# [Skin Project]

Please review Jiaoran's previous reports on:
https://drive.google.com/drive/folders/1NA_vGXik8bWhp_9kGz1laQTbLAZmFEJq
Codes on github:
https://github.com/CatStrain/Cat_skin/tree/Development_Jiaoran
Document, data on:
https://drive.google.com/drive/folders/17BO_wfRsTleYT59AnQB0KZygjYjnu2hu

If you have any question, feel free to contact Jiaoran though:
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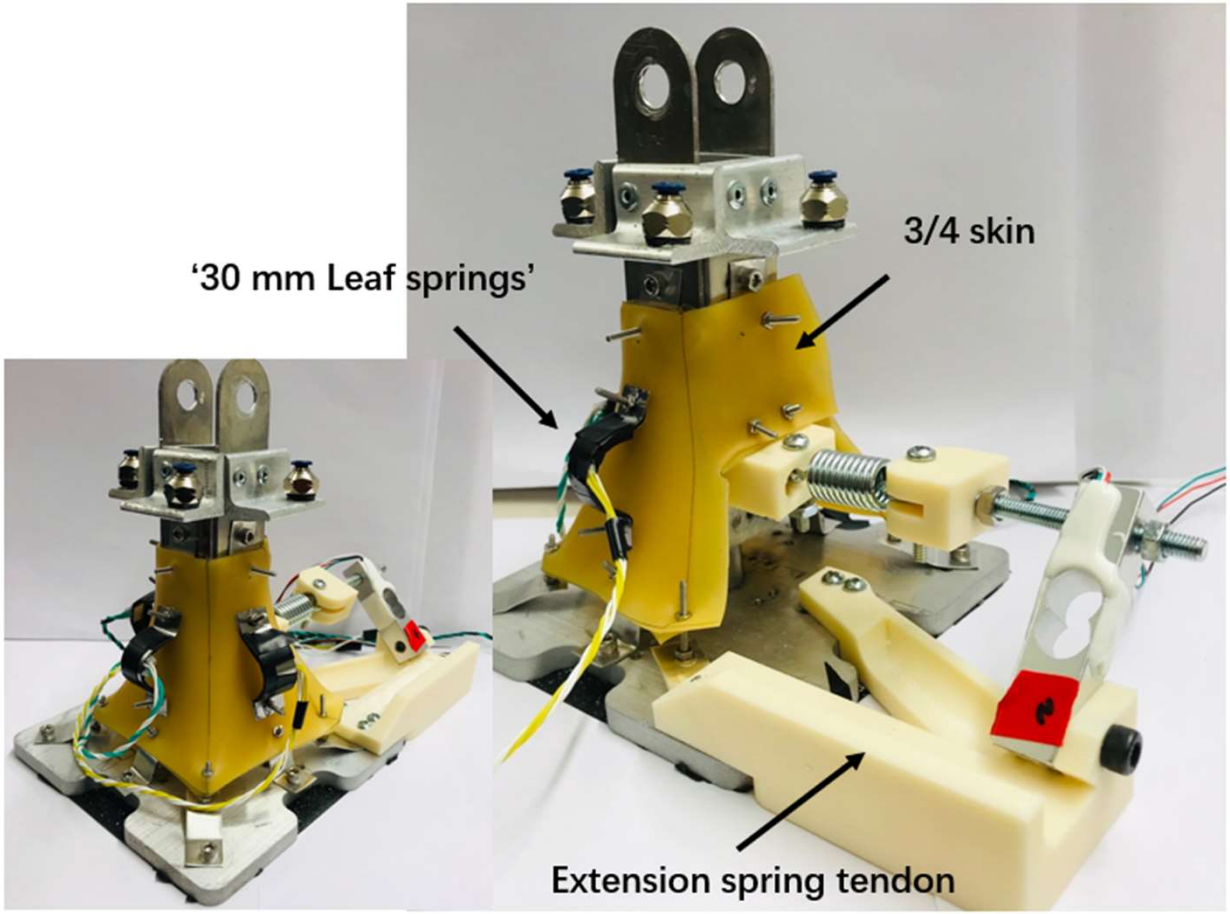
Personal email: AmandaWang0125@usc.edu
Github: AmandaWang0125

## Design and manufacturing

There are 4 versions of leg-skin structure: [3/4 skin + spring ligament] like the right figure shows.

