Team 8: Plasticity Model

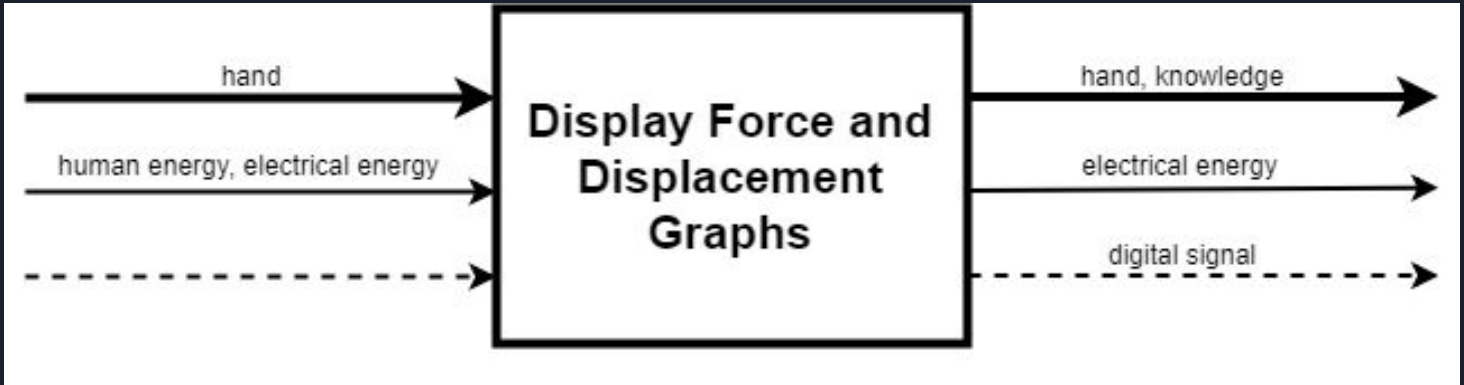
Dillon Edlund, Zachary Morrison,
Laken Yargus, Stephanie Yazzie

Project Description

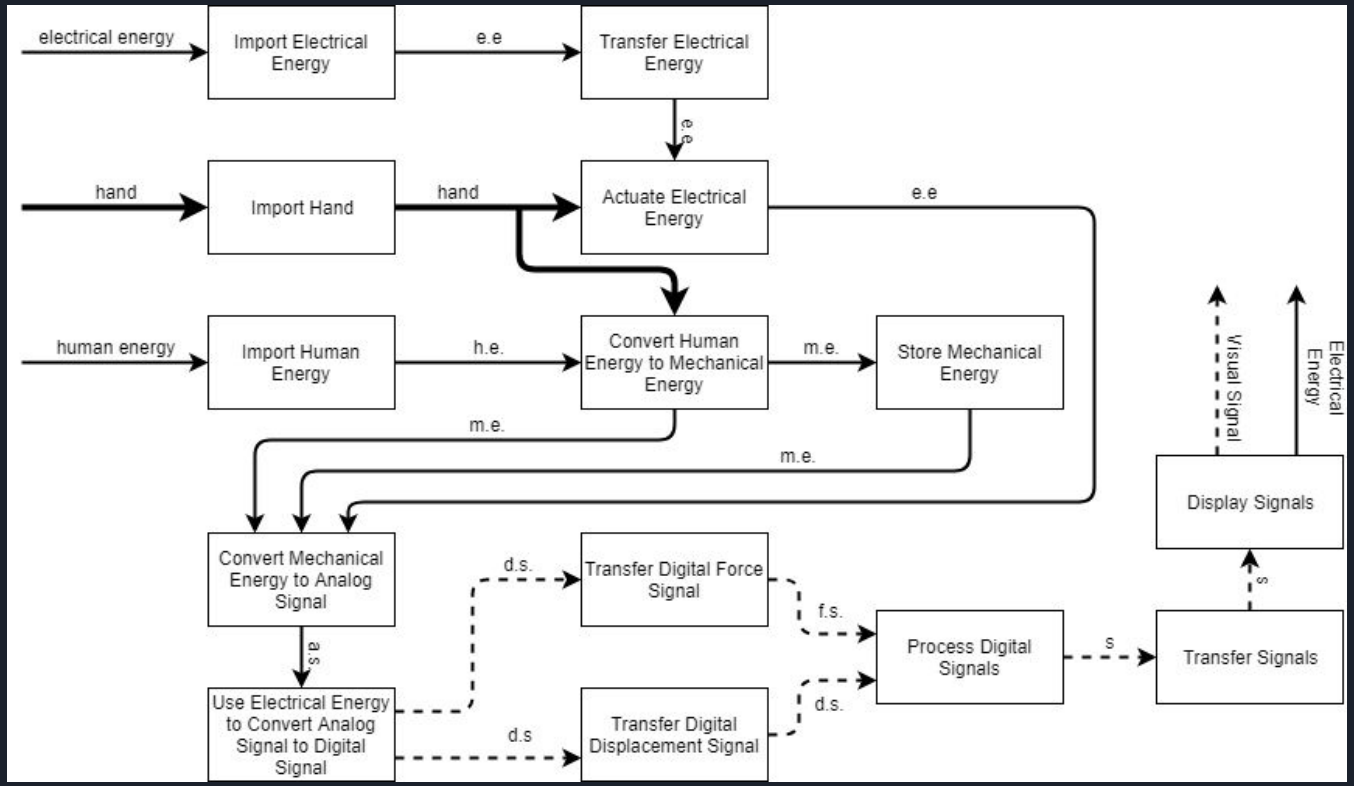
- Client: Dr. Heidi Feigenbaum
- ME 561 Engineering Plasticity
- Student will “Use physical models to describe plasticity behavior of materials in 2D (LO1.1, 1.3)”
- Plasticity theory describes a materials behavior beyond the elastic limit. This behavior can be modeled using friction and spring reactions to force. The model must output force and displacement.
- Educational model

