

Vernier excavator

Parts list and extra parts required

- 3d printed parts
- 1 x arduino nano no pins
[Arduino nano on Amazon](#)
- 1 x SG90 servo
[SG90 servo on Amazon](#)
- 1 x B103 10k potentiometer
[B103 10k potentiometer on Amazon](#)
- 1 x slide switch - we will call this the mode switch in the instructions
[Slide switch on Amazon](#)
- 1 x micro lever switch - we will call this the trigger switch in the instructions
[Micro lever switch on Amazon](#)
- 5 M2 x 10mm cap head screws
- 2 M2 x 20mm cap head screws
- Tooth picks - we will refer to these as pins in the instructions (metal pins can be used if available)
- Hookup wire (i use some cat5)
- 3 x 10k ohm resistors
- Super glue
- 1mm x 20mm double sided foam tape

Tools required

- Hex keys (allen keys) 1.5mm
- Drill with a 1.5mm and 2mm bit
- Soldering iron and solder
- Small wire cutters
- Small philips screw driver (for servo screws provided with servo)
- Utility knife or deburrer to clean up 3D prints
- Lighter

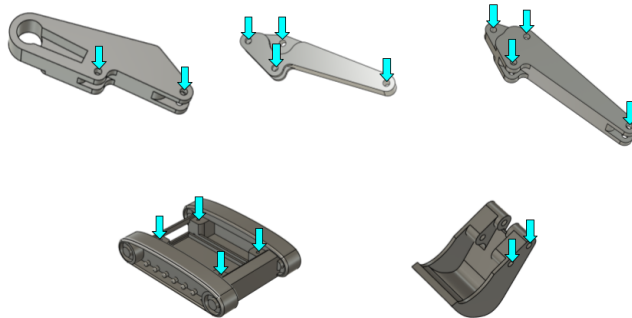
Build instructions

Print parts

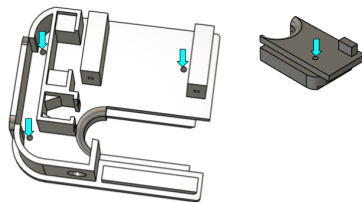
- Print parts, please be aware I have used small tolerances for these parts.

Drill out holes 1.5mm and 2mm

- Drill out the holes in the tracks, arms and bucket to 2mm



- Drill out the holes in the body to 1.5mm



Tap holes

- Push the body and tracks together and use a m2x10mm cap head screws to create threads in the 1.5mm holes from the previous step. This ensures hole alignment
- Remove screws

Clean up parts

- Clean up all the edges of the parts and around the freshly drilled holes with your utility knife or deburrer

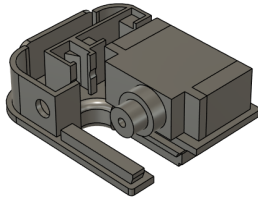
Program arduino

- Copy the code from the web page and load it onto your Arduino nano.
- There are lots of good videos on YouTube that cover how to program an arduino. The below link is to an easy to follow video on how to program an arduino Uno and can easily be adapted for an arduino nano.

<https://www.youtube.com/watch?v=fJWR7dBuc18&list=PLGs0VKk2DiYw-L-RibttcvK-WBZm8WLEP>

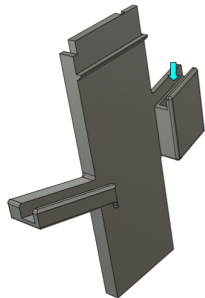
Mount servo

- Mount the servo in the body using the screws provided. Note the orientation of the servo

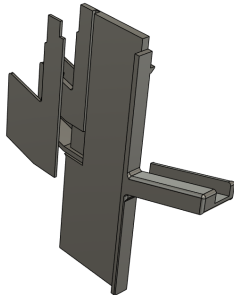


Assemble vernier holder and fit to tracks

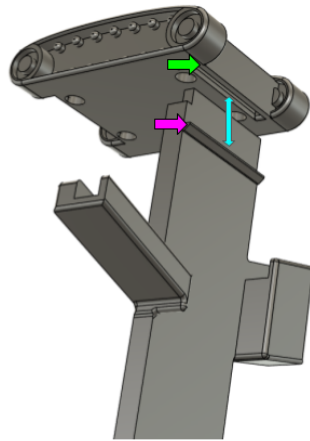
- Soldering irons can reach high temperatures. Take care while using.
- Solder 2 100mm long wires to the trigger switch : one to the common (C) and one to the normally open (NO)
- Feed the wires through the switch cavity of the vernier mount from the top



- Mount the trigger switch in the vernier holder. This will press into place
- Seat the wires in the cavity and superglue the wire cover in place

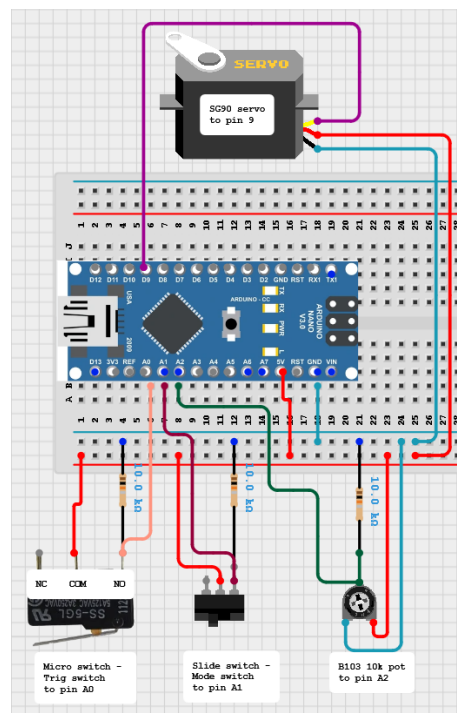


- Push the vernier holder into the slot at the bottom of the tracks till the **boss** is touching the **bottom surface of the tracks**. Note that this is a tight fit



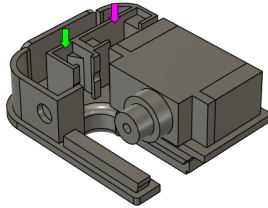
Assemble electronics

- Soldering irons can reach high temperatures. Take care while using.
- Assemble the electronics according to the below wiring diagram. This should not be done on bread board as per the image, solder direct to the nano and components making sure you have sufficient length on the wires to place components in their mounts.

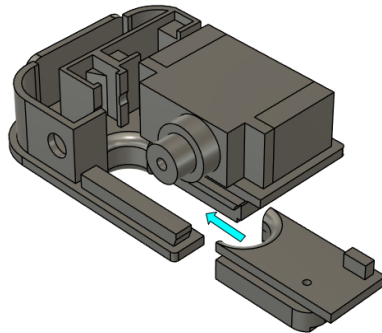


Mount switch and pot (centre pot)

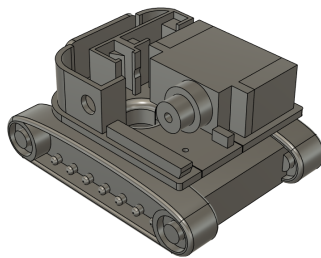
- Mount the **potentiometer** and the **mode switch** in their respective cavities



- Slide the body wire slide into the body



- Screw the tracks and the body together with 4 M2 x 10mm cap head screws as done when forming the threads



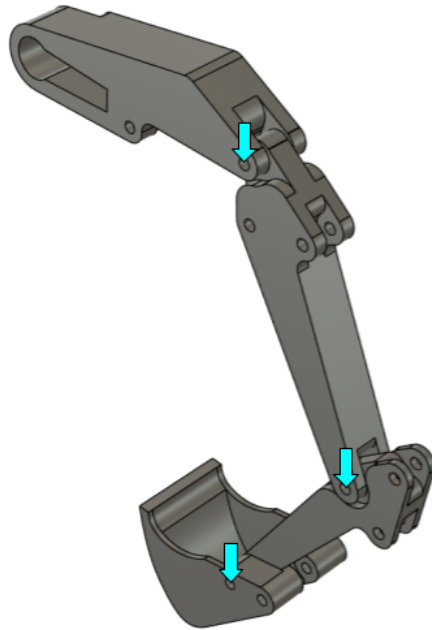
Test electronics

- Press trig button. The servo should rotate one direction then back the other direction. This is normal operation mode. If this does not happen, move the slide switch to its other position and try again.
- Move the slide switch into its other position. This is it in setup mode. The servo should rotate in a single direction

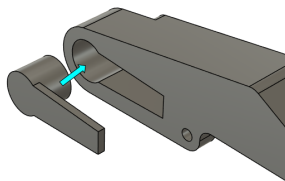
- While the switch is in the setup mode position, rotate the potentiometer either direction and the servo motor should rotate. Centralise the potentiometer.

Assemble arm main parts

- Cut 5 toothpicks in half
- Pushing the pointy side through the hole first, assemble the 3 main arm bits together and the bucket ensuring assembly in the correct orientation and using the correct holes. In total, there will be 3 pins to press in

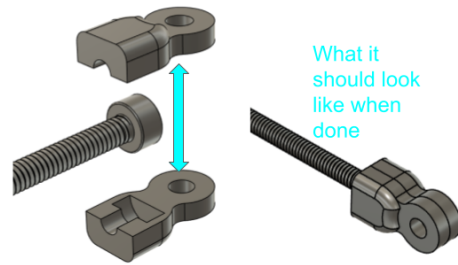


- Trim pins flush with the surface
- Push the servo horn into the recess making sure it is fully seated. Take note of the orientation.



Assemble eyelets

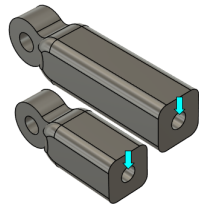
- Be aware that you will be heating metal and ensure that you use appropriate safety equipment and work in an environment which is suitable to do so
- You will need the 6 cylinder eyelets , 2 M2x20mm cap head screws and 1 M2x10mm cap head screws
- Heat the head of one of the M2x20mm cap head screw and press 2 of the eyelets around the head of the cap head screw. Ensure that there are no gaps between the inner surface of the eyelets.



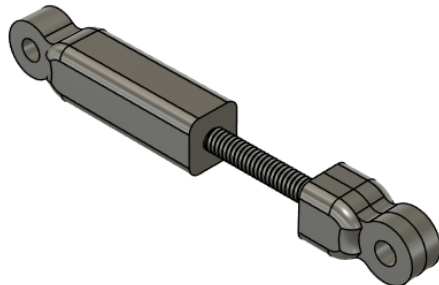
- Repeat this for the remaining two cap head screws and eyelets

Assemble cylinders

- Drill out the hole on the cylinder and the eyelet assembly that will attach to the arms to 2mm
- Drill down the centre of the cylinders with a 1.5mm bit



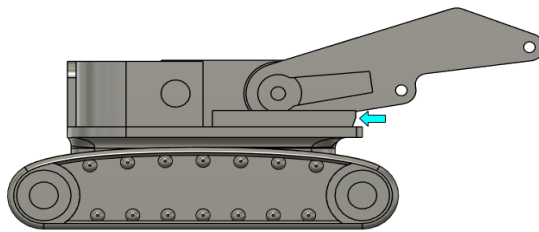
- Screw the eyelet assemblies into the cylinders. It should take minimal force to do this. , making sure you can screw them in almost the full way to the cylinder attach point.
Note : f you feel they are to tight remove the eyelet assembly and use a spare M2 cap head and an allen key to form the treads



Fit arm to servo

- Power arduino
- Put the arduino into setup mode using the mode switch

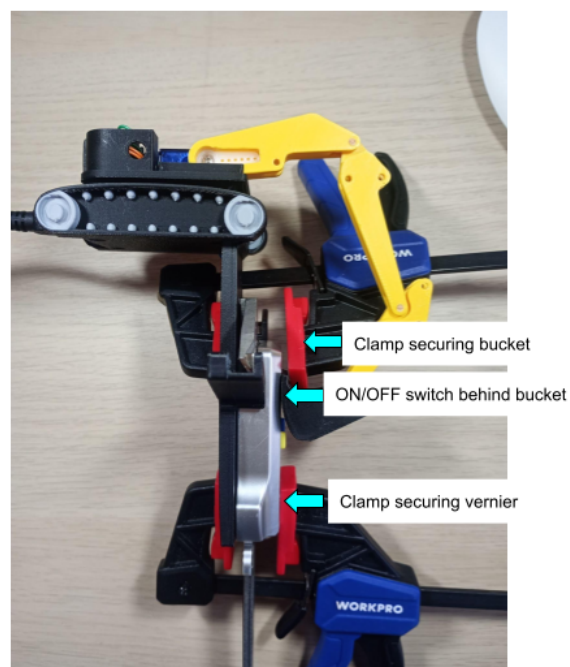
- Push the arm onto the servo leaving a couple degrees of movement between the body and arm for fine adjustment later



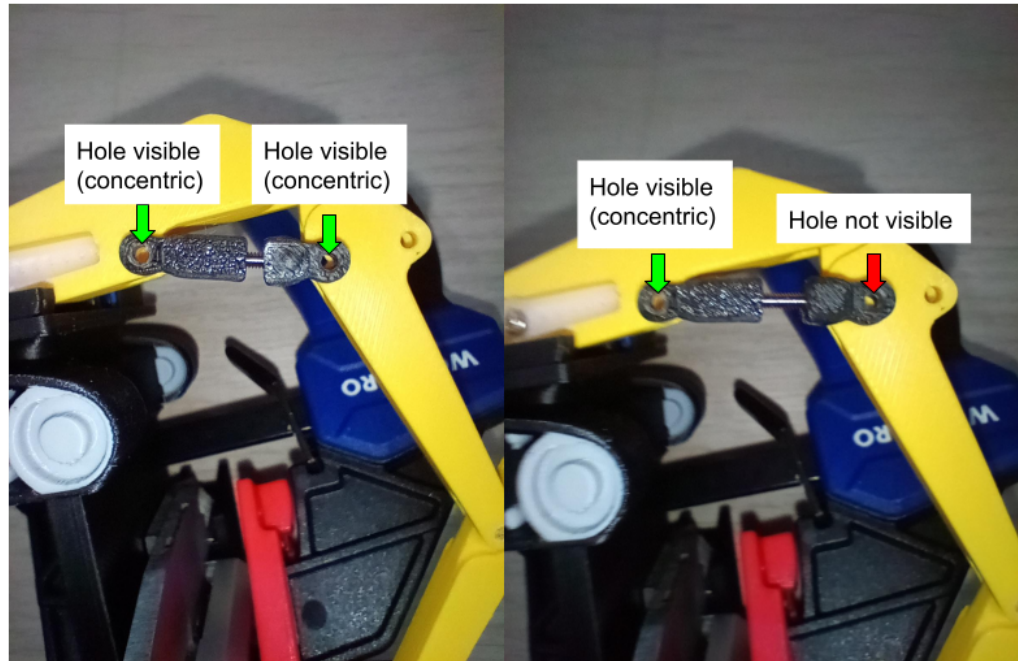
- Screw the servo horn into the servo with screw provided with the servo

Adjust arm (the fun bit)

- Secure your vernier to the mount in its mounted position
- Move the bucket into the best position for it to press on the on/off switch of your vernier and secure it in place



- Check the length of the cylinders and adjust them by holding them over their attachment holes and adjusting so you can see the holes through the eyes on the cylinder assembly



- Remove the securing devices
- Remove vernier
- Take arduino out of setup mode using the mode switch

Install cylinders 1 side pin only

- Install the cylinder assemblies onto the arm using the same method used to attach the arms to one another in an earlier step only attaching one side permanently for now and just placing a pin in the other hole till it gives a bit of resistance



- Trigger the trig switch by removing the vernier from the mount and then placing it back onto the mount
- If the bucket is far away from triggering the vernier's on/off switch, remove the temporary pins and make adjustments to the length of the cylinders.
- Repeat the trigger of the trig switch and make any adjustments as needed.

Fine tune

- If the bucket is close to the vernier's on/off switch but not quite there, put the arduino into setup mode using the slide switch and use the potentiometer to adjust the arm/bucket to the desired position
- Remember to take the arduino out of setup mode using the slide switch when you are done or need to do further tests.
- If the entire assembly is working as intended and switching the vernier off when placed in the holder, press the temporary pins in and trim flush with the surface

Finish up

- Push on the cab followed by the canopy
- Apply some 1mm foam tape to the back of the vernier mount and attach to the side of your PC monitor
- You now have a completed vernier excavator!
- Witness the majesty of your completed vernier excavator which will switch off your vernier once you have finished using it after being put on its easily accessible mount on the side of your PC monitor