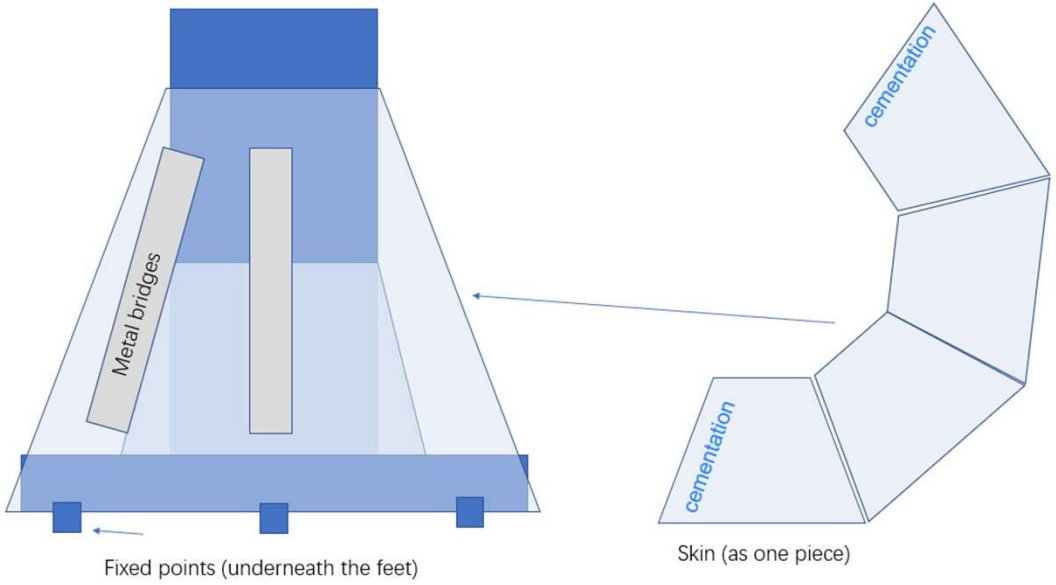
[Skin + leaf spring] [band +leaf spring] and [ligament + leaf spring]

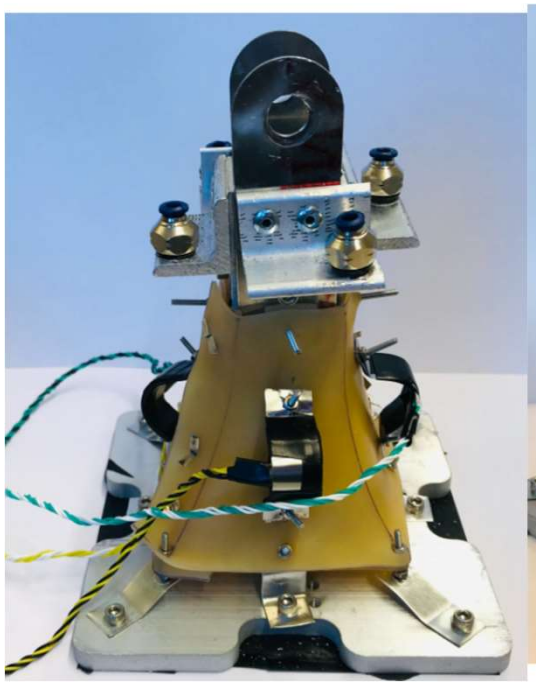
The model and design idea will be shown in the following pages.

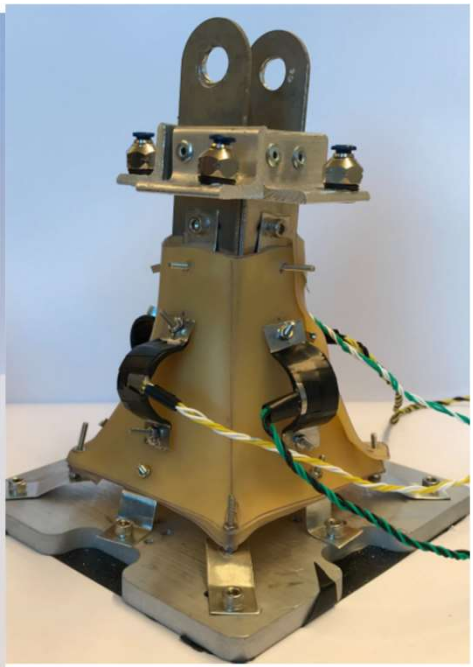



- Front
- Back
- 3/4 skin with 30 mm Leaf springs + extension spring tendon

**[Skin + leaf spring]**





The skin design is double layered with screw connection. Please note that the skin need to be pretensioned when applied to the leg.
The whole skin design are using latex rubber (in the material list).