Functional Decomposition

Black Box Model

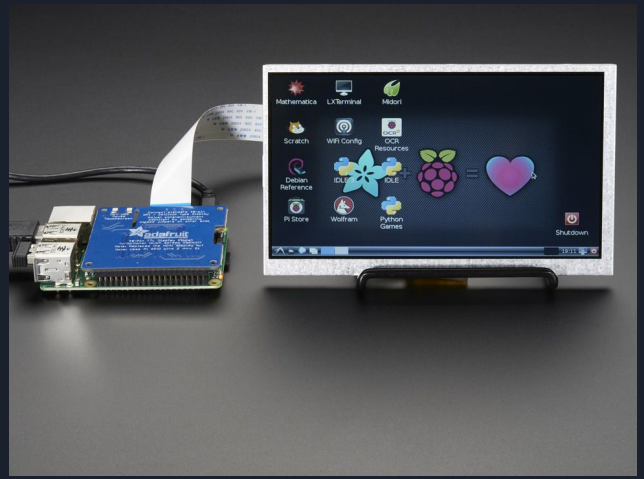


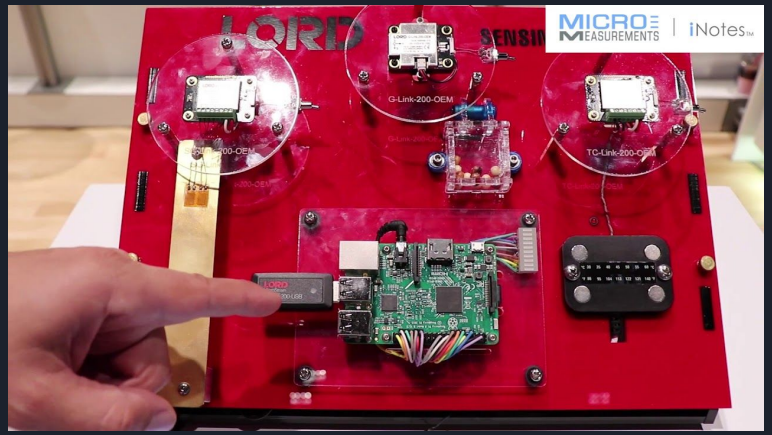
Functional Decomposition



Raspberry Pi Self Contained Model

- Integrated 7” touchscreen display.
- Power source included on device.

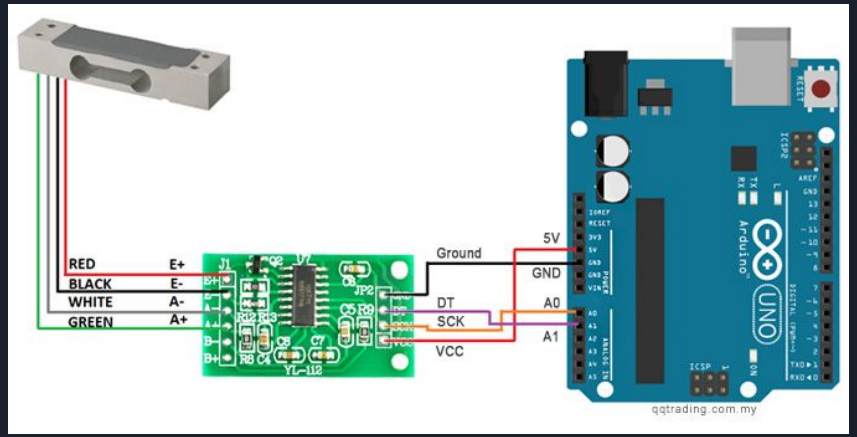




- Wireless analog-to-digital converter.
- HDMI/Bluetooth display output for presentation on projector.
- Strain and Displacement measurements.

