BIOMIMETIC DESIGN

Day 2

ITP 2013 Fall
Biomimetic Design
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SCHEDULE

Over the course of 7 weeks *[15:30 - 18:00]*

3 Assignments:

[1 week]
[1 week]
[4 weeks : this is your core project]

TODAY

1. Readings
3:30 - 4:10

2. Go over your projects
4:10 - 4:40

2. Lecture : 4:40 - 5:30
Types of motion & actuators
[break]
Achieving Motion with form & code

4. Biological systems
Debrief & Assignment #2
5:30 - 6:00

NEXT WEEK

1. Discussion + Lecture:
AI / Cybernetics & Cyborgs
Synthetic biology & Living design
Renewable Energy
Biological & Digital Inputs: Sensors

2. HW presentations

3. Launch Final Assignment

In class worktime on initial ideas

BIOMIMETIC EXAMPLES

What makes a biomimetic design effective?

Is it always effective to use biology as an inspiration for optimization and model?

What are the limitations?

What is the potential?

BIOMIMETIC PRINCIPLES

- *Nature runs on sunlight*
- *Nature uses only the energy it needs*
- *Nature fits form to function*
- *Nature recycles everything*
- *Nature rewards cooperation*
- *Nature banks on diversity*
- *Nature demands local expertise*
- *Nature curbs excesses from within*
- *Nature taps the power of limits*

- Jan Benyus

CLOACA

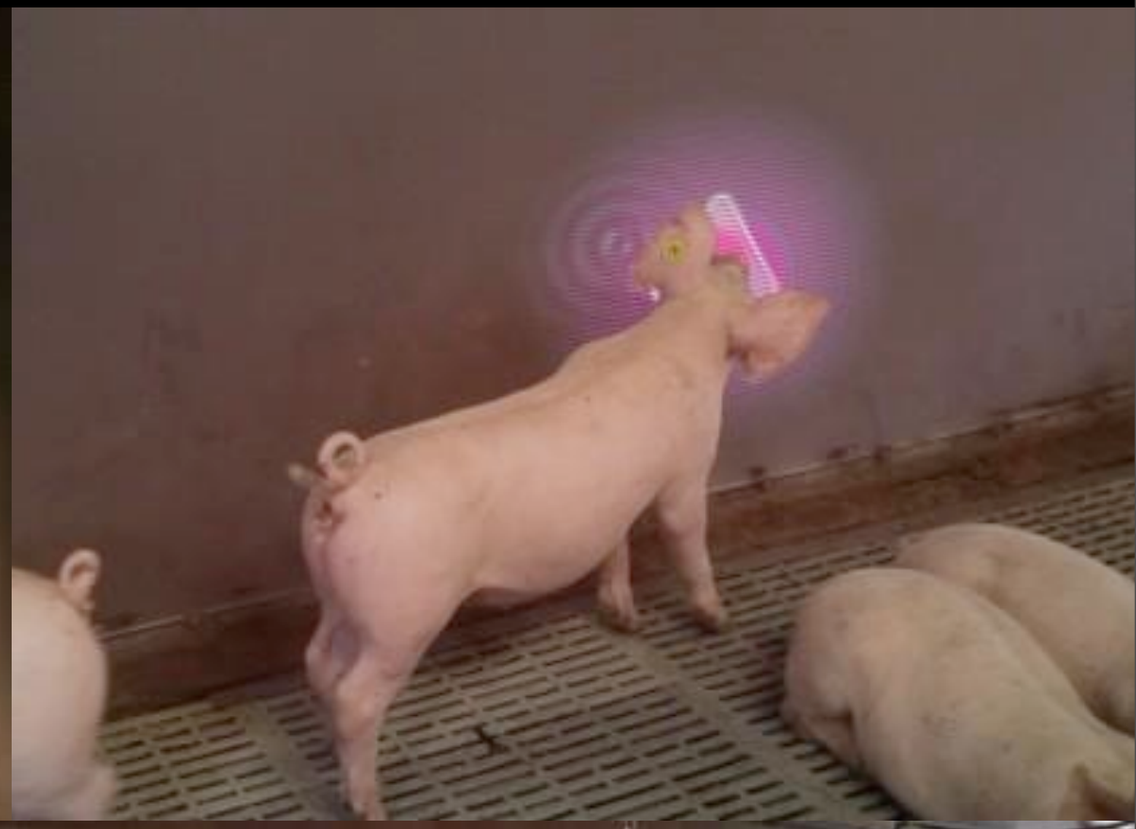
mimicking human digestion

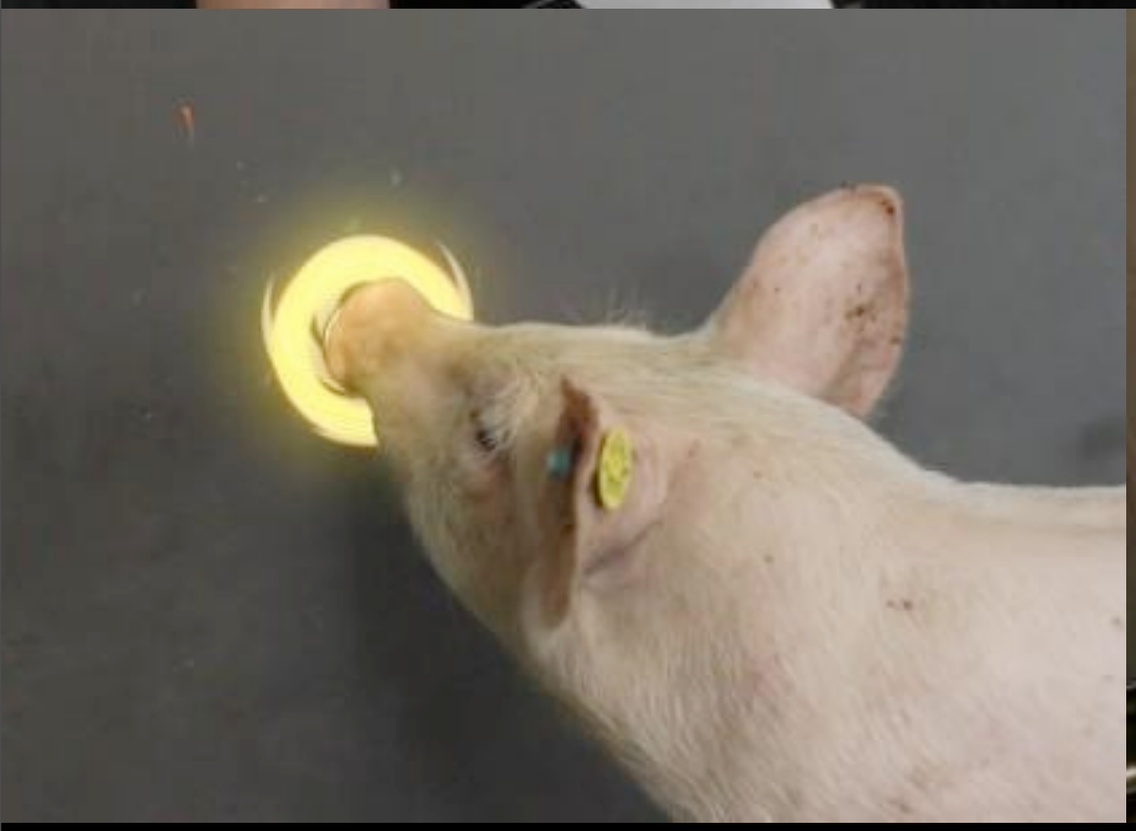
CIRCUMVENTIVE ORGANS

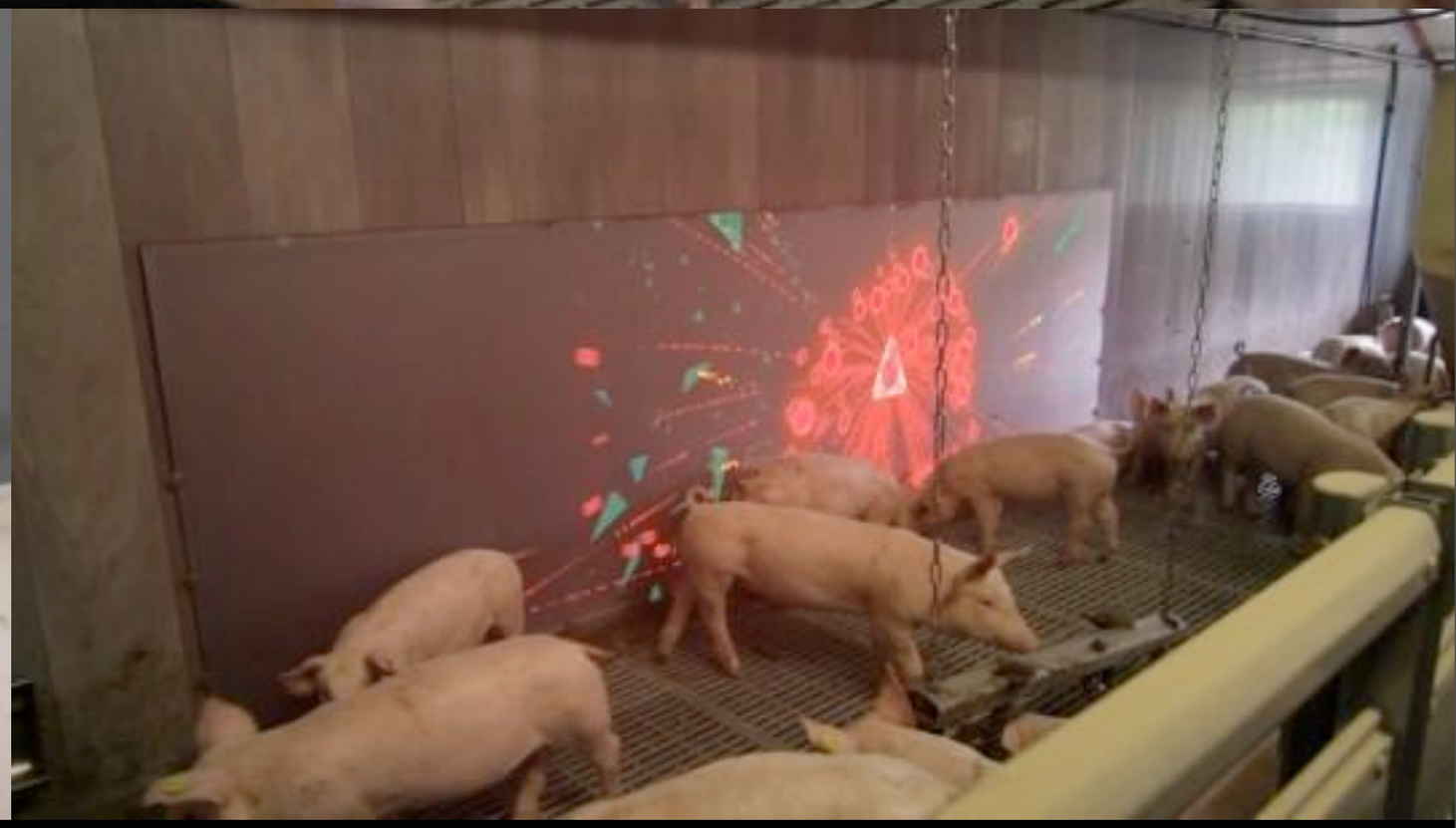
FLOOD-READY MANHATTAN

Inspired by flexible mesh webbing to increase resilience

ANIMAL - COMPUTER INTERACTION







Utrecht School of the Arts, Playing with Pigs, Pig Chase

ANIMAL - COMPUTER INTERACTION

Natalie Jeremijenko, Communication Technology for Birds,

PROJECTS

Project presentations [7 minutes]

1. *What biological system or joint is your device based on?*

2. *What type of motion is it?*

3. *What is the purpose of the system?*

MOTION

1. Types of Motion

2. Simple Machines

3. Actuators to create motion

4. Types of Algorithms for motion:
-Oscillation
-sine waves
-frequency, period, amplitude, wavelength
-Inverse Kinematics

CODE

github.com/gabriella/exploringBiomimicry

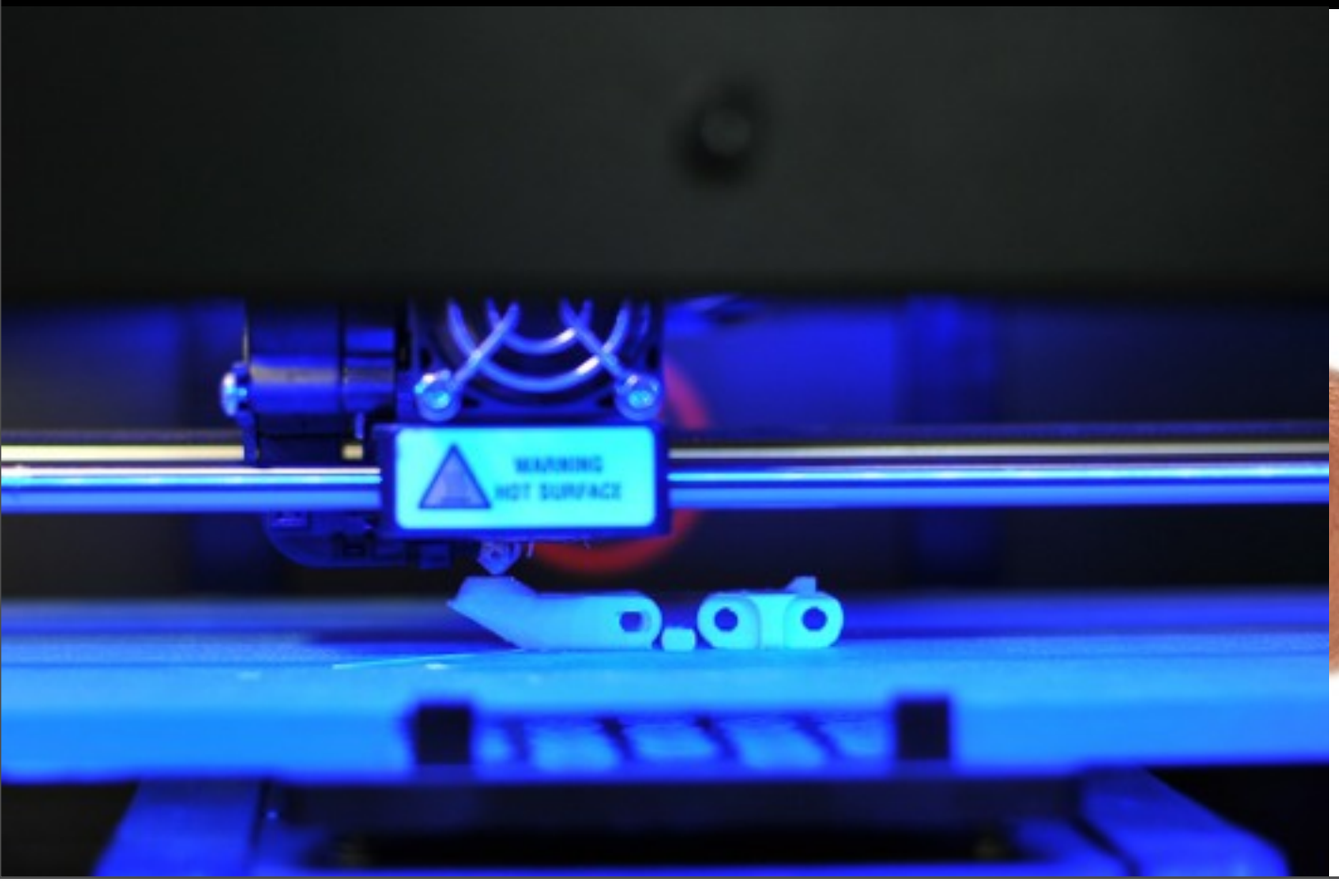
TYPES OF MOTION

1. Linear
2. circular (around an axis)
3. oscillation or periodic motion
4. vibration [reciprocating]
5. random [Brownian]

