 | 1 |  |
| 16mm Nylon Spacer | am-1529 | 1 |  |
| 16mm Aluminum Spacer | am-1530 | 2 |  |
| 5mm Nylon Spacer | am-1531 | 2 |  |
| M4-0.7 x 25mm Socket Head Cap Screw | am-1532 | 1 |  |
| M4-0.7 x 30mm Socket Head Cap Screw | am-1533 | 2 |  |
| M4-0.7 Lock Nut | am-1435 | 2 |  |
| 6-32 x 1.000” Hex Head Cap Screw | am-1426 | 2 |  |
| 6-32 Lock Nut | am-1419 | 2 |  |

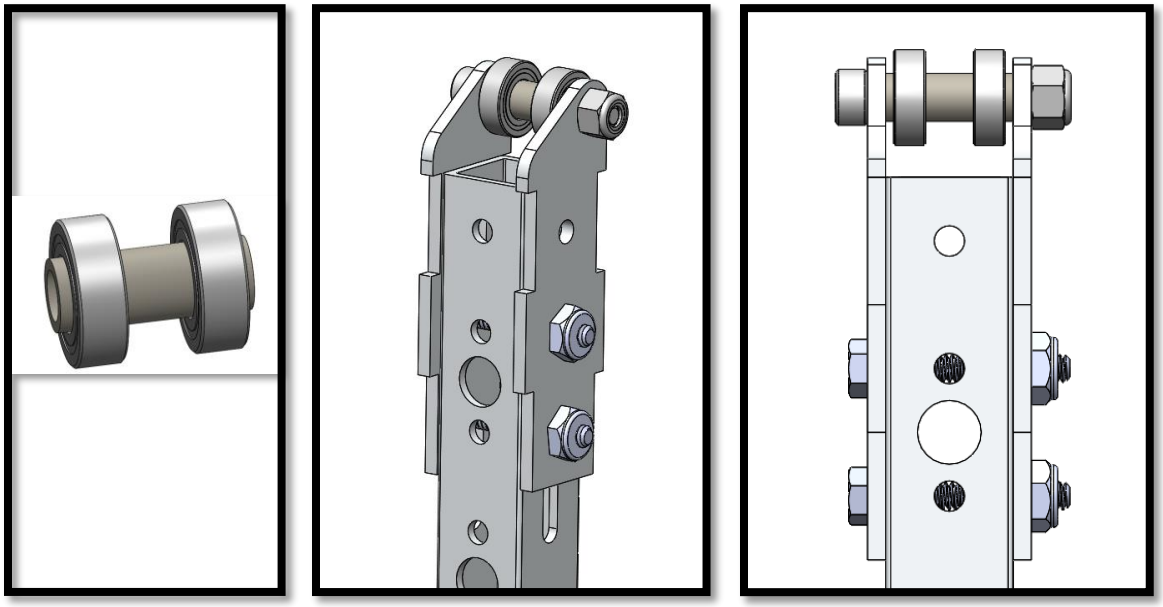
## Bearing End Assembly

**Step 1:** Attach the S3 Linear Motion Main Plates to the S3 extrusion of your choice (customizable for different lengths). Use 6-32 Lock Nuts and Screws; as shown below 6-32 x 1.000" long screws will be most ideal. These screws can be swapped out for longer ones to accommodate other mechanisms. (See parts list for part number info)

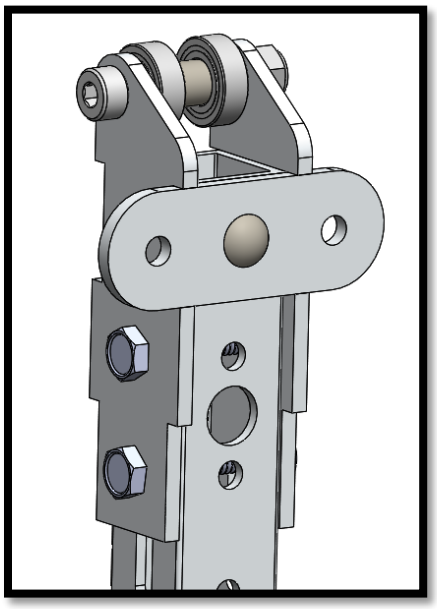


*Use pictures for part/assembly orentation

**Step 2:** Slide two 6mm Bearings onto the 16mm long Nylon spacer. They should be pushed just past the end of the spacer. This is so that they will not rub on the Main Plates. Secure this assembly with the M4-0.7x25mm screw and lock nut. (Keep the M4 bolt a bit loose for now)