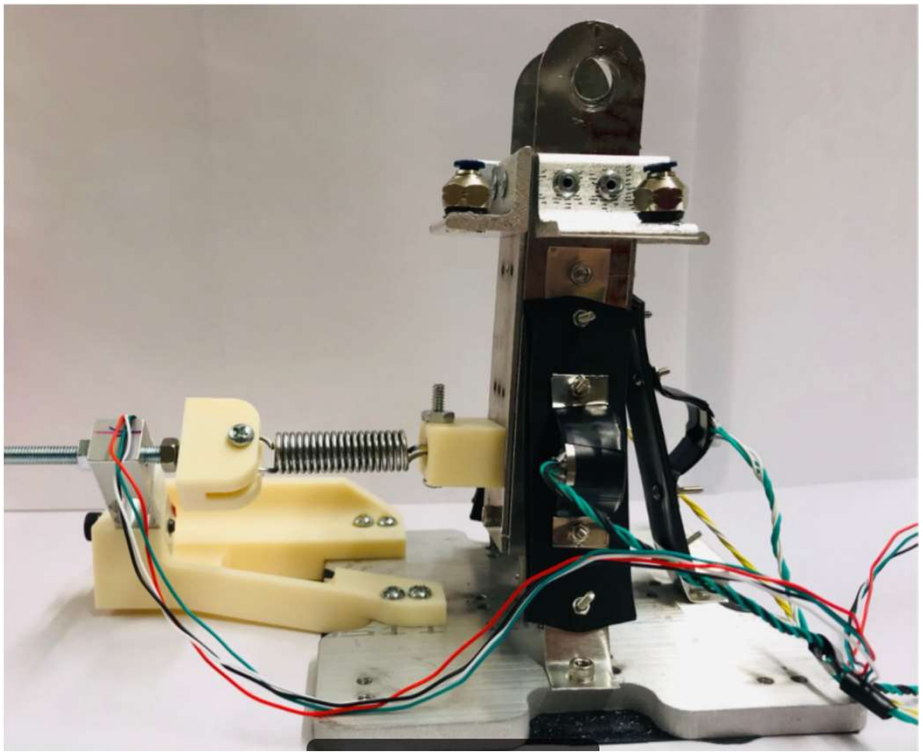
[Band Assembly]
Four elastic band devices are symmetrical mounted around the leg with two ends of each device being respectively connected to the ‘ankle’ and the ‘foot’ to form an interactive relationship with the leg locomotion. During the assembly/installation process, the double-layer highly elastic rubber polymer is stretched to certain length to hold a pre-tension force, which ensures its tensioning state during all of the leg locations. The pre-tension set and symmetrical mounting method provide balance support for the leg which enable the leg to remain upright while no external force applied.

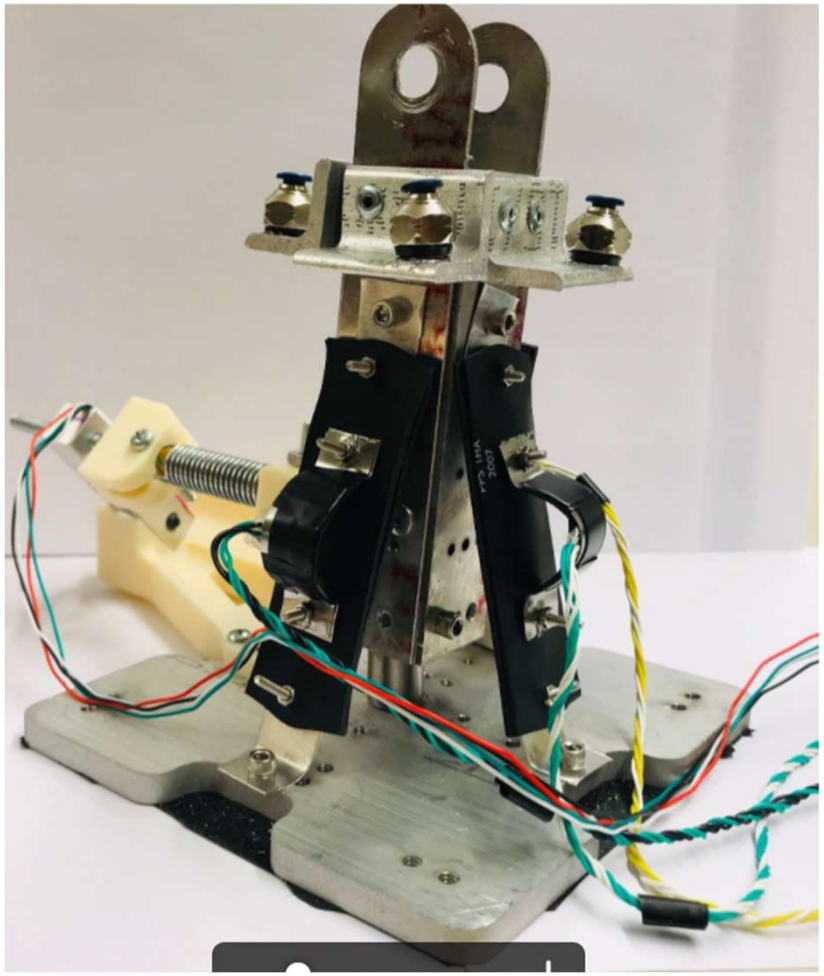
[Skin Manufacture]
The double-layer circumferential skin structure is designed as a complement to the elastic band device(version two-indirect connection). With the same connecting points, the skin structure design is attached to the ‘ankle’ and the ‘foot’ and wrap around the leg which combining the interactive performance of four elastic band devices. Comparing to the four separated elastic band devices, the skin structure design adds four metal connectors to the instep for better fixation.