LINEAR

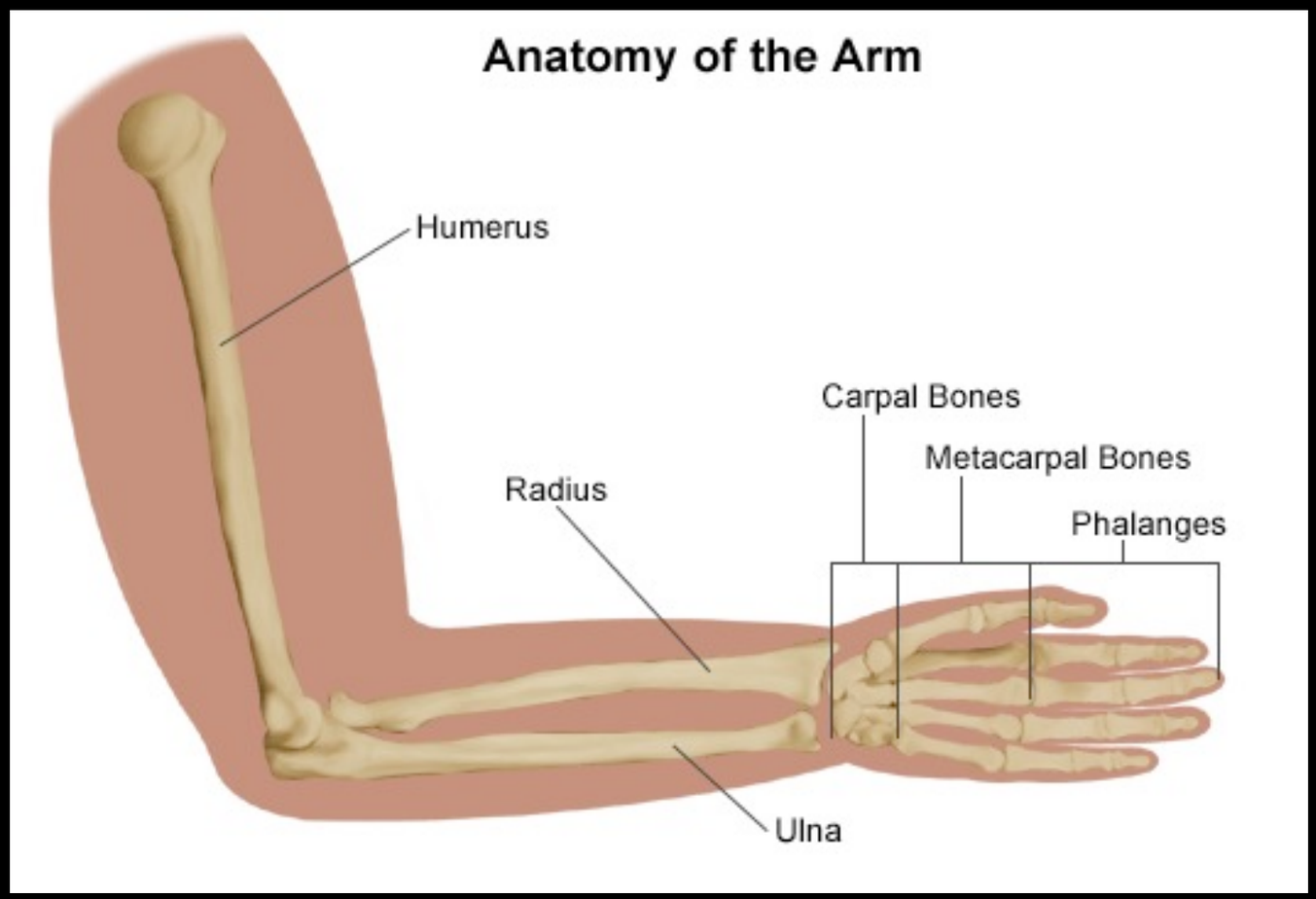
One dimensional: Motion along a straight line

A. uniform (constant velocity, no acceleration)
B. variable velocity



LINEAR

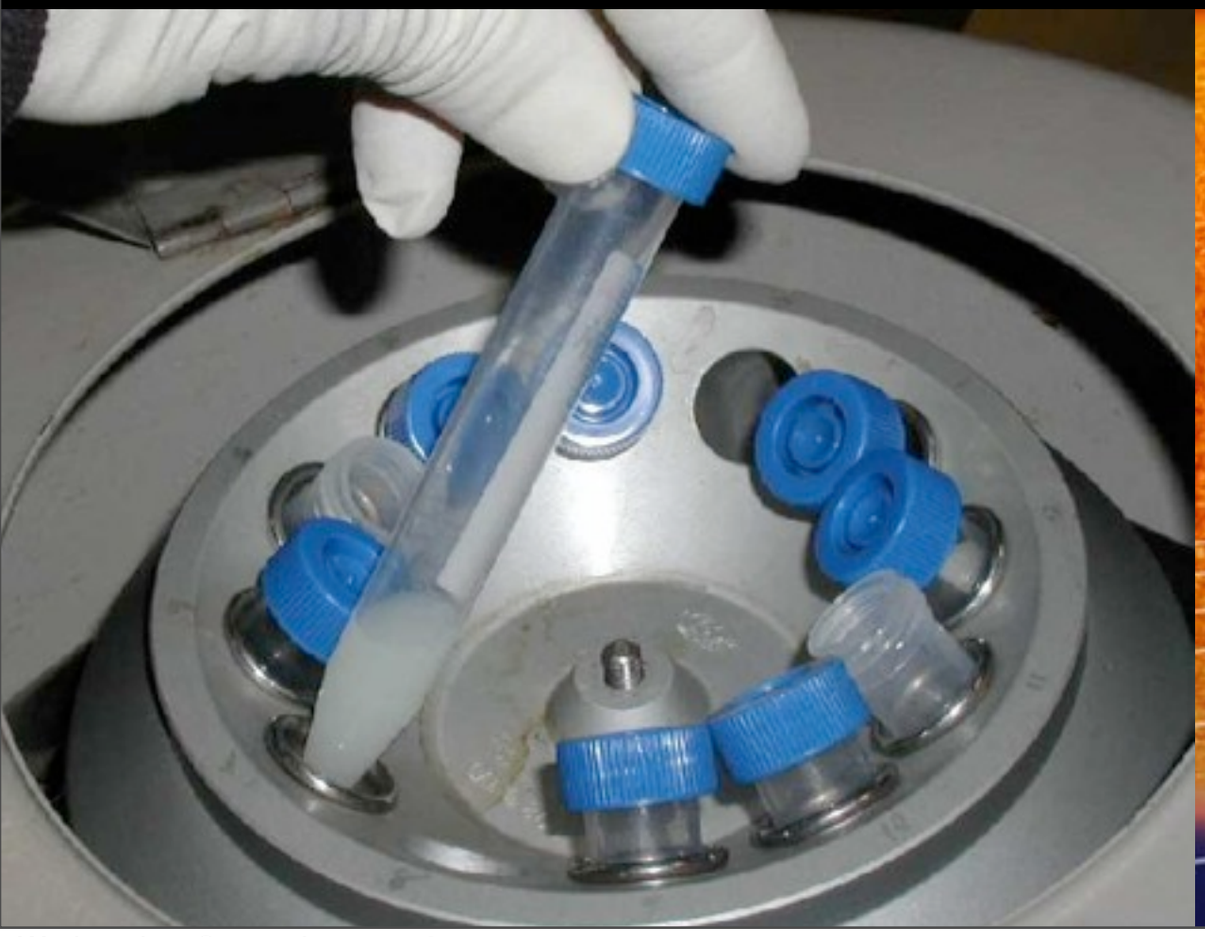
ELBOW
KNEE

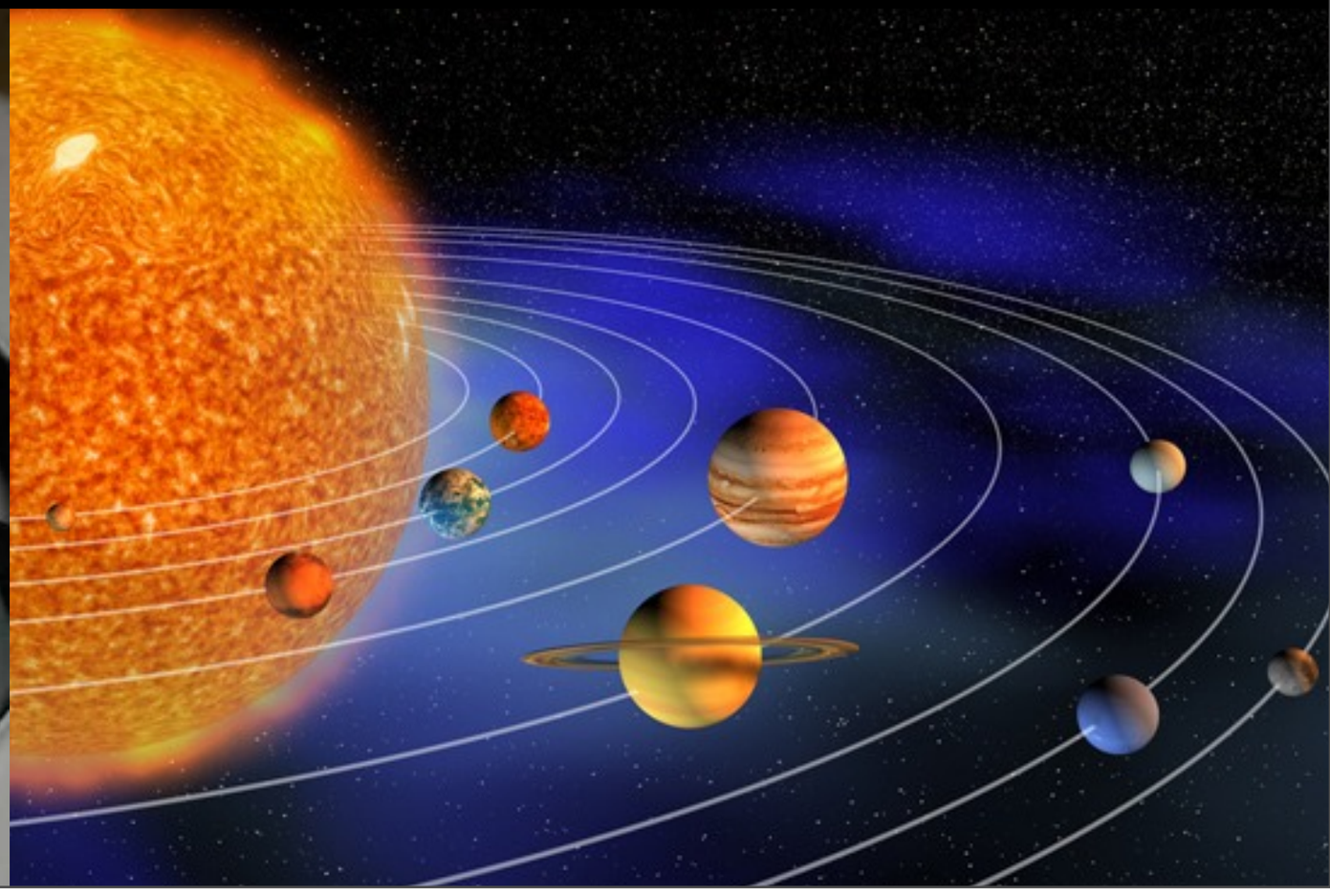


CIRCULAR

Around a fixed axis, or on a circular path

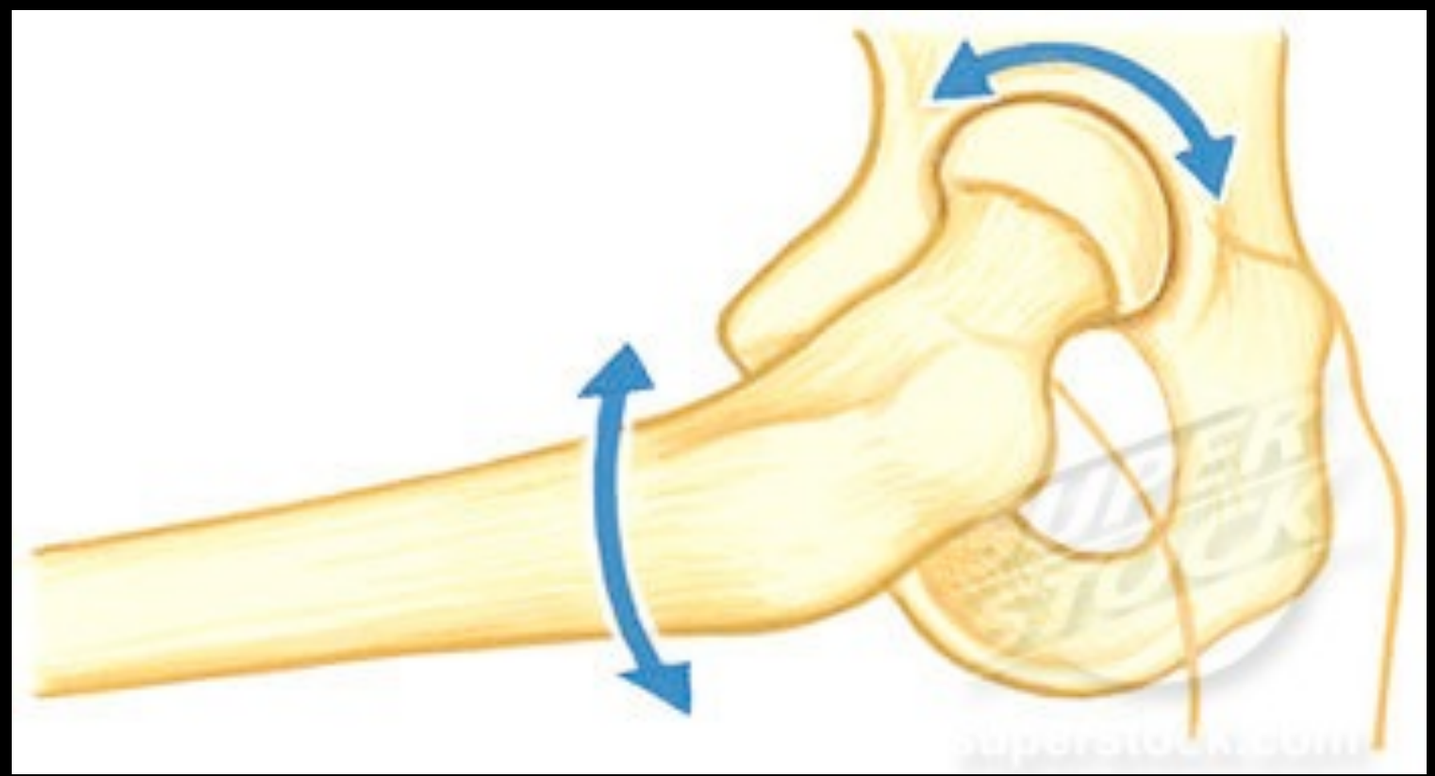
A. uniform (constant velocity, no acceleration)
B. variable velocity