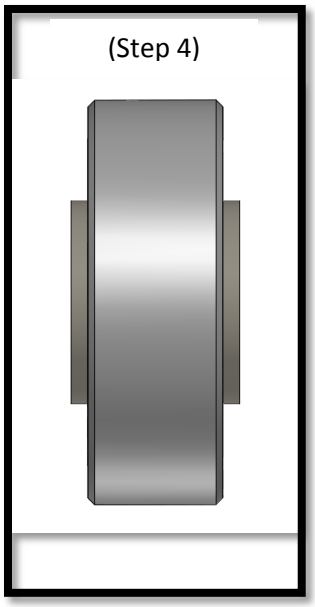


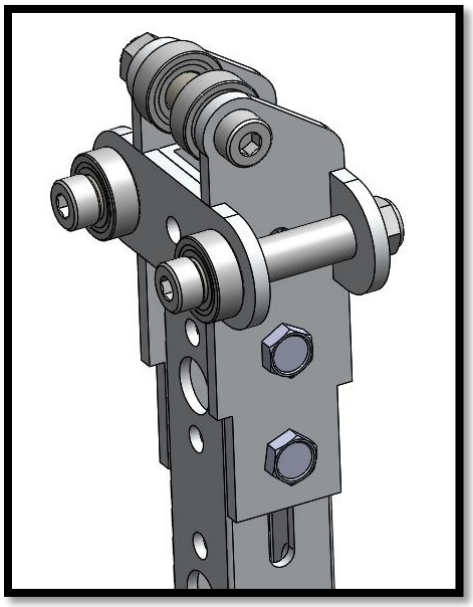
**Step 3:** Use the Push in Rivet to attach the S3 Linear Motion Bearing Holder to the back of the S3 extrusion. This holds the Bearing Holder centered on the S3 and within the assembly.

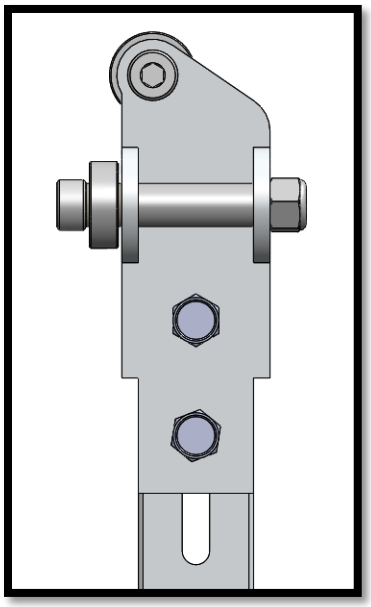


**Step 4:** Insert a 5mm long Nylon spacer into two more of the 6mm Bearings. The Bearing should be centered on this spacer so that it doesn't rub on the brackets and runs along the right path on the S3 extrusion.

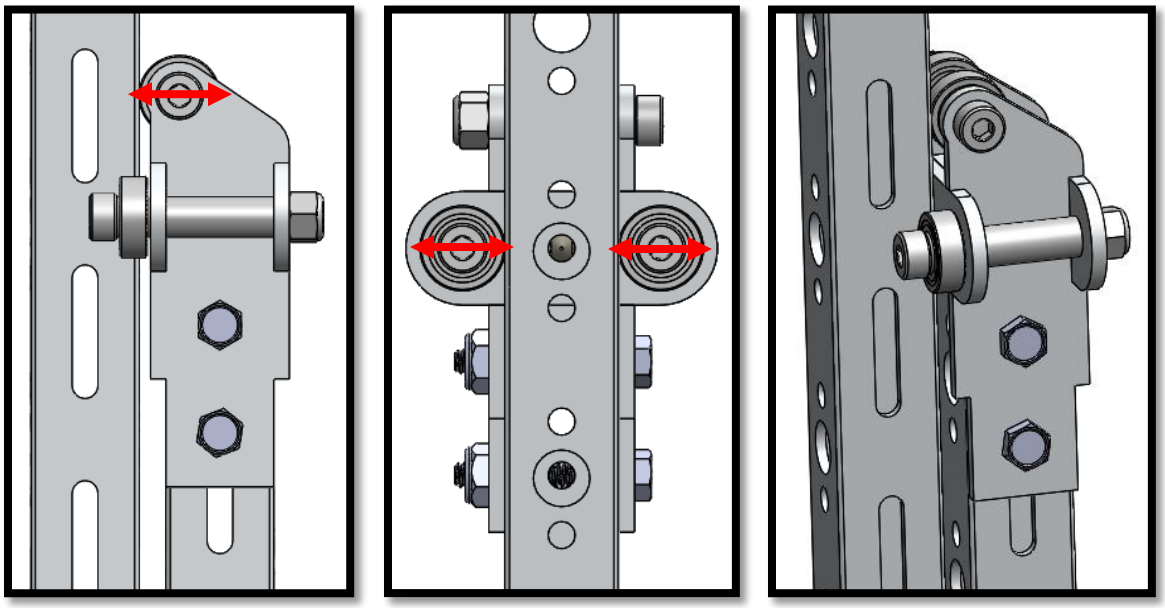
**Step 5:** Add the second Bearing Holder. Secure on each side of the assembly using a M4-0.7x30mm Screw and a lock nut, a Bearing with Spacer, and 16mm aluminum. (Keep the M4 bolts a bit loose for now)