Arduino Load Cell Model

- Arduino based system.
- Controlled by external computer source.



http://qqtrading.com.my/load-cell-amplifier-weighing-sensor-module-hx711

https://www.aliexpress.com/w/wholesale-metal-gear-film.html

Pros:

- Load cell and potentiometer compatible
- Low cost
- Open source, easy to implement

Cons:

- Calibration of load cells may be difficult
- Potentiometer needs to be modified

2D Displacement Tracking

- XY coordinate tracking
- Pulling force always applied perpendicular to block.
- In theory the spring force and friction force are constants, measured empirically.
- Can program control board to calculate “pull force” from knowns and displacement.

Pros:

- No need for strain gauges.
- No need for expensive analog-to-digital converters.

Cons:

- Difficult to control other parameters.
- Periodic calibration necessary.

https://www.thingiverse.com/thing:718271

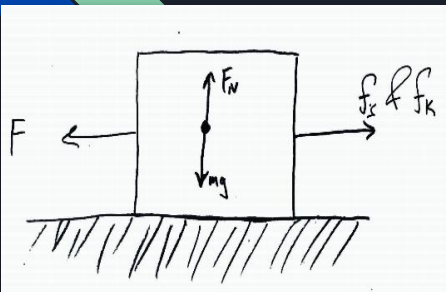
Springs

- Tension and Compression springs
  - Pros: Consistent data, light duty
  - Cons: Using two separate springs, switching springs
- Wire Rope Springs
  - Pros: Operates for tension and compression
  - Cons: Heavy, Too big in size, expensive
- Design and Manufacture
  - Pros: Adheres to projects specifications
  - Cons: Time, trial and error

Frictional Surface and Block

- Waxed metal block on rubber-like base
  - Pros: Smooth graphs, Durable
  - Cons: Heavy, Possible lubricant, Difficult spring attachment
- Rough adjustable weighted block with cloth base
  - Pros: Smooth graphs, Low cost. Springs easily attached
  - Cons: Cloth may wear out overtime, more pieces
- Rubber block on glass-like base
  - Pros: Smooth graphs, lower cost, springs easily attached
  - Cons: Possibly fragile

Back of the Envelope Calculations



Metal block on Rubber-like base

$\mu_s = 0.69$ dry

Lubrication can drop it by 70.1%

$\mu_s = 0.448$ wet

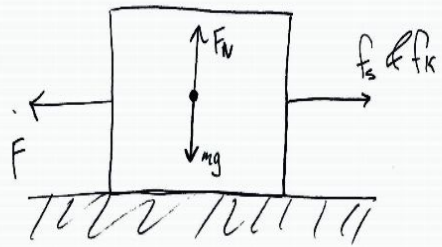
$F_N = 13.345\,N$

$f_{s\,dry} = 8.541\,N = 1.92\,lbf$

$f_{s\,wet} = 5.979\,N = 1.344\,lbf$

$F > 1.92\,lbf$ dry & $1.344\,lbf$ wet

mg needs to increase to get higher F



Rubber on glass

$mg = 3\,lb\text{-}f = 13.345\,N$

$F_N = 13.345\,N$

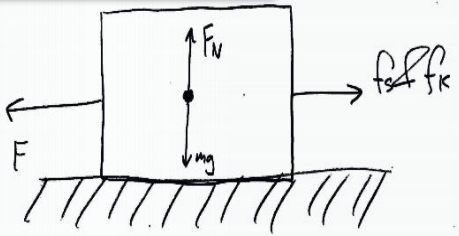
$f_s = F_N \times \mu_s$

μ_s & $\mu_K = 2.0$

$f_s = f_K = 26.69\,N$

$= 6.00\,lbf$

$F > 6.00\,lbf$



Rough block w/ cloth base

Sand paper on wood $\mu_s = 0.6\text{-}0.8$

Assuming Sand paper on cloth is double

$\mu_s = 1.2\text{-}1.6$

$F_N = 13.345\,N$

$f_s = 16.014\,N$ for $\mu_s = 1.2$

$= 21.352\,N$ for $\mu_s = 1.6$

$F = 4.8\,lbf$

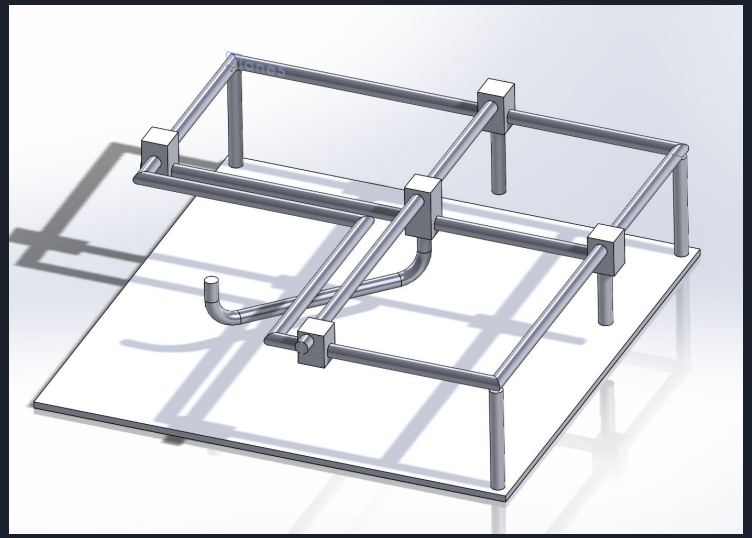
$F > 4.8\,lbf$ if $mg = 3\,lbf$

Pugh Chart

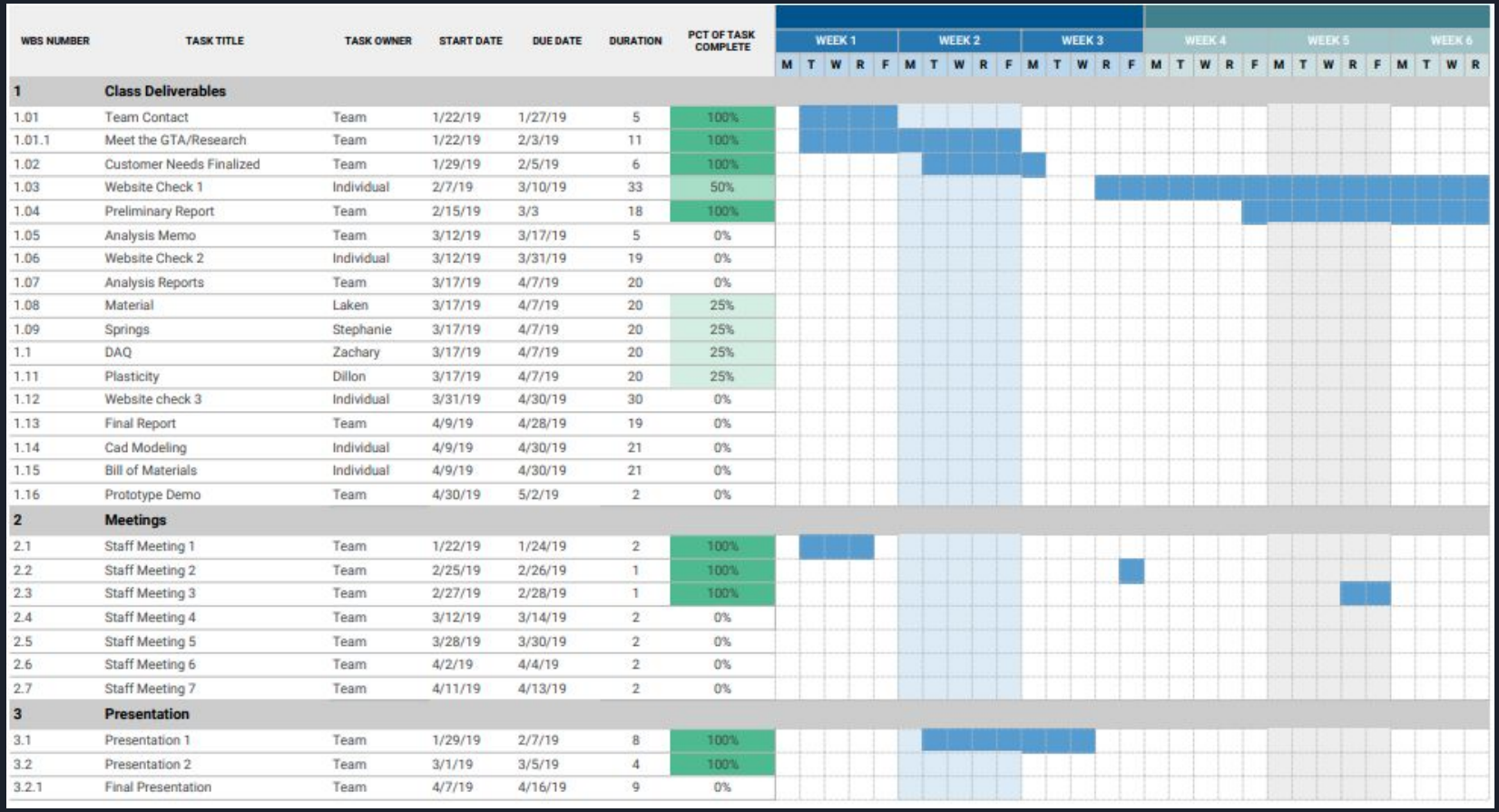
	Concept									
	Full System			Subsystem						
Selection Criteria	1	2	3	4	5	6	7	8	9	10
Cost	-	+	+	+	+	-	-	+	+	-
Performance	+	-	+	+	-	+	+	-	+	+
Feasability	-	+	+	+	-	-	0	0	0	+
Sum (+)	1	2	3	3	1	1	1	1	2	2
Sum (-)	2	1	0	0	2	2	1	1	0	1
Sum (0)	0	0	0	0	0	0	1	1	1	0
Total	**-1**	**1**	**3**	**3**	**-1**	**-1**	**0**	**0**	**2**	**1**