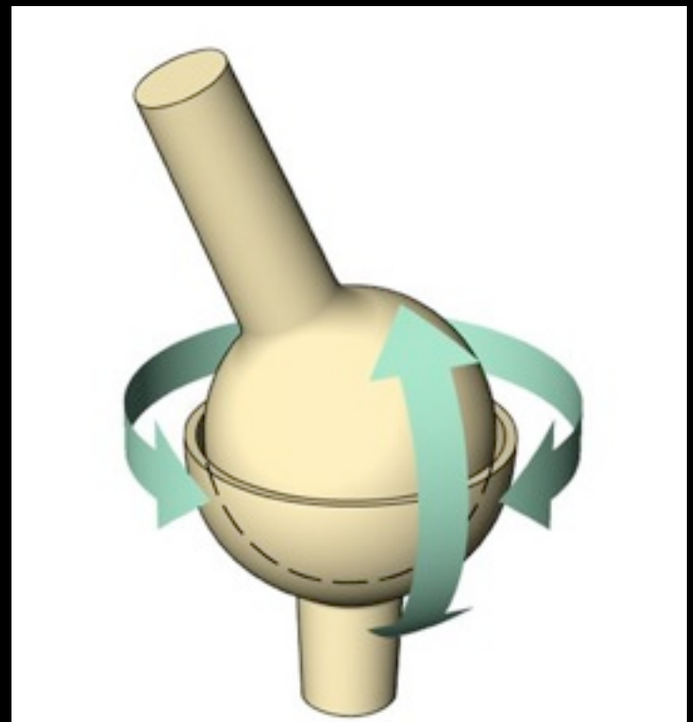




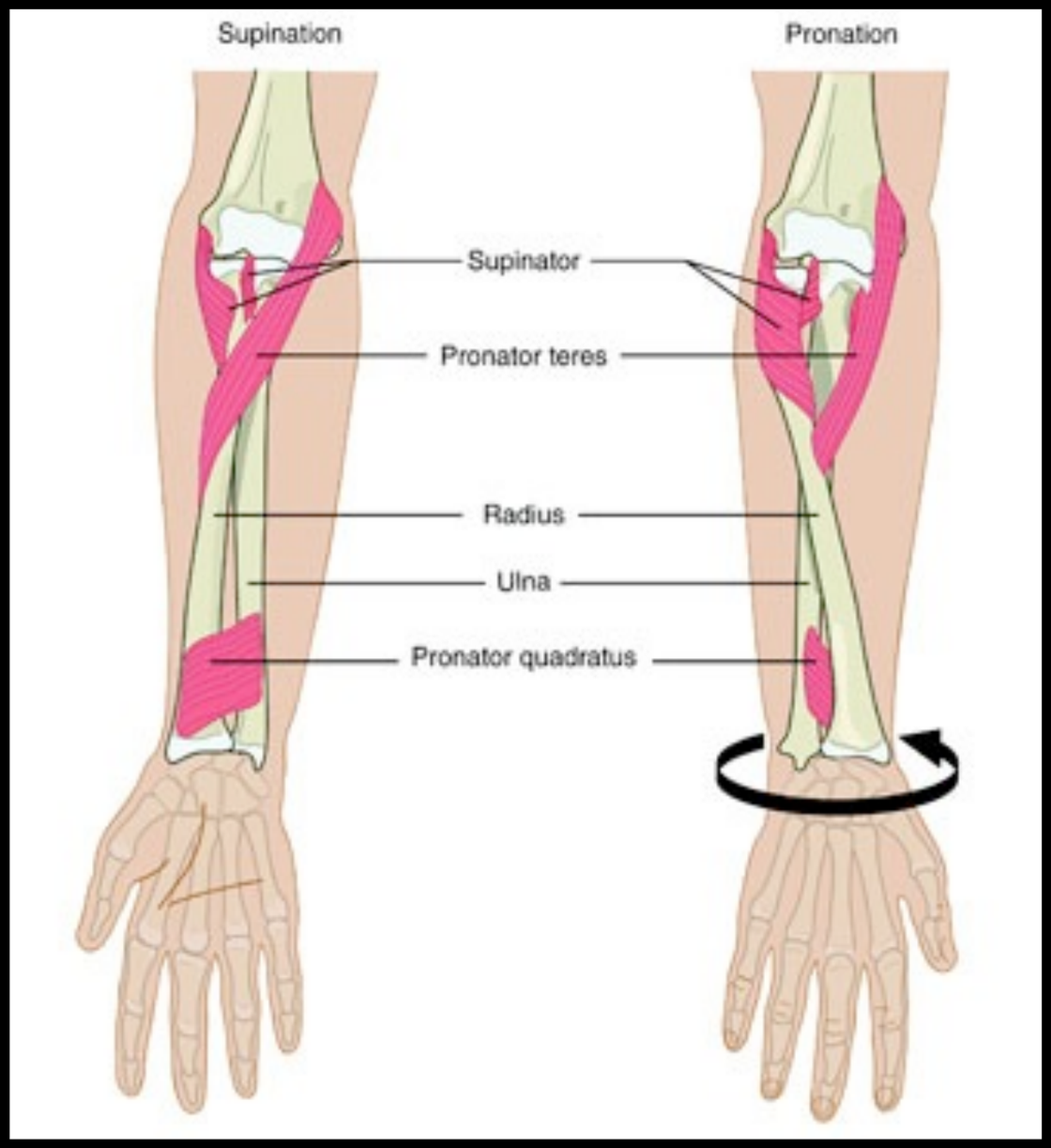
BALL IN SOCKET

SHOULDER
HIP



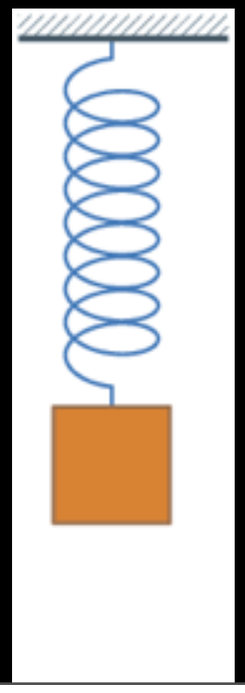


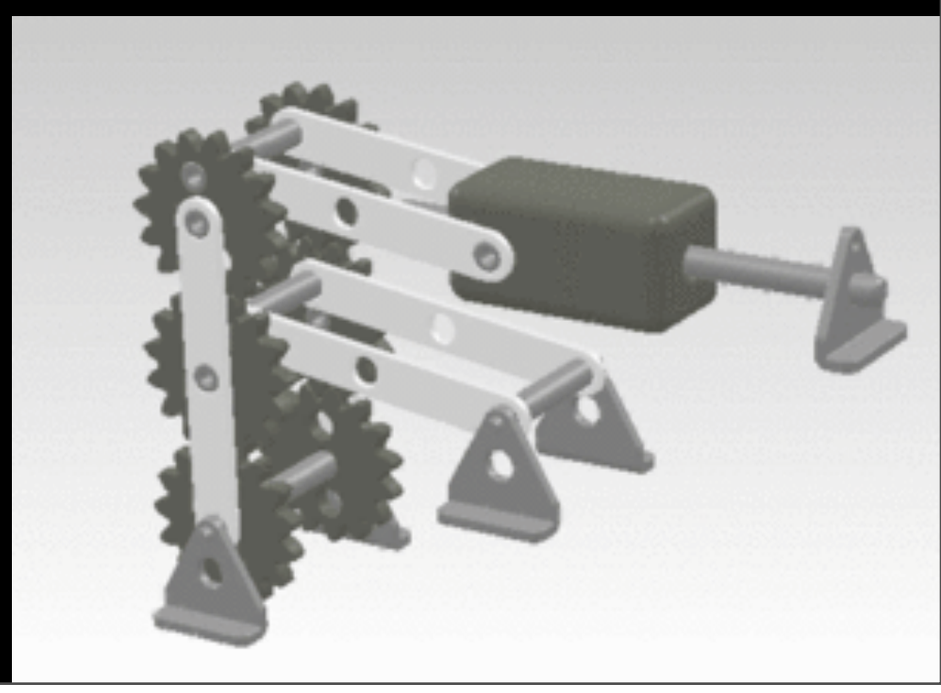
ROTATION


Supination
Pronation
Supinator
Pronator teres
Radius
Ulna
Pronator quadratus

OSCILLATON

Periodic : back and forth at regular intervals
Reciprocation : repetitive back and forh



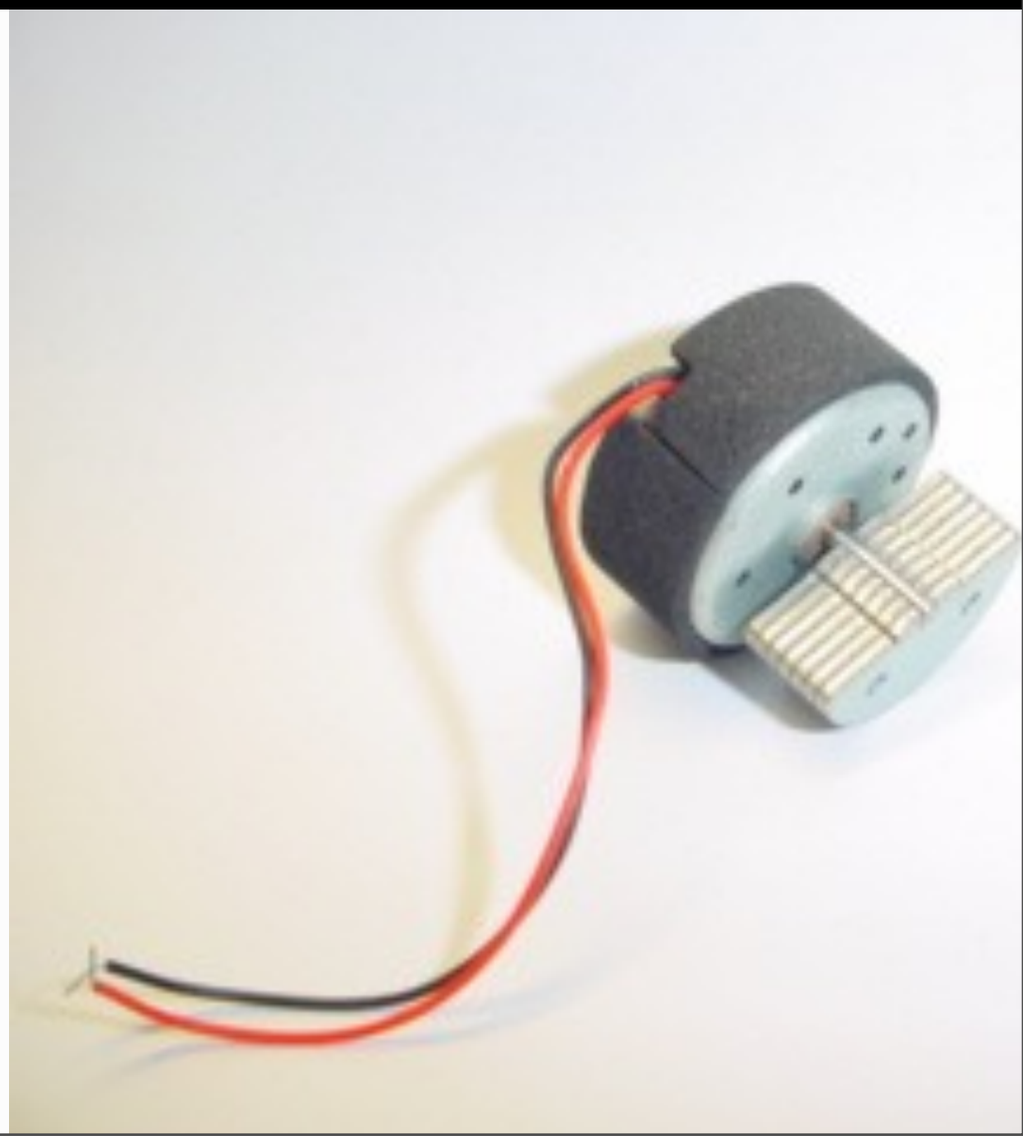


OSCILLATON

EARTHWORM
MILLIPEDE

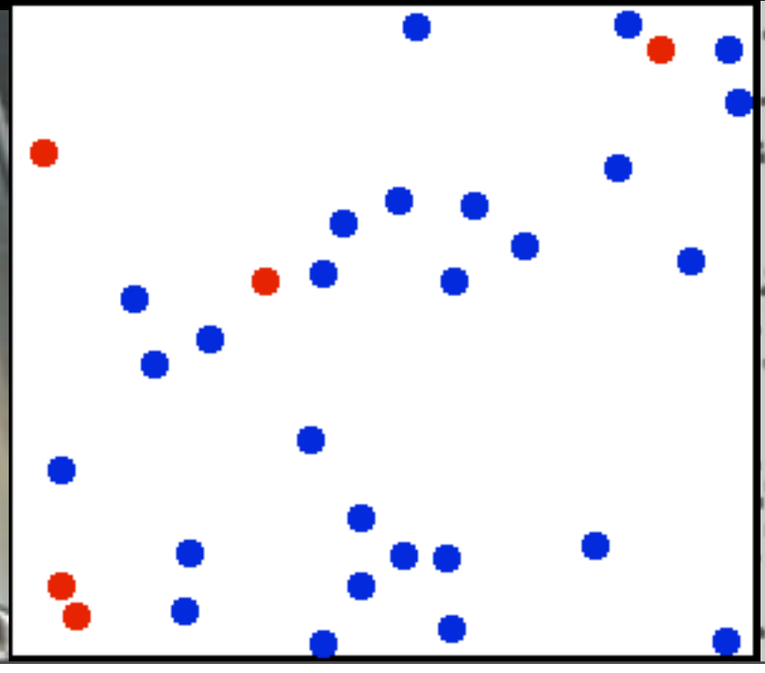
VIBRATION

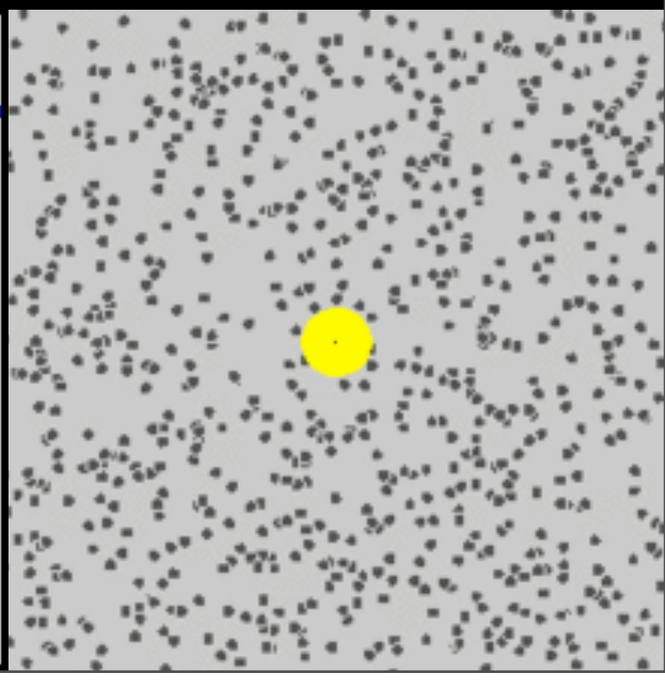
movement around one equilibrium point



RANDOM

Random moving of particles suspended in a fluid





ACTUATORS

servo motors (continuous or ~180)

linear actuators

stepper motors

dc motors (w/ encoders)

motorless (muscle wire, air)

MOTORLESS MOTION

Fluid Pressure
Hydraulics
Pneumatics

"Artificial Muscle"
Memory Alloy
Nitinol wire
Polymers

STELARC'S PNEUMATICS

LOW POWER ROBOT

NITINOL

JAMECO® ELECTRONICS

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NITINOL WIRE 500 UM 1 METER

Jameco Part no. 357798	
Manufacturer	MONDOTRONICS
Manufacturer no.	3-401

Catalog 131 , page 164

Data Sheet (current) [613 KB]

View Larger Image

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MONDO-TRONICS

Pricing & Availability

$16.95

# of Unit	Price
1+	$16.95
5+	$15.49

Availability: Ship today

+ Add to my favorites

Quantity 1 ADD TO CART

Overview | Specifications | Related Products

Nitinol Shape Memory Alloy Wire

Untrained, as-drawn Ni-Ti wire in various sizes, cross sections and temperatures. Form and anneal to your own shapes for springs, thermal actuators, "memory wire" magic tricks, etc. Use with Actuator Design Manual.