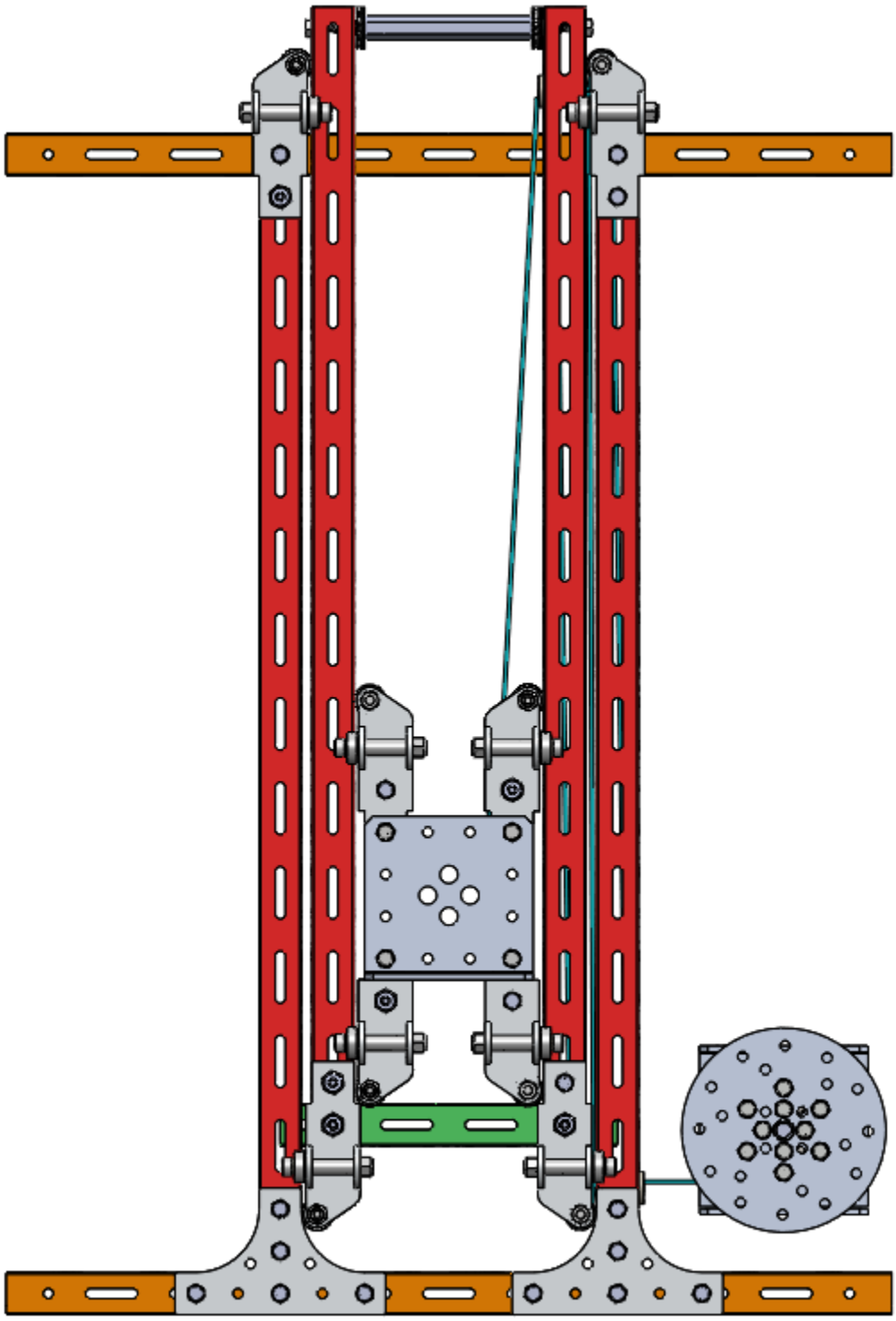


**Step 6:** Adjust the position of the bearings so that they roll smoothly* on a second piece of S3 extrusion. The top bearings should also be concentric with the rounded top of the Main Plates. When everything is in position, tighten the M4 screws and nuts until there is no play in the screws. YOU DO NOT NEED TO SUMMON THE POWER OF HERCULES TO TIGHTEN THESE SCREWS!