Installation: the two ends are connected. During the installation process, the belt is stretched and there is a certain pre-tension force, which ensures its tensioning state during the leg movement.

The four straps are symmetrical mounted around the legs, and the two ends of the straps are respectively connected to the ankle and the foot to form an interactive relationship with the leg movements. Preloading and symmetrical mounting provide balance support for the legs, enabling them to remain upright and at rest when no external force is applied

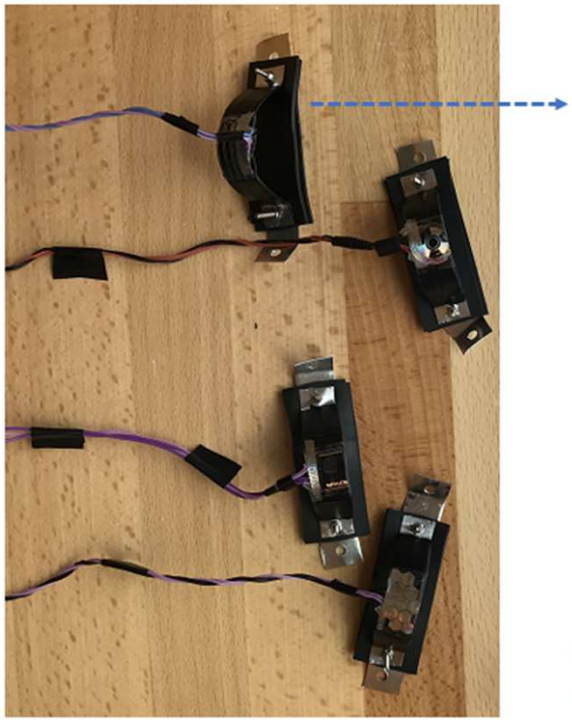
**[ligament + leaf spring]**



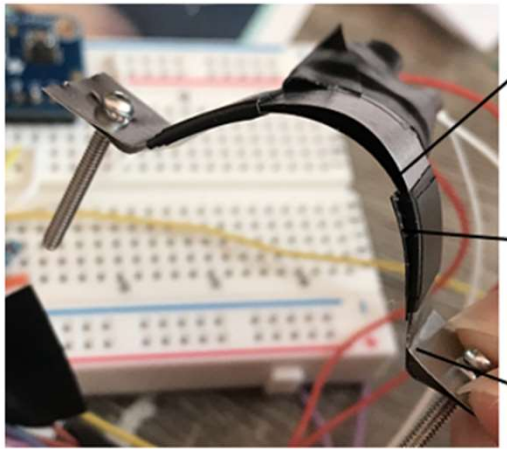


- Please pay attention to the fixation point
- Spring ligament has two different spring tightness. Adjustment should be applied to keep the upside down testing mode in balance.

## Leaf spring (with band) design

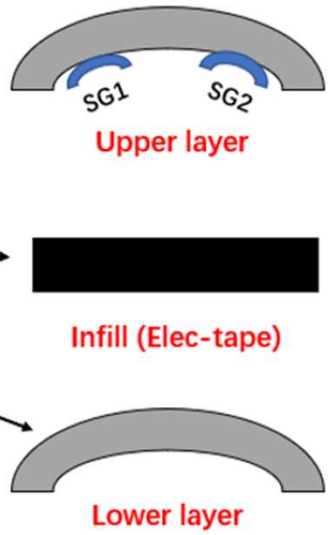


- 4* reduce-size elastic bands



- Double layered Aluminum part (Half bridge)