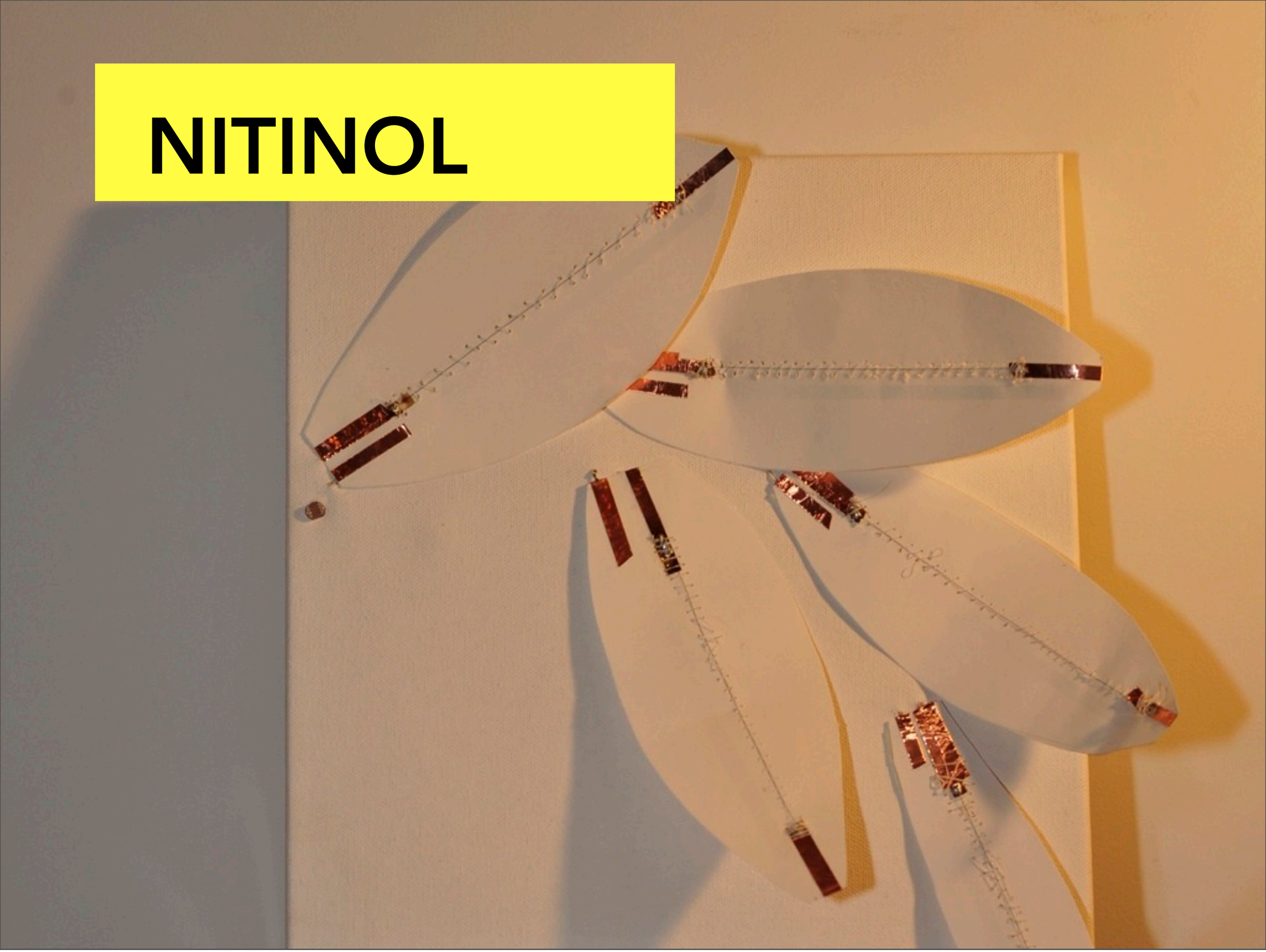
- 500µm

RELATED PRODUCTS

MW PROJECT BOOK & SAMPLE KIT,MUSCLE WIRE

NITINOL

NITINOL

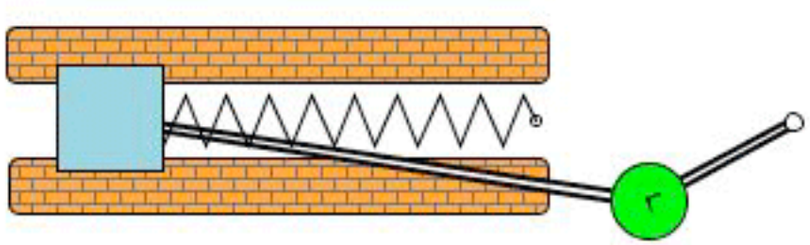


CONVERTING MOTION

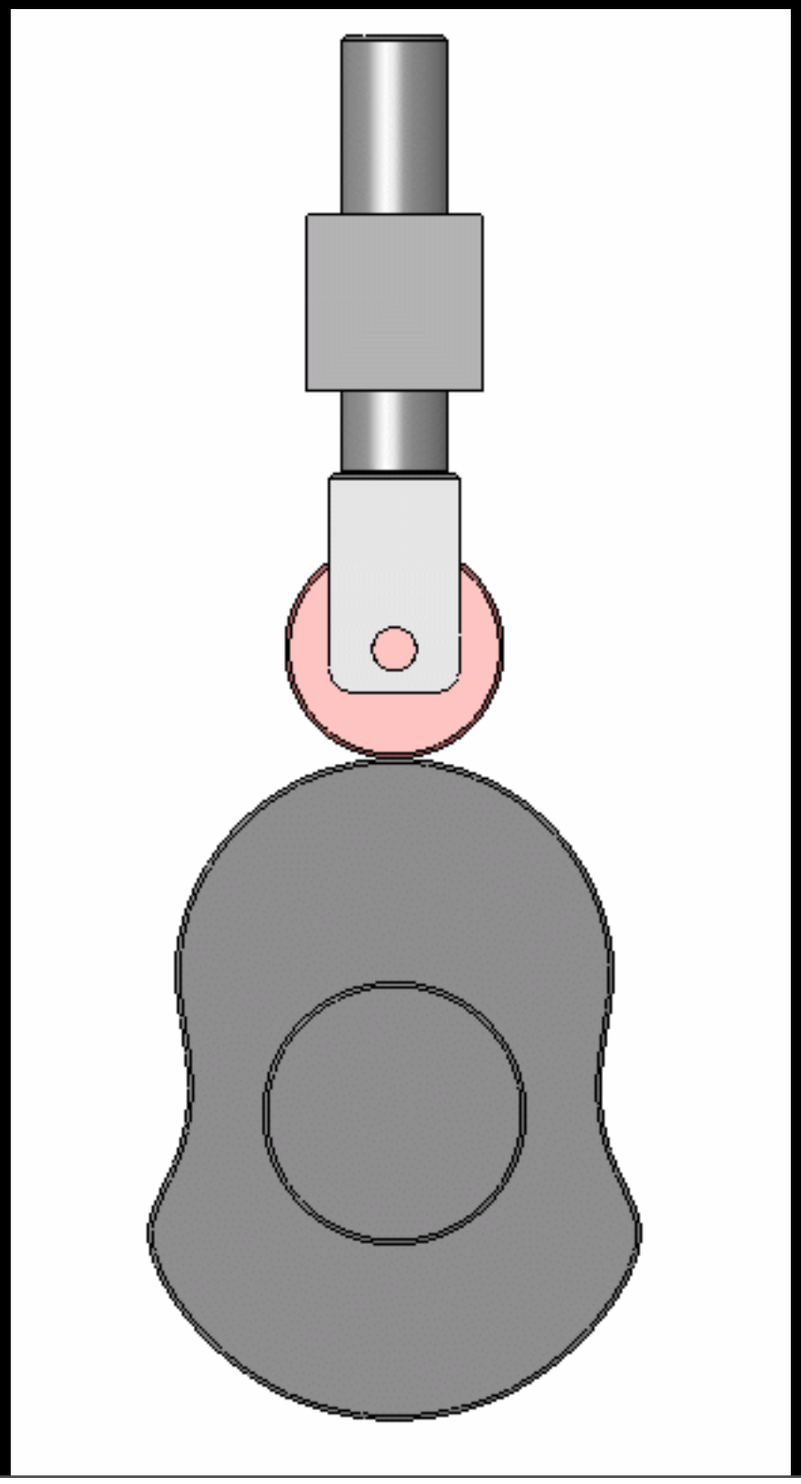
Cranks
Cams
Linkages

CRANKS

Rotary to oscillating motion



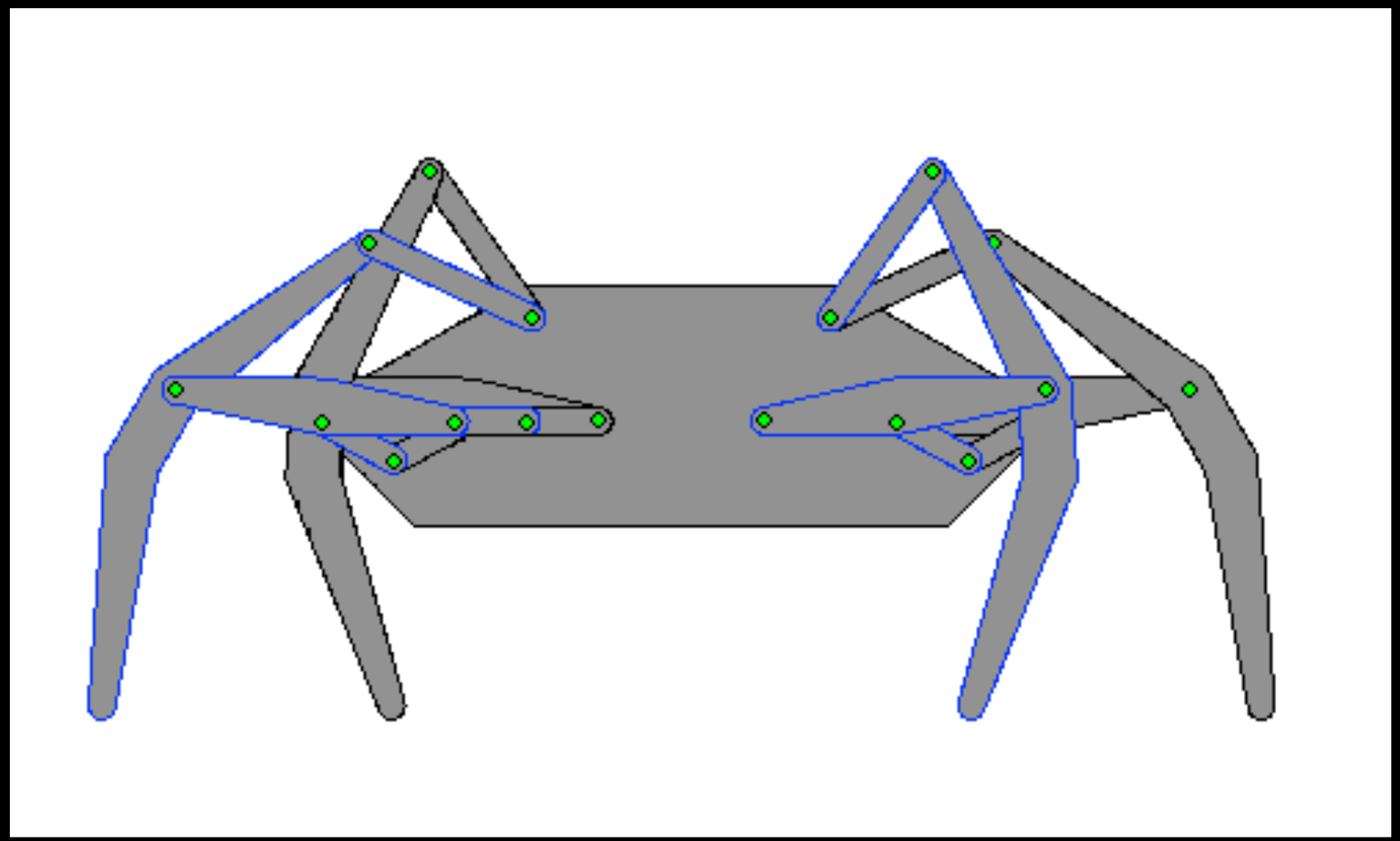
CAMS



The cam turns and the cam follower moves up and down

LINKAGES

Connection between units, at a joint

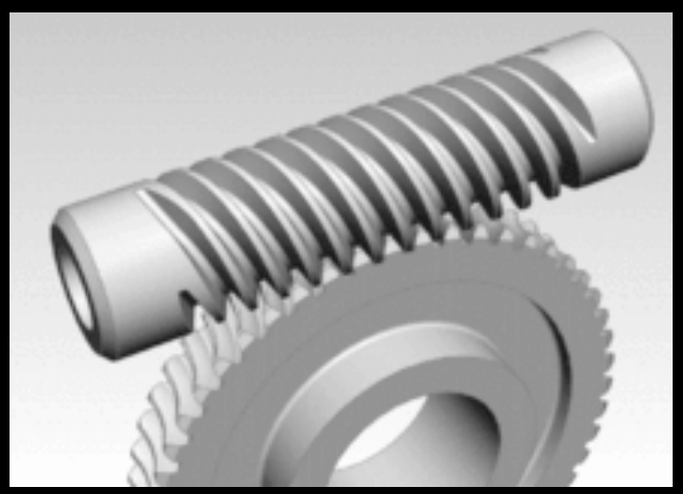


6 SIMPLE MACHINES

1. *Gears*
2. *Pulleys*
3. *Levers*
4. *Wheels*
5. *Screws*
6. *Inclined Planes*

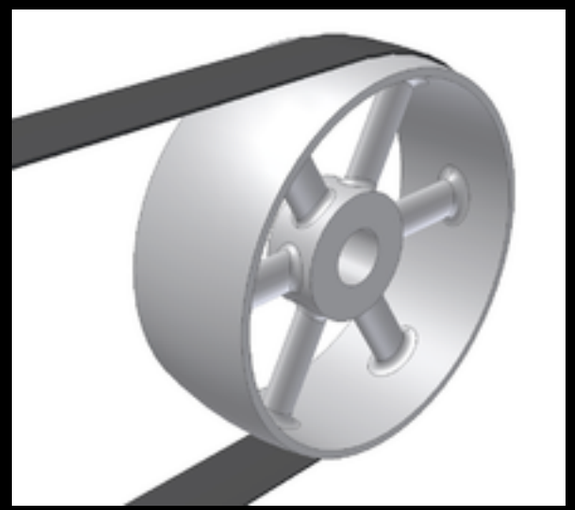
GEARS

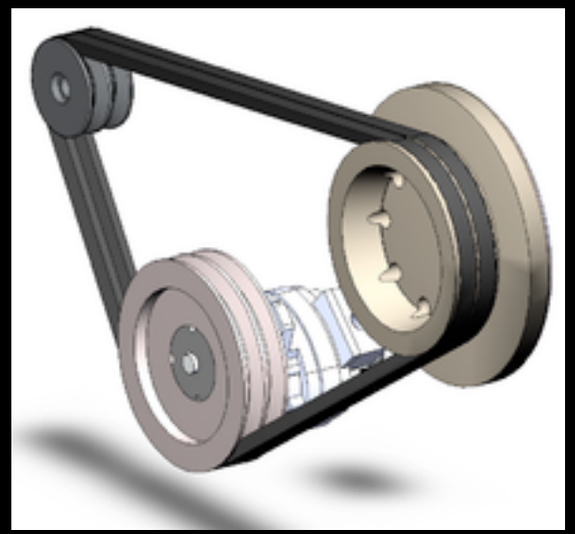
Spur Gears
Worm Gears
Rack and Pinion



PULLEYS

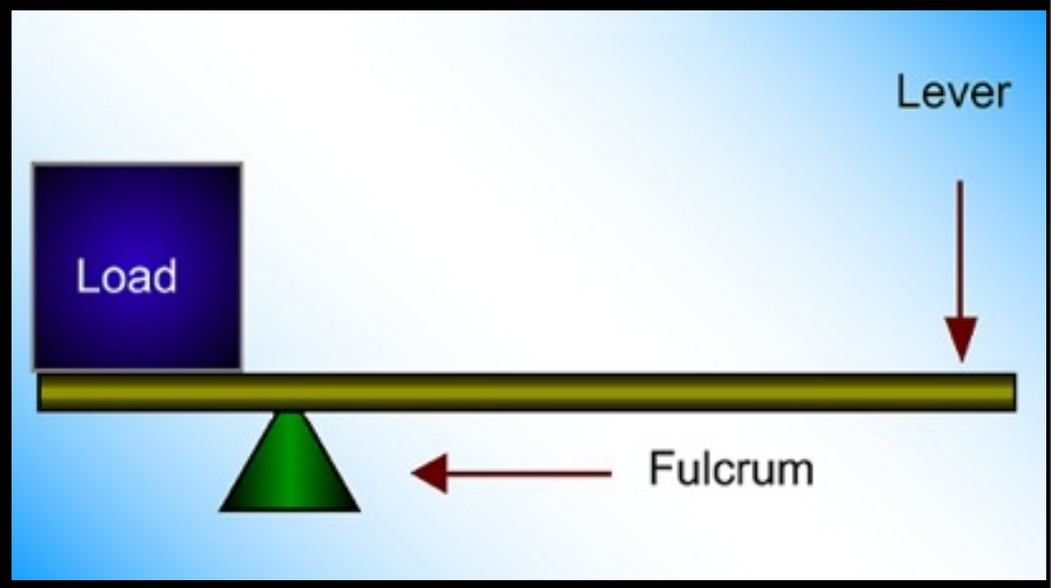
Wheel on an axel supports movement of a cable



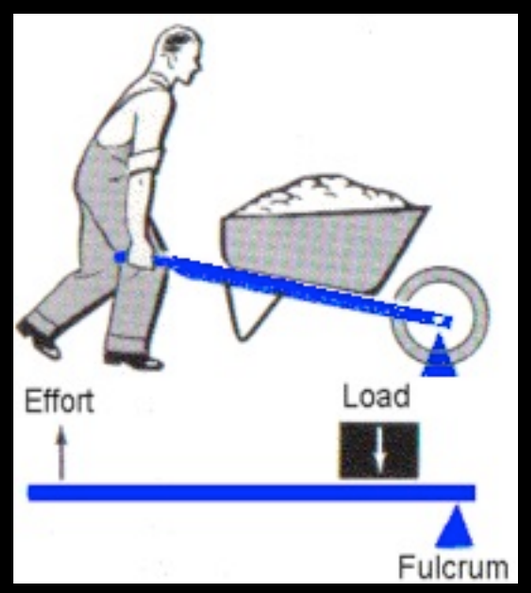


LEVERS

1st class lever:

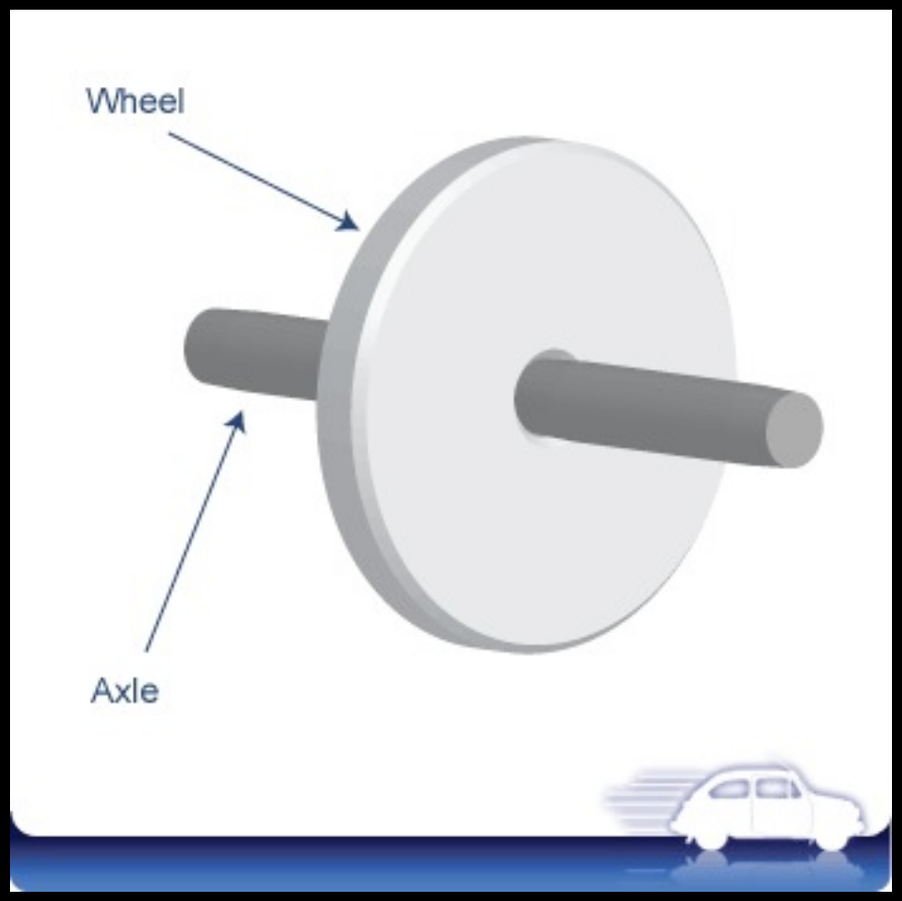


2nd class lever:



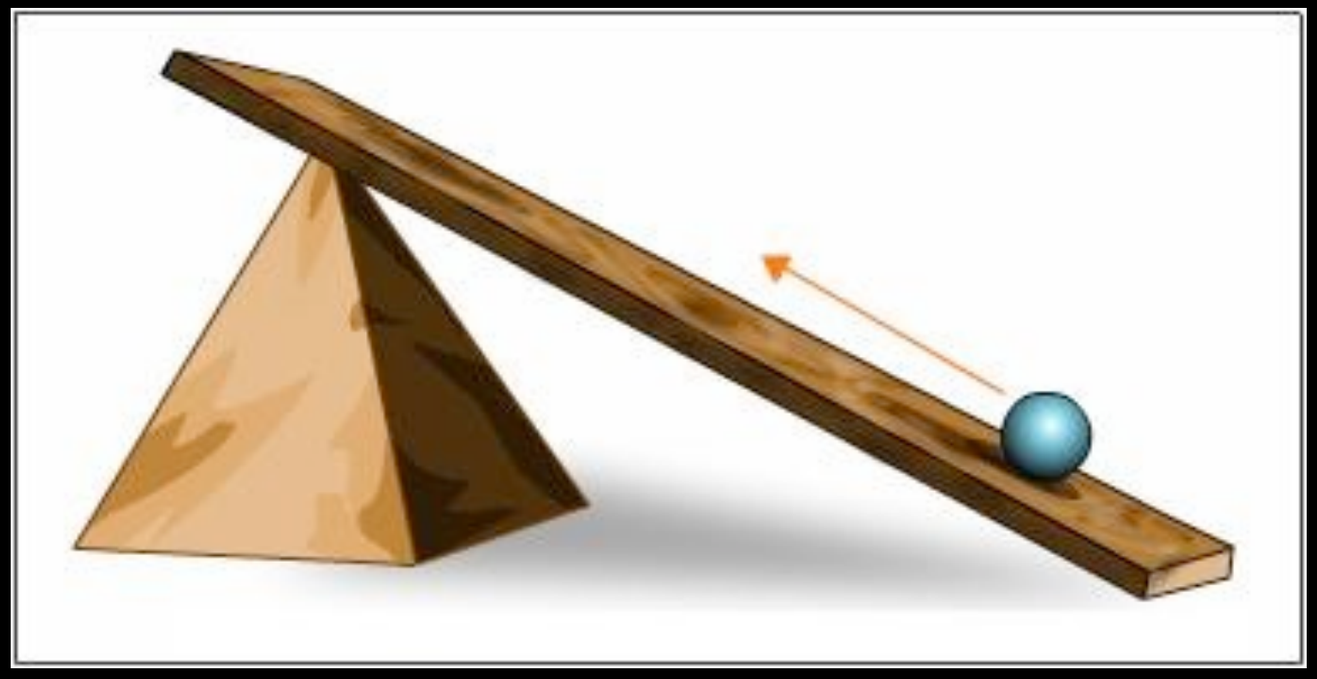
WHEELS

Rotation around the axel



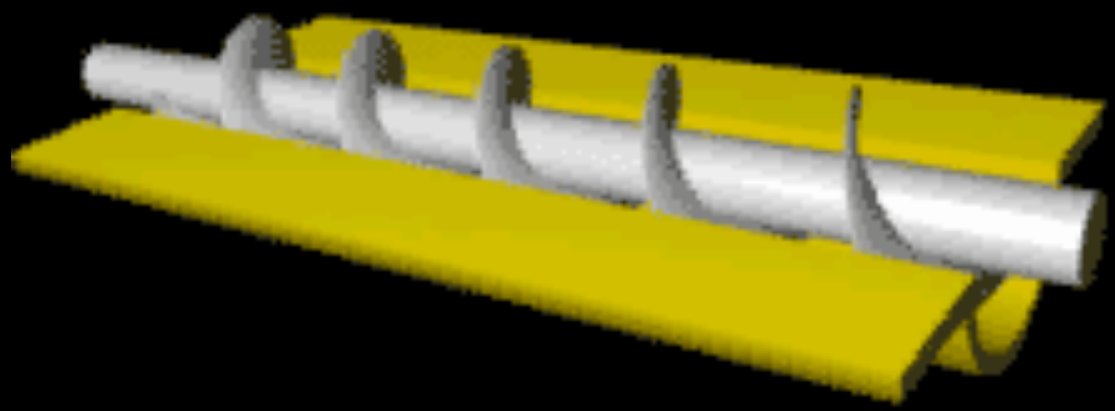
INCLINED PLANES

Mechanical advantage = length/height



SCREWS

Special type of inclined plane around interior shaft



MOTIONS IN CODE

Sine wave
Inverse Kinematics

[Flocking
Particle Systems
Line Following
Edge Detection]

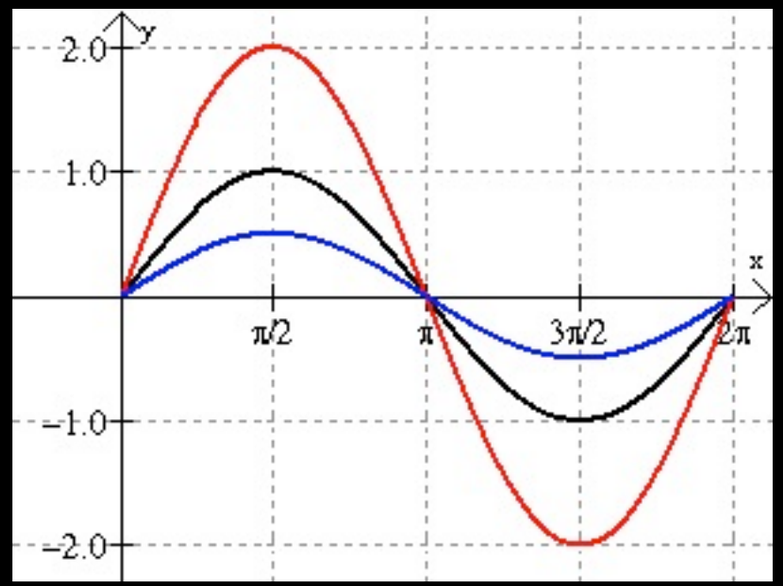
SINE WAVE

y = A * sin(b)

A = amplitude of the wave
b = period (cycles between 0 and 360 degrees (2PI))

SINE WAVE

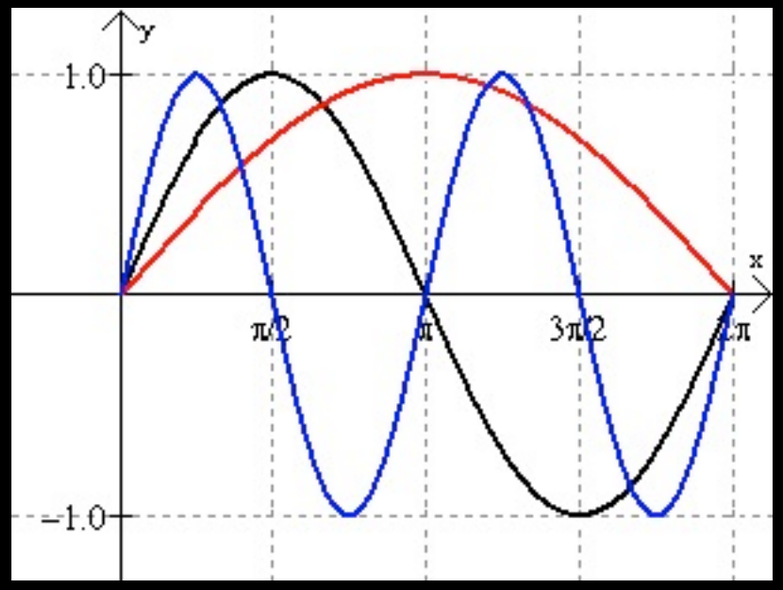
A = 1
A = 2
A = 1/2



y = A * sin(b)

SINE WAVE

y = sin(x)
y = sin(1/2x)
y = sin(2x)



y = A * sin(b)

SINE WAVE

$$y = A * \sin(b)$$

Workbook1

100%

Search in Sheet

Home | Layout | Tables | Charts | Chart Layout | Format | SmartArt | Formulas | Data | Review

Change Chart Type: Column, Line, Pie, Bar, Area, Scatter, Other

Insert Sparklines: Line, Column, Win/Loss

Data: Select, Switch Plot

Chart Quick Layouts

Chart Styles

Chart 1

A	B	C	D	E	F	G	H	I	J
90	98.98	107.88	116.6	125.05	133.15	140.82	147.98	154.56	160.5
94									
98.9									
103.4									
107.8									
112.2									
116									
120.8									
125.0									
129.1									
133.1									
137.0									
140.8									
144.4									
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160									
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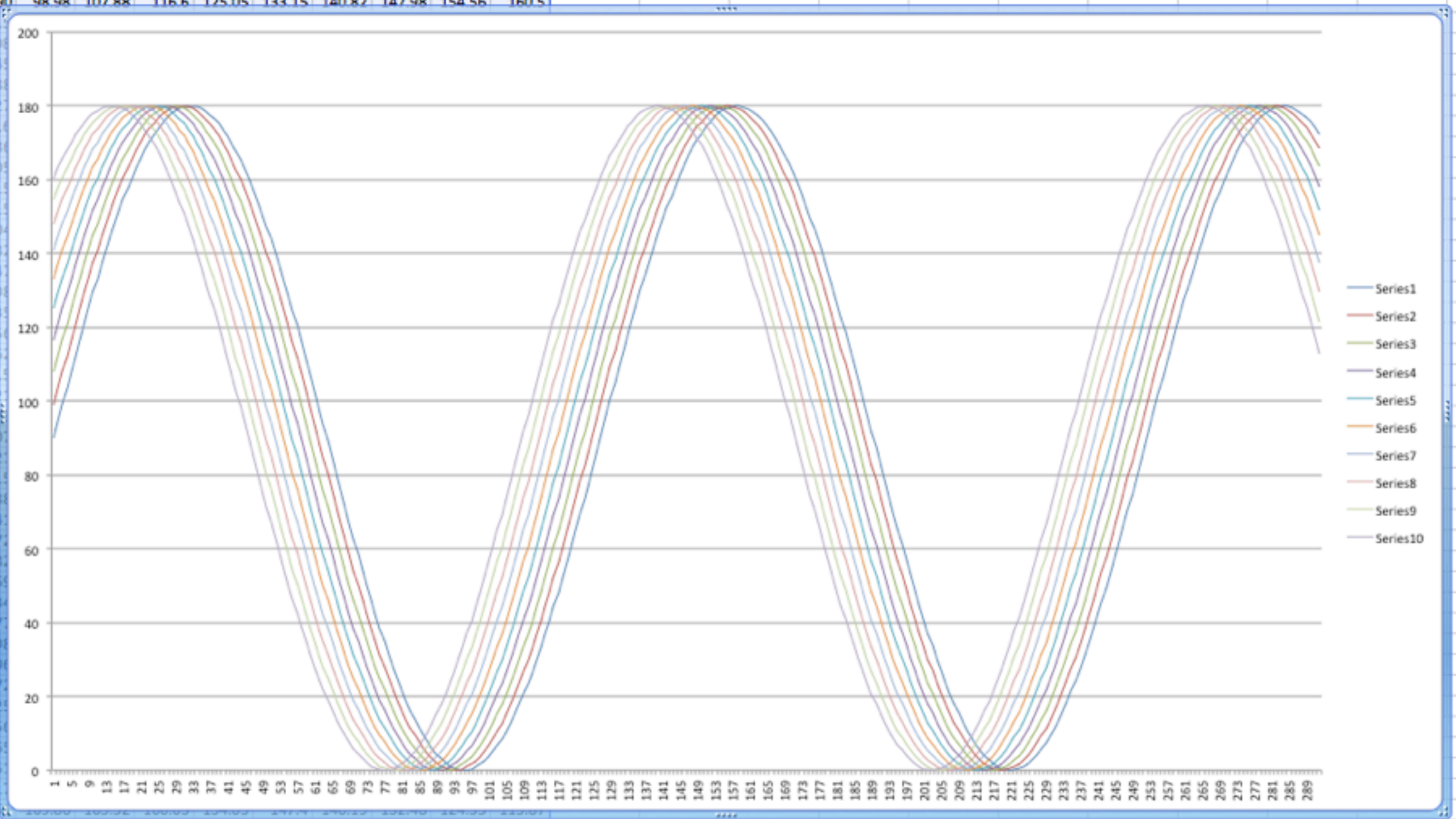
179.7									
179.2									
178.5									
177.6									
176.5									
175.1									
173.6									
171.84	167.69	162.76	157.11	150.79	143.86	136.4	128.46	120.15	111.53
169.86	165.32	160.03	154.03	147.4	140.19	132.48	124.35	115.87	107.14
167.69	162.76	157.11	150.79	143.86	136.4	128.46	120.15	111.53	102.7
165.32	160.03	154.03	147.4	140.19	132.48	124.35	115.87	107.14	98.23



Sheet1

Normal View | Ready | Sum=90

Workbook12

100%

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Change Chart Type: Column, Line, Pie, Bar, Area, Scatter, Other

Insert Sparklines: Line, Column, Win/Loss

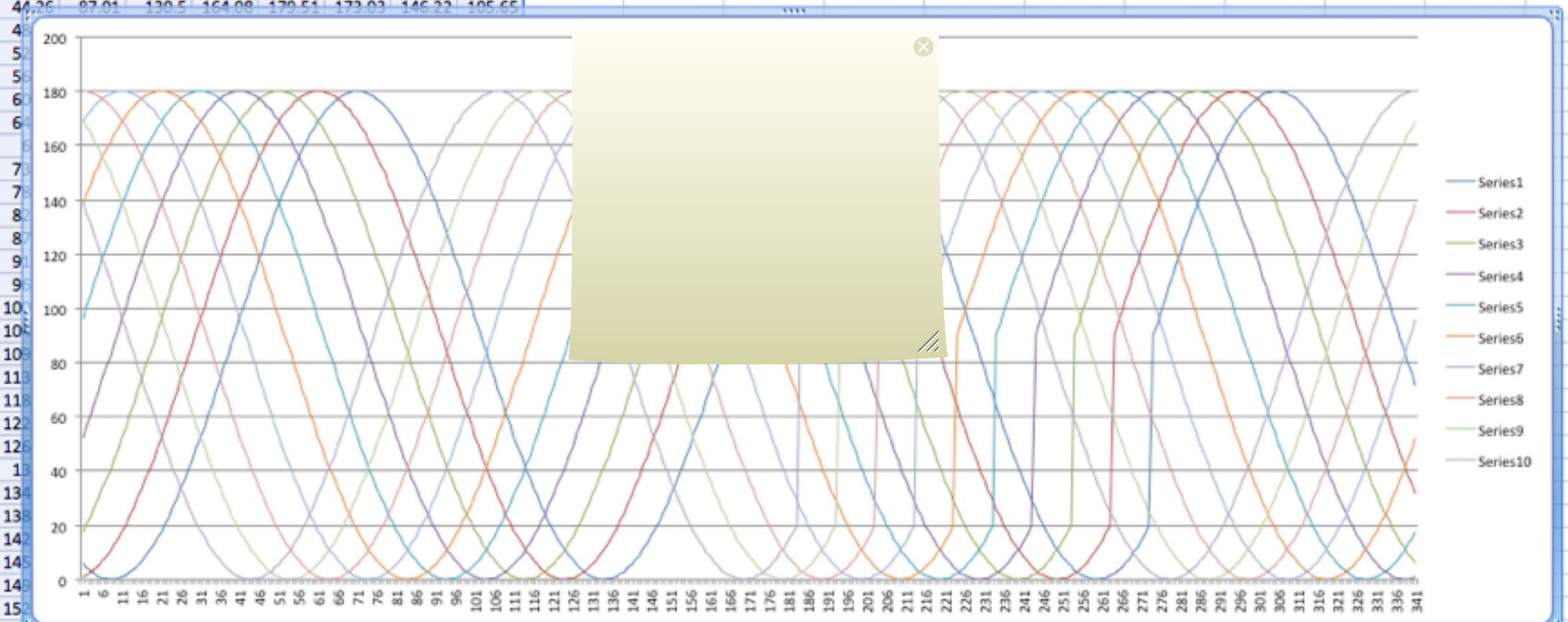
Data: Select, Switch Plot

Chart Quick Layouts

Chart Styles

Chart 1

	A	B	C	D	E	F	G	H	I	J
1	5.85	0.85	17.68	52.22	96.01	138.33	168.81	180	169.15	138.93
2	4.36	1.58	20.45	56.35	100.49	142.06	170.88	179.9	166.91	135.09
3	3.08	2.53	23.39	60.57	104.94	145.66	172.76	179.59	164.48	131.14
4	2.02	3.7	26.5	64.85	109.36	149.13	174.42	179.04	161.86	127.09
5	1.18	5.08	29.77	69.2	113.73	152.45	175.87	178.28	159.07	122.94
6	0.57	6.68	33.19	73.61	118.04	155.61	177.11	177.29	156.09	118.72
7	0.18	8.48	36.75	78.05	122.28	158.6	178.13	176.09	152.96	114.42
8	0.01	10.49	40.44	82.52	126.44	161.43	178.94	174.67	149.67	110.06
9	0.06	12.7	44.26	87.01	130.5	164.08	179.51	173.03	146.22	105.65
10	0.35	15.1	48.19	91.51	134.47	166.54	179.87	171.19	142.64	101.2
11	0.85	17.68	52.22	96.01	138.33	168.81	180	169.15	138.93	96.72
12	1.58	20.45	56.35	100.49	142.06	170.88	179.9	166.91	135.09	92.22
13	2.53	23.39	60.57	104.94	145.66	172.76	179.59	164.48	131.14	87.71
14	3.7	26.5	64.85	109.36	149.13	174.42	179.04	161.86	127.09	83.21
15	5.08	29.77	69.2	113.73	152.45	175.87	178.28	159.07	122.94	78.73
16	6.68	33.19	73.61	118.04	155.61	177.11	177.29	156.09	118.72	74.31
17	8.48	36.75	78.05	122.28	158.6	178.13	176.09	152.96	114.42	69.9
18	10.49	40.44	82.52	126.44	161.43	178.94	174.67	149.67	110.06	65.54
19	12.7	44.26	87.01	130.5	164.08	179.51	173.03	146.22	105.65	61.24
20	15.1	48.19	91.51	134.47	166.54	179.87	171.19	142.64	101.2	57.02
21	17.68	52.22	96.01	138.33	168.81	180	169.15	138.93	96.72	52.87
22	20.45	56.35	100.49	142.06	170.88	179.9	166.91	135.09	92.22	48.81
23	23.39	60.57	104.94	145.66	172.76	179.59	164.48	131.14	87.71	44.84
24	26.5	64.85	109.36	149.13	174.42	179.04	161.86	127.09	83.21	40.97
25	29.77	69.2	113.73	152.45	175.87	178.28	159.07	122.94	78.73	37.21
26	33.19	73.61	118.04	155.61	177.11	177.29	156.09	118.72	74.31	33.57
27	36.75	78.05	122.28	158.6	178.13	176.09	152.96	114.42	69.9	30.3
28	40.44	82.52	126.44	161.43	178.94	174.67	149.67	110.06	65.54	27.01
29	44.26	87.01	130.5	164.08	179.51	173.03	146.22	105.65	61.24	23.88
30	48.19	91.51	134.47	166.54	179.87	171.19	142.64	101.2	57.02	20.91
31	52.22	96.01	138.33	168.81	180	169.15	138.93	96.72	52.87	18.11
32	56.35	100.49	142.06	170.88	179.9	166.91	135.09	92.22	48.81	15.48
33	60.57	104.94	145.66	172.76	179.59	164.48	131.14	87.71	44.84	13.03
34	64.85	109.36	149.13	174.42	179.04	161.86	127.09	83.21	40.97	10.77
35	69.2	113.73	152.45	175.87	178.28	159.07	122.94	78.73	37.21	8.71
36	73.61	118.04	155.61	177.11	177.29	156.09	118.72	74.31	33.57	6.85
37	78.05	122.28	158.6	178.13	176.09	152.96	114.42	69.9	30.3	5.32
38	82.52	126.44	161.43	178.94	174.67	149.67	110.06	65.54	27.01	3.9
39	87.01	130.5	164.08	179.51	173.03	146.22	105.65	61.24	23.88	2.7
40	91.51	134.47	166.54	179.87	171.19	142.64	101.2	57.02	20.91	1.72
41	96.01	138.33	168.81	180	169.15	138.93	96.72	52.87	18.11	0.95

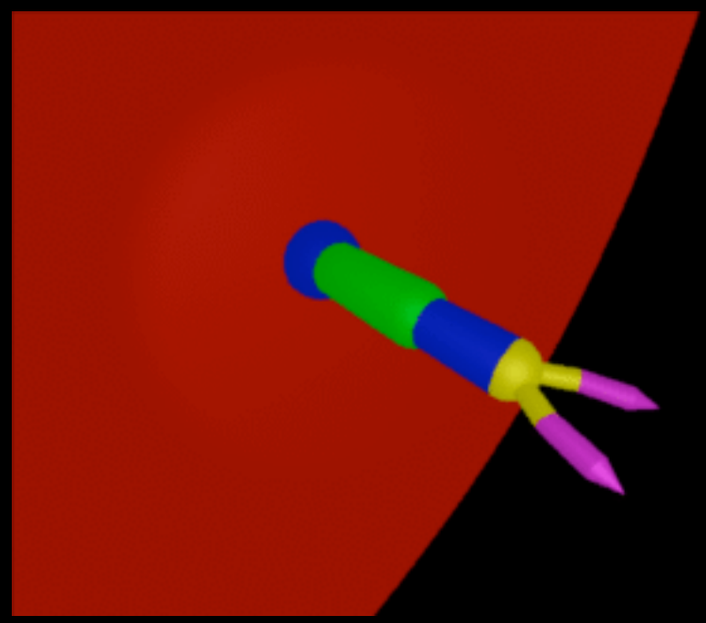


Sheet1

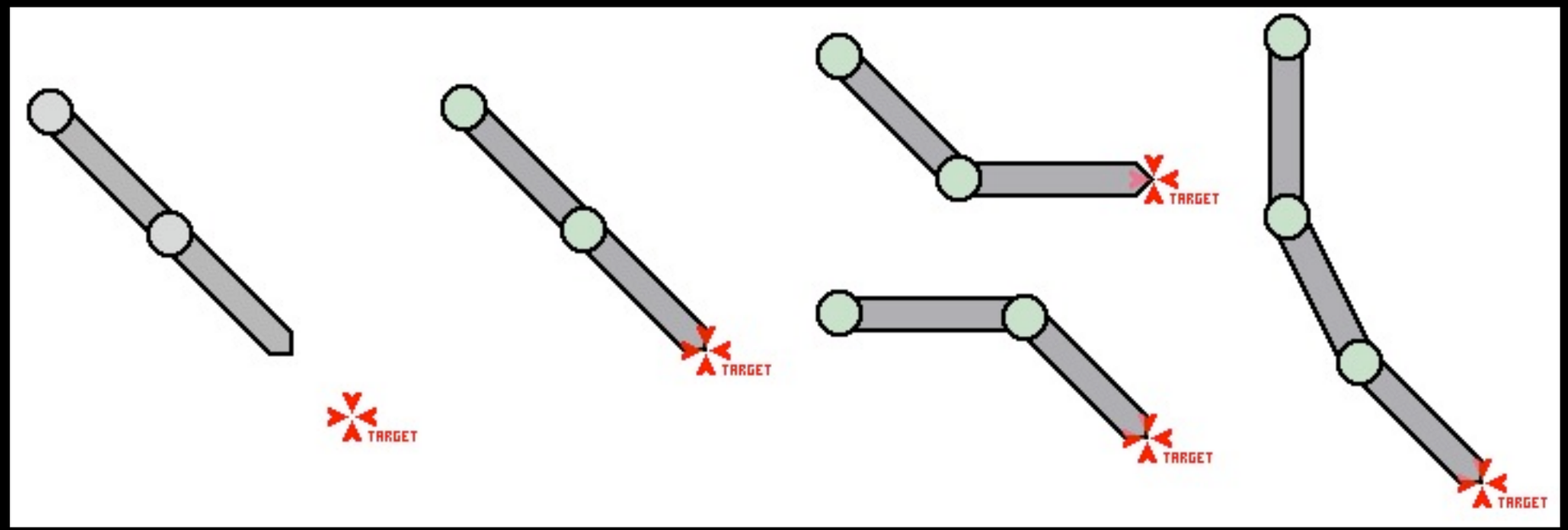
Normal View | Ready | Sum= 5.85

Wednesday, September 11, 13

INVERSE KINEMATICS



INVERSE KINEMATICS



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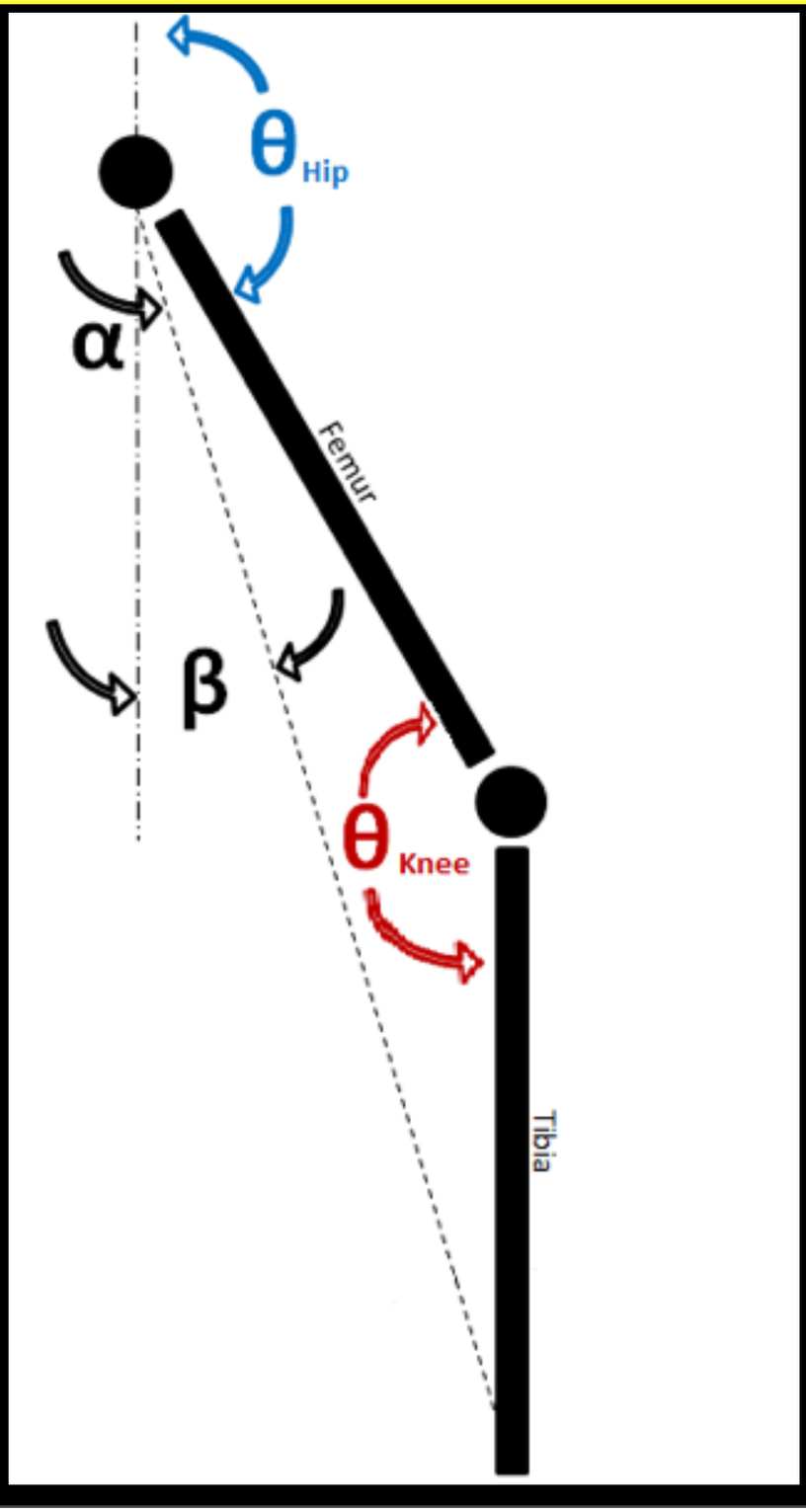


INVERSE KINEMATICS

some code

IN HARDWARE

1. sweep

2. wave table array

3. servo sine wave class

4. inverse kinematics

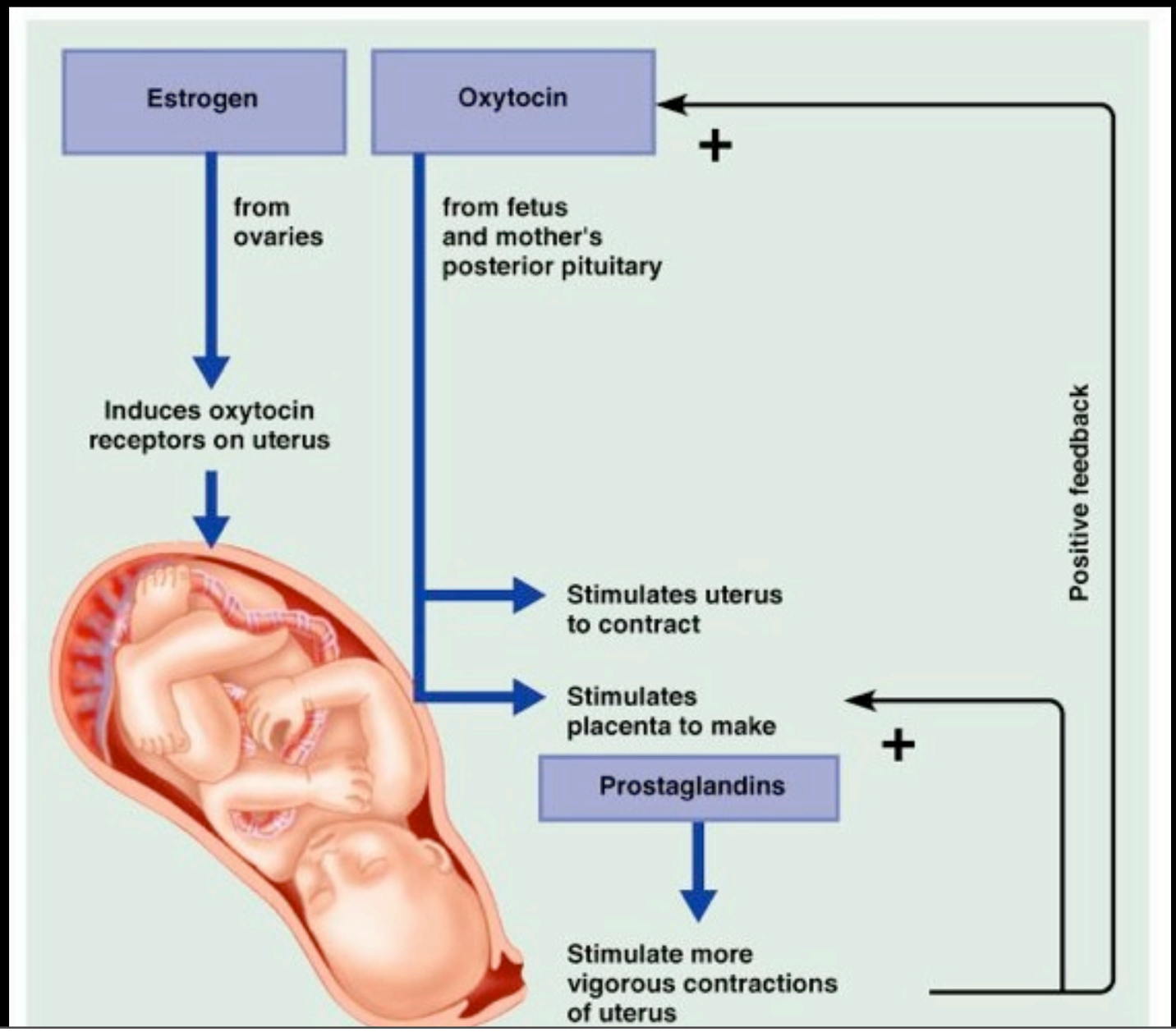
BIOLOGICAL FUNCTIONS

1. Maintenance
2. Metabolism
3. Nutrition
4. Respiration
5. Growth
6. Exchange of Materials
7. Transportation
8. Excretion
9. Irritability

VIRUSES?