*Note: Once in the final assembly, the bearings should prevent the second piece of S3 extrusion from moving or twisting in all directions except one, the one to rule them all.

**Step 7:** Yay! This bearing assembly is complete! Now repeat the process for as many assemblies as you need.



(The colors are to help show the different parts being used. See the product web pages for true colors)

## Forward:

Why Linear Motion Machine and not Elevator or Lift? Simply put, because you could use this kit and these tips to build whatever you want. If you need something to move horizontally, this can do it. If it needs to move vertically, this can do that too. If you want to put one machine on another and make an X-Y table you can even do that too. Use this guide as a starting point and let your imagination take you to places untold!

## Stages:

The number of stages that your linear motion machine will need is dependent on how tall it can be fully collapsed (retracted), how far you need to reach, and how much overlap you have from one stage to the next. This kit typically will have about 4 inches (100mm) overlap from one stage to the next.

$$Number\ of\ Stages = \frac{Total\ Reach}{(Collapsed\ Height - Overlap)}$$

This Result will need to be rounded up to the nearest whole number of stages. One way to get extra travel from your linear motion machine is to use a Carriage as your final stage. This 'mini' stage rides on the inside of your last full length stage and allows you to reach from the bottom of the collapsed height to the top of the extended height. In the Example Elevator image above you can see the carriage built from 128mm S3 beams and the two full stages built from 448mm beams.

## Maintenance:

In order to ensure smooth, low friction movement of your linear motion machine be sure to inspect it regularly (every few matches). Look for wobble in the stages and adjust bearings as needed to keep the mechanism running smoothly. Be sure to also look for debris and other foreign objects that maybe caught in the path of the string or bearings.

## Powering your Machine:

There are many different ways to power your linear motion machine and they all have their pros and cons. THERE IS NO ULTIMATE SOLUTION THAT IS BEST IN ALL CASES. There are solutions that are better optimized for different applications, but many of these different options will work for the needs of an FIRST team. Power train options include but are not limited to:

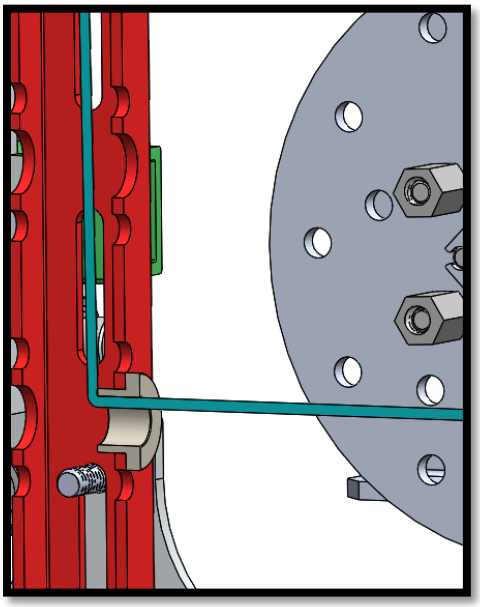
- String, chain, toothed belt, V-belt
  - Continuous Routing
  - Cascade Routing
- Rack gear
- Lead screw
- Linear Servo
- Pneumatic Pistons (Not FTC Legal)
- Combinations of multiple options
- One way power (ie: powered up with gravity or springs pulling down, or powered up with springs and down with a string)
- Two way power (double wound strings pulling both ways)

For our Example Elevator above, we used a Continuously Routed String and winch. This was an easy configuration as it requires only a few parts. Just like it's important to get the gear ratios right for rotary systems (chassis drive train, etc.), you need to look at the total mechanical advantage of a linear system. With the parts we used it's easy to alter the mechanical advantage by 1) changing the diameter of the standoffs in the winch, 2) changing the gearhead on the NeveRest Motor, 3) adding a PicoBox to get more gearing options or 4) adding more motors to add power.