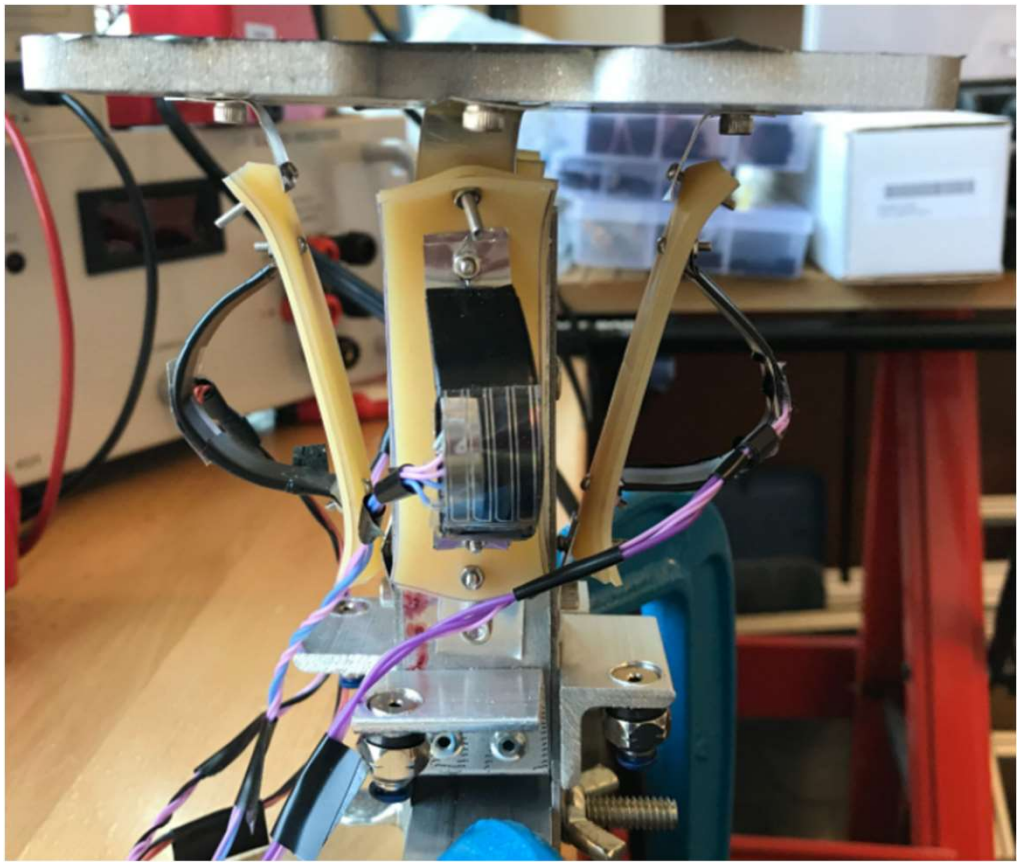
- Inner side of upper layer




[band + leaf spring]

- The aluminum stripe(in the material list) is W25mm*L60mm, after being curved, the end to end length is 30mm
- The strain gauge is glued to the inner surface of upper layer using super glue. Electric tape is used as infill and buffer.
- Screw connection for leaf spring and elastic band.

## Single leg testing



There are two different trial applied to single leg: Data collection]

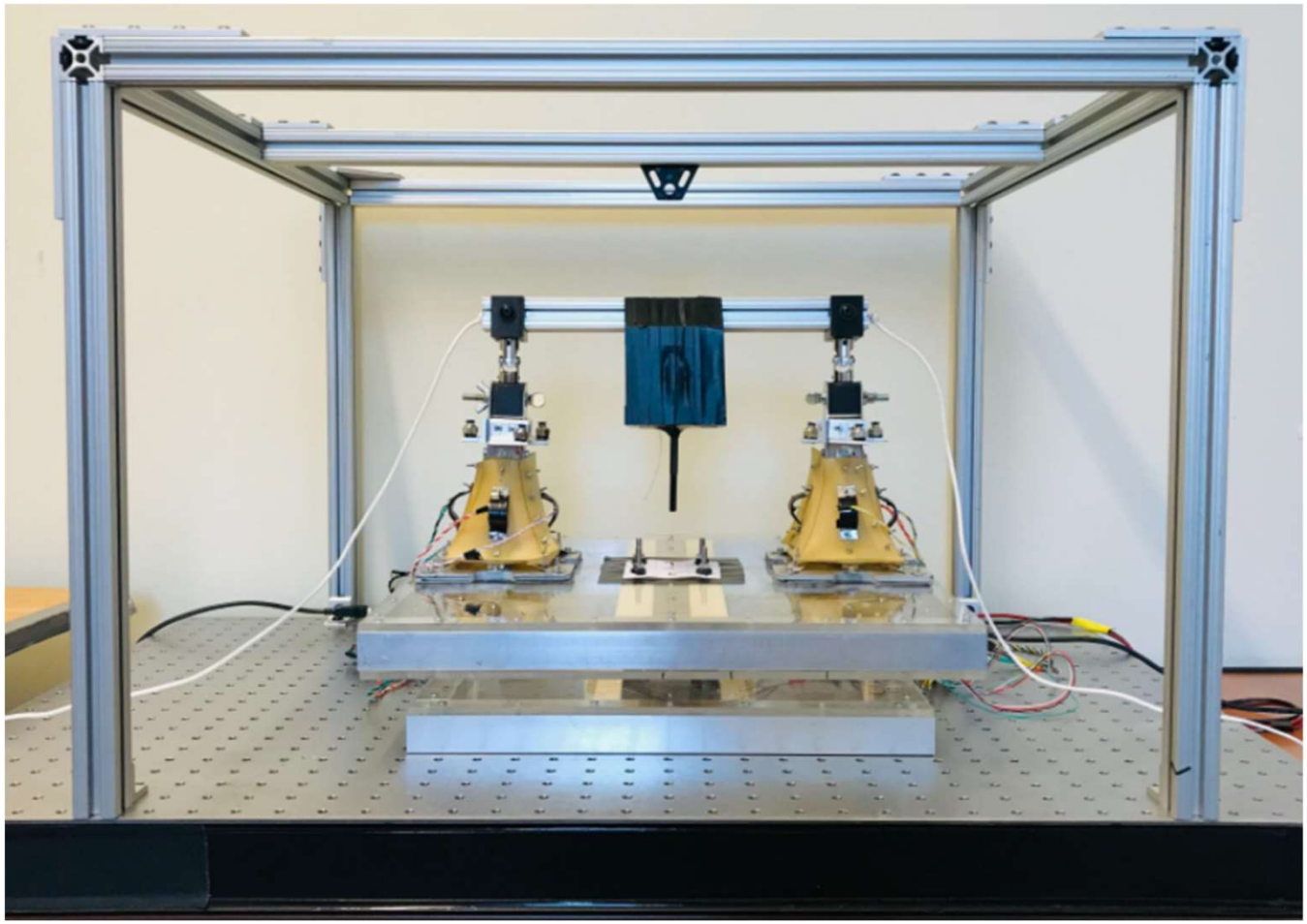
1. Constant force testing:
- 1-9 points with constant force (weight centered in different points) 900g
- 25000 time steps(around 11.5 mins)
- Repeat the trial twice.

2. Random force testing:
- The force should be in random/different, but in sequence(1-9)

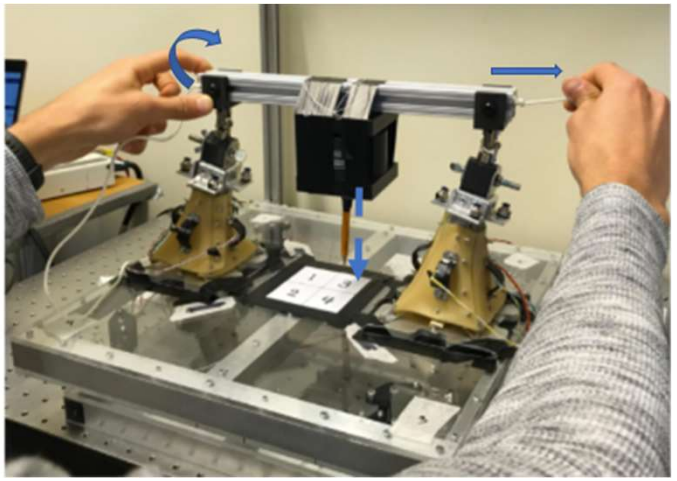
We test 4-grid, 9-grid and 16-grid with centered force (900g/random force)

Note:
The length of band will influence the tension and pretension of the sole balance/movement balance. We are using 60mm for all the design.

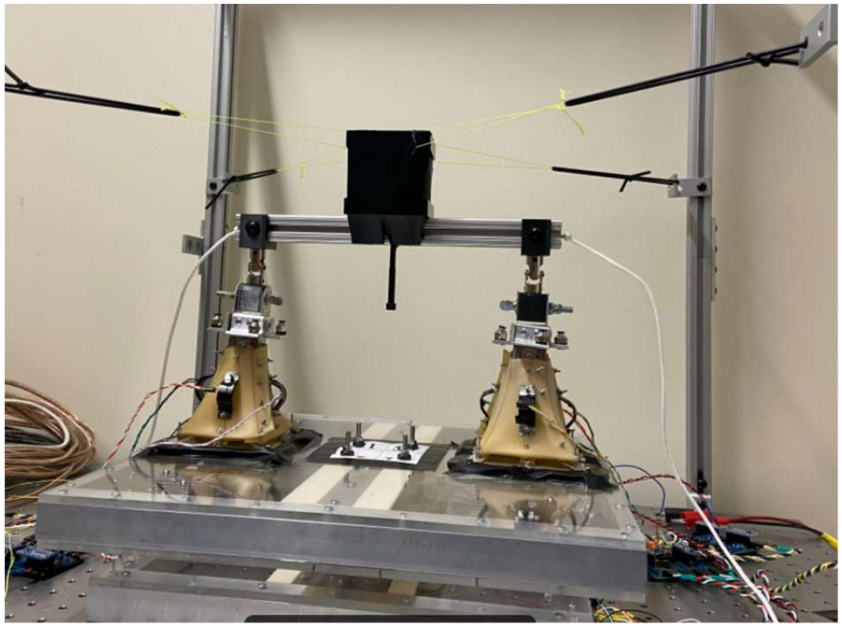
## Biped leg test (mass under the hip)



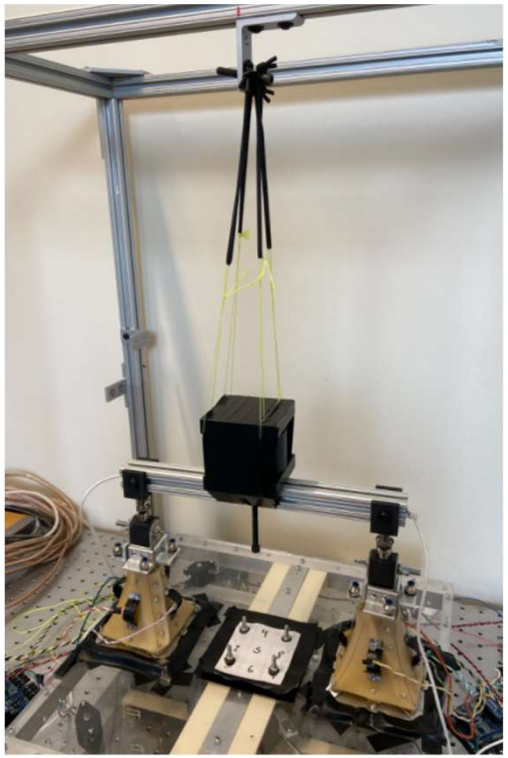
The black mass with pointer is facing the center of force plate.
Note:
Force plate need to be fixed to the ground.
While moving the plant, please do not adding more vertical force to the force plant.



**Biped leg test (mass above the hip)**



- **Horizontal**

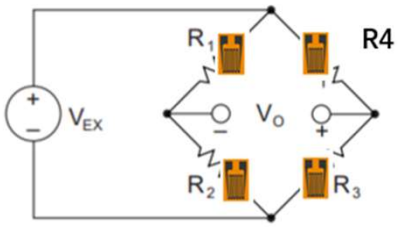


- **Vertical**

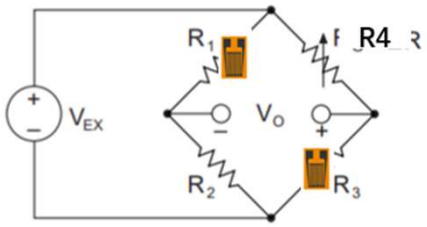
The horizontal and vertical designs are used for above mass balance.

**Note:
[training test] the training test is used for biped leg test. Using the weight (same as the weight of plant) and put onto the force plate. The contacting area is small so that the weight can be applied to the force plate though small area to train the plate.
[Training test] need to be conducted before other test.

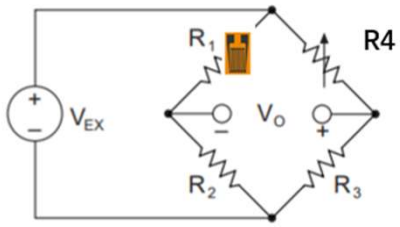
## Circuit connection:



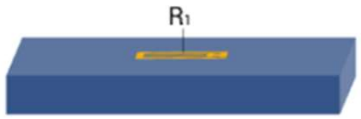

Full bridge

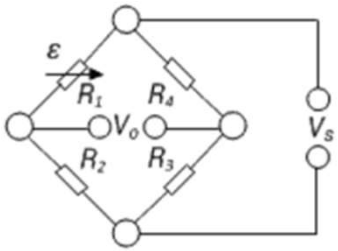



Half bridge(diagonal)



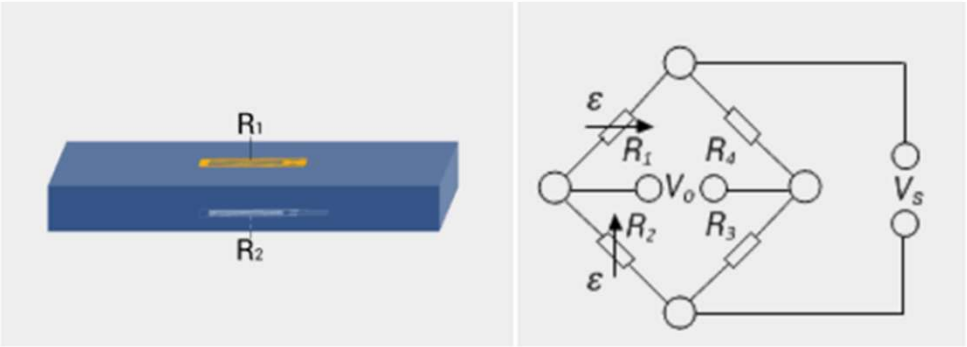

Quarter bridge




**Simple quarter bridge**
Simple quarter bridge circuit with one active strain gauge

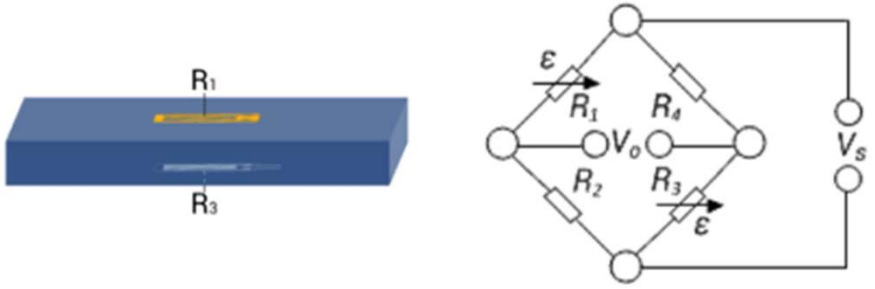
**Advantages and disadvantages**
+ Easy installation
- Normal and bending strain are superimposed
- Temperature effects not automatically compensated




**Half bridge**
Two strain gauges are installed on opposite sides of the structure

**Strain measurement on a bending beam**

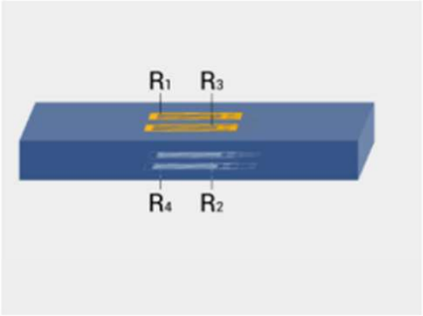
**Advantages and disadvantages**
+ Temperature effects are well compensated
+ Separation of normal and bending strain (only the bending effect is measured)

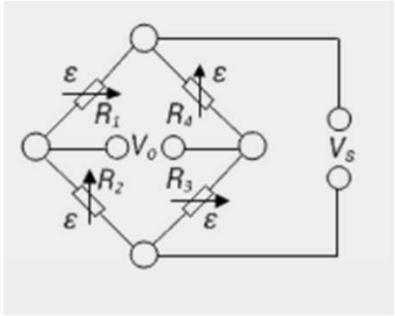



**Diagonal bridge**
Two strain gauges are installed on opposite sides of the structure

**Strain measurement on a tension/ compression bar**

**Advantages and disadvantages**
+ Normal strain is measured independently of bending strain (bending is excluded)




**Full bridge**
Four active strain gauges are connected as a full bridge

**Advantages and disadvantages**
+ Separation of normal and bending strain (only the bending effect is measured)
+ High output signal and excellent common mode rejection (CMR)
+Temperature effects are well compensated

https://www.hbm.com/en/7163/wheatstone-bridge-circuit/

https://www.transducertechniques.com/wheatstone-bridge.aspx

https://www.hbm.com/en/7163/wheatstone-bridge-circuit/

**By comparing different Wheatstone bridge, we finally choose diagonal bridge connection. For amplifier connection reference, please check this tutorial:**
https://docs.google.com/document/d/1uM-ecAYn0rlVvSDHSfJ-qM77rOF09bAblT7r3tcCmas/edit

## Material lists:

[leaf spring]
https://docs.google.com/spreadsheets/d/1KtwK1BqACXDiFwhAMDHHmAnz3afcsnINaIONL22clPI/edit#gid=0
[Skin material:]
https://docs.google.com/spreadsheets/d/1m5tcsF74EaJ4fukWg31T3iJFO0t71Gdhfl904rr3UhU/edit#gid=0