Concept Generation : Selected Design

2D Displacement Tracking with tension and compression springs and rubber on glass



Gantt Chart



WBS NUMBER	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION	PCT OF TASK COMPLETE
1	**Class Deliverables**					
1.01	Team Contact	Team	1/22/19	1/27/19	5	100%
1.01.1	Meet the GTA/Research	Team	1/22/19	2/3/19	11	100%
1.02	Customer Needs Finalized	Team	1/29/19	2/5/19	6	100%
1.03	Website Check 1	Individual	2/7/19	3/10/19	33	50%
1.04	Preliminary Report	Team	2/15/19	3/3	18	100%
1.05	Analysis Memo	Team	3/12/19	3/17/19	5	0%
1.06	Website Check 2	Individual	3/12/19	3/31/19	19	0%
1.07	Analysis Reports	Team	3/17/19	4/7/19	20	0%
1.08	Material	Laken	3/17/19	4/7/19	20	25%
1.09	Springs	Stephanie	3/17/19	4/7/19	20	25%
1.1	DAQ	Zachary	3/17/19	4/7/19	20	25%
1.11	Plasticity	Dillon	3/17/19	4/7/19	20	25%
1.12	Website check 3	Individual	3/31/19	4/30/19	30	0%
1.13	Final Report	Team	4/9/19	4/28/19	19	0%
1.14	Cad Modeling	Individual	4/9/19	4/30/19	21	0%
1.15	Bill of Materials	Individual	4/9/19	4/30/19	21	0%
1.16	Prototype Demo	Team	4/30/19	5/2/19	2	0%
2	**Meetings**					
2.1	Staff Meeting 1	Team	1/22/19	1/24/19	2	100%
2.2	Staff Meeting 2	Team	2/25/19	2/26/19	1	100%
2.3	Staff Meeting 3	Team	2/27/19	2/28/19	1	100%
2.4	Staff Meeting 4	Team	3/12/19	3/14/19	2	0%
2.5	Staff Meeting 5	Team	3/28/19	3/30/19	2	0%
2.6	Staff Meeting 6	Team	4/2/19	4/4/19	2	0%
2.7	Staff Meeting 7	Team	4/11/19	4/13/19	2	0%
3	**Presentation**					
3.1	Presentation 1	Team	1/29/19	2/7/19	8	100%
3.2	Presentation 2	Team	3/1/19	3/5/19	4	100%
3.2.1	Final Presentation	Team	4/7/19	4/16/19	9	0%

WEEK 1 WEEK 2 WEEK 3 WEEK 4 WEEK 5 WEEK 6

M T W R F M T W R F M T W R F M T W R F M T W R F M T W R

Budget

- Total Available:
  - ~$400.00
- Anticipated expenses:
  - Raspberry Pi and Sensors, $150
  - Springs, $10
  - Block and Frictional Surface, $50
  - Track System, $30
  - Structure, $50
- Actual expenses to date:
  - $0
- Resulting balance:
  - ~$110

Questions?