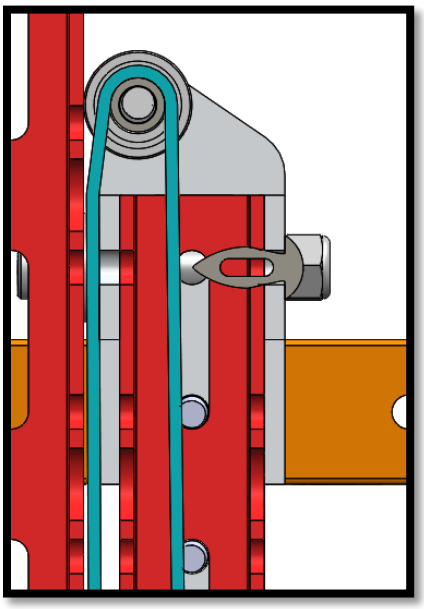
## String Routing:

Here we'll take a closer look at how to route the string within your machine. Using the hollow centers of the S3 extrusions gives us the opportunity to tuck the string away so that it's protected from everything that goes on during a match. This also prevents the string from hopping off externally mounted pulleys and causing loss of functionality for the system.

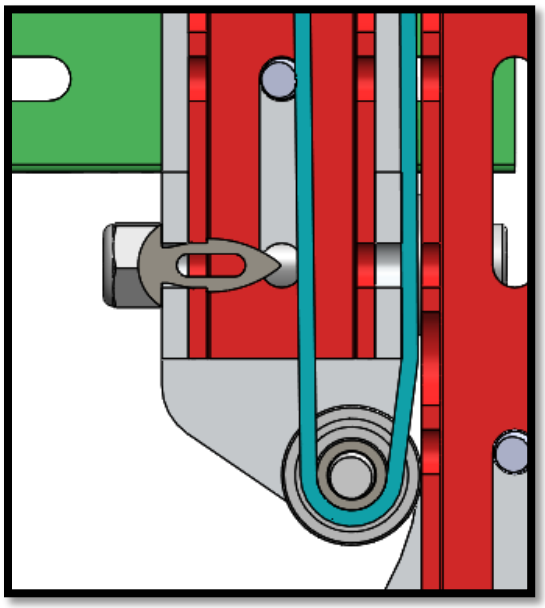
**Step 1:** The string leaves the winch and enters the first stage of the elevator through a nylon bushing (am-1289). The nylon gives the string a low friction surface to slide against but you should be mindful of the tight 90 degree turn the string makes. If you can, try slightly rounding over this edge (deburring tools or counter-sinks work well) to remove some resistance.



**Step 2:** The string routes up, through the S3 extrusion and over the top of the spacer that holds two of the bearings. It will then descend down, between the S3 extrusions of adjacent stages.

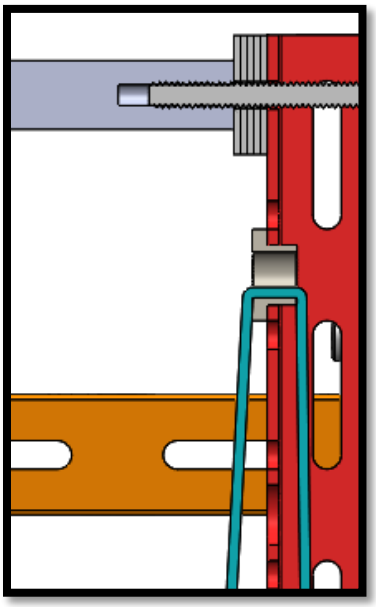


**Step 3:** At the bottom of the next stage, the string makes another turn under the bearing spacer and heads back up through the middle of the S3 extrusion.

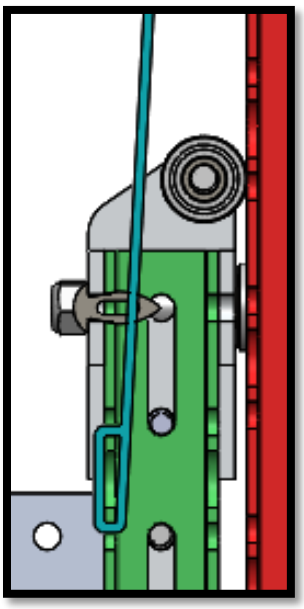


**Step 4:** Steps 2 and 3 repeat for as many similar style stages as you have.

**Step 5:** At the top of the final stage the string needs to exit the interior of the S3 beam, turn 180 degrees and get attached to the carriage so that it can be moved by the winch. The turn can be achieved with another nylon bushing (again try to remove sharp edges where possible).



**Step 6:** The last step is to tie the string off on the carriage so that it can lift the most important part of your linear motion machine. It's a good idea to try and keep this last run of the string as close to parallel to the other strings as possible. This will help insure that as you near max extension, 1 inch of string on the winch will still be 1 inch of travel. (The knot on the image below is poorly modeled)



## Detail of String Routing: