FREE3DHANDS

Kinetic Hand

Assembly Manual
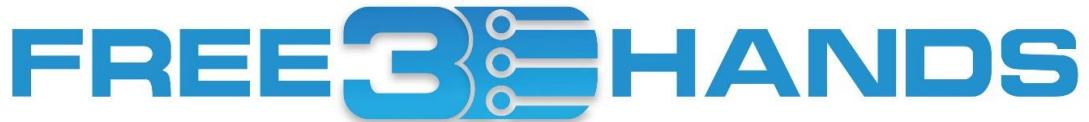
Author: Mat Bowtell   **Revision: 9/10/2020**

FREE3HANDS

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This design is released for trial and evaluation purposes only, and is intended to benefit certain individuals with specific hand differences and is not intended, and shall not be used, for commercial purposes.

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All design files are available for free download at:
www.free3dhands.org

We are continuously improving this design, so please check back regularly to obtain the latest version.

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About the Design

At Free 3D Hands, we have been designing, trialling and improving the Kinetic Hand for almost three years since November 2017. Over that period, we have made continuous incremental improvements to the design based on recipient feedback. The Kinetic Hand is a body powered device, and is designed to be used by people with congenital hand differences, with a functioning wrist to open and close the fingers. The hand has been designed using a virtual clay modelling software called Geomagic Freeform Plus to create an organic shape, and then has been engineered and simulated in Solidworks with support of an add-in called Power Surfacing RE.

Flexible Tensioners

Protective Gauntlet Cover

Individual Tensioner Adjustment

Soft Customisable Insert

Silent Hinge Dampeners

Flexible Wrist Hinges

Stretch-fit Elastic Finger Hinges

Soft and Flexible Palm Cover

Moulded Silicone Grips

Design Merits

Silent Operation

The flexible hinges are designed to prevent any contact between rigid parts, allowing for silent operation of the hand.

Moulded Silicone Finger Grips

Using a scalable 3D printed mould, grippy silicone finger grips allow the fingers to better grip a wide range of objects. This also eliminates the need to use consumer products such as Lee Tippi Micro-Gel finger grips which are hard to source, expensive and limited to only a few sizes.

Split Hinges

The hinges are designed to fit from one side, and stretch fit from the other. This prevents the hinge from sliding out laterally. Hinges do not require any glue, and provide an ideal amount of elasticity to open the fingers.

Dual Tendons

The need to tie tendons in the fingers has been eliminated, with tendons looping back through the fingers and hand being tied only once at the tensioner.

Flexible Tensioners

The tensioners are made from an elastic material to allow individual fingers to come to a close while the other fingers continue to travel. There is no inter-connection between fingers, allowing for even grip distribution on a wide range of different object shapes.

Design Merits

Part Numbering

All of the finger parts, hinges and grips are individually numbered to assist during assembly, ensuring correct part position and orientation.

Allowance for Partial Thumb

By optimising wall thicknesses and tendon routing, we have created additional space inside the Palm cavity to allow for a partial thumb.

Flexible Palm Cover

The flexible Palm Cover improves comfort for the user, since this is where all of the force is applied during use. It can also stretch to help when inserting the partial hand.

Adjustable Tensioner Positions
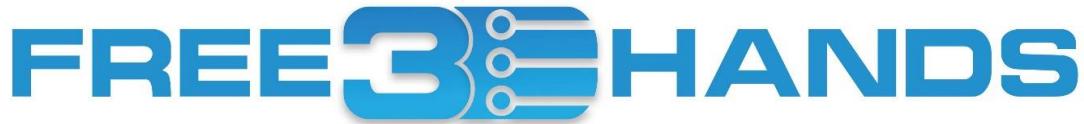
Tensioner positions can be adjusted under the Gauntlet Cover to allow individual finger open and close positions to be incrementally adjusted to suit individual preference.

Protective Gauntlet Cover

Tensioners and tendon knots are protected by the Gauntlet Cover to improve durability and prevent damage.

Improved Scalability

The Kinetic Hand has been tested successfully between scales of 50% and 100% of the CAD model, which is designed at the scale of a large adult. We recommend 60% as the minimum scale to use for part strength and ease of assembly.

Design Merits

Printing Support Elimination

All parts have been designed and oriented to eliminate the need for printing supports which are difficult and time consuming to remove.

Smooth Part Surfaces

The parts have been oriented to minimise the appearance of 3D print layers, whilst maintaining strength in design.

Increased Durability

The flexible hinges allow fingers to be bent and twisted to the same degree as a human finger without breaking.

Three Directional Scalability

Since the Kinetic Hand uses flexible hinges rather than snap pins, it can be scaled in X, Y and Z directions independantly without compromising part fitment or function.

Eased Fitting Tolerances

Regardless of hand scale and size, the flexible hinges are designed to fit tightly with no need for fitting tolerances at different scales.

Reduced Closing Angle

The Kinetic Hand only requires 18 degrees of wrist movement to allow the fingers to fully close, making it able to be used by people with very limited wrist movement.

Multiple Palm Variants

To accommodate for various levels of hand difference, we have designed multiple palm variants to suit these conditions.

Printed Parts List (PLA/PLA+)

Palm

Gauntlet

Silicone Grip Mould

Gauntlet Cover

Finger Part 1
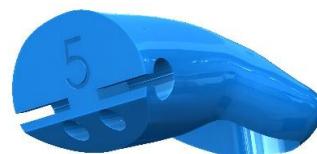
Finger Part 2

Finger Part 3

Finger Part 4

Finger Part 5

Finger Part 6
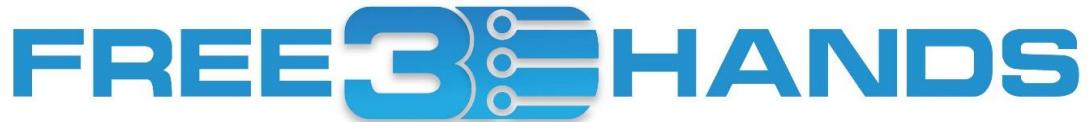
Finger Part 7
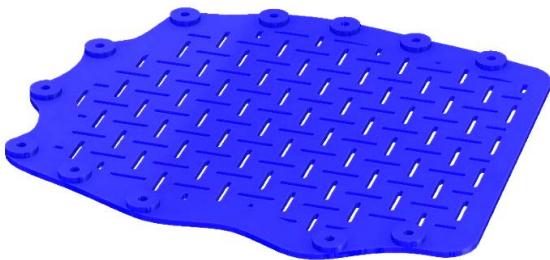
Finger Part 8

Finger Part 9

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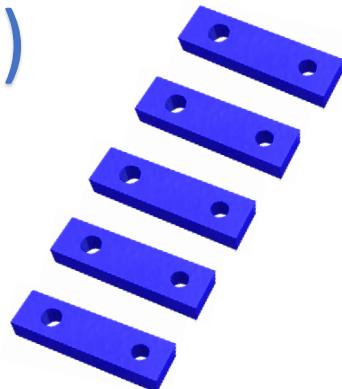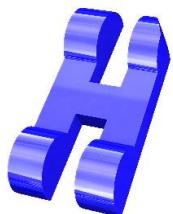
Printed Parts List
(Ninjaflex/TPU)

Palm Cover

Tensioners x5

Wrist Hinge 1   Wrist Hinge 2   Insert A,B,C,D or E

Finger Hinge 1   Finger Hinge 2   Finger Hinge 3

Finger Hinge 4   Finger Hinge 5   Finger Hinge 6
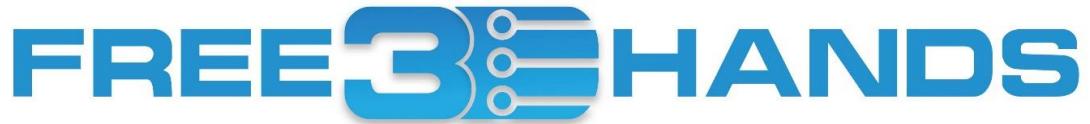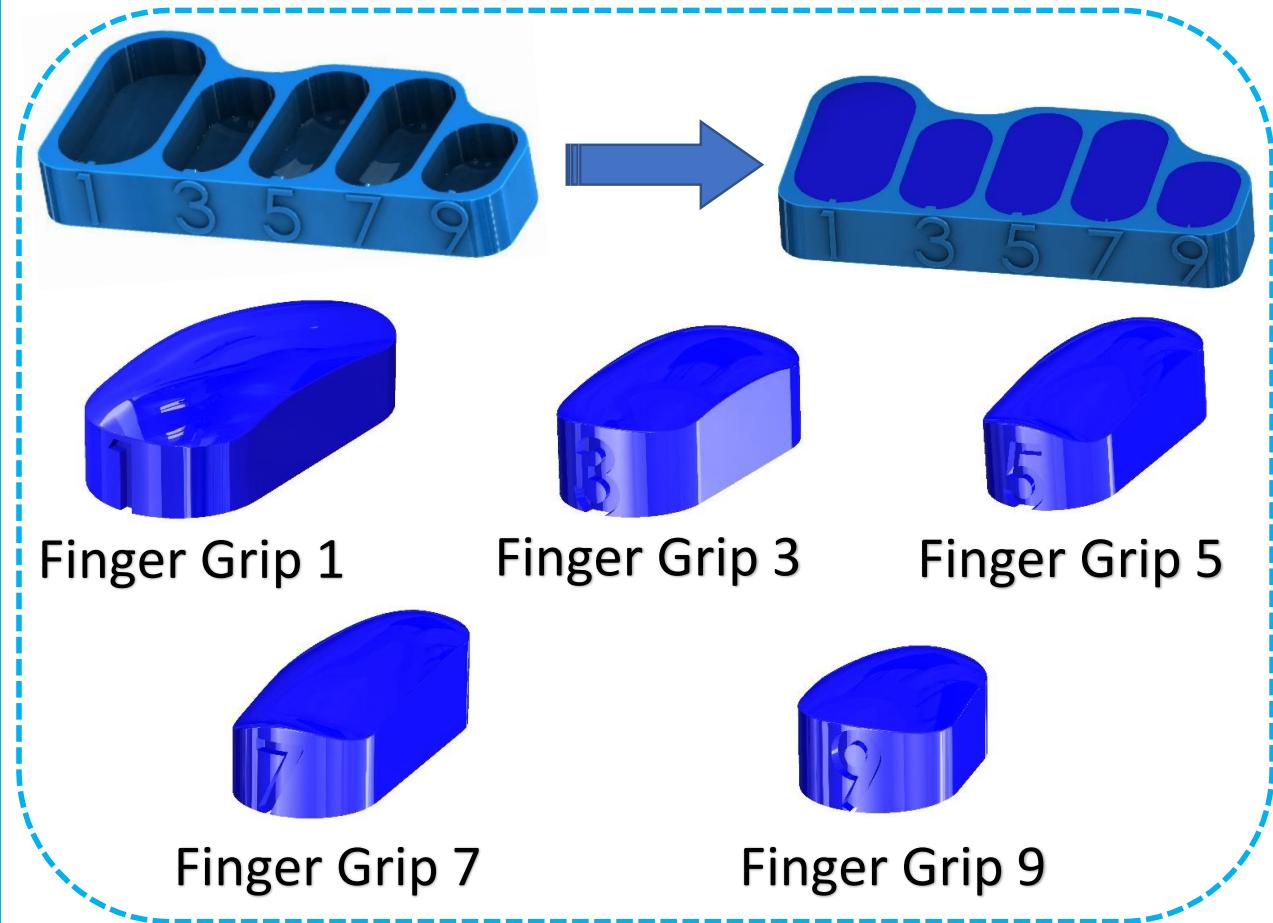
Finger Hinge 7   Finger Hinge 8   Finger Hinge 9

Moulded Parts List
(Silicone)

Finger Grip 1   Finger Grip 3   Finger Grip 5

Finger Grip 7   Finger Grip 9

OR
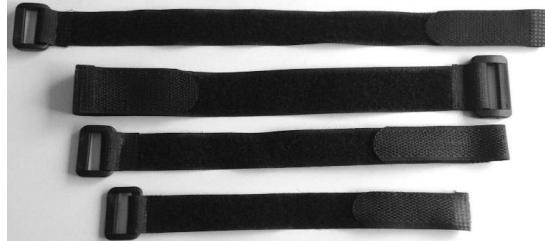
3D Printed NinjaFlex/TPU Finger Grip set

Purchased Parts List

Braided fishing line,
80-100LB strength,
0.3-0.5mm diameter

Nylon Hook and Loop Straps,
2cm width, 20-25cm length
(hand size dependant)
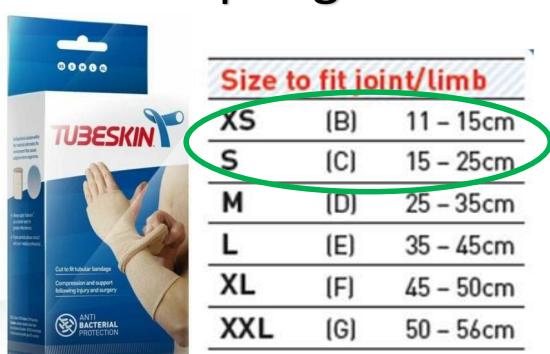
High strength,
precise application
thick super glue.

Skin-safe two-part silicone,
P25-P45 hardness

| Size to fit joint/limb		
XS	(B)	11 – 15cm
S	(C)	15 – 25cm
M	(D)	25 – 35cm
L	(E)	35 – 45cm
XL	(F)	45 – 50cm
XXL	(G)	50 – 56cm

Tubular compression
bandage

M2 Phillips Pan Head
Self Tapping Screws
Lengths: 6mm, 8mm, 10mm
(hand size dependant)

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Assembly Tool List

Hobby file set

Pointed side cutters for plastic

Needle-nose pliers

Precision screw-driver set

Sharp hobby knife

Step 1: Trim PLA/PLA+ parts

Required tools:
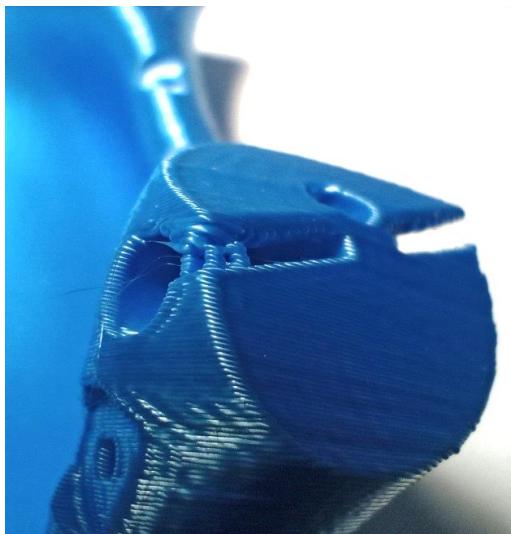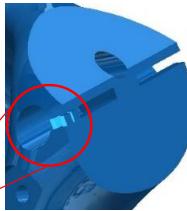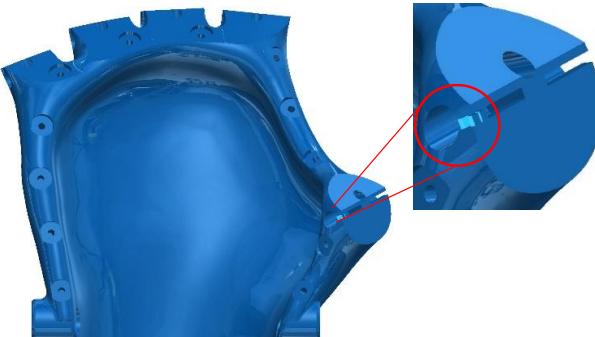
Hobby file set   Pointed side cutters for plastic

Trim thumb joint support material

Before trimming   After trimming

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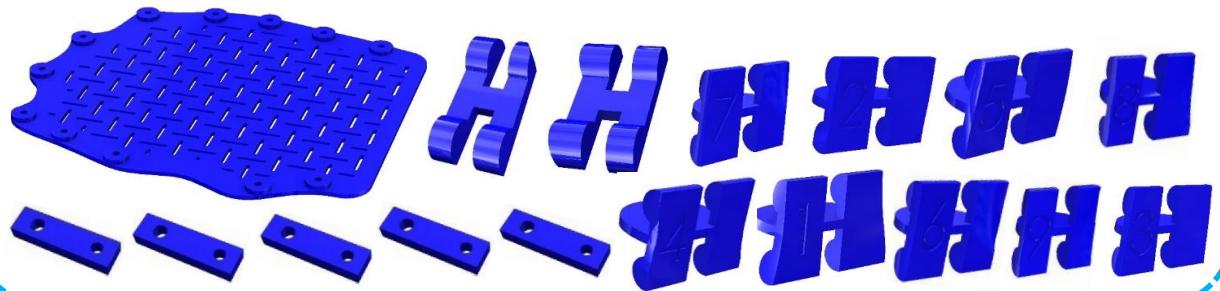
Step 2: Trim Ninjaflex/TPU parts

Required tools:
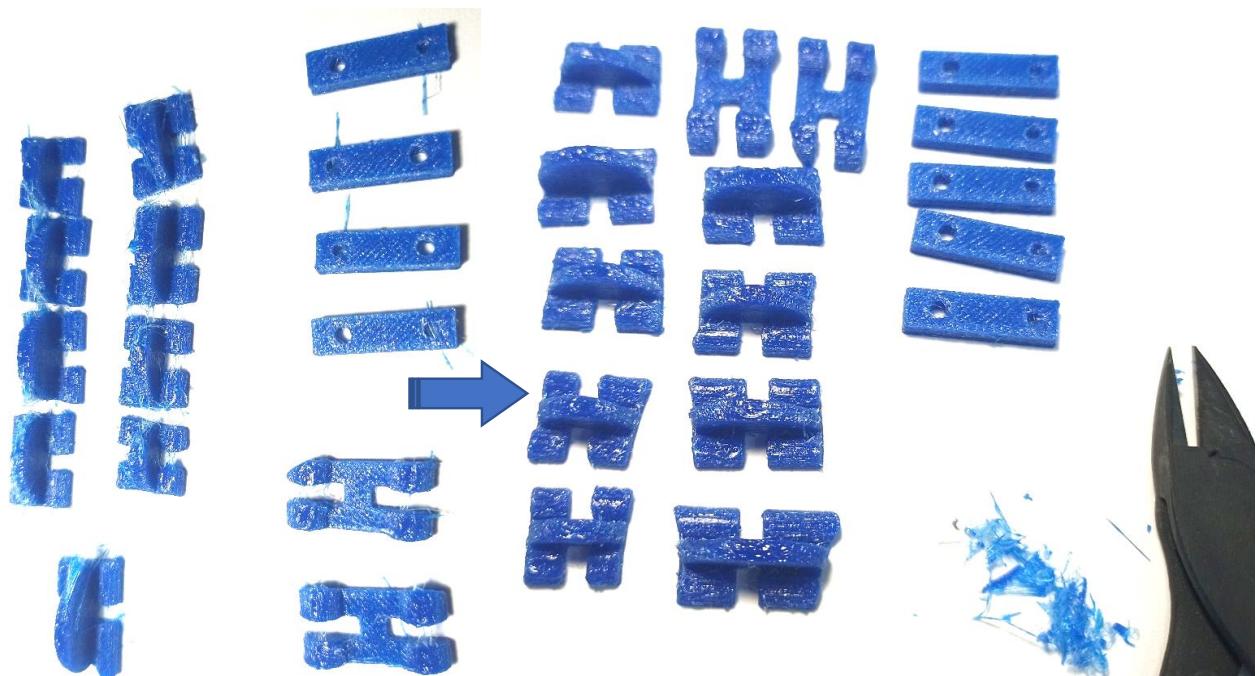
Pointed side cutters for plastic

Required parts: All flexible parts (see page 3)

Trim any stringing from parts caused during printing.

Before trimming   After trimming   13

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Step 3: Insert Thumb Hinge

Required tools:
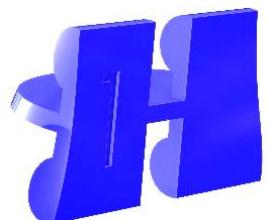
Needle-nose pliers

Required parts:

Palm   Finger Hinge 1

Fit one side of the hinge, and use the pliers to stretch fit the other side of hinge. Ensure that the pliers do not come into contact with the palm to avoid damage.

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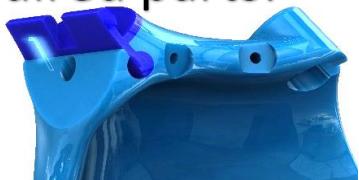
Step 4: Insert Finger Hinges

Required tools:
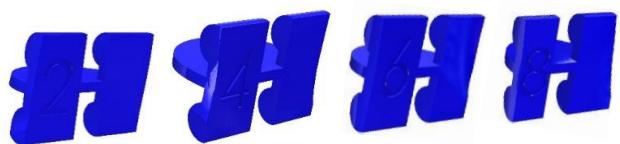
Needle-nose pliers
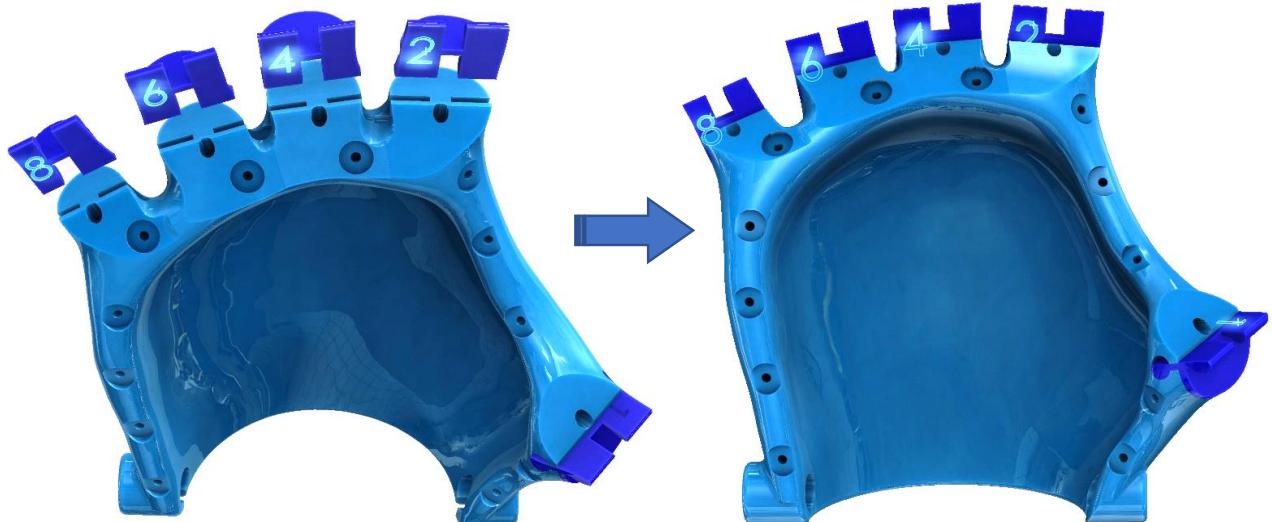
Required parts:

Palm with Hinge 1 assy

Finger Hinges 2,4,6,8

Fit one side of the hinge, and use the pliers to stretch fit the other side of the hinge. Ensure that the pliers do not come into contact with the palm to avoid damage.

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Step 5: Insert Palm Cover Screws
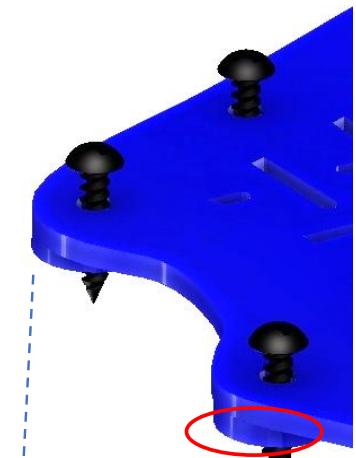
Required parts:

Palm Cover

M2 Screws x12
(see page 4)

Pre-install the screws into the Palm Cover to make it easier to attach to the Palm in the next step.

Note: The locating lugg orientation is away from the screw head.

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x12 locations

Step 6: Attach Palm Cover to Palm

Required tools:
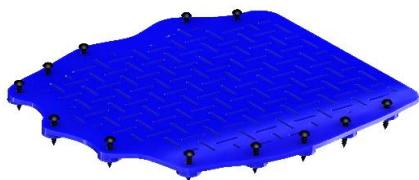
Precision screw-driver set

Required parts:
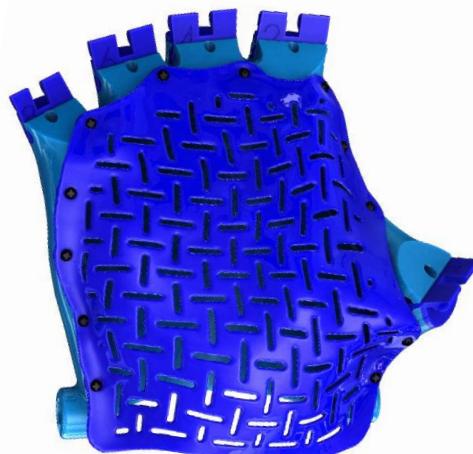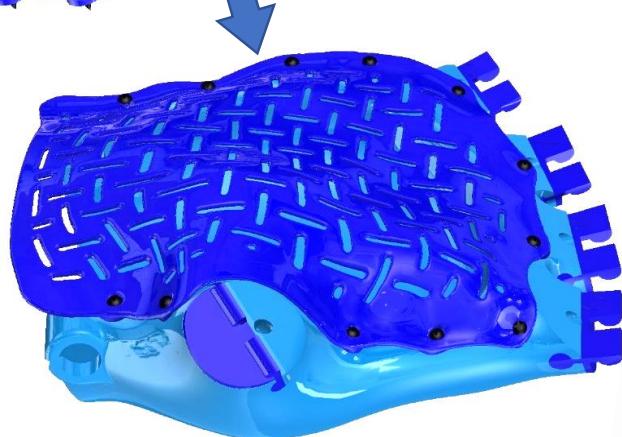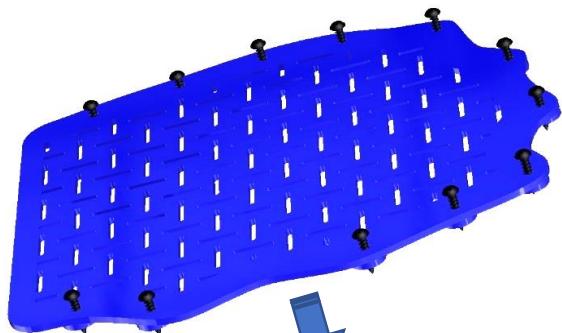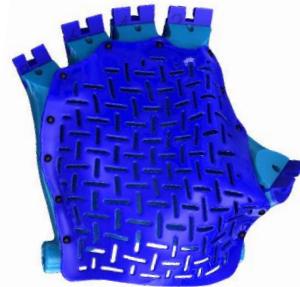
Palm with hinges   Palm Cover Assy

Tighten all screws until tight. Do not overtighten to avoid damaging the Palm Cover or stripping the hole in the Palm.

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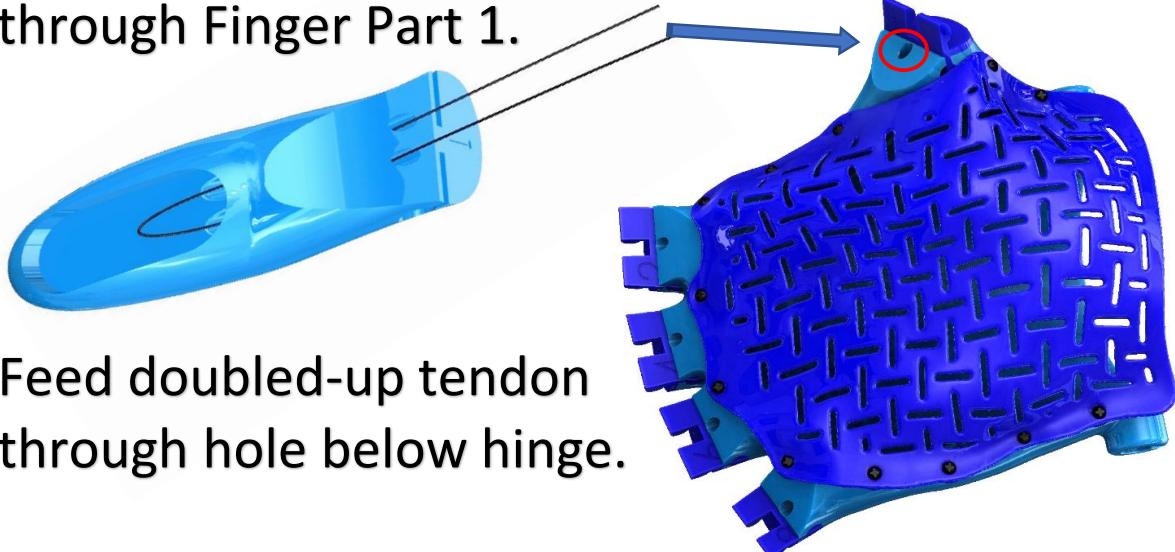
Step 7: Feed Thumb Tendon

Required parts:
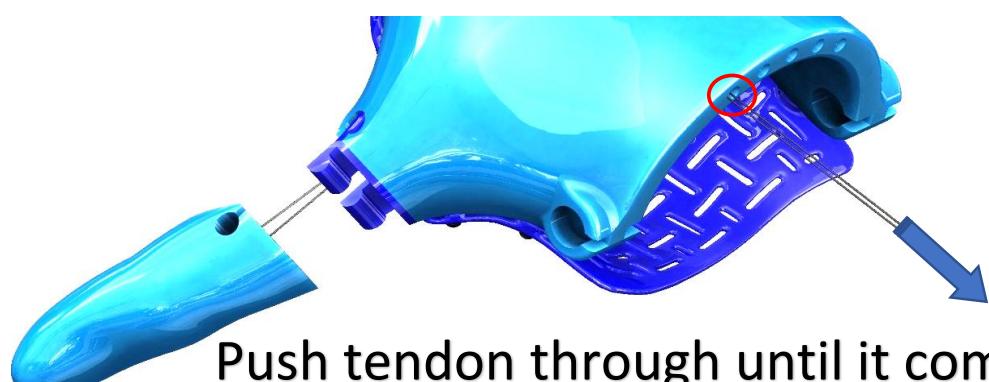
700mm tendon

Finger Part 1

Completed Palm

Feed tendon cut to 700mm in length in a loop through Finger Part 1.

Feed doubled-up tendon through hole below hinge.

Push tendon through until it comes out of the hole in the base of Palm.

Step 8: Attach Thumb to Palm

Required parts:
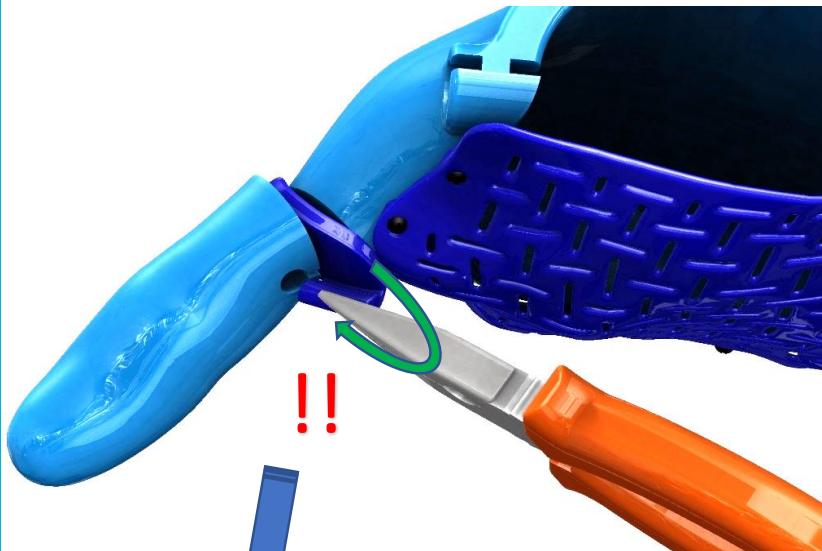
Palm & Thumb Assy
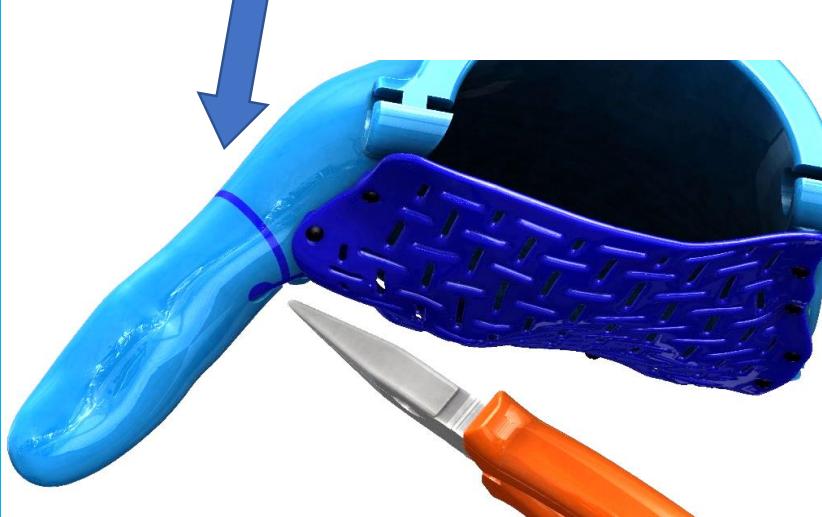
Required tools:

Needle-nose pliers

!!

Insert the hinge from one side by hand, then use pliers to stretch and fit into the other side of the thumb (Finger Part 1).

!!

Ensure that the pliers do not come into contact with the PLA parts to avoid damage.

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Step 9: Feed Remaining Tendons
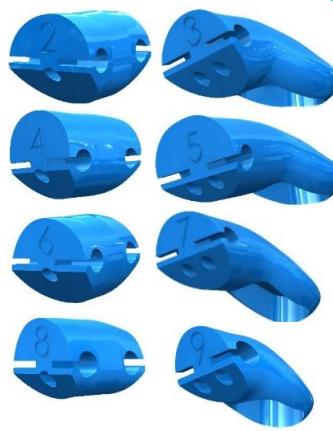
Required parts:

Thumb tendon sub-assy
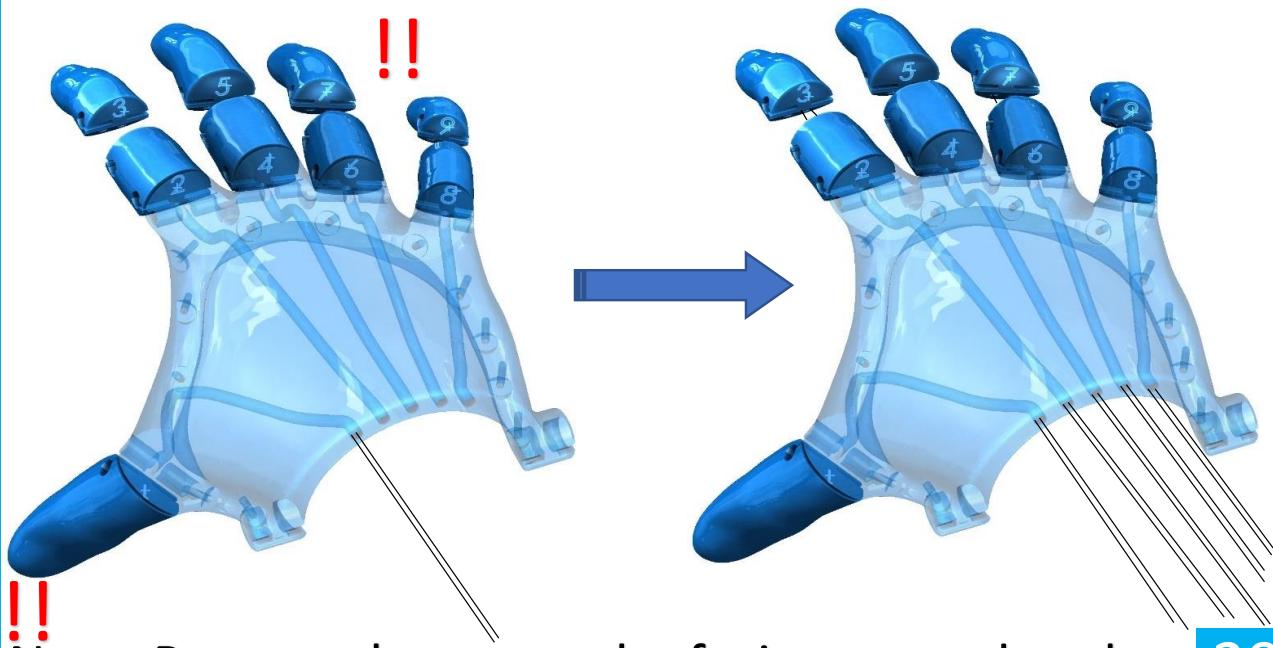
700mm tendon x4   Finger Parts 2-9

Repeat Process in Step 6 to feed remaining tendons.
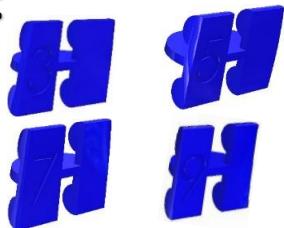
Finger Parts:
2 + 3 (Index Finger)
4 + 5 (Middle Finger)
6 + 7 (Ring Finger)
8 + 9 (Little Finger)

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Note: Part numbers must be facing towards palm. 20

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Step 10: Insert Remaining Hinges
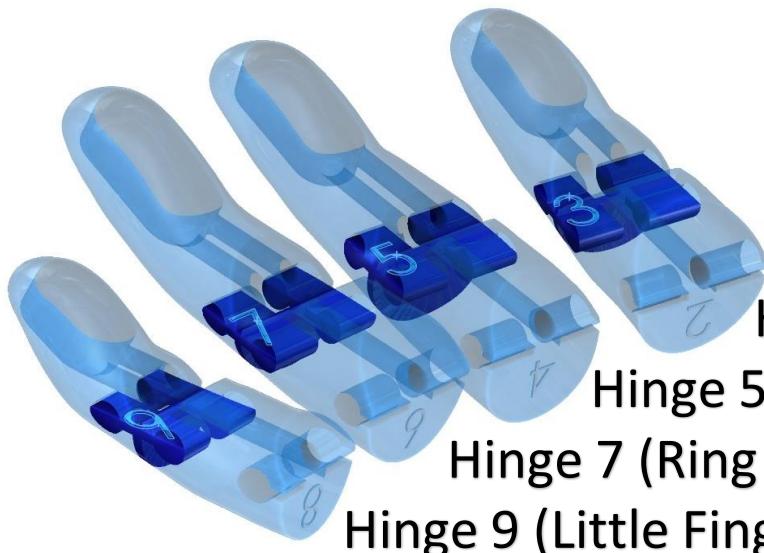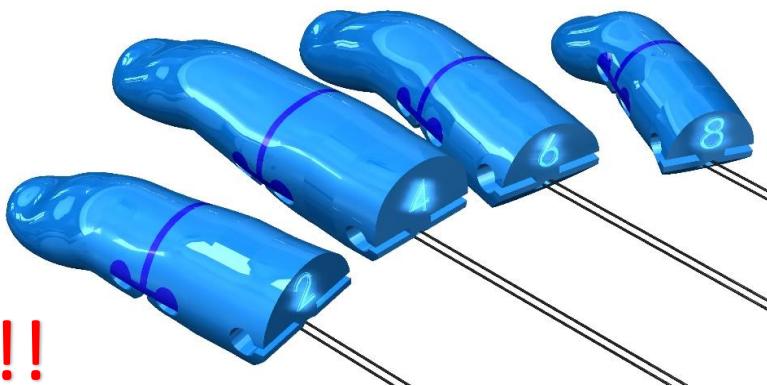
Hinge Orientation:

Hinge 3 (Index Finger)
Hinge 5 (Middle Finger)
Hinge 7 (Ring Finger)
Hinge 9 (Little Finger)
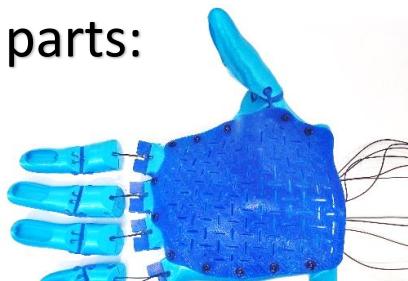
!!
Insert the hinge from one side by hand, then use pliers to stretch and fit into the other side of the fingers.

!!
Ensure that the pliers do not come into contact with the PLA parts to avoid damage.

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Step 11: Attach Fingers to Palm

Required parts:

Palm sub-assy

Required tools:

FatMax

Needle-nose pliers

1) Insert by hand

2) Insert using pliers

3) Insert by hand

4) Insert using pliers
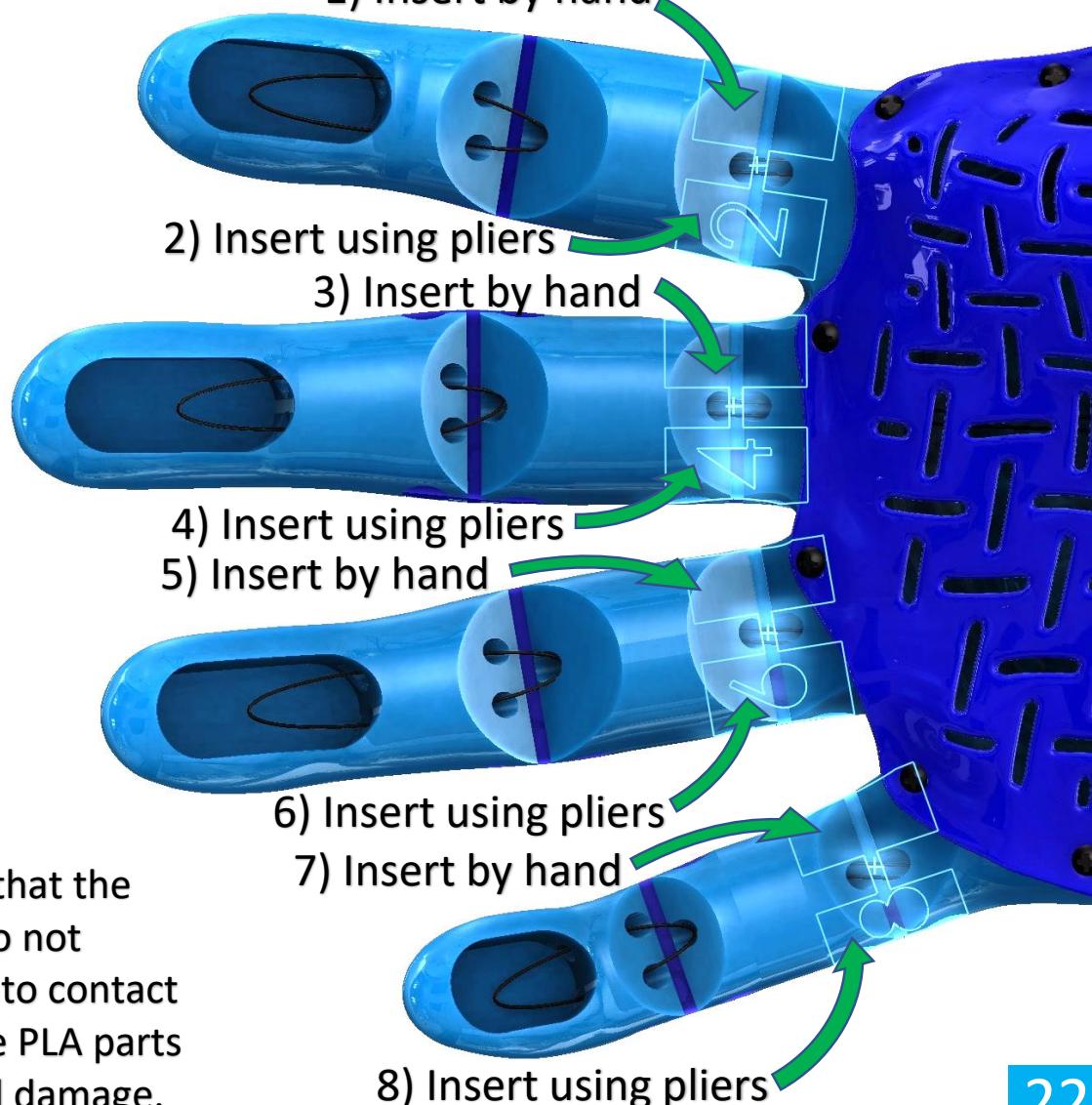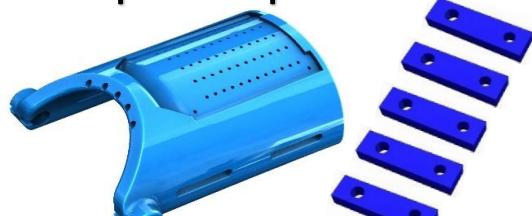
5) Insert by hand

!!
Ensure that the pliers do not come into contact with the PLA parts to avoid damage.

6) Insert using pliers

7) Insert by hand

8) Insert using pliers

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Step 12: Attach Flexible Tensioners

Required parts:

Gauntlet   Tensioner   M2 Screws
            x5   x12

Required tools:

STANLEY

Precision screw-driver set

Use the second row of holes

Tighten screws into the 5 pilot holes.
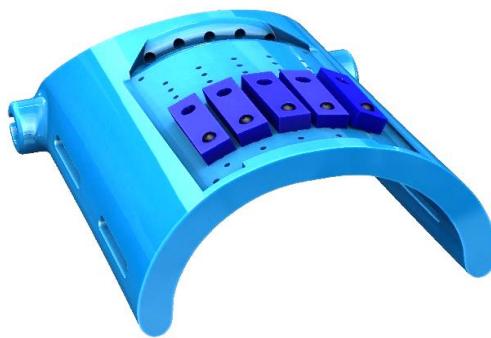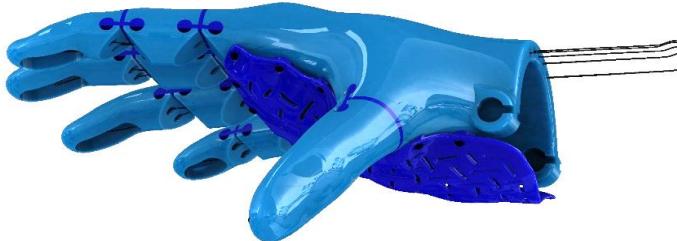
Screw into the smaller of the two holes on the tensioner
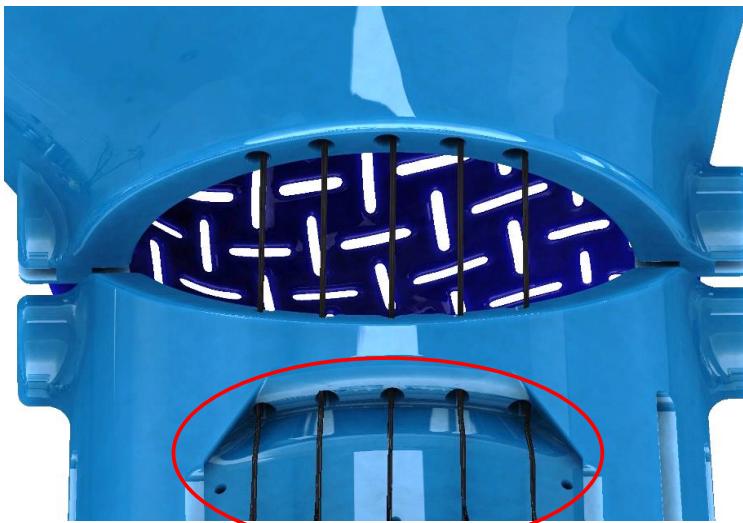
Ensure screws do not protrude

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Step 13: Feed tendons to Gauntlet
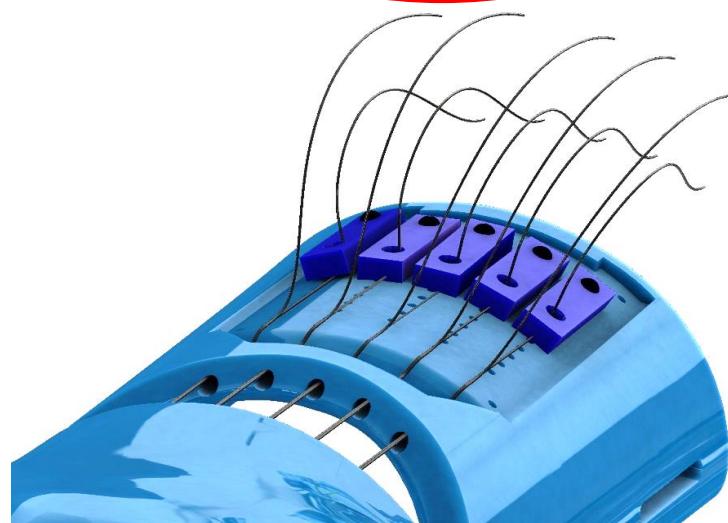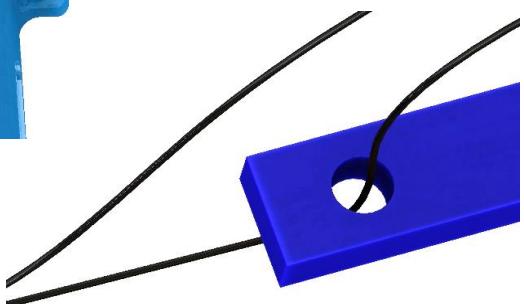
Required parts:

Palm with tendon assy   Gauntlet & Tensioner assy
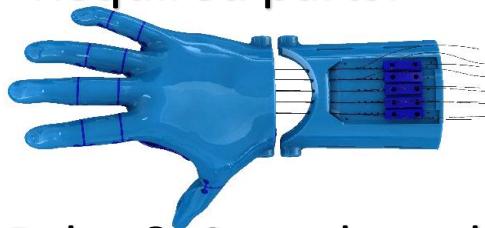
Feed each tendon pair through the corresponding tendon channel in the Gauntlet.

Feed one of the tendons in each pair through the hole in each tensioner from the bottom.

Step 14: Attach Wrist Hinges to Palm

Required parts:
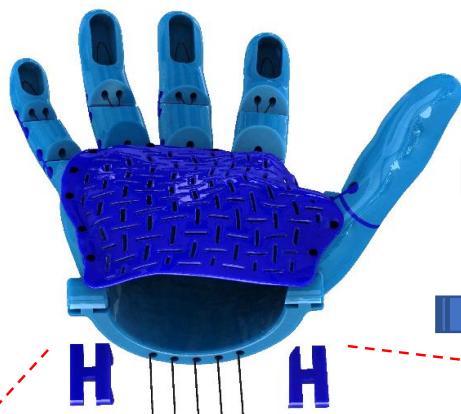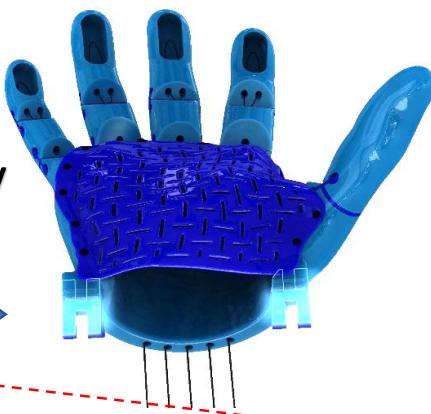
Wrist Hinge 1   Wrist Hinge 2

Palm & Gauntlet sub-assy

Insert hinges by hand.

!!

flat   curved   Hinge orientation is very important to fit correctly.   curved   flat
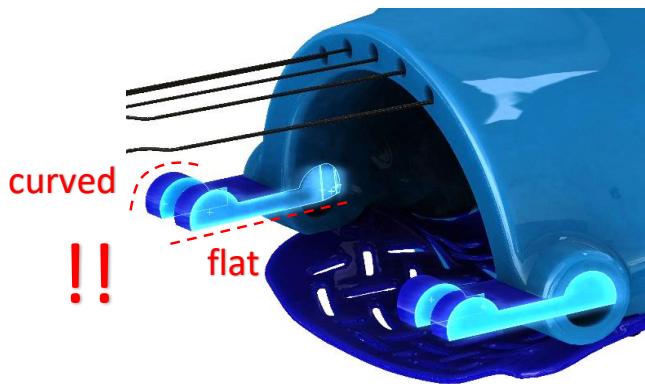
Wrist Hinge 2   Wrist Hinge 1

curved

!!   flat
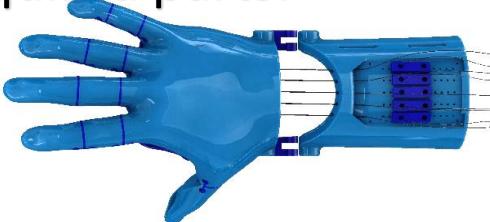
!! Ensure that the rounded side of the hinge joint is facing towards the top of the Palm.

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Step 15: Attach Wrist Hinges to Gauntlet

Required parts:

Palm & Gauntlet sub-assy

Required tools:

Needle-nose pliers

1) Insert by hand

2) Insert by hand

4) Insert using pliers
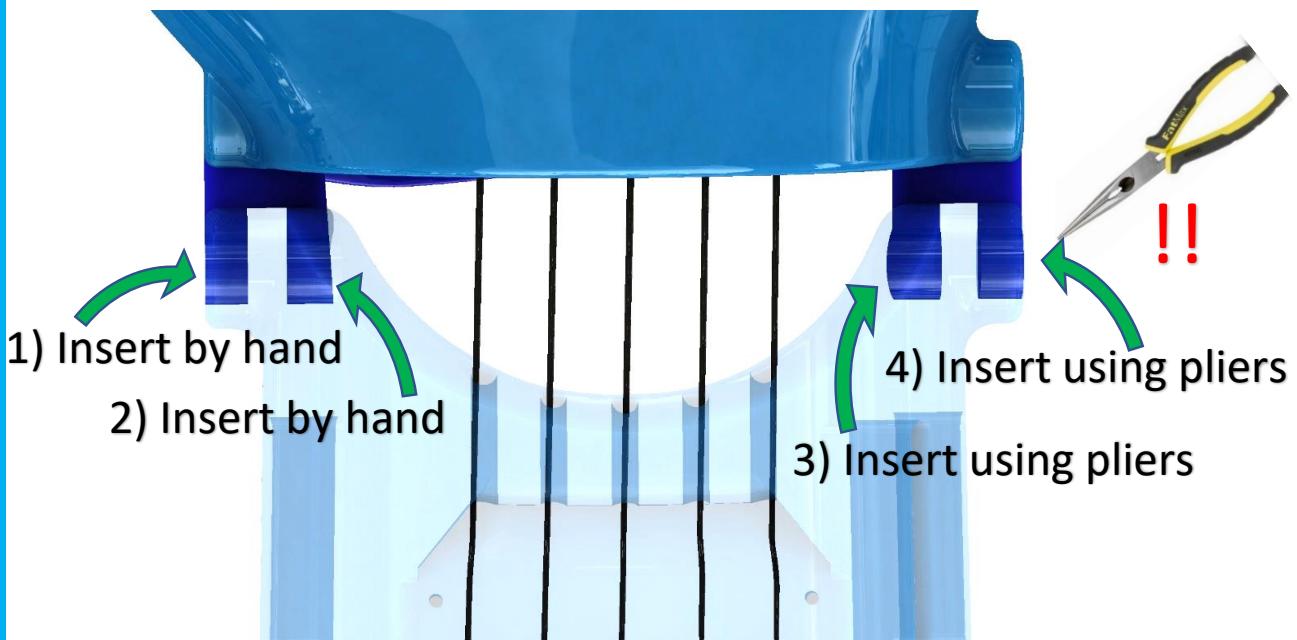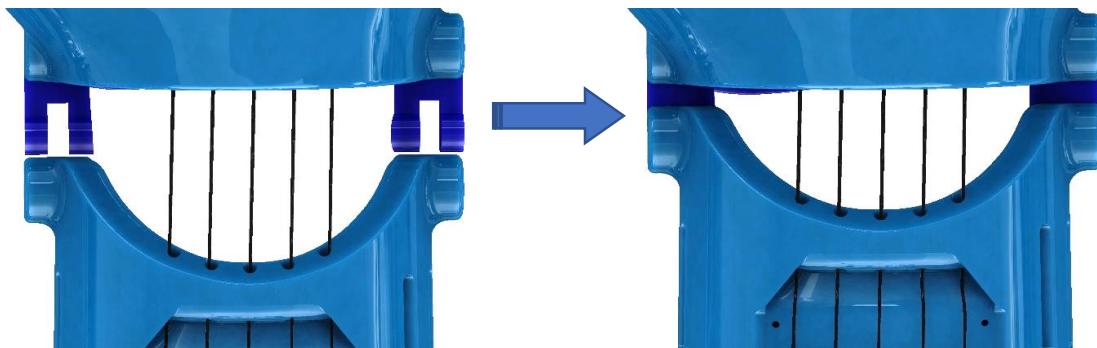
3) Insert using pliers

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‼ Ensure that the pliers do not come into contact with the PLA parts to avoid damage.
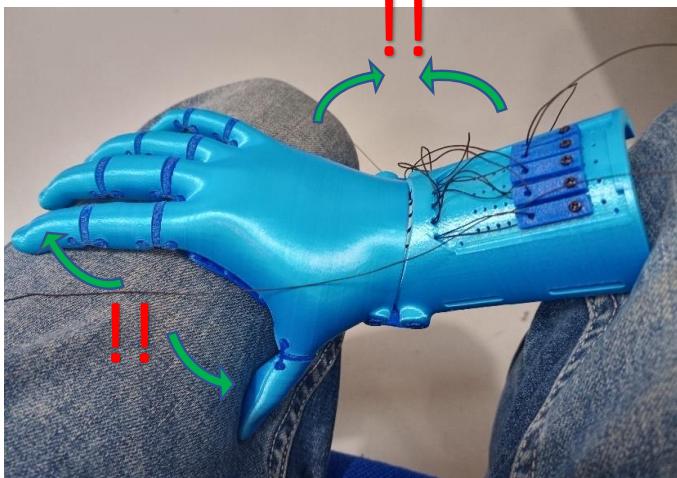
Step 16: Temporary Tensioner Knots

Required parts:
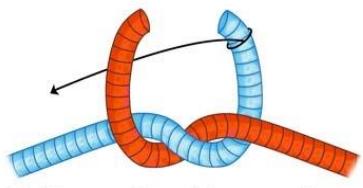
Palm & Gauntlet   sub-assy
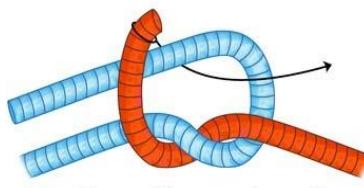
Before making temporary knots in the tendons for tuning, position the fingers and thumb in the fully opened position, with the Palm and Gauntlet touching as a reference point. Using your knees to do this will free up your hands to tie the knots.
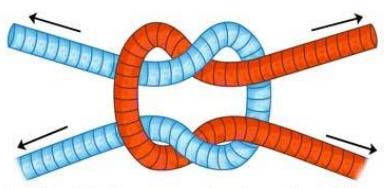
Square (Reef) Knot Instructions
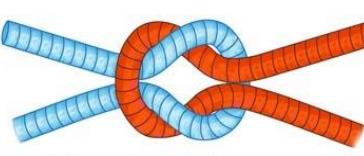
1 Cross the blue and red ends

2 Pass the red end through the blue loop

3 Pull the ends to tighten

4 The knot is complete

Right over left, left over right!

Tie one reef knot at the base of each of the 5 tensioners. The knots need to be tight, but able to slip a little during the next tuning process.

27

FREE3HANDS

Step 17: Ideal Finger Closing Condition

Required parts:

Palm & Gauntlet   sub-assy

1

2

3

4

Note: The knots are still kept loose to allow for adjustment.
Gently bend the palm downwards to confirm that;
1) All fingers and thumb start moving at the same time,
2) As the fingers curl, they follow a uniform curve,
3) The thumb tucks in **below** the index finger,
4) All fingers come to a full close.

28

FREE3HANDS

Step 18: Tuning Finger Positions

Required parts:

Palm & Gauntlet sub-assy
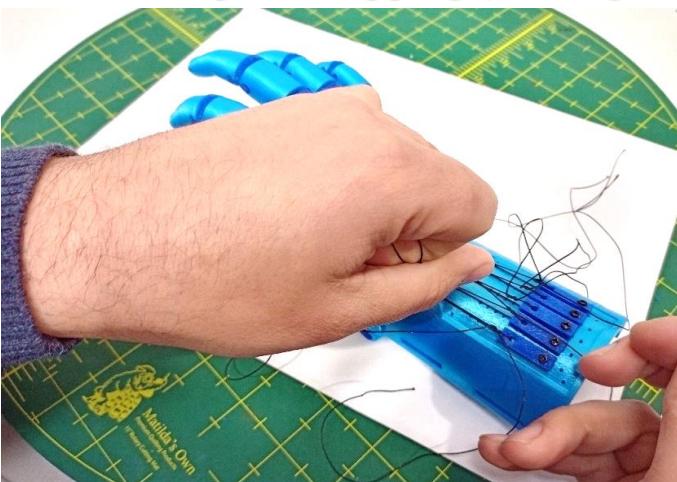
Case #1 - Finger is leading (*closing ahead of other fingers*)

Solution:
Hold the finger whilst gently bending the wrist to allow the knot to slip to the desired position. Reconfirm closing position shown on Page 28.

Case #2 - Finger is lagging (*closing behind other fingers*)
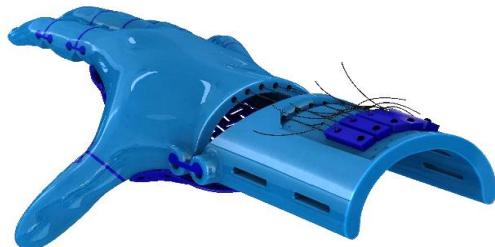
Solution:
Wrapping the tendons around both index fingers, tighten the knot at the corresponding tensioner for that finger. Reconfirm closing position shown on Page 28.

29
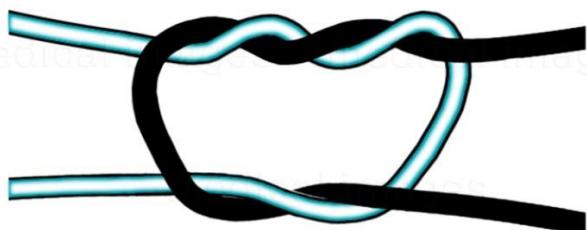
Step 19: Tie the Final Tensioner Knots

Required parts:

Palm & Gauntlet sub-assy

Surgeons' Knot

Tie a "surgeon's knot" by doing **5** loops. Guide the loops to the initial knot and pull the knot tight. It will form a neat ball that will no longer slip.
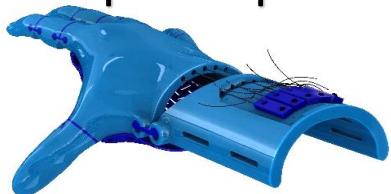
Repeat the process for all of the other tensioner knots. Wrapping the tendon around your index fingers will help you to pull the tendons tight.

Step 20: Finishing and Trimming Knots

Required parts:

Palm & Gauntlet sub-assy

Required tools:

High strength, precise application thick super glue

Sharp hobby knife

Place a small dab of thick super glue onto the knot to prevent any future slipping. Once the glue has set, use a sharp hobby knife, cut the tendons about 5mm from the knot.

Step 21: Re-confirm and Adjust Tensioners

Required parts:
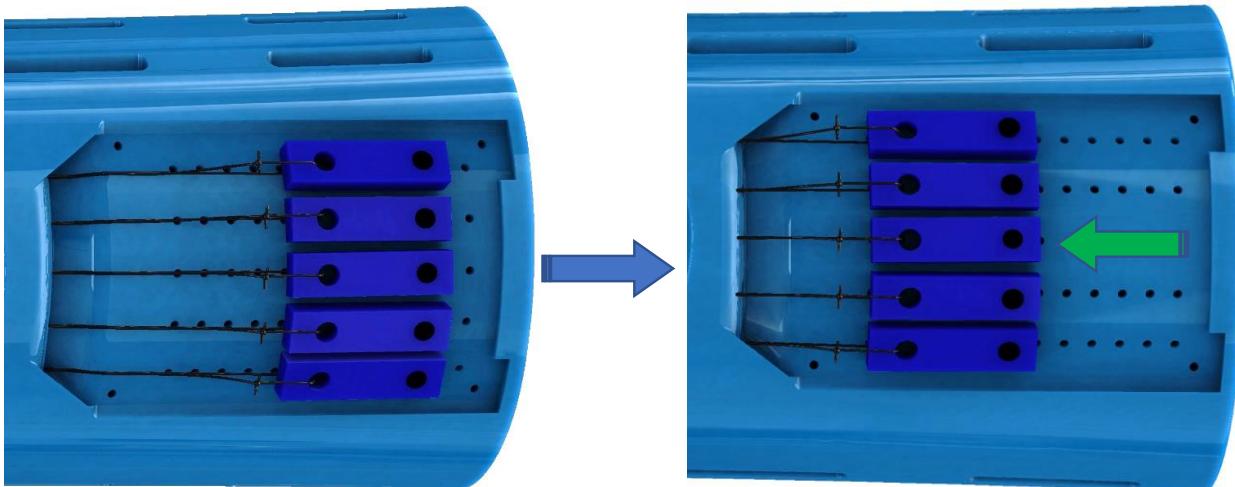
Palm & Gauntlet sub-assy
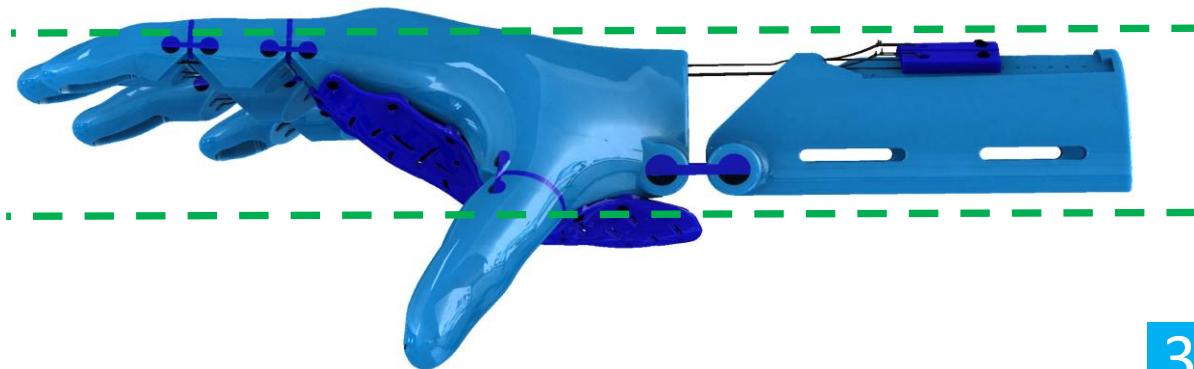
Required tools:

Precision screw-driver set
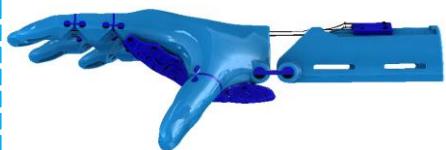
Loosen the screws from the Tensioners and move them **four** holes forward into their final positions. This will allow the Kinetic Hand to have fingers in the open position when the wrist is parallel to the Palm.

FREE3HANDS
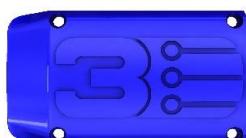
Step 22: Fit Gauntlet Cover

Required parts:

Kinetic Hand sub-assy
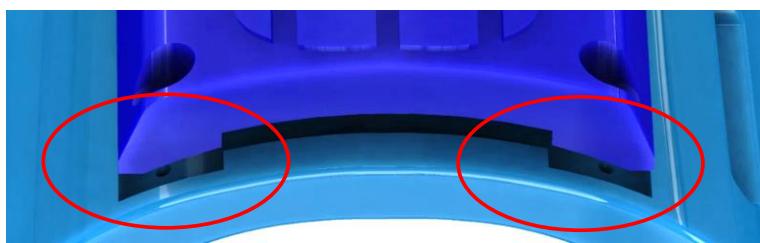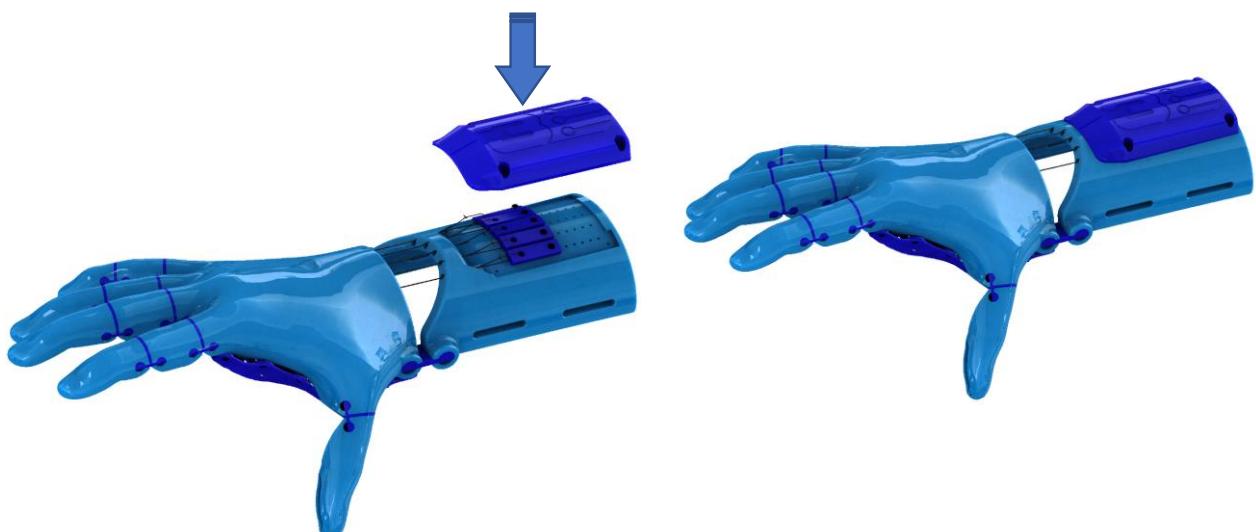
Gauntlet Cover

M2 Phillips Pan Head Self Tapping Screws 10mm **x4**

Required tools:

STANLEY **x6**
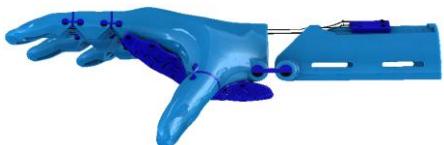
Precision screw-driver set
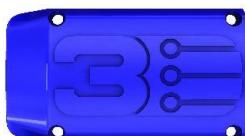
Align the Gauntlet Cover into position using the locating tabs. It should snap into place.

Step 23: Attach Gauntlet Cover

Required parts:

Kinetic Hand sub-assy

Gauntlet Cover

M2 Phillips Pan Head Self Tapping Screws 8-10mm **x4**

Required tools:

STANLEY ×6

Precision screw-driver set

3

4

1

2
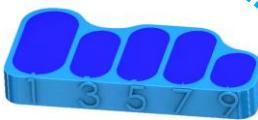
Tighten the four screws until tight. Do not overtighten to avoid damaging the Gauntlet Cover or stripping the holes in the Gauntlet.

Step 24: Test Fitting the Finger Grips

Required parts:

Moulded Silicone Grips
OR

Kinetic Hand sub-assy

3D Printed NinjaFlex TPU Finger Grip set

Required tools:

LOCTITE SUPER GLUE

High strength, precise application thick super glue.

Test fit the Silicone Grips into the fingers and thumb. **Ensure that the Grip identification numbers are facing away from the finger tips**.

Step 25: Attach Finger Grips

Required parts:

Kinetic Hand sub-assy

Moulded Silicone Grips
OR
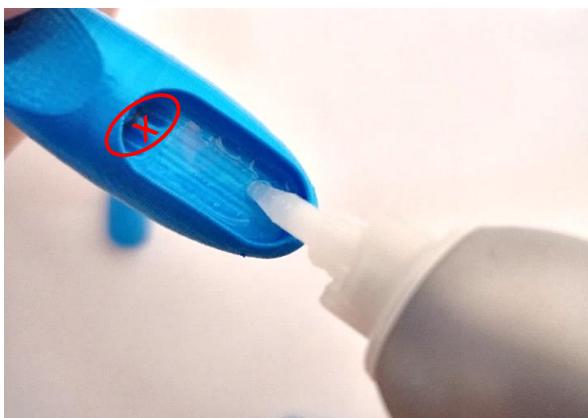
3D Printed NinjaFlex TPU Finger Grip set

Required tools:

LOCTITE SUPER GLU
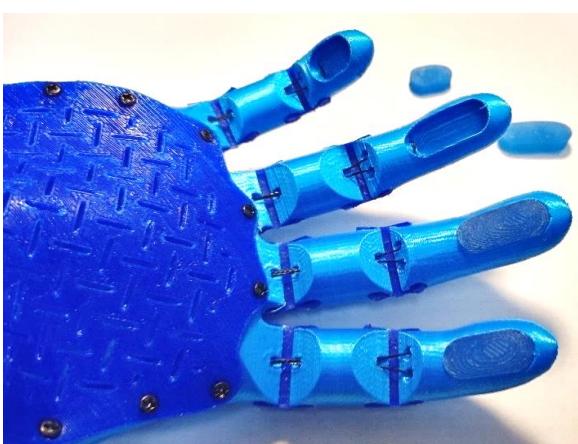
High strength, precise application thick super glue.

Apply a thin, even coat of super glue to the grip cavity inside the thumb (Finger Part 1).
Do not apply super glue to the area around the tendon.
Confirming the orientation on Page 35, insert the Grip, and wipe away any excess super glue with a cloth.
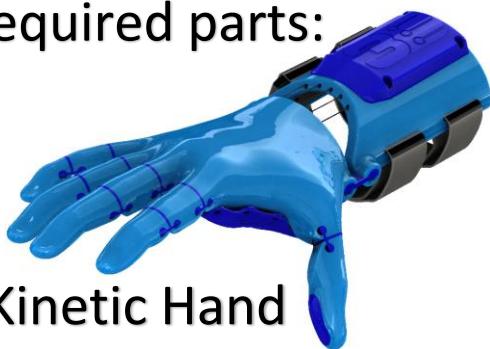
Repeat this process for each of the fingers, one at a time.

Allow the super glue to dry before applying any force.

36

Step 26: Install the Insert (If Required)

Required parts:
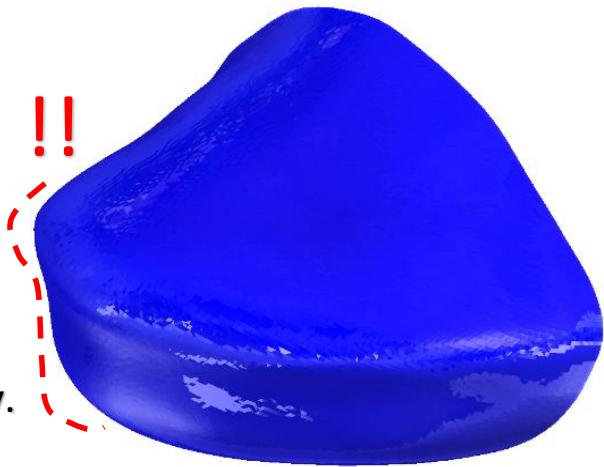
Kinetic Hand

Insert A,B,C or D

The Insert is designed to be a soft cusion inside of the Kinetic Hand. It is sized to stop the partial hand from sliding forward.
It also ensures that the wrist is kept at the Wrist Hinge position to allow the Kinetic Hand to function properly.
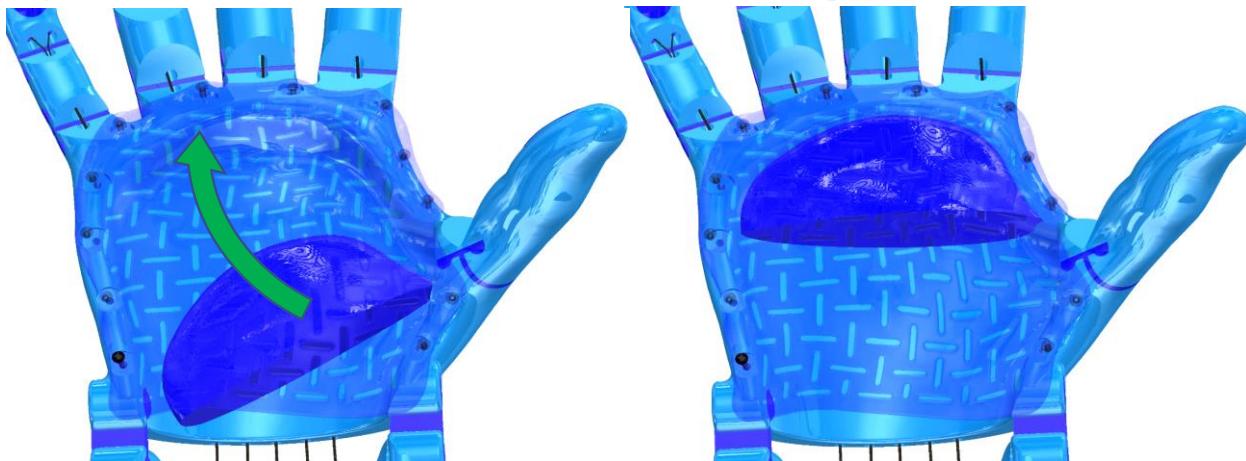
!!

Note: The insert can only be fit one way.
It is shaped as a precise fit into the cavity of the Palm.
Pay attention to the orientation when inserting.

FREE3HANDS
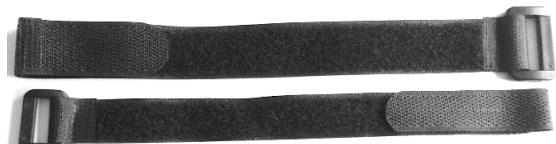
Step 27: Install the Hook and Loop Straps

Required parts:

Kinetic Hand
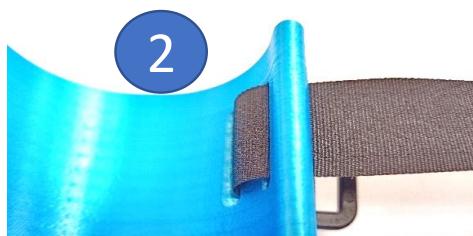
Nylon Hook and Loop Straps, 2cm width, 20-25cm length (hand size dependant)

1 On the side with the dual slots, feed the strap through with hook and loop surface facing away from the Gauntlet.

2 Feed the strap back through the other slot.

3 Feed the strap through the ring of the clip.

4 Feed the strap through the single slot on the other side.

5 Fasten the strap.
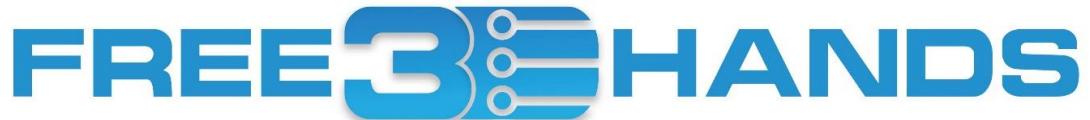
6 Repeat for the other strap.

The Kinetic Hand is Complete!

Make sure to do a final quality and function confirmation.

FREE3HANDS

Some of Our Recipients

FREE3 HANDS

Acknowledgments

We would like to thank all of the recipients who have helped to test and validate the design of the Kinetic Hand. We would also like to thank all of the occupational therapists, prosthetists, biomedical engineers, university researchers, prosthetic and bionic arm developers, makers and limb-difference support groups for their open and transparent collaboration and constructive feedback during the design and development process. Thank you to all of the kind and generous supporters of our charity Free 3D Hands- without your support we wouldn't be able to continue what we do.

Through global collaboration, we can all work together to make assistive technology accessible to all. It is my hope that others will find ways to improve upon this design further, with a shared goal of helping others.

We would love feedback on the design, and please share any recipient photos or feedback to us at: info@free3dhands.org

Thank you for your support.

Mat Bowtell,
Founder, Free 3D Hands Ltd.

All design files can be downloaded at www.free3dhands.org 41

FREE3HANDS

Sponsors and Supporters

We would like to thank all of our kind sponsors, supporters and collaborators during the Kinetic Hand development.
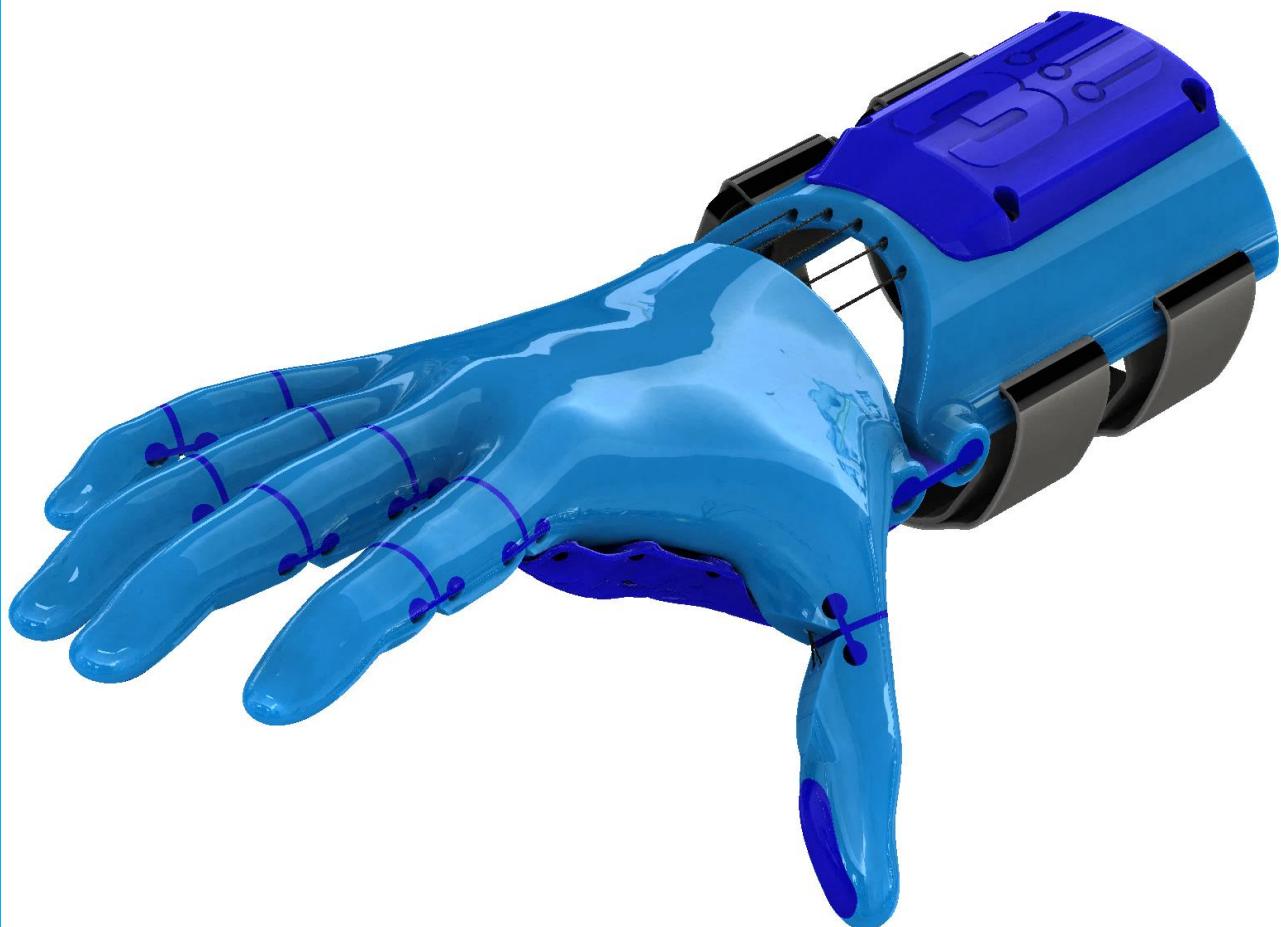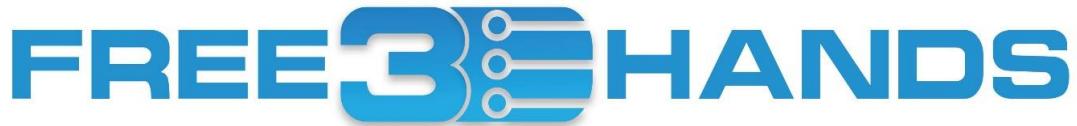
![FREE3DHANDS logo]
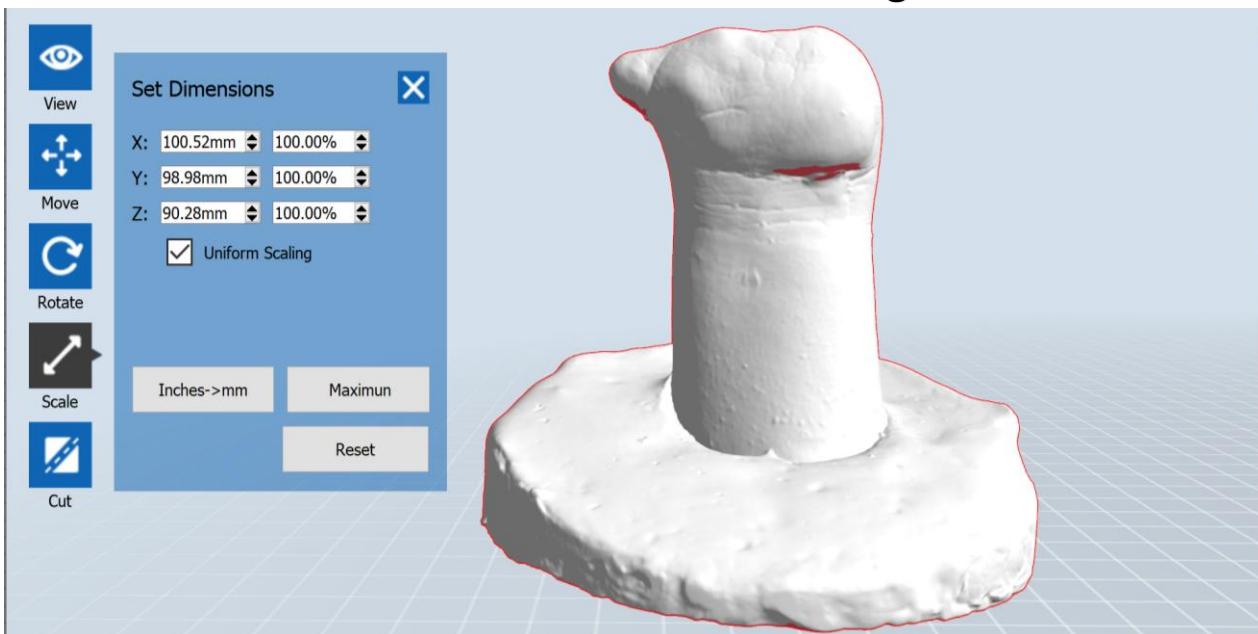
Kinetic Hand

Appendix 1
Measurement and Scaling Guide

FREE3HANDS

Hand Measurement Instructions

The ideal condition for scaling a Kinetic Hand to the correct size is to take a plaster cast of the affected hand which can be 3D scanned to form a 3D model for digital fitment. 3D models can also be created without a plaster cast by using a scanner capable of doing a free-scan in air of the actual hand, however this can be more difficult to achieve an accurate scan if the subject moves whilst being scanned.
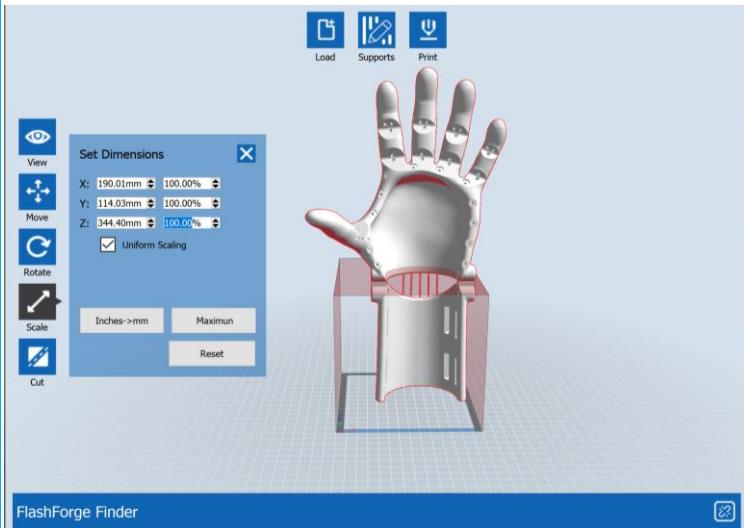
The scan can be loaded into the 3D printing software. We use Flashprint to create our print files. For more information on this software, please see our **3D Printer Software Recommendations** in our **Printing Guide**.

M1

FREE3HANDS
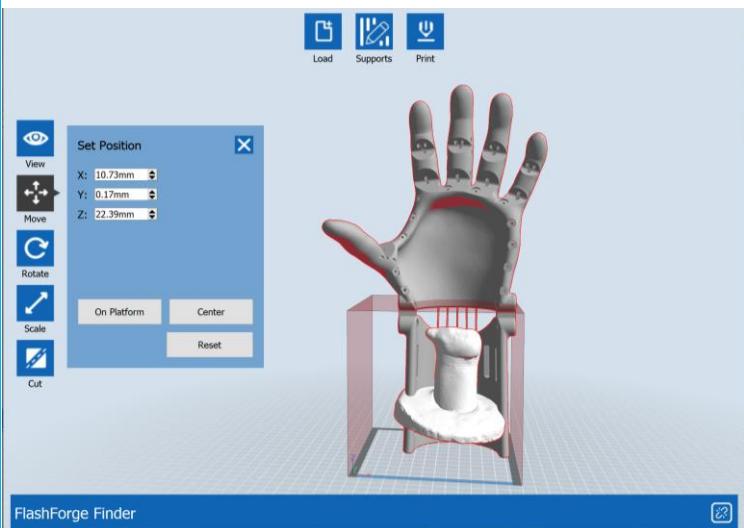
Hand Measurement Instructions

1) Load the **Kinetic Hand low res for fitment (RH100%).stl** file onto the build platform. This file can be mirrored into a left hand under **Edit**, **Mirror Models**, **Mirror X**.
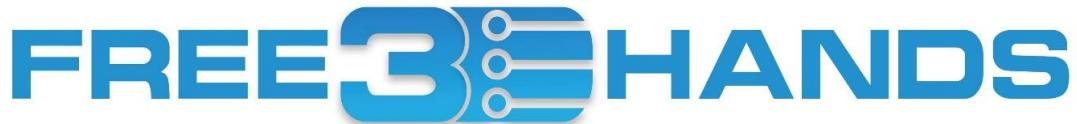
2) Load the 3D scan of the affected hand to the build platform. Using the **Rotate** tab, orient the scan into the same alignment with the Palm in X, Y and Z directions.
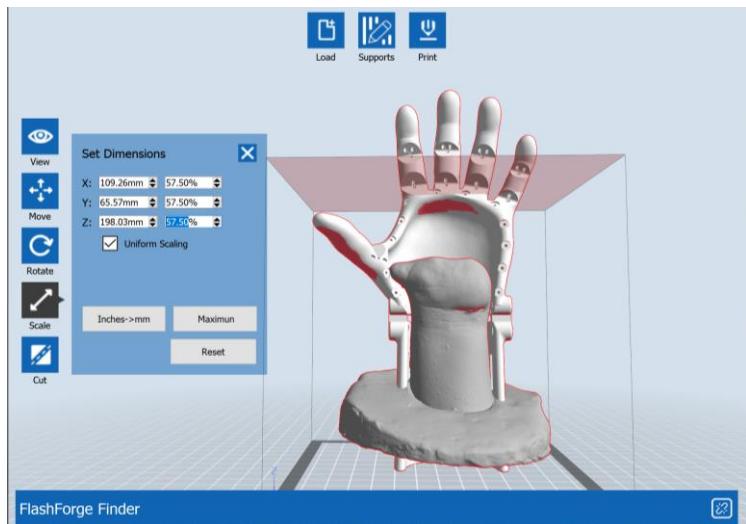
3) Using the **Move** tab, move the scan in X, Y and Z directions to a rough central position in the Palm.

Don't worry about the size or scale at this point.

M2

FREE3HANDS
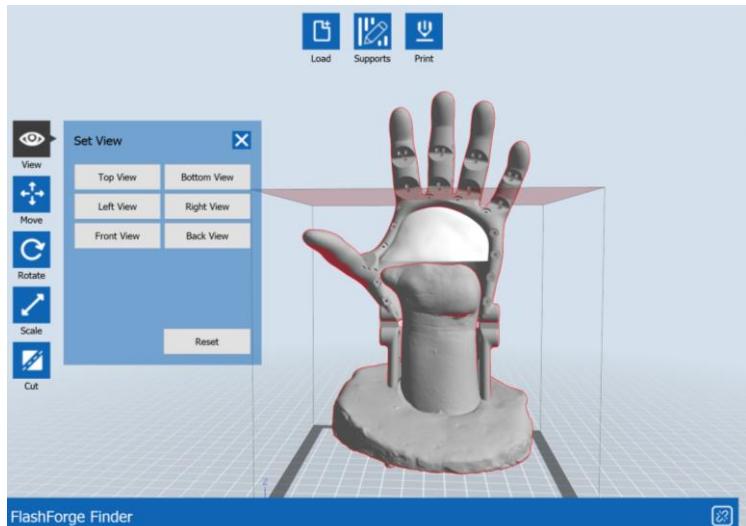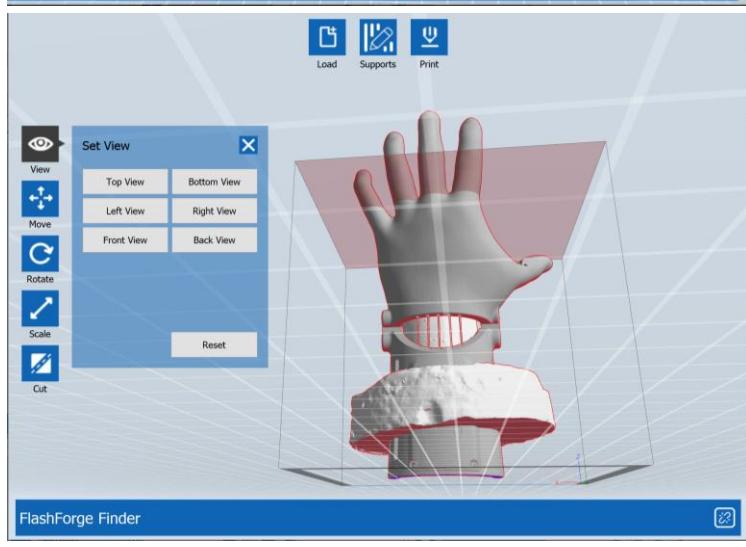
Hand Measurement Instructions

4) Clicking on the Palm and then using the **Scale** tab, Adjust the size of the Palm to match the scan. This may require clicking on the scan and re-positioning also. Leave about 2mm gap between the scan and the Palm.
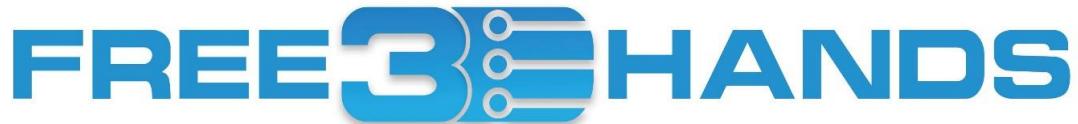
5) If there is space in the Palm cavity, **Load** one of the Inserts (A,B,C, D or E), scale it to the same size as the Palm and **Mirror** it if required before moving the Insert into position.

6) Rotate the model and confirm that there is no interference between the Palm and the scan.

In this case, a left handed Kinetic Hand at 57.5% scale with an Insert E was selected.

M3

FREE3HANDS
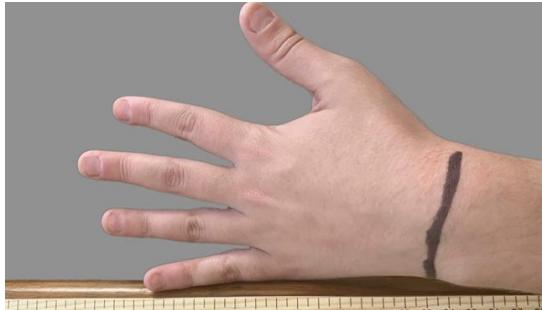
Hand Measurement Instructions

It is also possible to create a set of test palms to determine the correct size for a recipient on location. At Free 3D Hands, we have a set of 24 test hands between 60% and 87.5% scale, in increments of 2.5%. We have printed each hand in a different colour, which also helps recipients choose which colour combination that they would like. This is a very quick and accurate way to determine the correct size.

M4

FREE3HANDS

Hand Measurement Instructions
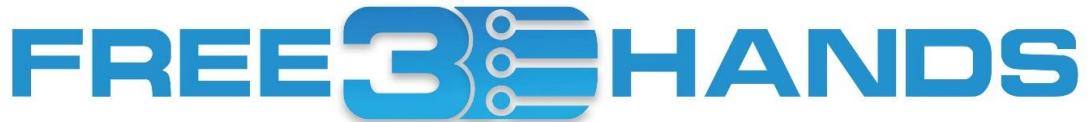
How to take manual measurements if a 3D scan, plaster cast or onsite test fitment is not possible:

1) Take a photo of the **unaffected hand** from directly above by placing a ruler along the edge of a table. **Make sure that the top of the hand and forearm are LEVEL with the top of the table.**

2) **With the palm facing down**, take a photo of the **affected hand** by placing a ruler or tape measure along the edge of a table. mark a line across where the wrist bends like shown. **Make sure that the top of the hand and forearm are LEVEL with the top of the table.**

3) **With the palm facing away from the table**, take a photo of **the affected hand**, flexing the wrist upwards to demonstrate the maximum upward angle of wrist movement (if any). This will help to determine the maximum "open" position of the Kinetic Hand.

4) **With the palm facing away from the table**, take a photo of the affected hand, bending the wrist downwards to demonstrate the maximum downward angle of wrist movement (if any). This will help to determine the "closed" position of the Kinetic Hand.

M5

Measurement Instructions
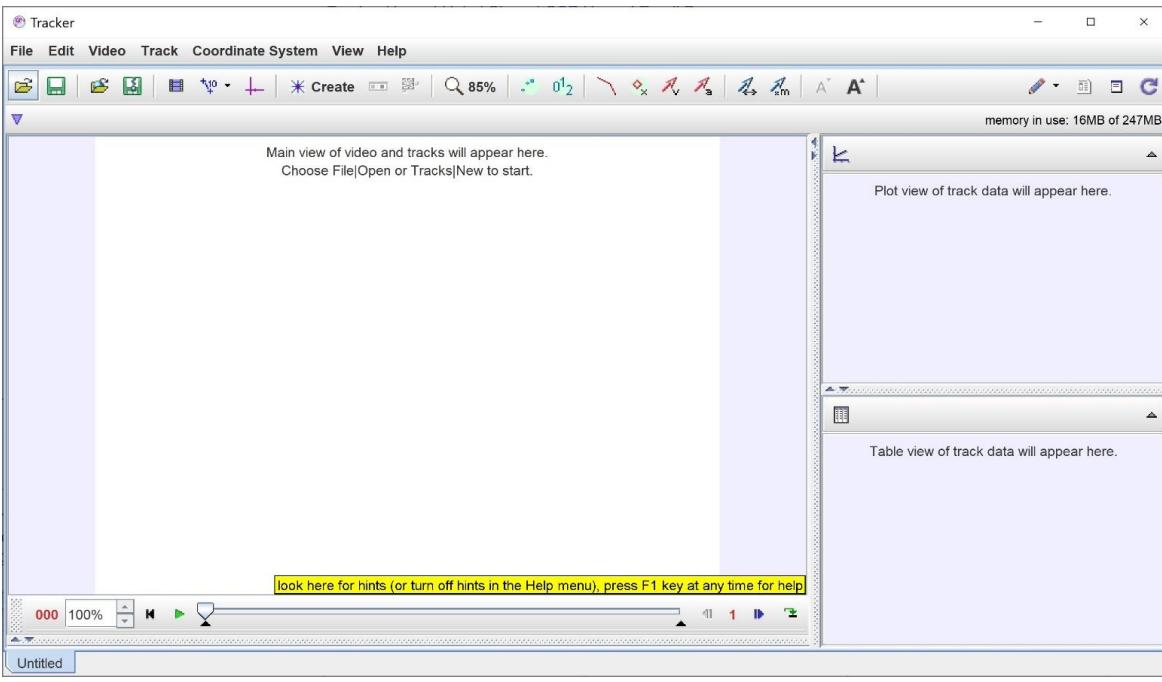
Visit https://physlets.org/tracker/ and download a program called Tracker to help with measuring the hand dimensions for size scaling. Select the correct installer from the list for your operating system.

Once downloaded, run the Tracker application.
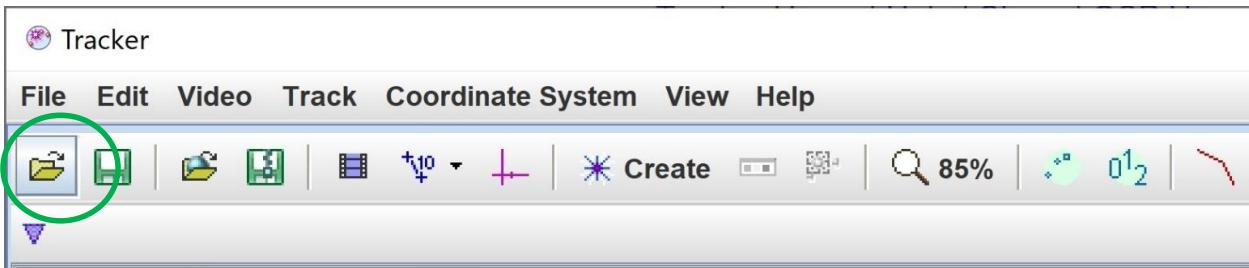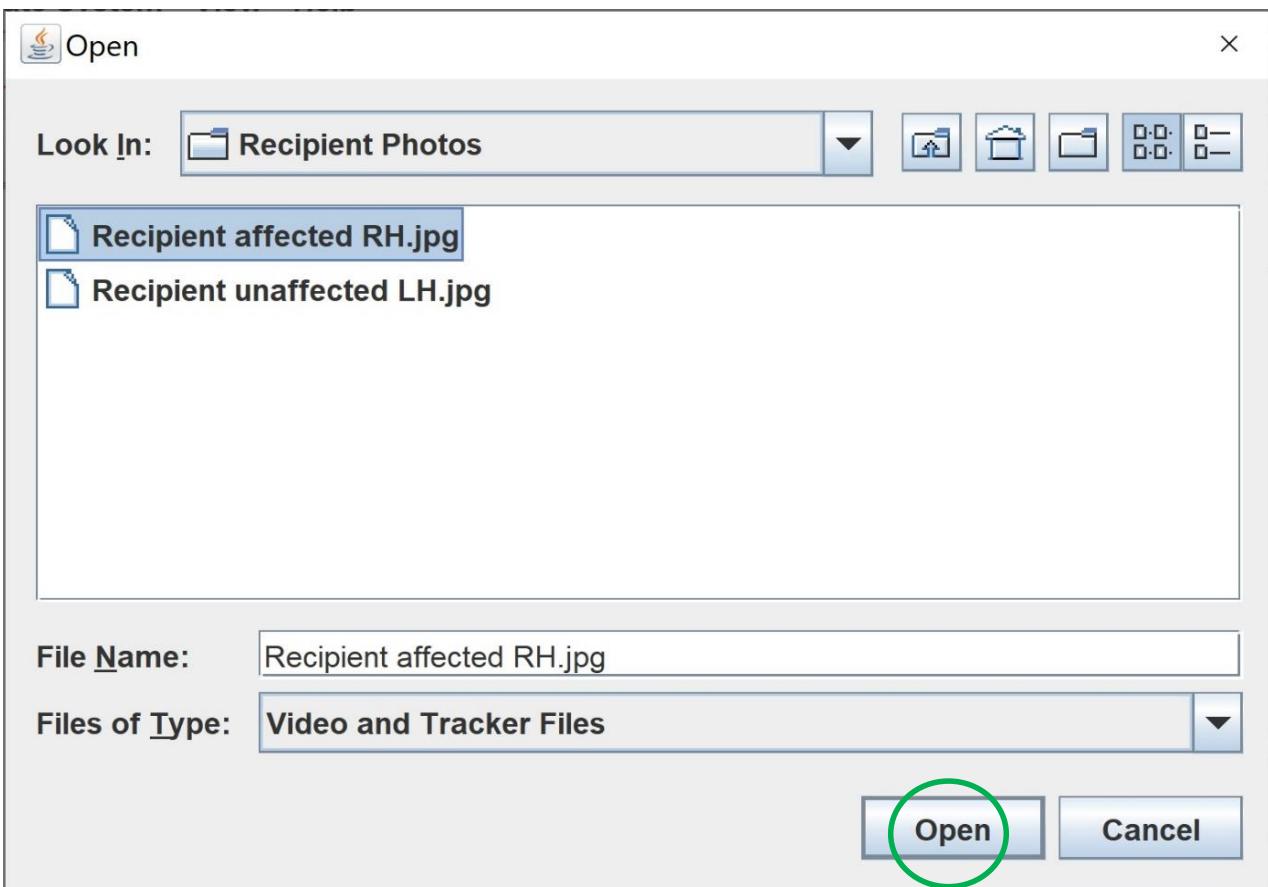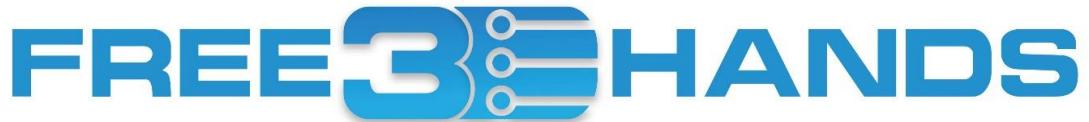
Measurement Instructions

Click on the "Open" icon to open a window to select a photo of the affected hand for measurement.
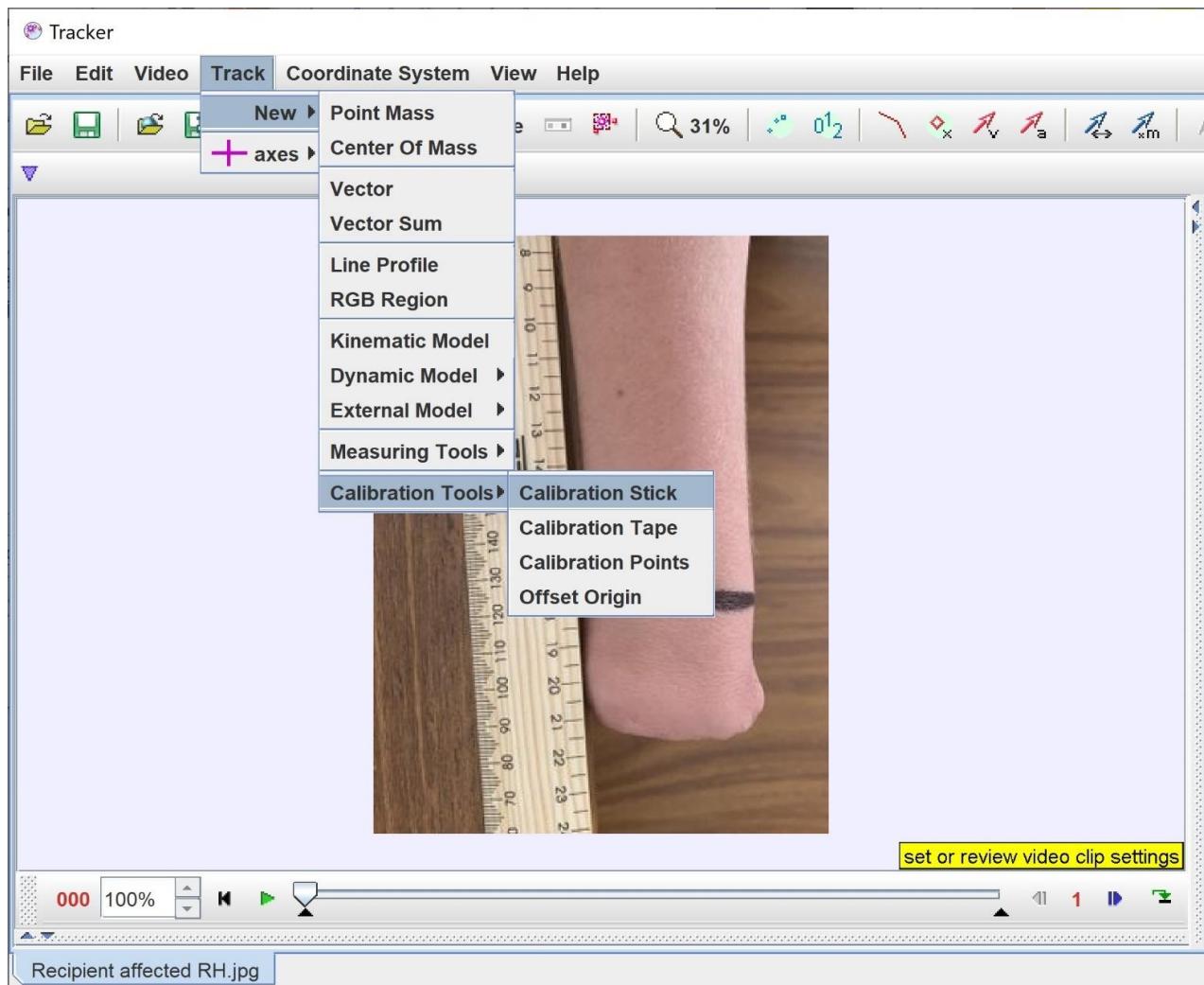
Select the photo for measurement and click "Open"

M7

Measurement Instructions
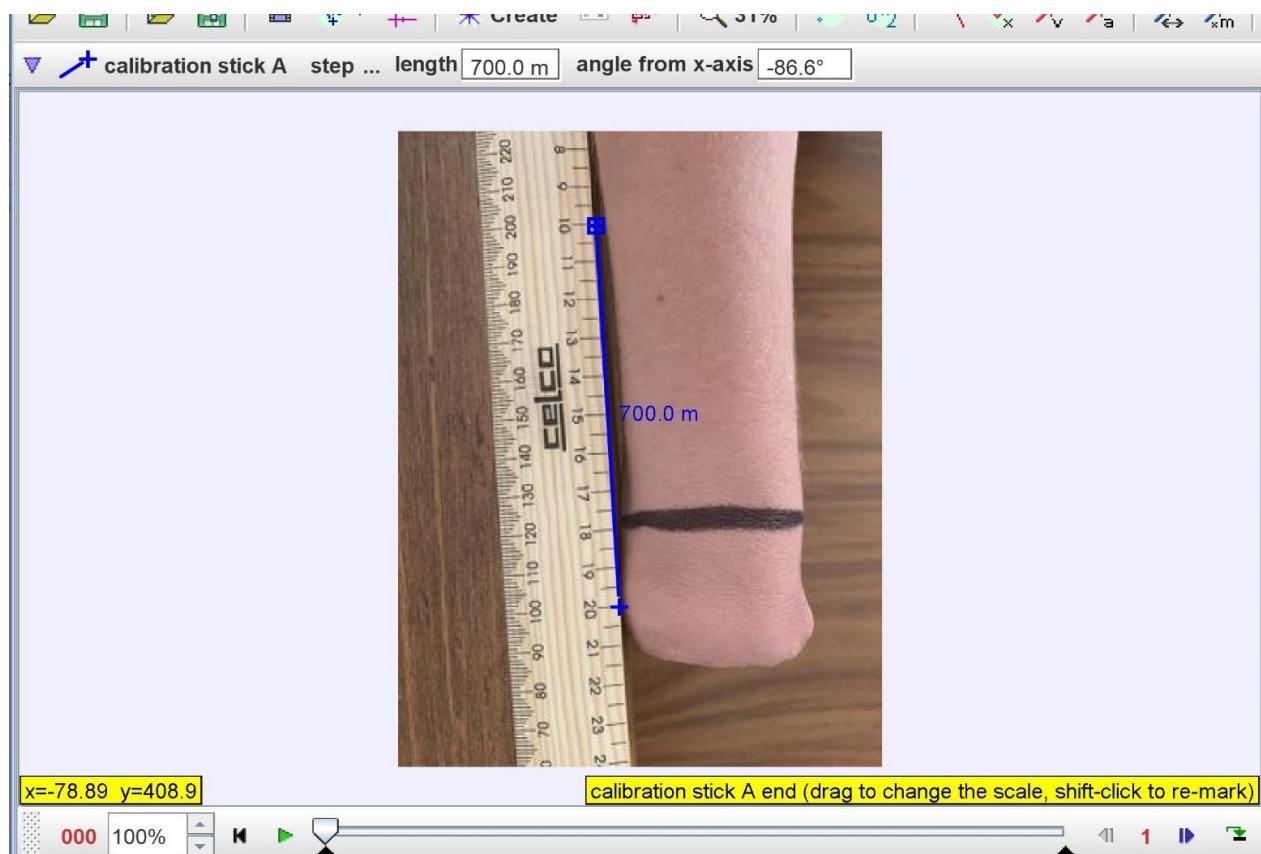
Once the photo has opened, click on the **Track** icon, and under **New**, **Calibration Tools**, select the **Calibration Stick** option.

Measurement Instructions
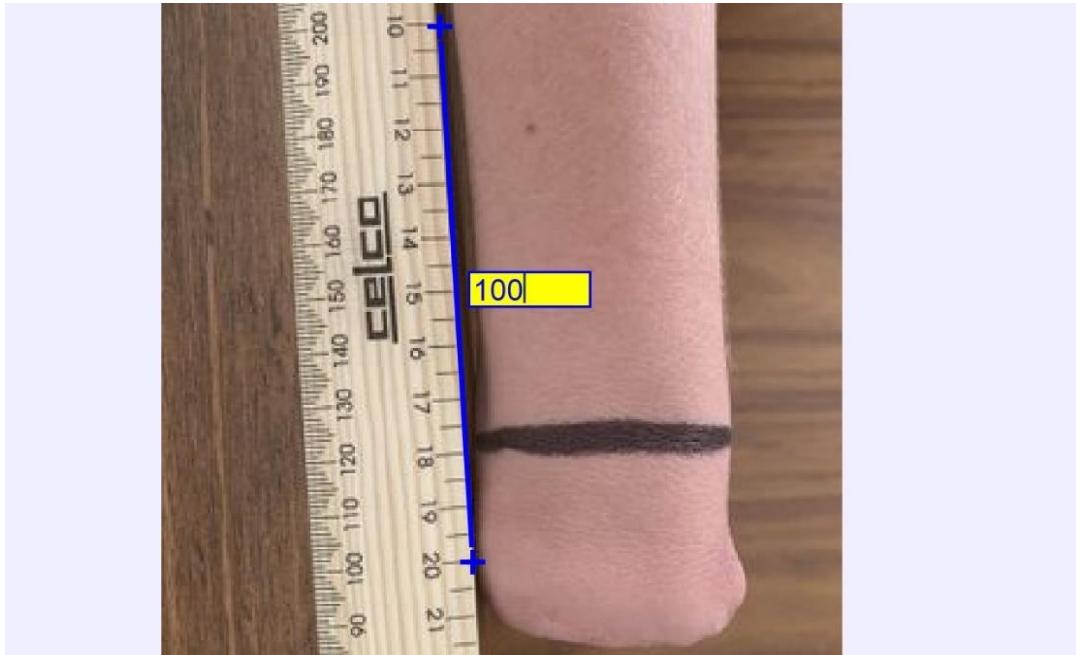
Holding the **Shift** key, select a point on the ruler that will allow you to take a calibration measurement of 100mm (10cm). Once the first point is selected, select a second point by holding the **Shift** key again. Once the points have been selected, you can zoom in and adjust each point for improved accuracy.

This is an important step, since all of the other measurements will be based on this.

M9
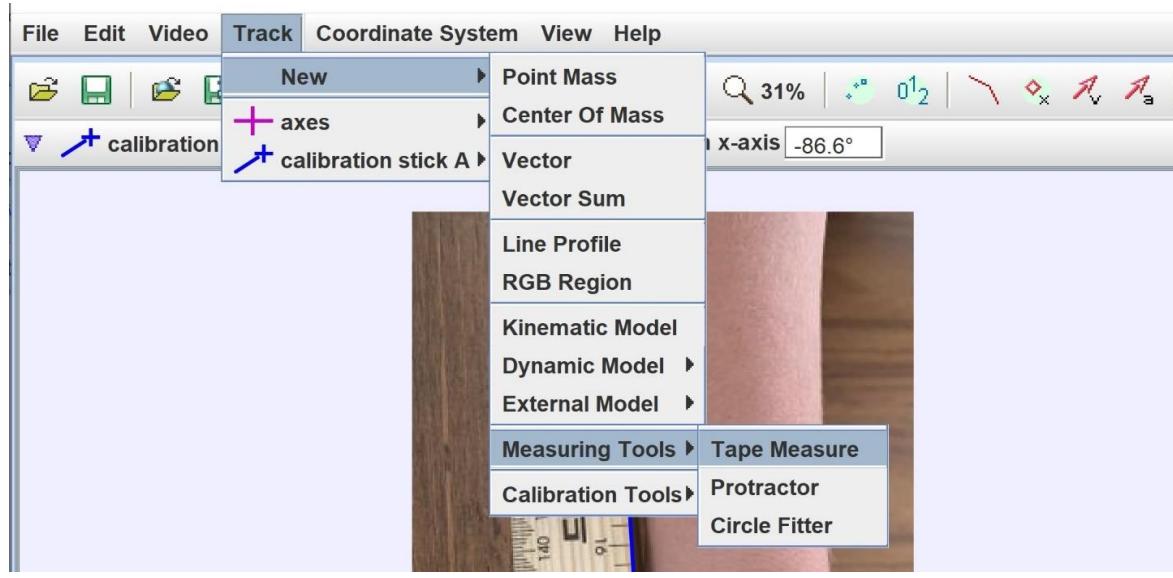
Measurement Instructions

Click on the **Calibration Stick** value to change it to the same value measured from the ruler.
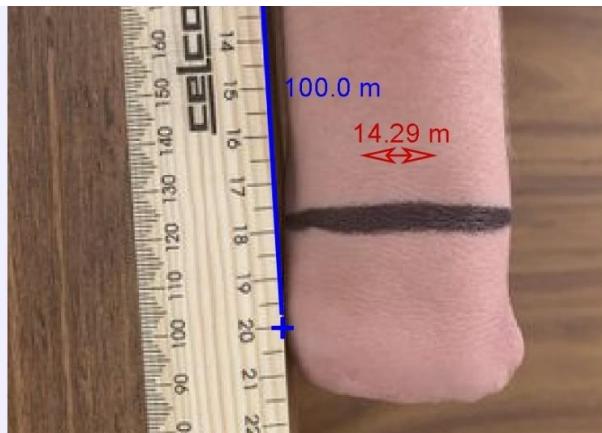
Once the calibration value has been set, click on the **Track** icon, and under **New**, **Measuring Tools**, select the **Tape Measure** option.

Measurement Instructions
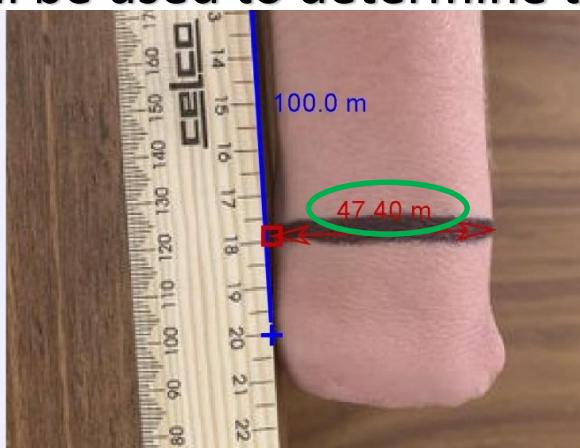
Once the red Tape Measure has appeared, use the mouse to drag one corner of the red arrow to the wrist position beside the table.

Using the mouse, drag the other corner of the red arrow to the other side of the wrist.
As you drag the arrow, the value will update based on the calibration stick value.
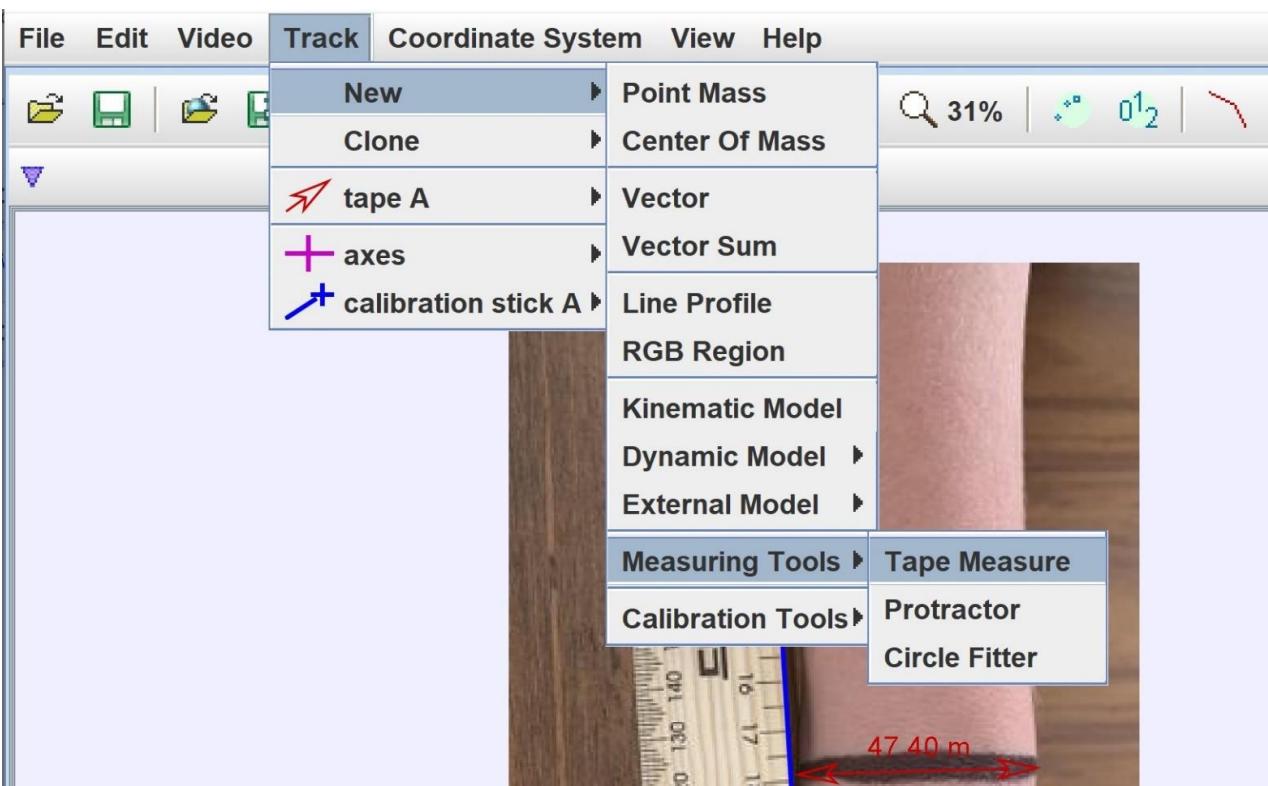
This value will be used to determine the **wrist width**.

![FREE3HANDS]
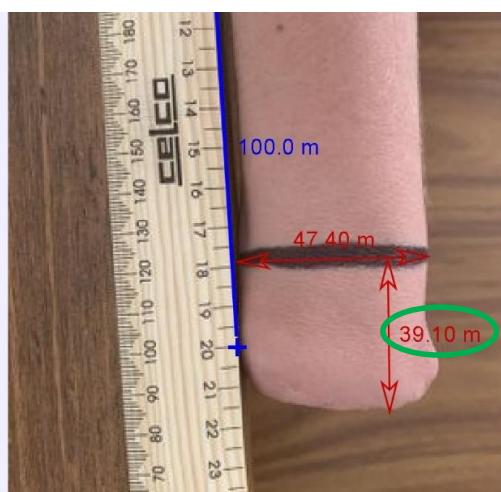
Measurement Instructions

Open a second Tape Measure following the same steps to measure from the wrist line to the longest part of the palm.
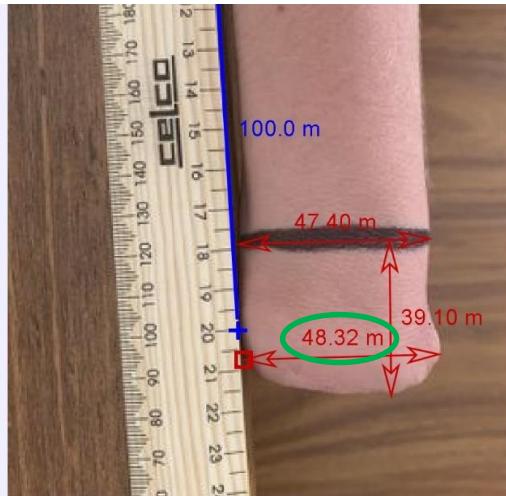
This value will be used to determine the **palm length**.
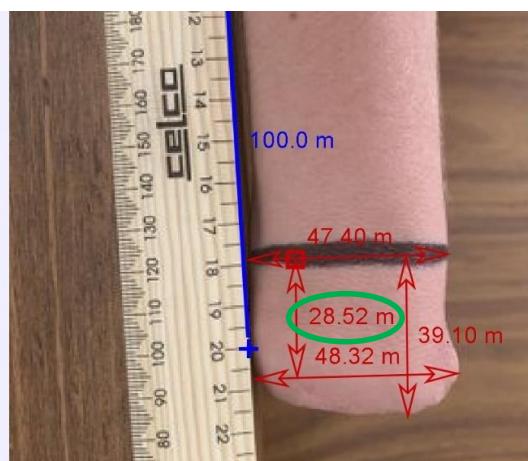
Measurement Instructions

Open a third Tape Measure following to measure the **maximum palm width**.
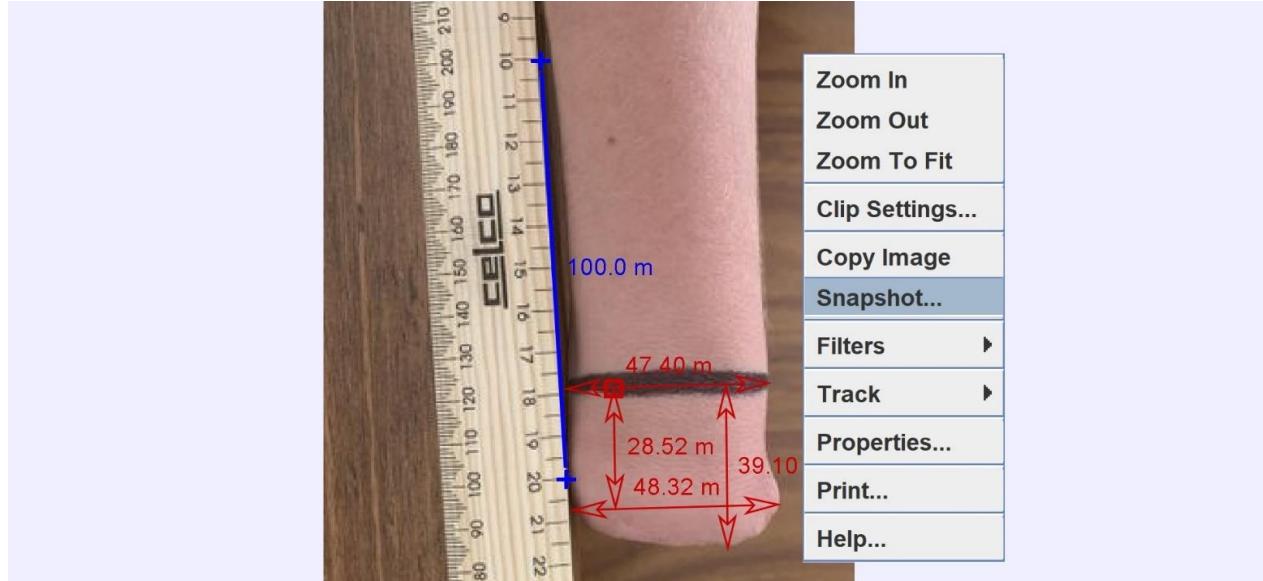
Open a fourth Tape Measure to measure between the wrist line and the **distance to the maximum palm width**.
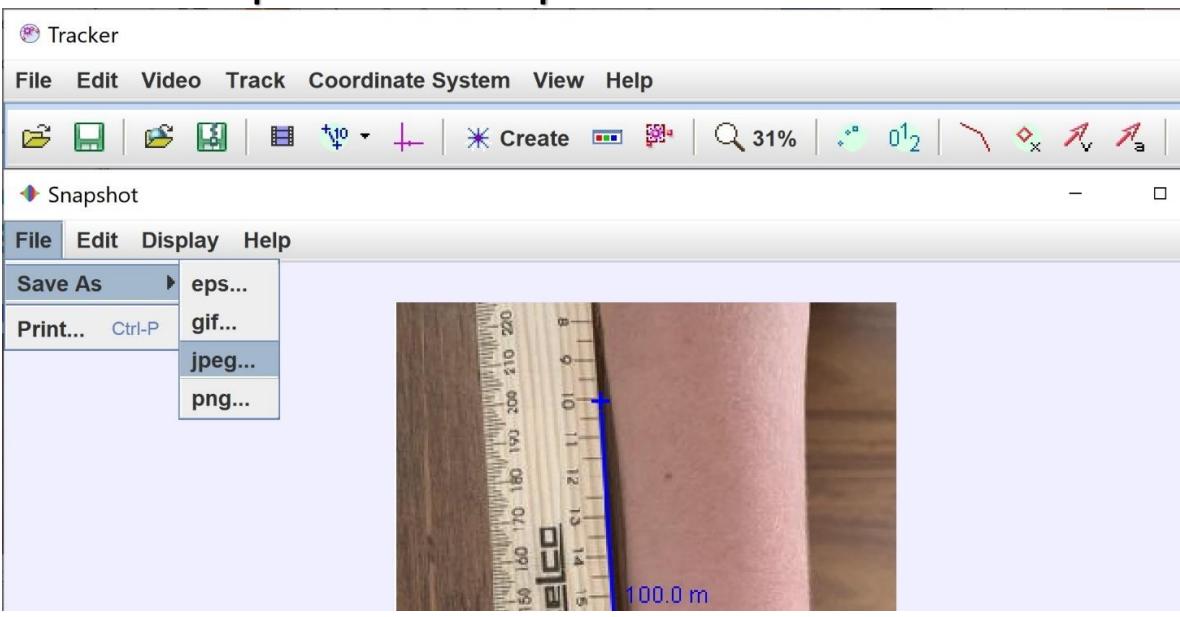
Measurement Instructions

Right-click on the photo and click on the Snapshot icon.
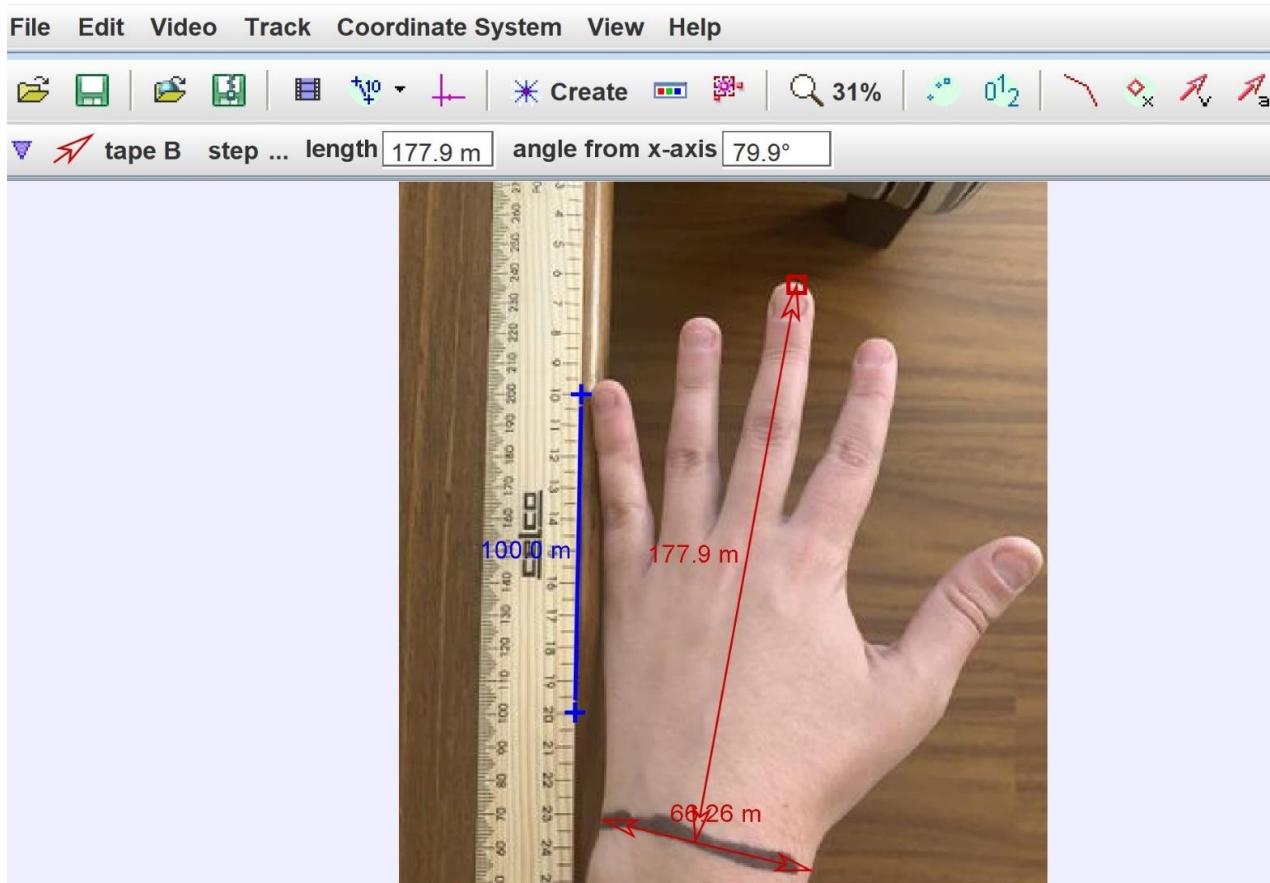
Under **File**, **Save As**, **jpeg**, save the photo for future reference during the scaling process.
Name the photo #Recipient Affected Hand Measured

M14

Measurement Instructions

Repeat Steps M3 to M9 to take measurements of the unaffected hand.

The only measurements required are the **wrist width** and the **overall hand length**.

Right-click on the photo and click on the Snapshot icon. Under **File**, **Save As**, **jpeg**, save the photo for future reference during the scaling process.

Name the photo **#Recipient Unaffected Hand Measured**

FREE3HANDS

Measurement Instructions

Record all of the measurements taken from the photos of the affected and unaffected hand.

	Wrist Width	Palm Length	Max Palm Width	Distance to Max Palm Width	Overall Hand Length
Affected Hand	46+3mm	54mm	61+3mm	39mm	
Unaffected Hand	46mm				122mm
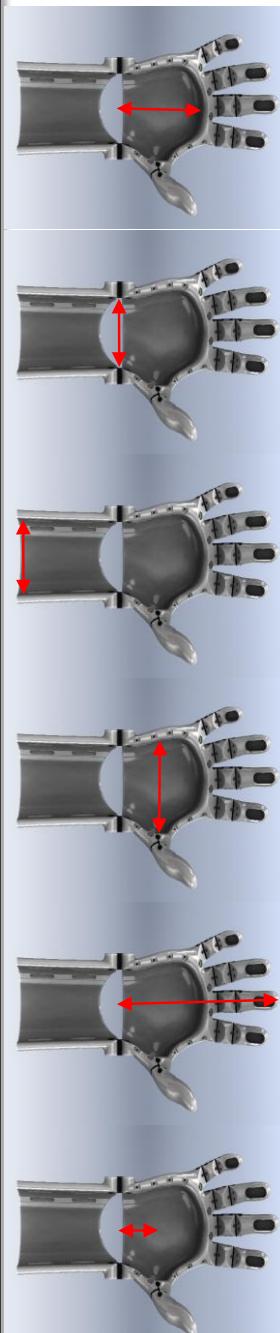
Add 3mm to the measurements for the affected hand **Wrist Width** and **Max Palm Width**, to allow for padding to protect the skin, create an antibacterial barrier and improve overall comfort when wearing the Kinetic Hand.

We recommend using a product like Tubeskin, or similar tubular compression bandage available at most pharmacies.

Size to fit joint/limb		
XS	(B)	11 – 15cm
S	(C)	15 – 25cm
M	(D)	25 – 35cm
L	(E)	35 – 45cm
XL	(F)	45 – 50cm
XXL	(G)	50 – 56cm

M16

FREE3HANDS

Hand Scaling Chart

M17

Scale	Palm length	Wrist width	Forearm width	Max palm width	Overall hand length	Distance to max palm width	Insert A	Insert B	Insert C	Insert D	Insert E
50	50	35	37	46	108	22	8	12	17	21	25
52.5	52	37	39	48	114	24	9	13	17	22	26
55	55	39	41	50	119	25	9	14	18	23	27
57.5	57	41	43	53	125	26	10	14	19	24	29
60	60	42	45	55	130	27	10	15	20	25	30
62.5	62	44	47	57	135	28	10	16	21	26	31
65	65	46	49	60	141	29	11	16	22	27	32
67.5	67	48	51	62	146	30	11	17	22	28	34
70	70	50	52	64	152	31	12	17	23	29	35
72.5	72	51	54	66	157	33	12	18	24	30	36
75	75	53	56	69	162	34	12	19	25	31	37
77.5	77	55	58	71	168	35	13	19	26	32	39
80	80	57	60	73	173	36	13	20	27	33	40
82.5	82	58	62	76	179	37	14	21	27	34	41
85	85	60	64	78	184	38	14	21	28	35	42
87.5	87	62	66	80	190	39	15	22	29	36	44
90	90	64	67	82	195	40	15	22	30	37	45
92.5	92	66	69	85	200	42	15	23	31	39	46
95	95	67	71	87	206	43	16	24	32	40	47
97.5	97	69	73	89	211	44	16	24	32	41	49
100	100	71	75	92	217	45	17	25	33	42	50

FREE3HANDS

Basic Hand Scaling (recommended)

Mark the measurements taken on the Hand Scaling Chart to assess the scaling requirements.

	Wrist Width	Palm Length	Max Palm Width	Distance to Max Palm Width	Overall Hand Length
Affected Hand	48+3mm	40mm	49+3mm	29mm	
Unaffected Hand	67mm				178mm

Hand Scaling Chart

Scale	Palm length	Wrist width	Forearm width	Max palm width	Overall hand length	Distance to max palm width	Insert A	Insert B	Insert C	Insert D	Insert E
50	50	35	37	46	108	22	8	12	17	21	25
52.5	52	37	39	48	114	24	9	13	17	22	26
55	55	39	41	50	119	25	9	14	18	23	27
57.5	57	41	43	53	125	26	10	14	19	24	29
60	60	42	45	55	130	27	10	15	20	25	30
62.5	62	44	47	57	135	28	10	16	21	26	31
65	65	46	49	60	141	29	11	16	22	27	32
67.5	67	48	51	62	146	30	11	17	22	28	34
70	70	50	52	64	152	31	12	17	23	29	35
72.5	72	51	54	66	157	33	12	18	24	30	36
75	75	53	56	69	162	34	12	19	25	31	37
77.5	77	55	58	71	168	35	13	19	26	32	39
80	80	57	60	73	173	36	13	20	27	33	40
82.5	82	58	62	76	179	37	14	21	27	34	41
85	85	60	64	78	184	38	14	21	28	35	42
87.5	87	62	66	80	190	39	15	22	29	36	44
90	90	64	67	82	195	40	15	22	30	37	45
92.5	92	66	69	85	200	42	15	23	31	39	46
95	95	67	71	87	206	43	16	24	32	40	47
97.5	97	69	73	89	211	44	16	24	32	41	49
100	100	71	75	92	217	45	17	25	33	42	50

From the measurements, circle the closest **Wrist width** value for the affected hand. This will determine the overall scale of the Kinetic Hand. In this case, the target scale will be 72.5%.

M18

FREE3HANDS

Basic Hand Scaling (recommended)

At the same scale as the **Wrist Width**, compare the value of the **design Palm length** to the measured **affected hand Palm Length**.

	Wrist Width	Palm Length	Max Palm Width	Distance to Max Palm Width	Overall Hand Length
Affected Hand	48+3mm	40mm	49+3mm	29mm	
Unaffected Hand	67mm				178mm

Hand Scaling Chart

Scale	Palm length	Wrist width	Forearm width	Max palm width	Overall hand length	Distance to max palm width	Insert A	Insert B	Insert C	Insert D	Insert E
50	50	35	37	46	108	22	8	12	17	21	25
52.5	52	37	39	48	114	24	9	13	17	22	26
55	55	39	41	50	119	25	9	14	18	23	27
57.5	57	41	43	53	125	26	10	14	19	24	29
60	60	42	45	55	130	27	10	15	20	25	30
62.5	62	44	47	57	135	28	10	16	21	26	31
65	65	46	49	60	141	29	11	16	22	27	32
67.5	67	48	51	62	146	30	11	17	22	28	34
70	70	50	52	64	152	31	12	17	23	29	35
72.5	72	51	54	66	157	33	12	18	24	30	36
75	75	53	56	69	162	34	12	19	25	31	37
77.5	77	55	58	71	168	35	13	19	26	32	39
80	80	57	60	73	173	36	13	20	27	33	40
82.5	82	58	62	76	179	37	14	21	27	34	41
85	85	60	64	78	184	38	14	21	28	35	42
87.5	87	62	66	80	190	39	15	22	29	36	44
90	90	64	67	82	195	40	15	22	30	37	45
92.5	92	66	69	85	200	42	15	23	31	39	46
95	95	67	71	87	206	43	16	24	32	40	47
97.5	97	69	73	89	211	44	16	24	32	41	49
100	100	71	75	92	217	45	17	25	33	42	50

Eg. 72mm - 40mm= **32mm** space in the Palm. From this value, select the closest size soft insert for that scale to fill the void. In this case, 30mm **Insert D**.

M19

Basic Hand Scaling (recommended)

In this case, we will make a RH 72.5% Kinetic Hand, with Insert D, using the basic uniform scaling method.

RH72.5% Insert D	Wrist Width	Palm Length	Max Palm Width	Distance to Max Palm Width	Overall Hand Length
Affected Hand	48+3mm	40mm	49+3mm	29mm	
Unaffected Hand	67mm				178mm

Hand Scaling Chart

Scale	Palm length	Wrist width	Forearm width	Max palm width	Overall hand length	Distance to max palm width	Insert A	Insert B	Insert C	Insert D	Insert E
50	50	35	37	46	108	22	8	12	17	21	25
52.5	52	37	39	48	114	24	9	13	17	22	26
55	55	39	41	50	119	25	9	14	18	23	27
57.5	57	41	43	53	125	26	10	14	19	24	29
60	60	42	45	55	130	27	10	15	20	25	30
62.5	62	44	47	57	135	28	10	16	21	26	31
65	65	46	49	60	141	29	11	16	22	27	32
67.5	67	48	51	62	146	30	11	17	22	28	34
70	70	50	52	64	152	31	12	17	23	29	35
72.5	72	51	54	66	157	33	12	18	24	30	36
75	75	53	56	69	162	34	12	19	25	31	37
77.5	77	55	58	71	168	35	13	19	26	32	39
80	80	57	60	73	173	36	13	20	27	33	40
82.5	82	58	62	76	179	37	14	21	27	34	41
85	85	60	64	78	184	38	14	21	28	35	42
87.5	87	62	66	80	190	39	15	22	29	36	44
90	90	64	67	82	195	40	15	22	30	37	45
92.5	92	66	69	85	200	42	15	23	31	39	46
95	95	67	71	87	206	43	16	24	32	40	47
97.5	97	69	73	89	211	44	16	24	32	41	49
100	100	71	75	92	217	45	17	25	33	42	50

The overall hand length of the Kinetic Hand will be 21mm shorter than the unaffected hand.
(178mm-157mm = **21mm**)

M20

Advanced Hand Scaling

Advanced scaling can be done to match the overall hand length of the Kinetic Hand to the unaffected hand. **Warning: This may affect Kinetic Hand function.**

|	Wrist Width	Palm Length	Max Palm Width	Distance to Max Palm Width	Overall Hand Length
Affected Hand	48+3mm	40mm	49+3mm	29mm	
Unaffected Hand	67mm				178mm

Hand Scaling Chart

Scale	Palm length	Wrist width	Forearm width	Max palm width	Overall hand length	Distance to max palm width	Insert A	Insert B	Insert C	Insert D	Insert E
50	50	35	37	46	108	22	8	12	17	21	25
52.5	52	37	39	48	114	24	9	13	17	22	26
55	55	39	41	50	119	25	9	14	18	23	27
57.5	57	41	43	53	125	26	10	14	19	24	29
60	60	42	45	55	130	27	10	15	20	25	30
62.5	62	44	47	57	135	28	10	16	21	26	31
65	65	46	49	60	141	29	11	16	22	27	32
67.5	67	48	51	62	146	30	11	17	22	28	34
70	70	50	52	64	152	31	12	17	23	29	35
72.5	72	51	54	66	157	33	12	18	24	30	36
75	75	53	56	69	162	34	12	19	25	31	37
77.5	77	55	58	71	168	35	13	19	26	32	39
80	80	57	60	73	173	36	13	20	27	33	40
82.5	82	58	62	76	179	37	14	21	27	34	41
85	85	60	64	78	184	38	14	21	28	35	42
87.5	87	62	66	80	190	39	15	22	29	36	44
90	90	64	67	82	195	40	15	22	30	37	45
92.5	92	66	69	85	200	42	15	23	31	39	46
95	95	67	71	87	206	43	16	24	32	40	47
97.5	97	69	73	89	211	44	16	24	32	41	49
100	100	71	75	92	217	45	17	25	33	42	50

From the measurements, circle the closest **Wrist width** value for the affected hand, and the target value for the **Overall hand length** of the unaffected hand.

Advanced Hand Scaling

At the same scale as the target **Overall hand length**, compare the value of the **design Palm length** to the measured **affected hand Palm Length**.

	Wrist Width	Palm Length	Max Palm Width	Distance to Max Palm Width	Overall Hand Length
Affected Hand	48+3mm	40mm	49+3mm	29mm	
Unaffected Hand	67mm				178mm

Hand Scaling Chart

| Scale	Palm length	Wrist width	Forearm width	Max palm width	Overall hand length	Distance to max palm width	Insert A	Insert B	Insert C	Insert D	Insert E
50	50	35	37	46	108	22	8	12	17	21	25
52.5	52	37	39	48	114	24	9	13	17	22	26
55	55	39	41	50	119	25	9	14	18	23	27
57.5	57	41	43	53	125	26	10	14	19	24	29
60	60	42	45	55	130	27	10	15	20	25	30
62.5	62	44	47	57	135	28	10	16	21	26	31
65	65	46	49	60	141	29	11	16	22	27	32
67.5	67	48	51	62	146	30	11	17	22	28	34
70	70	50	52	64	152	31	12	17	23	29	35
72.5	72	51	54	66	157	33	12	18	24	30	36
75	75	53	56	69	162	34	12	19	25	31	37
77.5	77	55	58	71	168	35	13	19	26	32	39
80	80	57	60	73	173	36	13	20	27	33	40
82.5	82	58	62	76	179	37	14	21	27	34	41
85	85	60	64	78	184	38	14	21	28	35	42
87.5	87	62	66	80	190	39	15	22	29	36	44
90	90	64	67	82	195	40	15	22	30	37	45
92.5	92	66	69	85	200	42	15	23	31	39	46
95	95	67	71	87	206	43	16	24	32	40	47
97.5	97	69	73	89	211	44	16	24	32	41	49
100	100	71	75	92	217	45	17	25	33	42	50

Eg. 82mm - 40mm= **42mm** space in the palm. From this value, select the closest size soft insert for that scale to fill the void. In this case, **Insert E**.

M22

FREE 3 HANDS
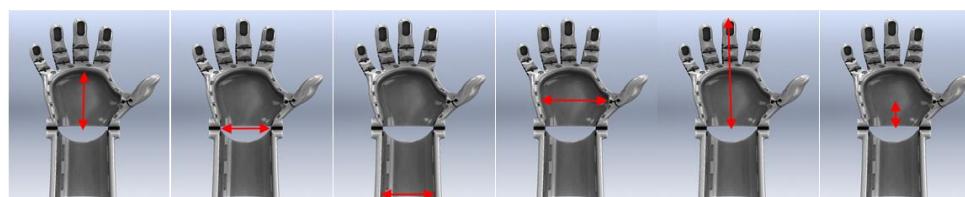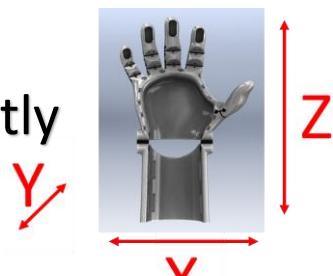
Advanced Hand Scaling

In this case, it can be seen that in order to achieve a realistic hand size, as well as a good fit at the wrist, the Kinetic Hand needs to be scaled differently in each direction. Wrist Width is affected by scaling in the XY direction, and overall hand length is affected by scaling in the Z direction.
(The Y direction may be scaled differently to change the depth of the Palm.)

Y

Z

X

Hand Scaling Chart

Scale	Palm length	Wrist width	Forearm width	Max palm width	Overall hand length	Distance to max palm width	Insert A	Insert B	Insert C	Insert D	Insert E
50	50	35	37	46	108	22	8	12	17	21	25
52.5	52	37	39	48	114	24	9	13	17	22	26
55	55	39	41	50	119	25	9	14	18	23	27
57.5	57	41	43	53	125	26	10	14	19	24	29
60	60	42	45	55	130	27	10	15	20	25	30
62.5	62	44	47	57	135	28	10	16	21	26	31
65	65	46	49	60	141	29	11	16	22	27	32
67.5	67	48	51	62	146	30	11	17	22	28	34
70	70	50	52	64	152	31	12	17	23	29	35
72.5	72	51	54	66	157	33	12	18	24	30	36
75	75	53	56	69	162	34	12	19	25	31	37
77.5	77	55	58	71	168	35	13	19	26	32	39
80	80	57	60	73	173	36	13	20	27	33	40
82.5	82	58	62	76	179	37	14	21	27	34	41
85	85	60	64	78	184	38	14	21	28	35	42
87.5	87	62	66	80	190	39	15	22	29	36	44
90	90	64	67	82	195	40	15	22	30	37	45
92.5	92	66	69	85	200	42	15	23	31	39	46
95	95	67	71	87	206	43	16	24	32	40	47
97.5	97	69	73	89	211	44	16	24	32	41	49
100	100	71	75	92	217	45	17	25	33	42	50

XY = 72.5%   Z = 82.5%

M23

FREE3HANDS

Below are the Kinetic Hands made from the previous **Basic Scaling** and **Advanced Scaling** examples.

Advanced Method:
Scaling X: 72.5%
Scaling Y: 72.5%
Scaling Z: **82.5%**

Basic Method:
Scaling X: 72.5%
Scaling Y: 72.5%
Scaling Z: **72.5%**

M24

As shown below, there are many levels and degrees of hand difference, and scaling to suit each case can be very difficult.

To accommodate some of the levels of hand difference, we have included some variants of the **Palm** that we have used.
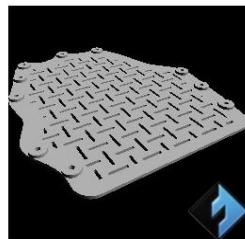
Palm (100%, no little finger)
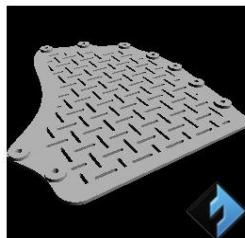
Palm (100%, no thumb or index finger)
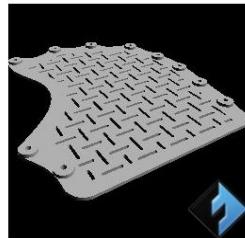
Palm (100%, no thumb)

Palm cover (100%, no little finger)

Palm cover (100%, no thumb or index

Palm cover (100%, no thumb)

M25
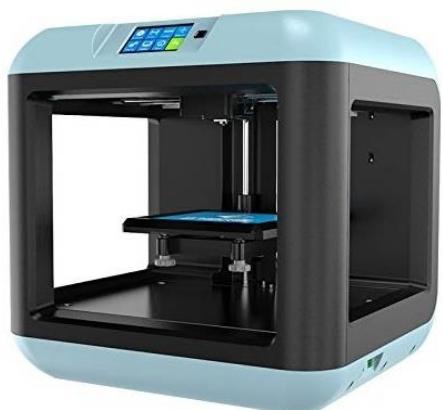
Kinetic Hand

Appendix 2
3D Printing Guide

FREE3 HANDS

3D Printer Recommendations

At Free 3D Hands, we use two models of 3D printer, which are both low cost, but deliver high quality and consistent results.

Flashforge Finder Lite
140 x 140 x 140mm (X,Y,Z)
Amazon AU, AUD$469

Despite it's small build volume, it is able to print all sizes of hand from 50% to 100% scale.
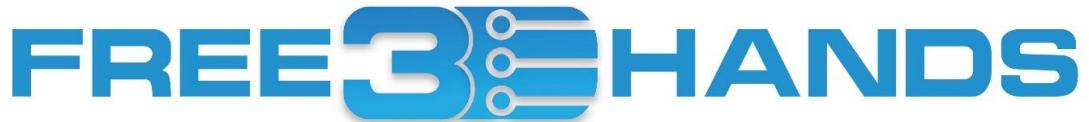
Flashforge Creator Pro
225 x 145 x 150mm (X,Y,Z)
Amazon AU, AUD$999

With the addition of a heated platform and larger build volume, it is able to produce other larger assistive devices as well as hands.

FREE3HANDS

3D Printing Filament Recommendations

NinjaTek NinjaFlex 85A Midnight 0.5kg 1.75mm

Used for flexible parts like hinges. Compared with other TPU flexible filaments, this brand has the highest elasticity, durability and print quality.
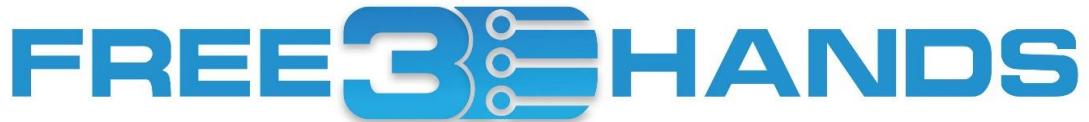
https://www.3dprintergear.com.au AUD$46/0.5kg

PLA+ filament 1.75mm-1kg

Used for rigid parts like the palm and fingers. We recommend using a high quality PLA, or PLA+ for additional strength. This brand prints extremely well without parts warping.

https://3dfillies.com
AUD$27/kg

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3D Printing Software Recommendations

The following suggested 3D print /slicer settings are optimal in our experience for the Flashforge Creator Pro and Finder Lite 3D printers. These settings may require adjustment for different models and brands of 3D printer.

Visit www.flashforge.com/download-center and download a free program called Flashprint that can be used with all Flashforge 3D printers. Select the correct installer from the list for your operating system

flashforge.com/download-center
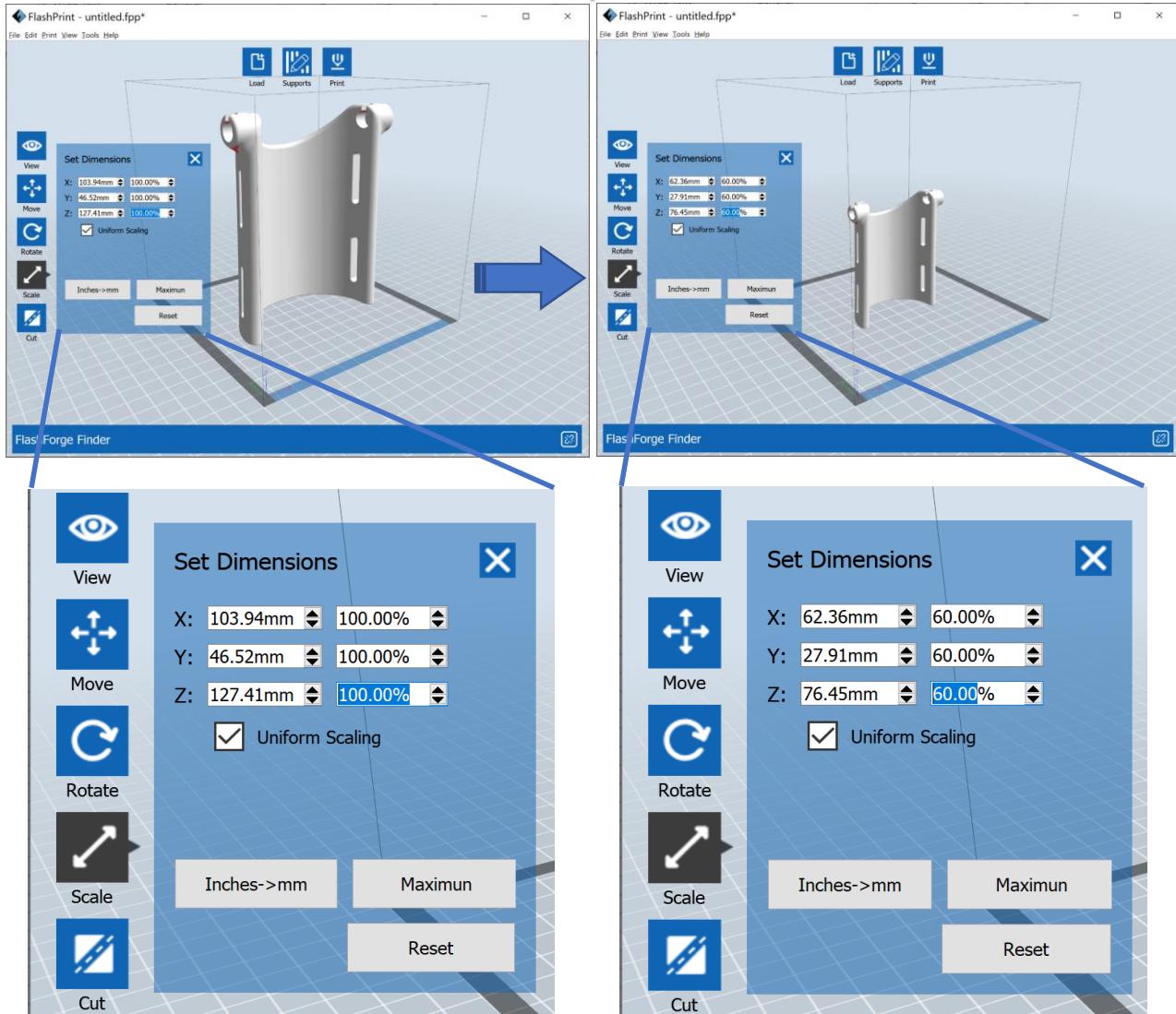
flashforge.com/download-center

hforge users, as we are going to upgrade our FlashCloud in the coming few days, it will not be allowed for you to access the site https://cloud.sz3dp.com/ or connect the FlashCloud with your printers. The web

FLASHFORGE
3D PRINTER

Solution   Professional   Consumer   Material   Software   Support   Contact Us   Shop

Feedback

Download Center

All Category
User Guide
Quick Start
FlashPrint Download
FlashAD

FlashPrint 4.4.0
Software Version : 4.4.0
Software Size : 28.67 MB
Upload date : 2020-08-25
Support System : win64

How to Scale the Part Files in Flashprint

All downloaded part files are scaled at 100% size, as a maximum size to print for a large adult's hand. Parts can be scaled down to 55%, as a minimum size for a small child's hand. Use the **Hand Scaling Chart** to determine the size for all parts to be scaled to. Use the **Scale** tool in Flashprint shown below:
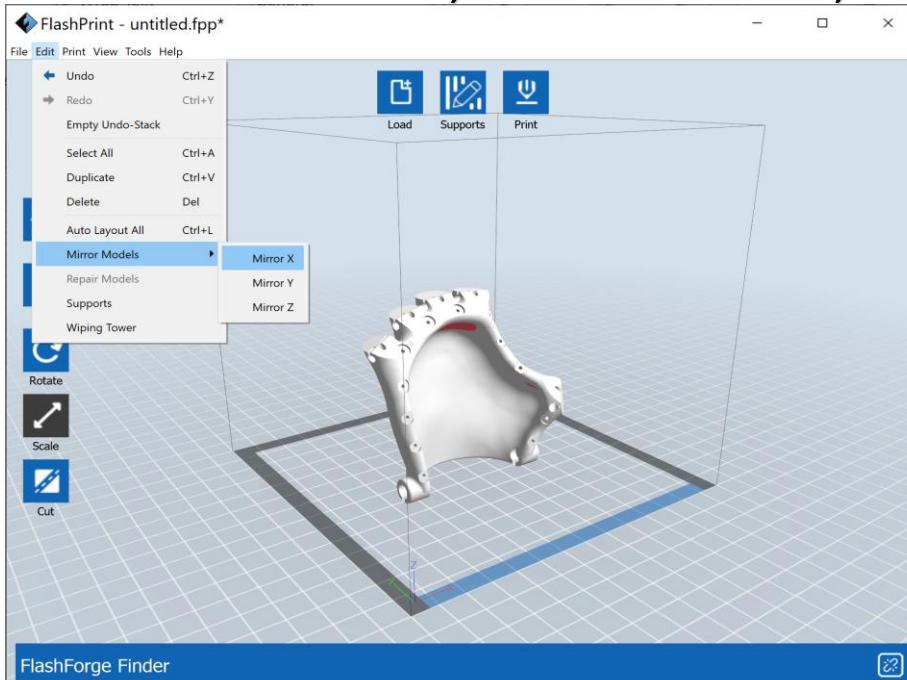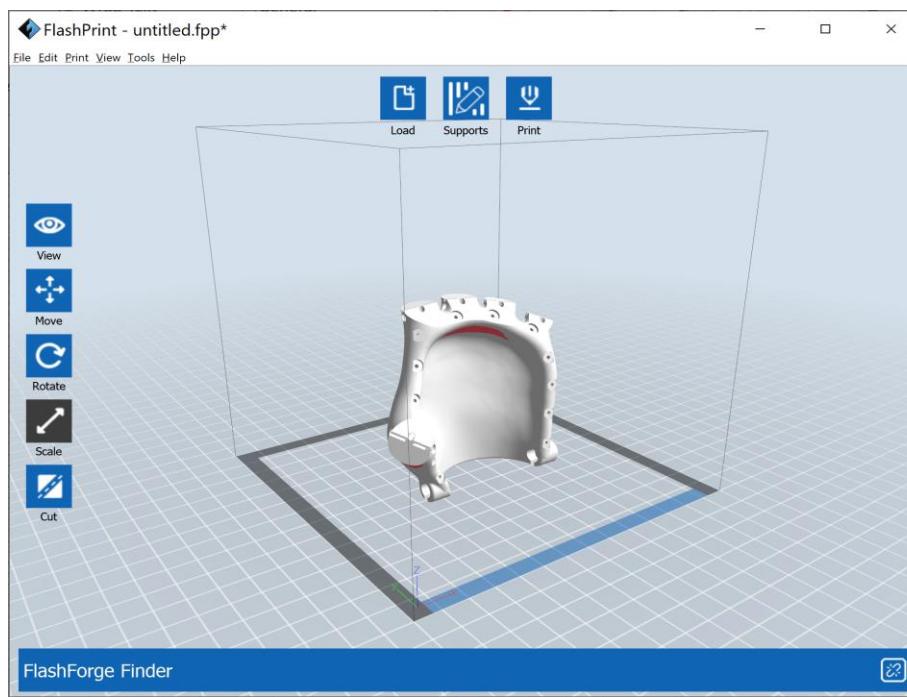
How to Mirror the Part Files in Flashprint
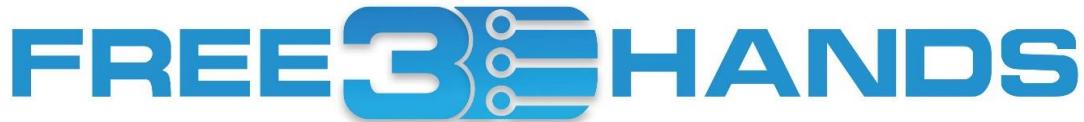
All design files provided are right hand models. To make a left hand, **all** files will need to be mirrored under the **Edit** tab, **Mirror Models**, **Mirror X**.

Standard RH, re-sized to 60% scale.
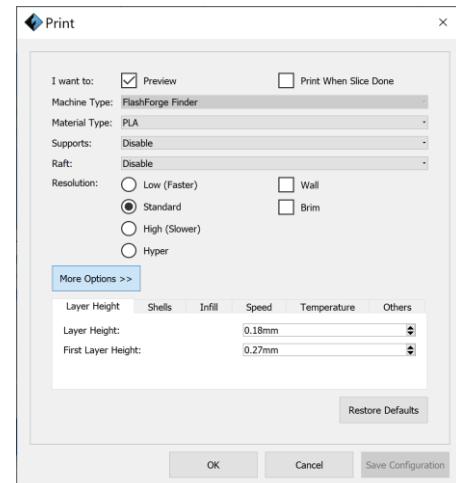
Mirrored LH, re-sized to 60% scale.

3D Printing Setting Recommendations
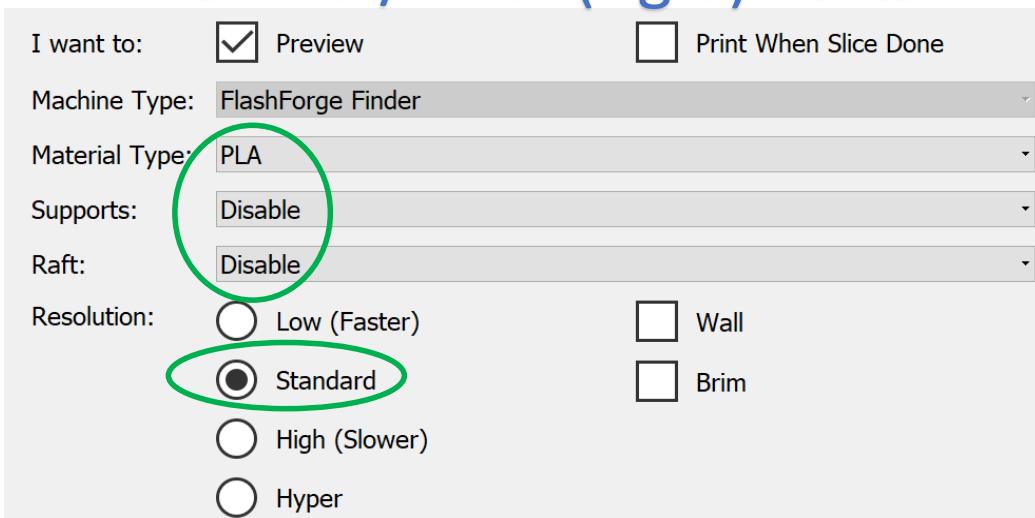
All parts have been designed to be printed **without** any support material, brim or raft.

Load **Supports** **Print**

Once scaled and mirrored to the correct size, click on the Print icon to open the print settings box.

The print settings for rigid PLA are very different to flexible Ninjaflex. Please pay close attention when creating (slicing) the files for each.

3D Printing Setting Recommendations for PLA/PLA+ (rigid) Parts

I want to:	☑ Preview		☐ Print When Slice Done
Machine Type:	FlashForge Finder		
Material Type:	PLA		
Supports:	Disable		
Raft:	Disable		
Resolution:	○ Low (Faster)	☐ Wall	
	◉ Standard	☐ Brim	
	○ High (Slower)		
	○ Hyper		

FREE3HANDS

3D Printing Setting Recommendations for PLA/PLA+ (rigid) Parts

Click on the More Options tab to enter print settings

More Options >>					
Layer Height	Shells	Infill	Speed	Temperature	Others

Layer Height: 0.18mm
First Layer Height: 0.27mm

Layer Height	Shells	Infill	Speed	Temperature	Others

Layer Height: 0.18mm
First Layer Height: 0.27mm
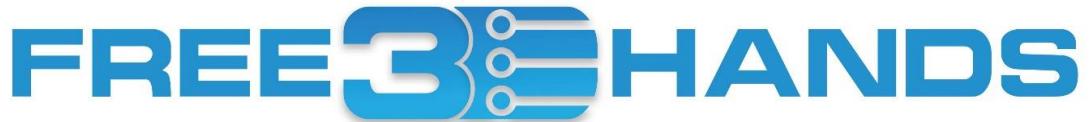
Layer Height	Shells	Infill	Speed	Temperature	Others

Perimeter Shells: 2
Top Solid Layers: 3
Bottom Solid Layers: 3

Layer Height	Shells	Infill	Speed	Temperature	Others

Fill Density: 40%
Fill Pattern: Hexagon
Combine Infill: Every 2 Layers

Layer Height	Shells	Infill	Speed	Temperature	Others

Print Speed: 60mm/s
Travel Speed: 80mm/s

Layer Height	Shells	Infill	Speed	Temperature	Others

Extruder: 220°C

Extruder temperature may vary between 200C and 225C for different brands of PLA/PLA+

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FREE3HANDS
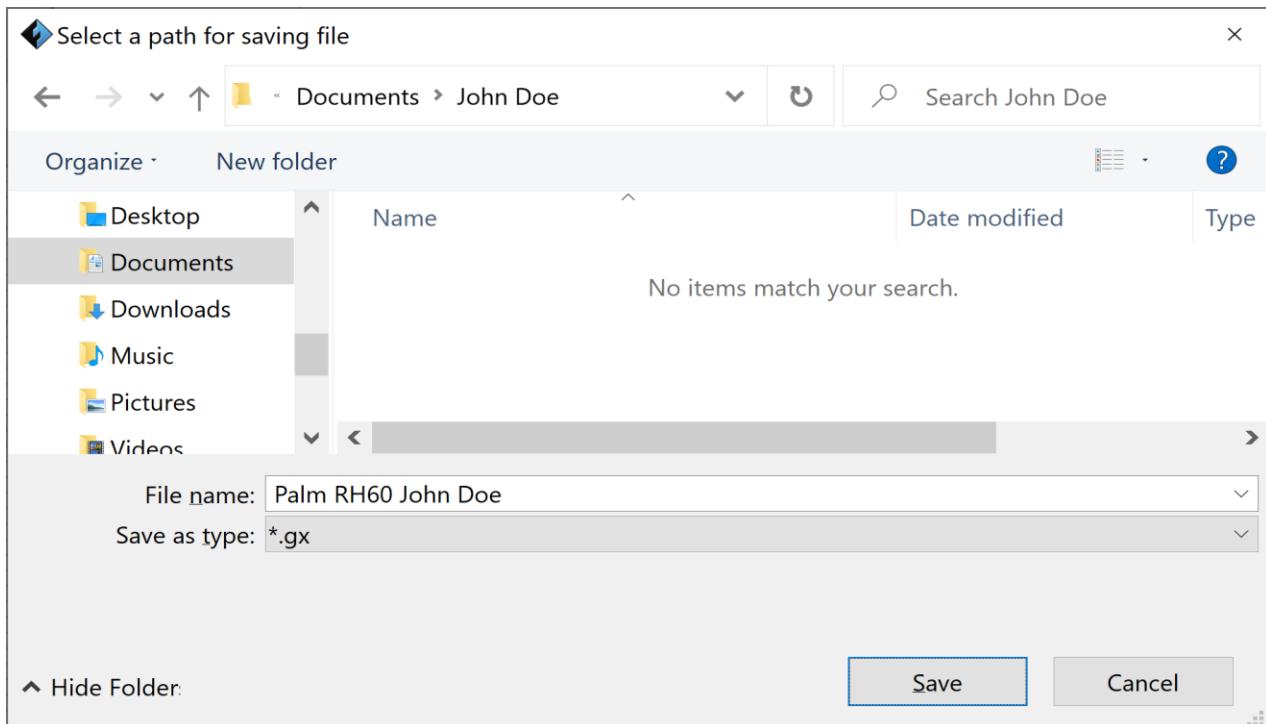
3D Printing Setting Recommendations for Ninjaflex (flexible) Parts
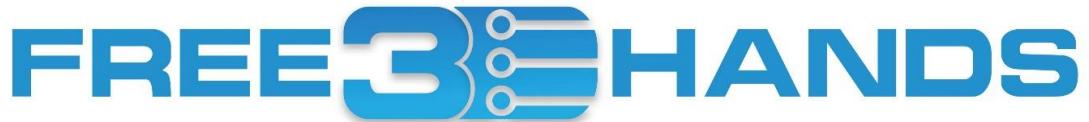
Machine Type:	FlashForge Finder
Material Type:	Flexible Filament
Supports:	Disable
Raft:	Disable

Resolution:
- ○ Low (Faster)
- ● Standard
- ○ High (Slower)

☐ Wall
☐ Brim

| Layer Height | Shells | Infill | Speed | Temperature | Others |

Layer Height:	0.18mm
First Layer Height:	0.27mm

| Layer Height | **Shells** | Infill | Speed | Temperature | Others |

Perimeter Shells:	2
Top Solid Layers:	3
Bottom Solid Layers:	3

| Layer Height | Shells | **Infill** | Speed | Temperature | Others |

Fill Density:	100%
Fill Pattern:	Hexagon
Combine Infill:	Every 2 Layers

| Layer Height | Shells | Infill | **Speed** | Temperature | Others |

Print Speed:	20mm/s
Travel Speed:	70mm/s

| Layer Height | Shells | Infill | Speed | **Temperature** | Others |

Extruder:	230°C

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FREE3HANDS

Saving Print Files from Flashprint

We suggest to create a folder with the recipients name to save all print files into. It is also wise to rename the files to include details such as the side **RH** or **LH**, the **scale** and **recipients name**. If this isn't done, print files may be incorrectly printed in the wrong material or to the wrong scale for the recipient.
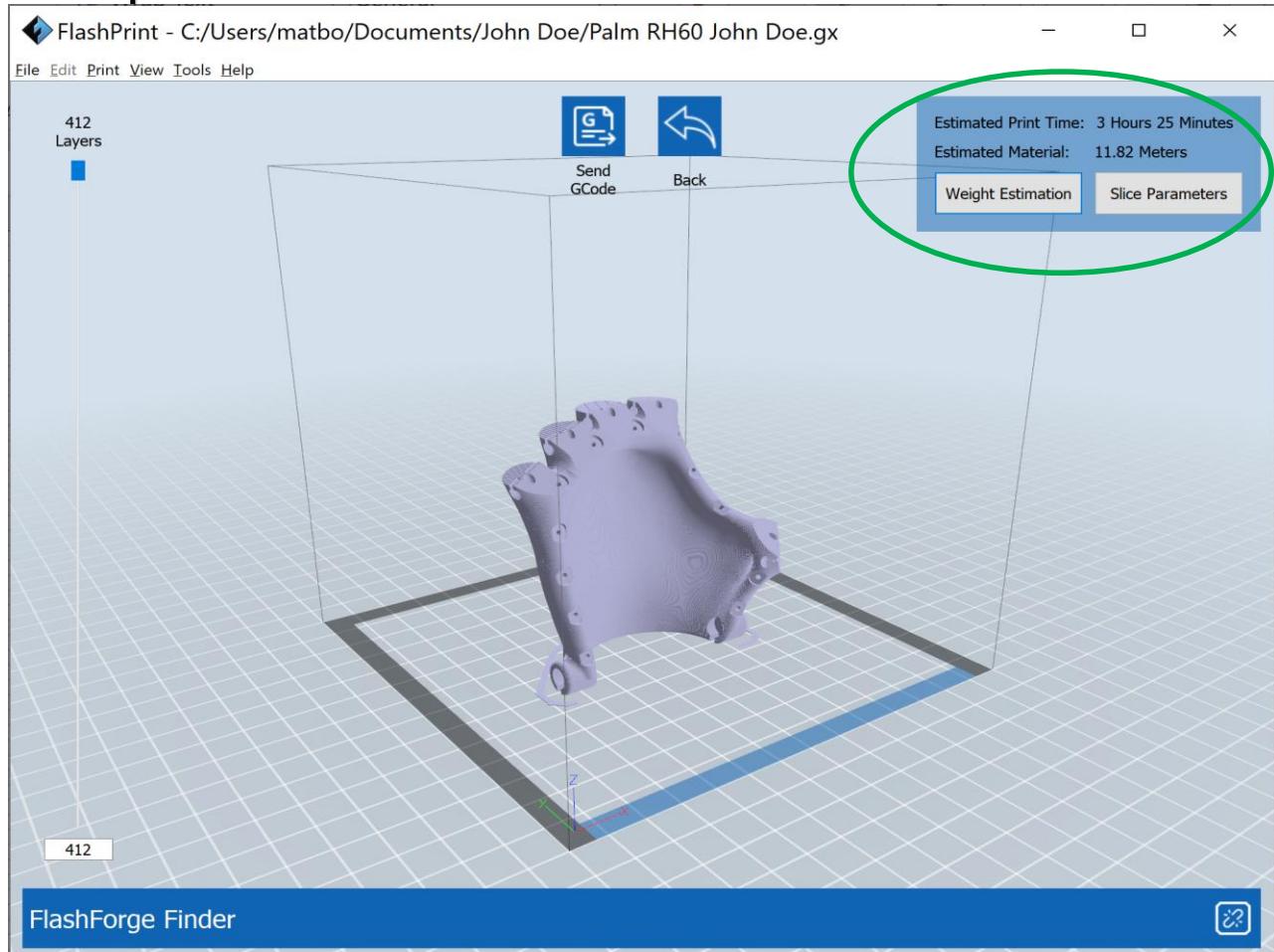
Eg. Rename **Palm (100%)** to **Palm RH60 John Doe**

Saving Print Files from Flashprint

Once the file is saved, Flashprint will slice the file into layers and provide an estimated print time. Other information such as weight estimation and slice parameters can also be accessed.

**FlashPrint - C:/Users/matbo/Documents/John Doe/Palm RH60 John Doe.gx**

File Edit Print View Tools Help

412 Layers

Send GCode

Back

Estimated Print Time: 3 Hours 25 Minutes
Estimated Material: 11.82 Meters

Weight Estimation   Slice Parameters

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FlashForge Finder

Weight Estimation
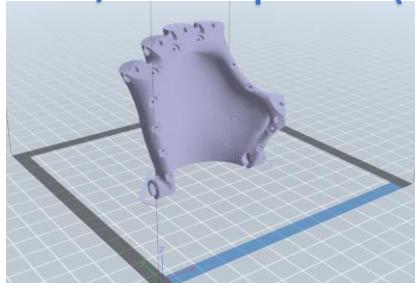
Filament Length:	11.82 Meters
Material Type:	PLA
Material Density:	1.24g/cm^3
Estimated Weight:	35.26g

Slice Parameters
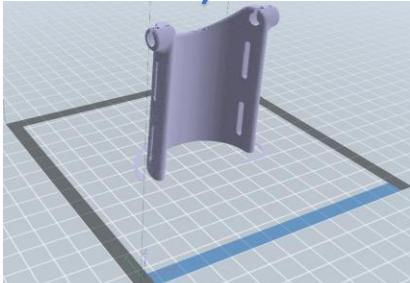
Layer Height:	0.18mm
Perimeter Shells:	2
Fill Density:	40%
Fill Pattern:	Hexagon
Print Speed:	60mm/s
Travel Speed:	80mm/s
Extruder:	220°C

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Print File Summary (Eg. For RH60 Hand)
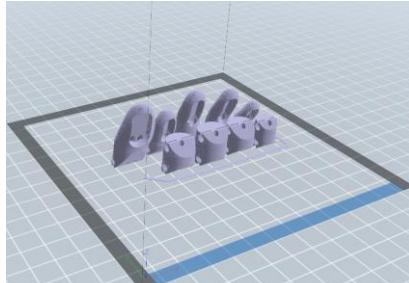
PLA/PLA+ parts (40% infill)
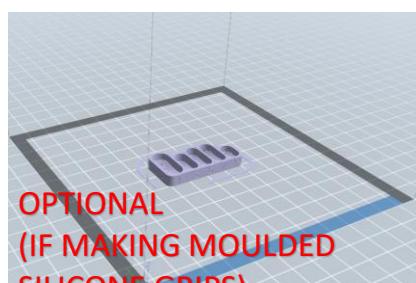
Palm RH60 (3h35m)

Gauntlet RH60 (2h15m)

Finger Plate RH60 (2h7m)
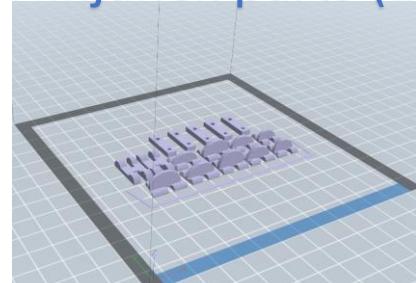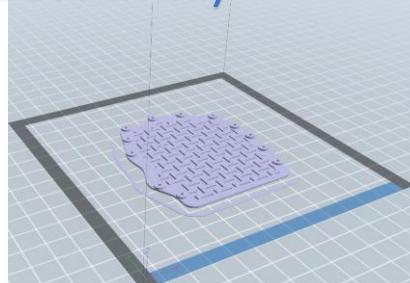
OPTIONAL
(IF MAKING MOULDED SILICONE GRIPS)
Silicone Mould RH60 (0h22m)

Gauntlet Cover RH60 (0h43m)

|	
Layer Height:	0.18mm
Perimeter Shells:	2
Fill Density:	40%
Fill Pattern:	Hexagon
Print Speed:	60mm/s
Travel Speed:	80mm/s
Extruder:	220°C

Ninjaflex parts (100% infill)
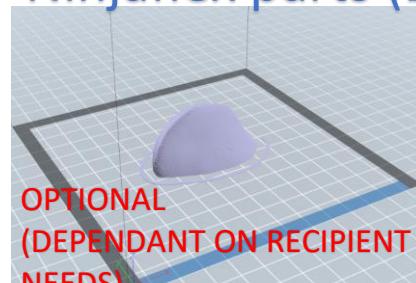
Hinge Plate RH60 (1h42m)
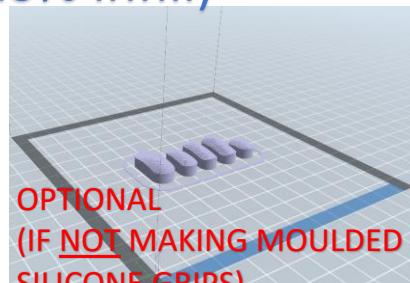
Palm Cover RH60 (1h29m)

Layer Height:	0.18mm
Perimeter Shells:	2
Fill Density:	100%
Fill Pattern:	Line
Print Speed:	20mm/s
Travel Speed:	70mm/s
Extruder:	230°C

Ninjaflex parts (10% infill)

OPTIONAL
(DEPENDANT ON RECIPIENT NEEDS)
Insert A,B,C or D RH60 (1h3m)
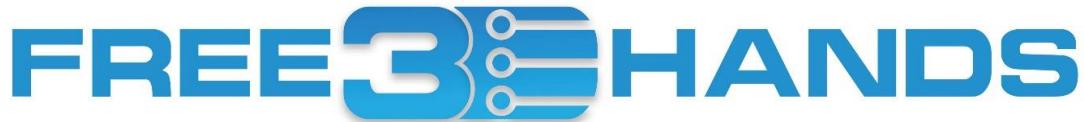
OPTIONAL
(IF NOT MAKING MOULDED SILICONE GRIPS)
Grip Plate RH60 (0h26m)

Layer Height:	0.18mm
Perimeter Shells:	2
Fill Density:	10%
Fill Pattern:	Line
Print Speed:	20mm/s
Travel Speed:	70mm/s
Extruder:	230°C

Note: All parts printed with **no raft, no supports, no brim**.
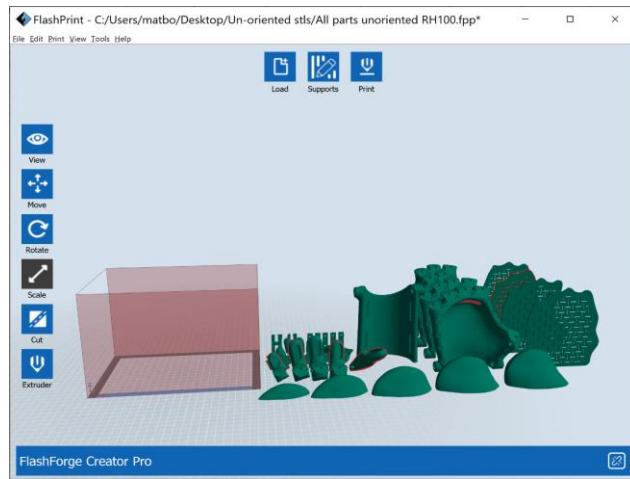
Advanced Customised Hand Scaling

It is highly recommended to print parts in uniform scaling. However, depending on certain hand differences, the design files may need to be scaled differently in x, y and z directions. This is a little more difficult and requires some additional steps before outputting the print files.

It is possible to apply scaling in different directions if the parts are oriented in the CAD model position as opposed to the print orientation. Once parts are scaled correctly, then they can be placed back into the best orientation for printing. (Refer to **P11**)

The following steps show how to do this.
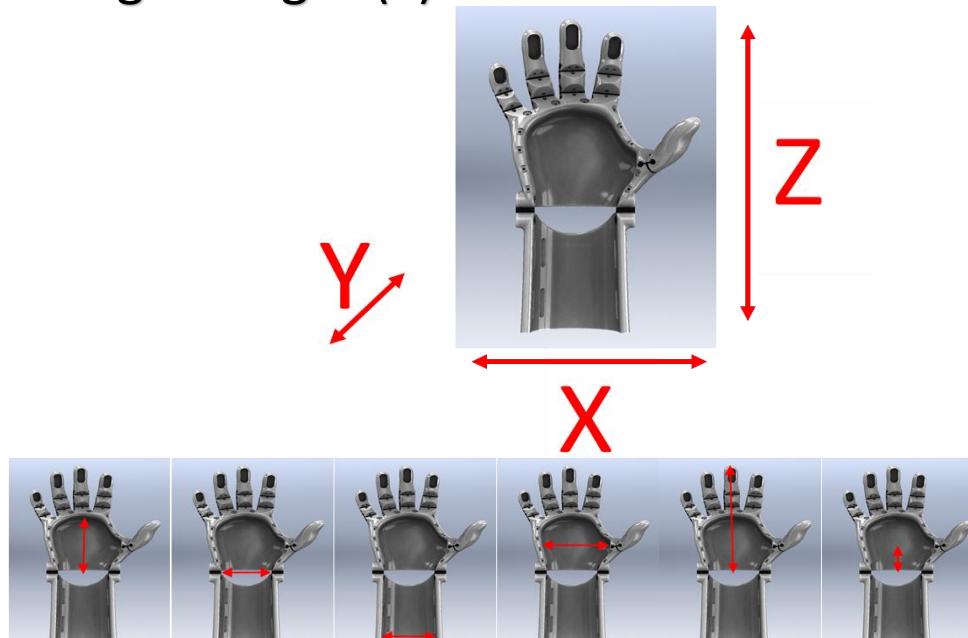
We have created a Flashprint Factory File (.fpp) called "**All parts un-oriented RH100**" which loads all the parts and palm variants to the side of the build platform ready for customised scaling in the CAD orientation.

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## Advanced Customised Hand Scaling

As per the example in the Measurement Instructions, we may want to make a hand that best matches the wrist width of the affected hand (X) but also matches the target length (Z) of the unaffected hand.

Z

Y

X

Hand Scaling Chart

| Scale	Palm length	Wrist width	Forearm width	Max palm width	Overall hand length	Distance to max palm width	Insert A	Insert B	Insert C	Insert D	Insert E
50	50	35	37	46	108	22	8	12	17	21	25
52.5	52	37	39	48	114	24	9	13	17	22	26
55	55	39	41	50	119	25	9	14	18	23	27
57.5	57	41	43	53	125	26	10	14	19	24	29
60	60	42	45	55	130	27	10	15	20	25	30
62.5	62	44	47	57	135	28	10	16	21	26	31
65	65	46	49	60	141	29	11	16	22	27	32
67.5	67	48	51	62	146	30	11	17	22	28	34
70	70	50	52	64	152	31	12	17	23	29	35
72.5	72	51	54	66	157	33	12	18	24	30	36
75	75	53	56	69	162	34	12	19	25	31	37
77.5	77	55	58	71	168	35	13	19	26	32	39
80	80	57	60	73	173	36	13	20	27	33	40
82.5	82	58	62	76	179	37	14	21	27	34	41
85	85	60	64	78	184	38	14	21	28	35	42
87.5	87	62	66	80	190	39	15	22	29	36	44
90	90	64	67	82	195	40	15	22	30	37	45
92.5	92	66	69	85	200	42	15	23	31	39	46
95	95	67	71	87	206	43	16	24	32	40	47
97.5	97	69	73	89	211	44	16	24	32	41	49
100	100	71	75	92	217	45	17	25	33	42	50

X = 72.5%   Z = 82.5%   P13

Advanced Customised Hand Scaling

Select all of the parts by clicking **CTRL+A** and navigate to the **Scale** tab. It will show that all parts are scaled to 100% in all directions.
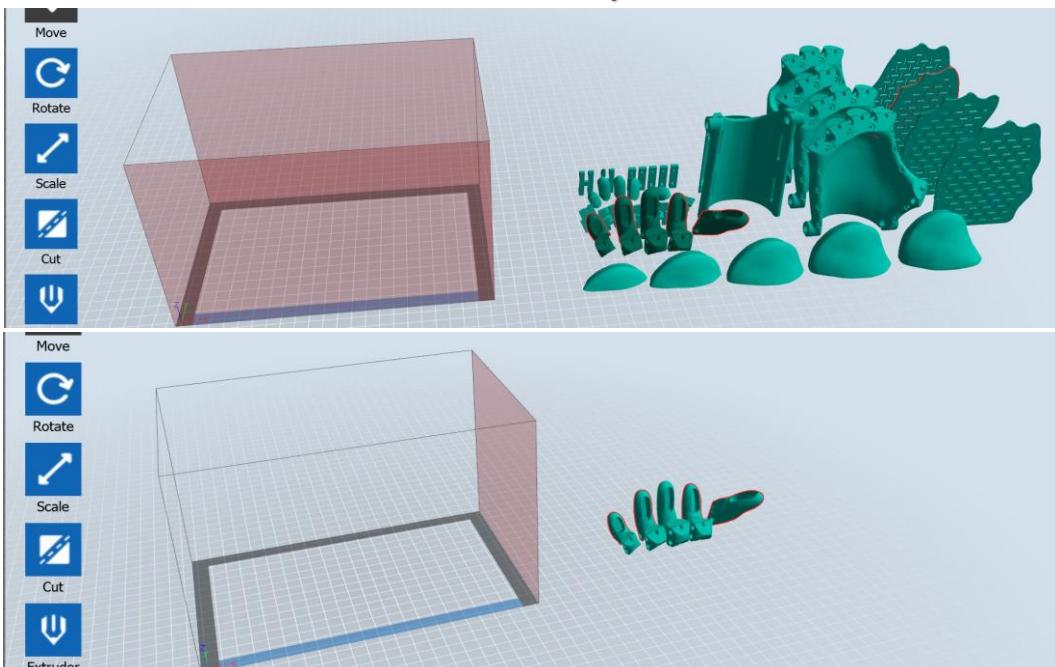
Un-check the **Uniform Scaling** box, and change the scaling percentages for x, y and z directions as required.
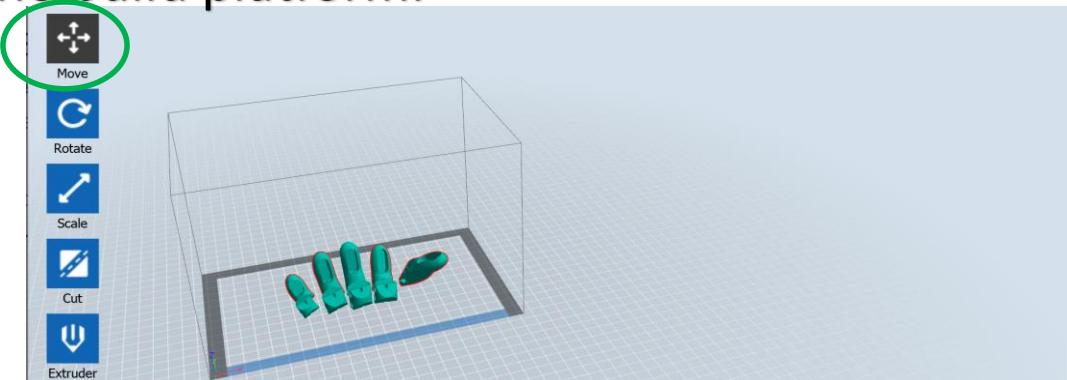
Advanced Customised Hand Scaling

Before proceeding, click **Save-as** to create a custom scaled .FPP file, renaming it accordingly.

Holding the **Ctrl** key, unselect the scaled parts that you would like to create a single print file for. For example, a custom **Finger Plate**. Once unselected, click **Delete** to isololate these parts.
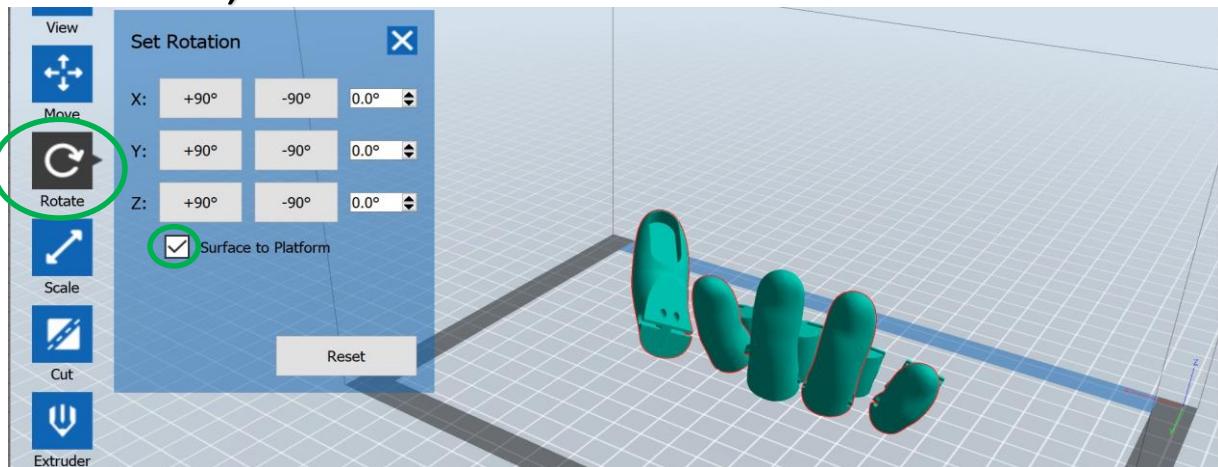

After clicking on the **Move** tab, drag the parts onto the build platform.
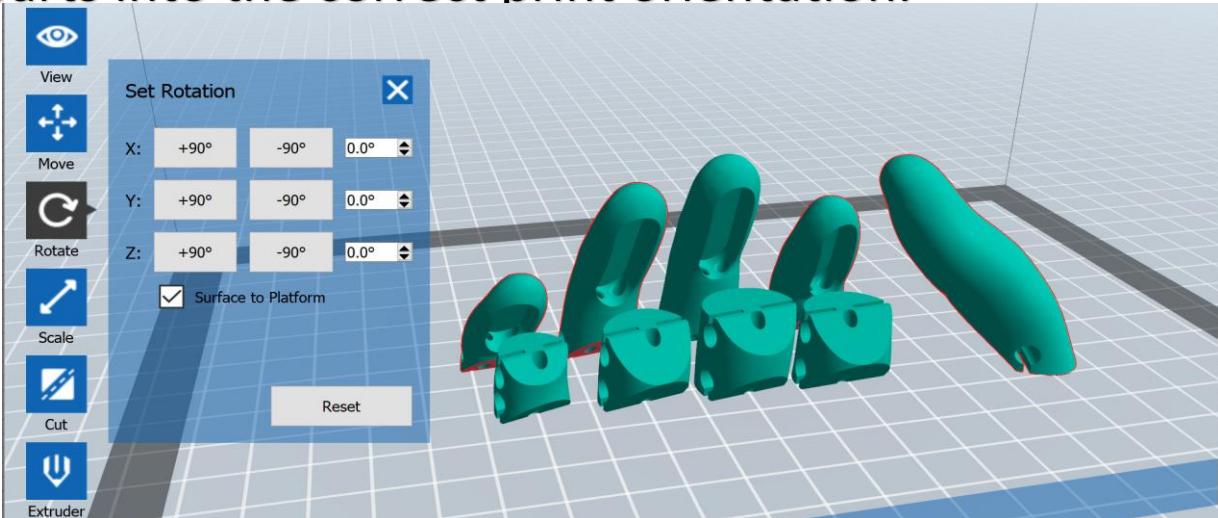
Advanced Customised Hand Scaling

The parts now need to be re-oriented into the correct printing orientation. After clicking on the **Rotate** tab, click the **Surface to Platform** check-box.

Double-click on the surface of each part that needs to sit on the platform to orient the custom scaled parts into the correct print orientation.
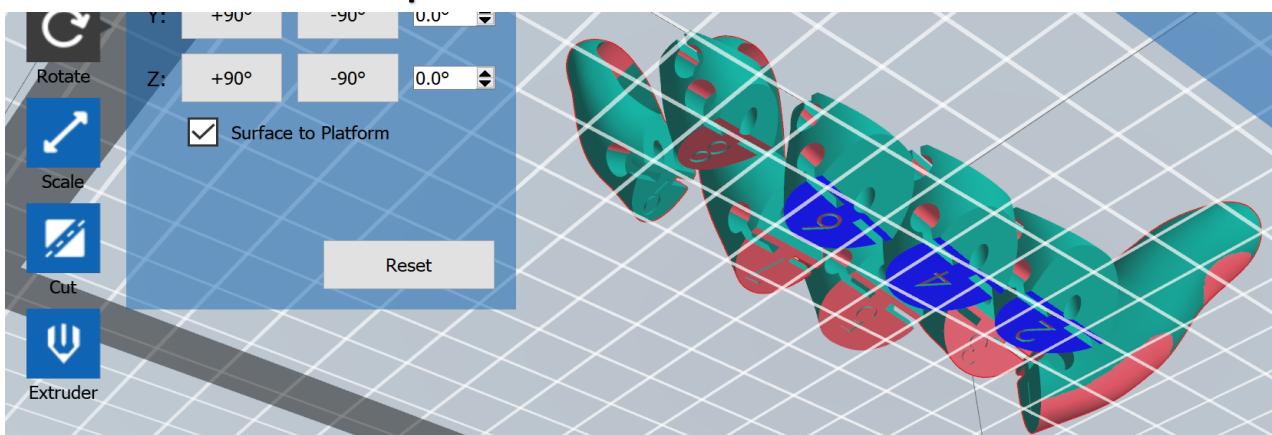

Save as a custom print file and repeat the process for each part/plate of parts by re-opening the custom scaled .FPP file that you created earlier.

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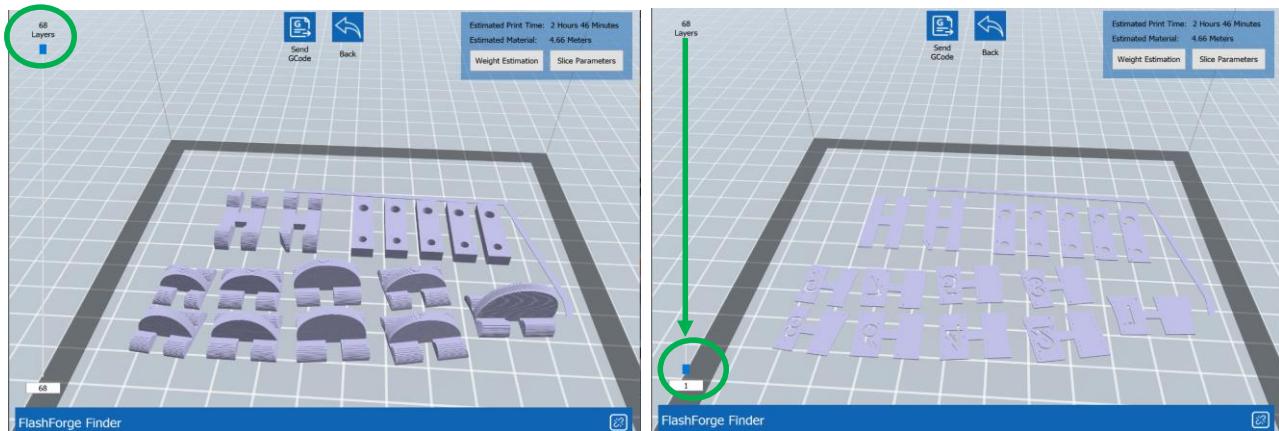
Advanced Customised Hand Scaling

When part surfaces have been successfully placed on the build surface, they will turn blue. To confirm this, look at the build platform from below.

After saving the print files, check the first layer to confirm that it is positioned correctly to print. You can do this by moving the **Layer** slider.
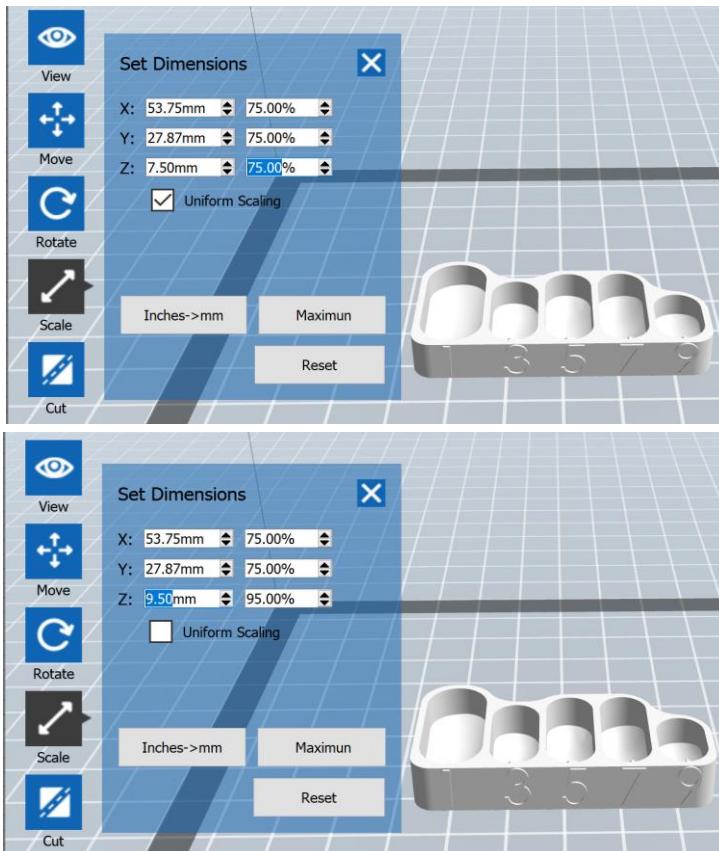
Important! When saving the print files, it is very important to confirm the print settings. (Material, temperature, speed and infill etc.) Refer to **P11** for the settings for each group of parts.
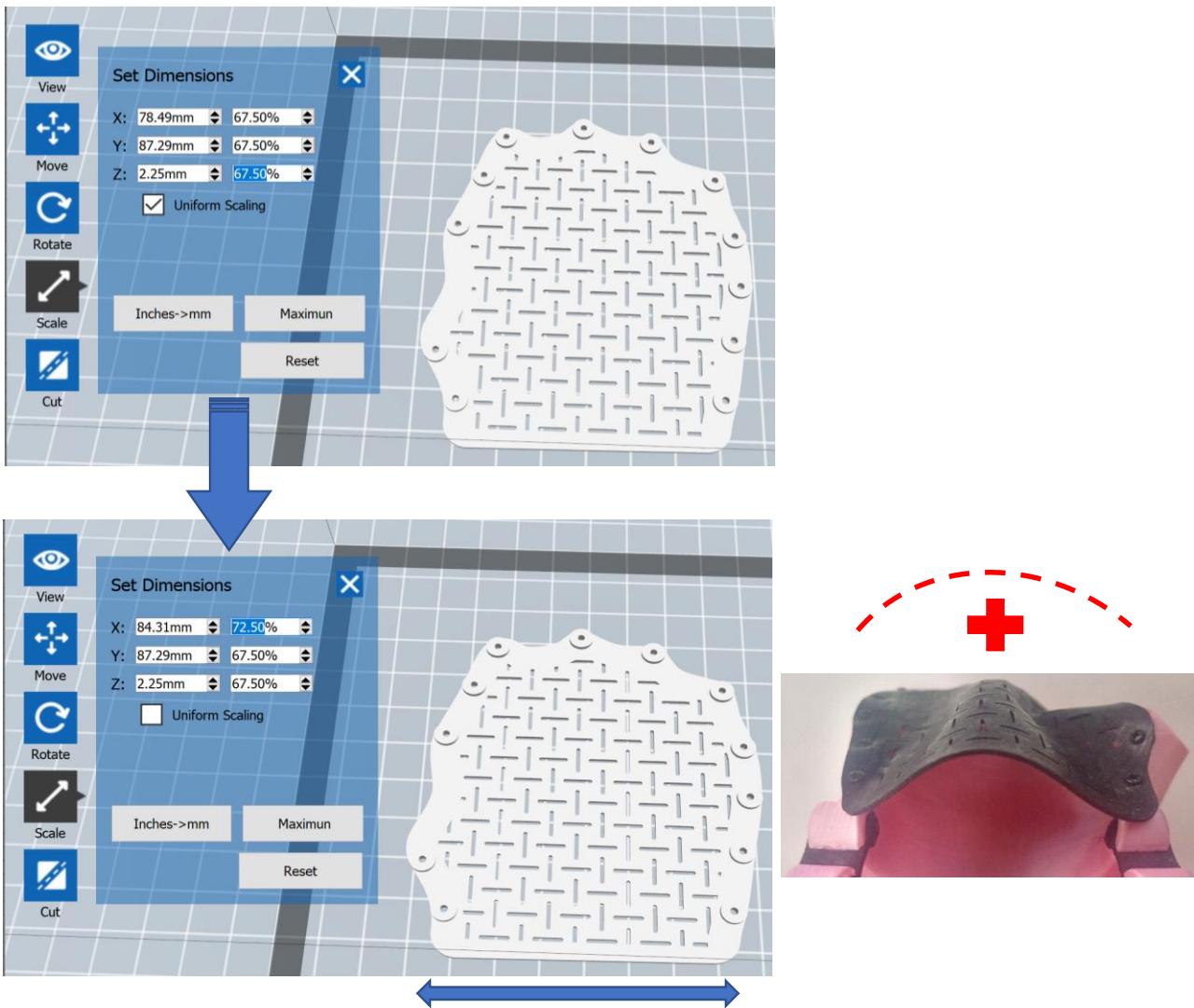
It is also possible to modify the dimensions of the 3D printed silicone mould to allow the silicone grips to protrude from the fingers for additional gripping surface and angle. This is not recommended for young children, since they may be inclined to pick at or chew the grips which will be easier to dislodge. **We recommend using standard scaling.**

The Z direction value can be increased to allow the grip to protrude from the fingers. In the case above, once we have achieved our desired overall scale of 75%, we have unchecked **Uniform Scaling**, and added **2**mm to the **Z** direction value.

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It is also possible to modify the dimensions of the flexible **Palm Cover** to allow for more room inside the **Palm** for recipients with well formed partial hands.
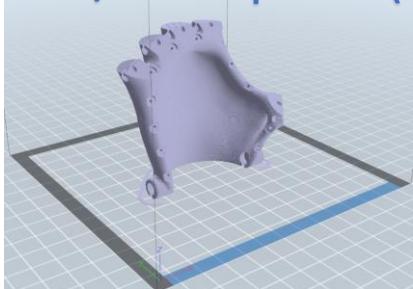

The **X** direction value can be increased by 5%. In the case above, once we have achieved our desired overall scale of 67.5%, we have unchecked **Uniform Scaling**, and added **5**mm to the **X** direction value.

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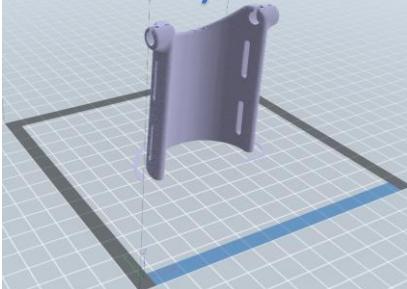
Printing a Test Palm for Size Confirmation

It is **very important** to print a test palm for size confirmation before providing a fully assembled hand to a recipient. This is necessary to ensure that the hand will be the correct size and to avoid any disappointment for the recipient.

PLA/PLA+ parts (40% infill)
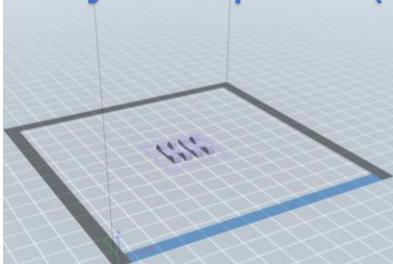
Palm

Gauntlet

Layer Height:	0.18mm
Perimeter Shells:	2
Fill Density:	40%
Fill Pattern:	Hexagon
Print Speed:	60mm/s
Travel Speed:	80mm/s
Extruder:	220°C

Ninjaflex parts (100% infill)

Wrist Hinges

Layer Height:	0.18mm
Perimeter Shells:	2
Fill Density:	100%
Fill Pattern:	Line
Print Speed:	20mm/s
Travel Speed:	70mm/s
Extruder:	230°C

The test palm can be used to determine the correct **Insert**.

Kinetic Hand

Appendix 3
Silicone Grip Moulding Guide

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Optional Silicone Grip Moulding

This is a guide how to make silicone finger grips. We strongly recommend making finger grips from a skin safe addition cure silicone. Grips printed out of Ninjaflex will have a similar amount of elasticity, but not the same amount of grip.
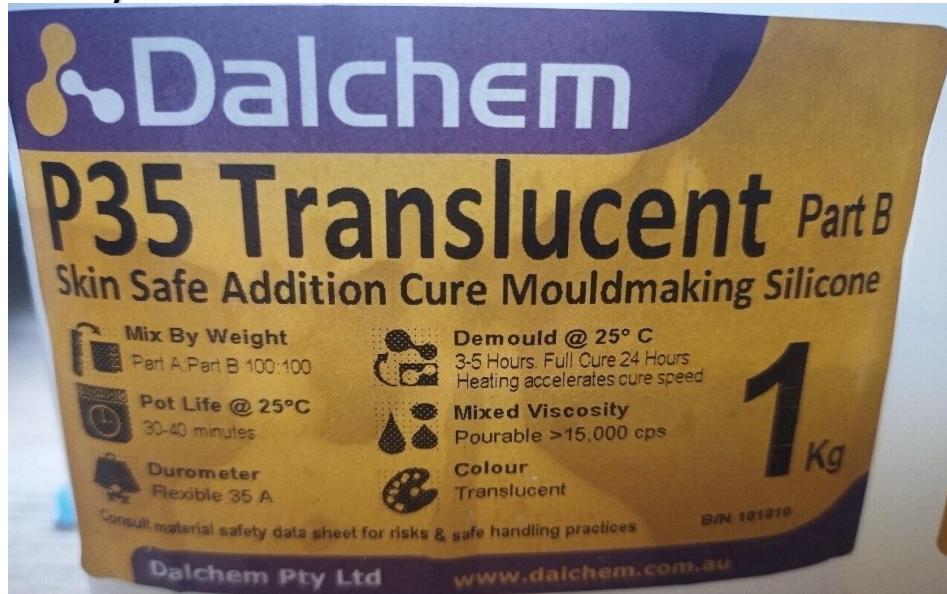
Required items:

1) 3D printed silicone grip mould
2) Skin-safe two-part silicone, P25-P45 hardness
3) Disposable syringes x2, 10ml
4) Oil paints or silicone pigment
5) Medicine cup for mixing
6) Thin wire for stirring
7) Small digital scale for measurement

Optional Silicone Grip Moulding

Choose a silicone that is skin safe, allows plenty of time to pour (long pot life) and is soft and flexible (P25 to P45).

Once cured, the silicone grips should be elastic, grippy, skin safe and durable. For these reasons, we do not recommend using silicones made for household applications such as window sealants.

Optional Silicone Grip Moulding

In this example, we will make silicone grips for a hand sized at 60% scale from the CAD model. The grips at this size weigh about 4.8g to give us an indication of how much silicone we require. Silicone on the bottom and sides of the measuring cup may not be fully mixed, so we will make **6g** of silicone.

Zero (TARE) the digital scale with the measuring cup before starting.

Optional Silicone Grip Moulding

Using a syringe, add equal amounts of silicone by **mass** of Part A and Part B into the measuring cup. (In this case, 3g Part A + 3g Part B = 6g.)

Mix thoroughly using a thin piece of wire. It is important to mix the silicone **before** adding any pigments to allow the two Parts to react properly.

Optional Silicone Grip Moulding

To create silicone grips in your own colour choice, you can add a small amount of oil colour paint or silicone pigment. You only need a tiny amount, and adding too much may cause the silicone not to set properly.

Stir the pigment into the silicone mix until you achieve a homogenous consistency. The mix should still look transparent.

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Optional Silicone Grip Moulding

Pour the silicone mix into the 3D printed mould. Use the metal wire to scrape any excess silicone off the top of the mould to ensure that the level is flush with the top of the mould. This is very important to ensure that the grips will fit properly into the fingers. Leave the grips to set as per the manufacturer's recommendations on a level surface.

Demould @ 25° C
3-5 Hours. Full Cure 24 Hours
Heating accelerates cure speed

Curing time will vary depending on temperature. We suggest leaving the grips in the mould for 24 hours.

Once set, use the thin wire to remove the grips from the mould.