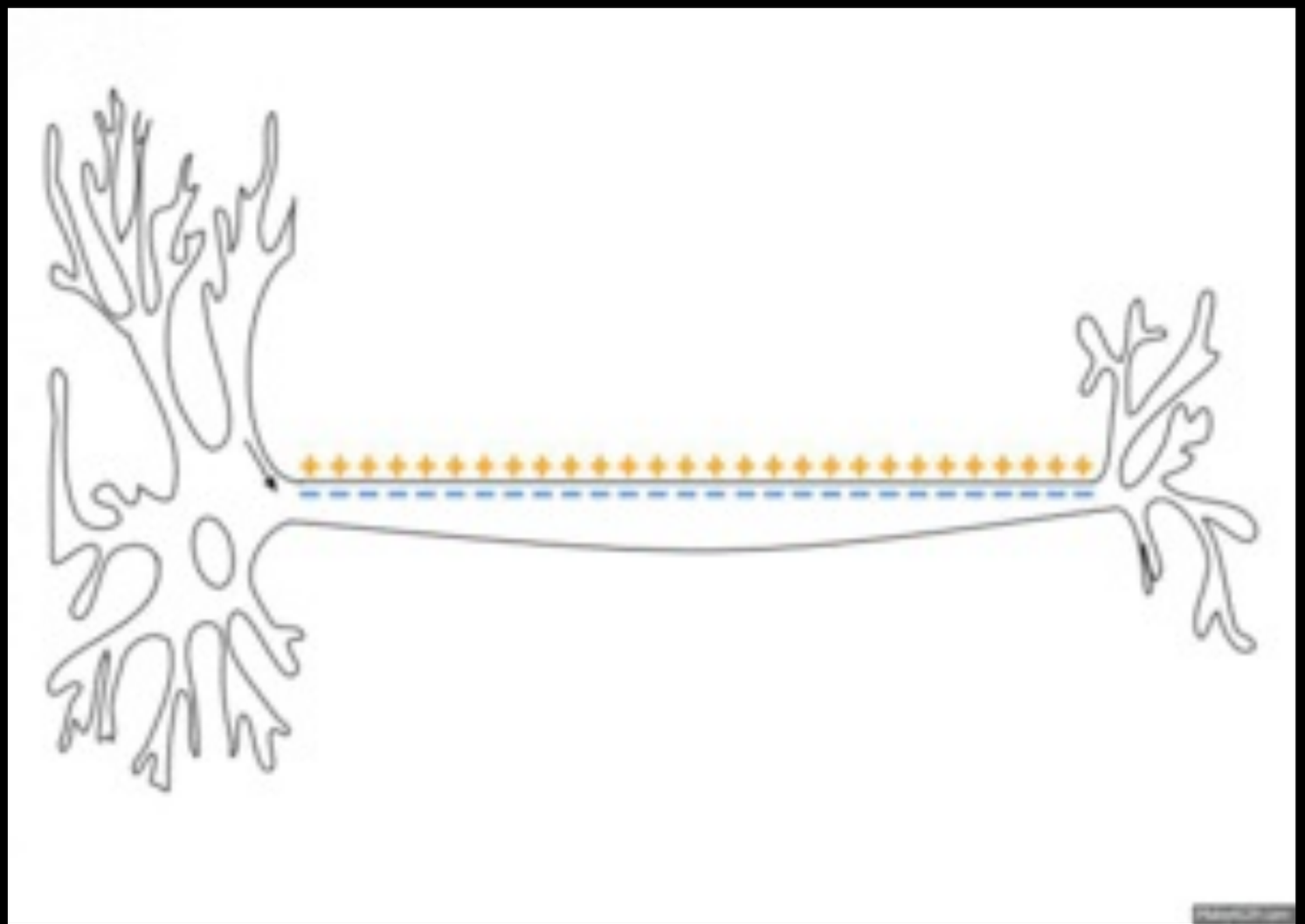
BIOLOGICAL FEEDBACK

POSITIVE FEEDBACK



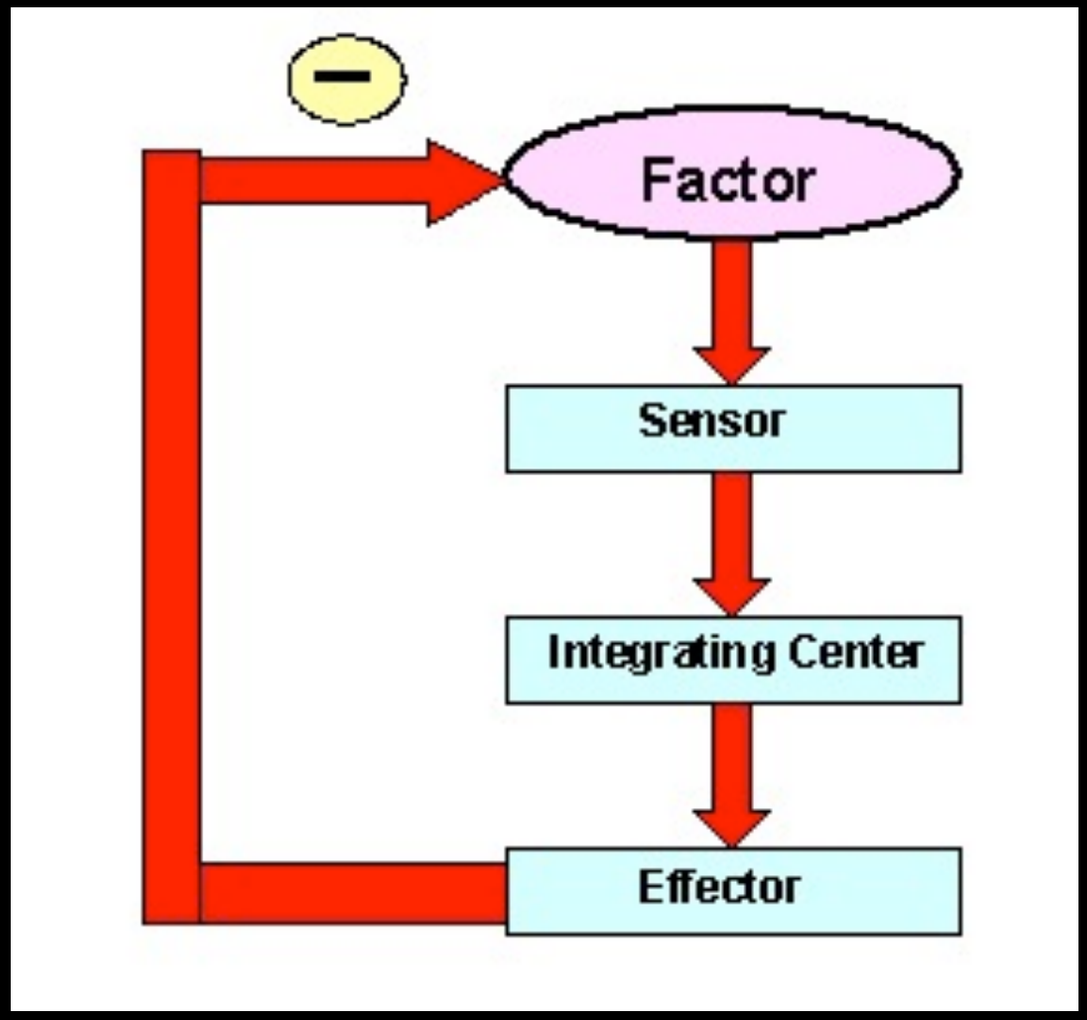
BIOLOGICAL FEEDBACK

POSITIVE FEEDBACK



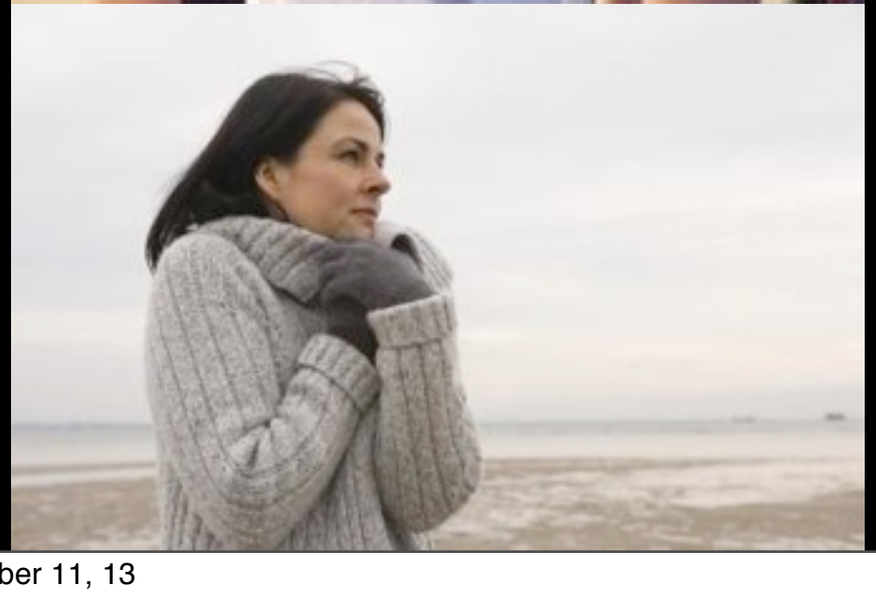
BIOLOGICAL FEEDBACK

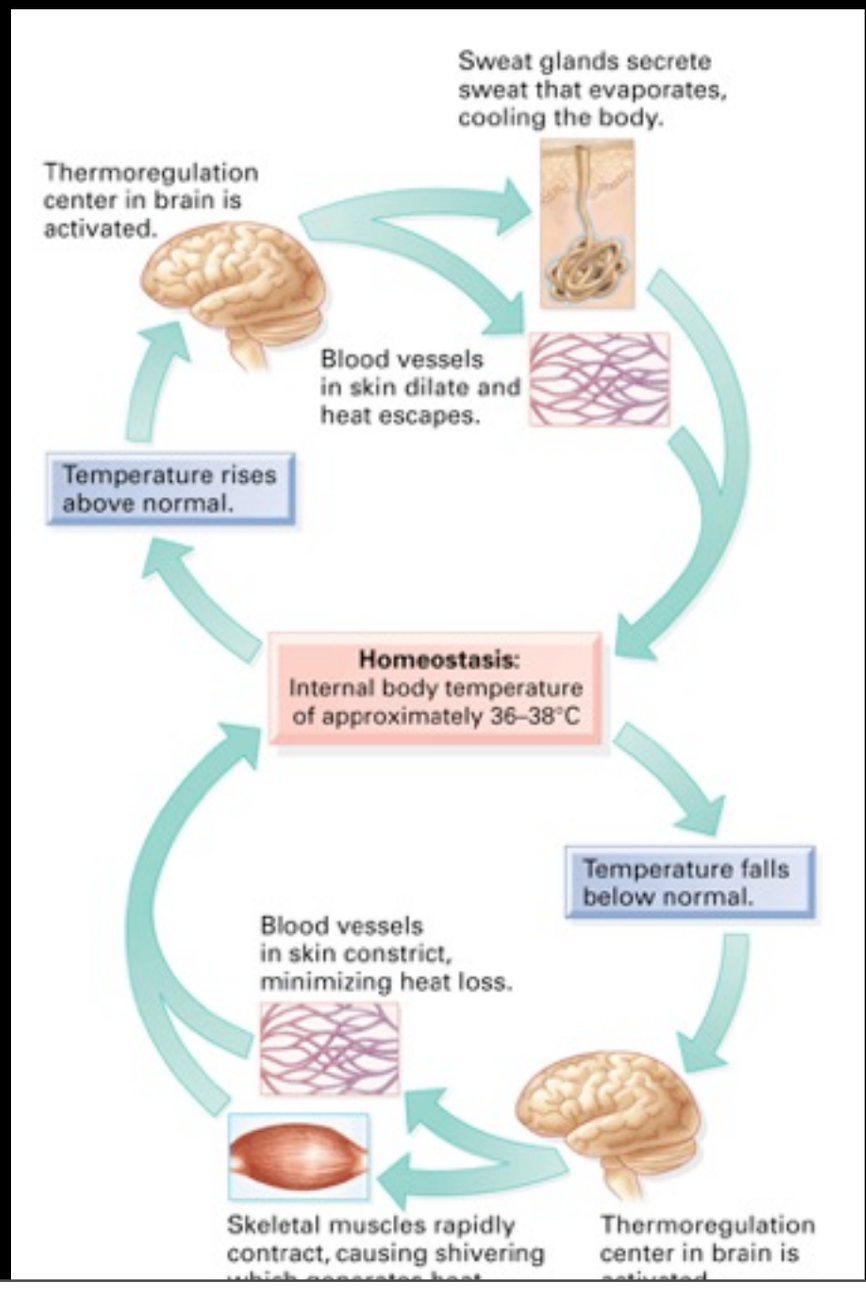
NEGATIVE FEEDBACK



BIOLOGICAL FEEDBACK

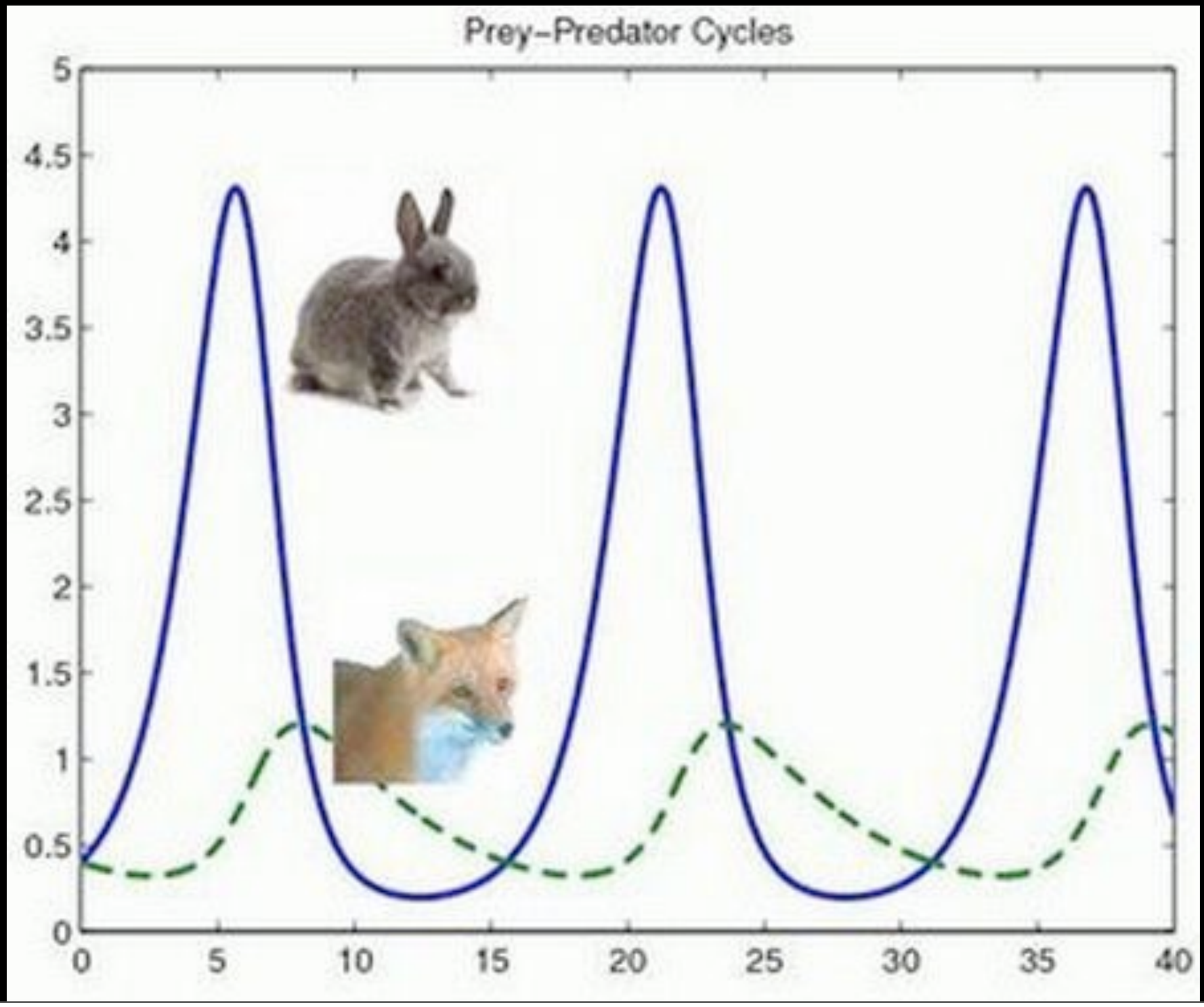
NEGATIVE FEEDBACK





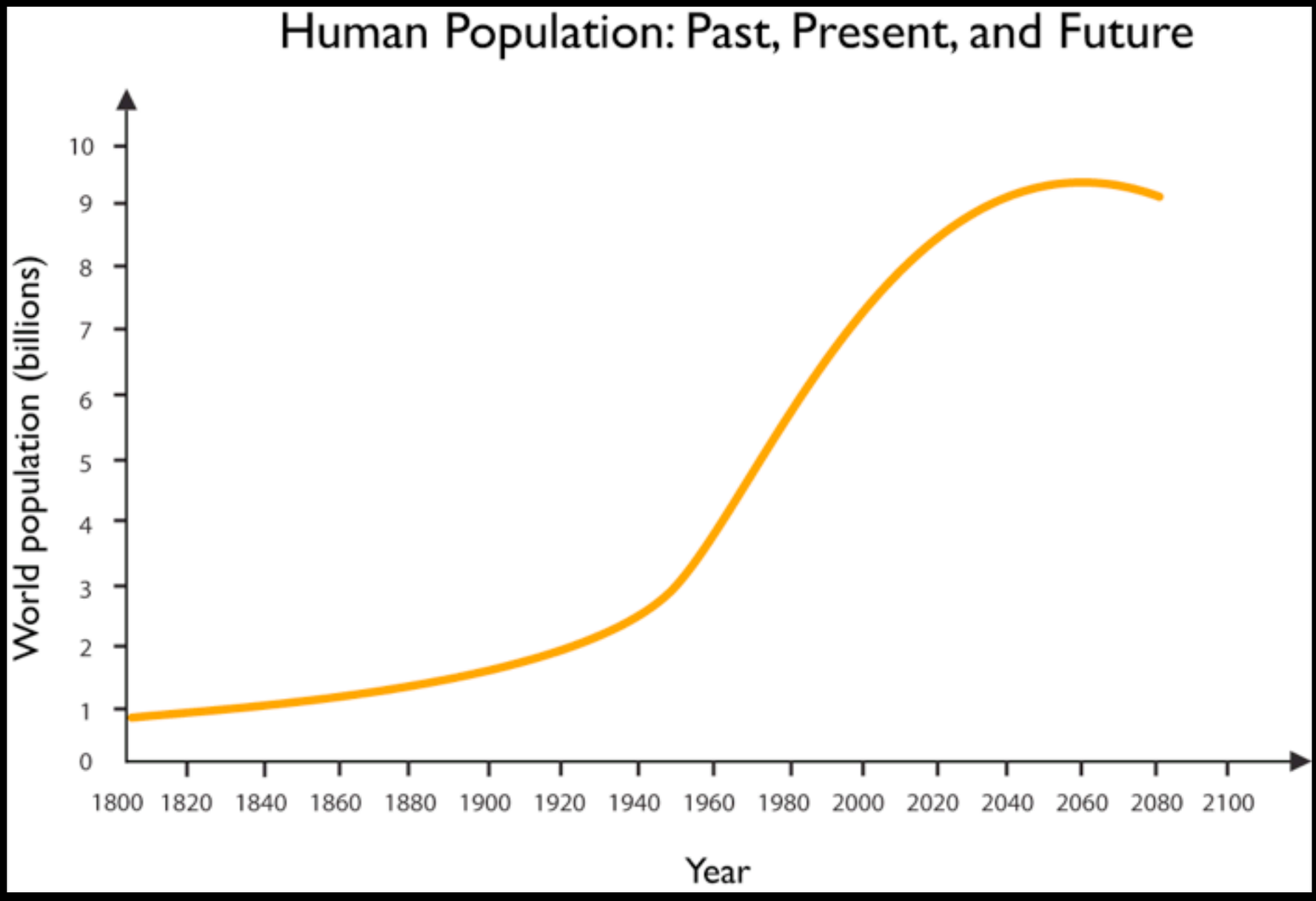
HOMEOSTASIS

HOMEOSTASIS



HOMEOSTASIS

HOMEOSTASIS



SYMBIOSIS : MUTUALISM

SYMBIOSIS : COMMENSALISM

SYMBIOSIS : PARASITISM

CORDYCEPS FUNGI

BIOMIMICRY in BIOLOGY

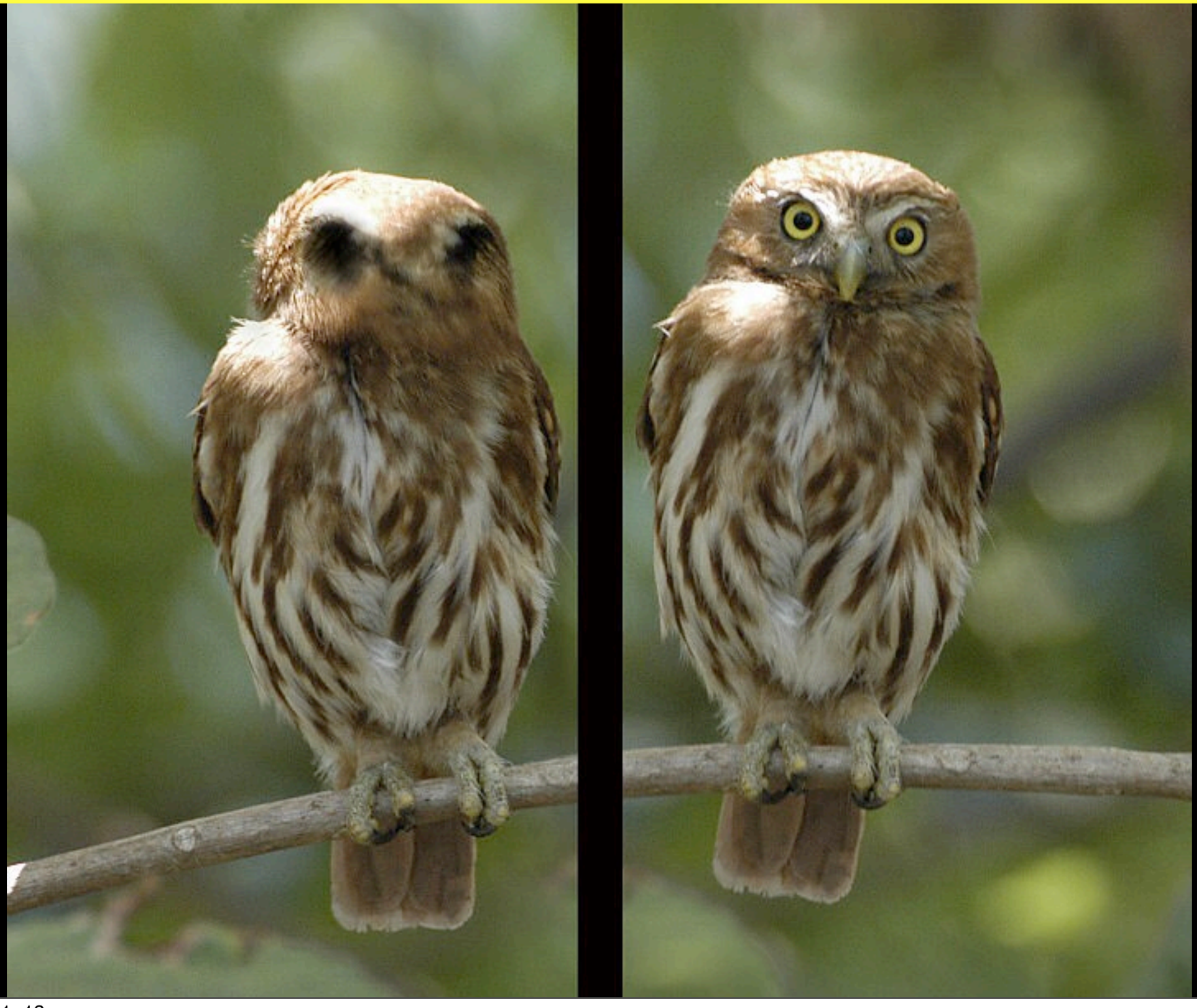
- *DEFENSIVE*
- *AGGRESSIVE*
- *AUTOMIMICRY*

BIOMIMICRY in BIOLOGY

BIOMIMICRY in BIOLOGY

BIOMIMICRY in BIOLOGY

BIOMIMICRY in BIOLOGY



TODAY

1. readings & homework

2. demo projects

2. methods of motion & lecture

4. assignment

NEXT WEEK

1. Discussion + Lecture:
AI / Cybernetics & Cyborgs
Synthetic biology & Living design
Renewable Energy
Biological & Digital Inputs: Sensors

2. HW presentations

3. Launch Final Assignment

In class worktime on initial ideas

ASSIGNMENTS

What ideas do you have for a final project in this class?

ASSIGNMENT

By Tuesday at 2 PM, have your posts (or links to posts) up online
GROUPS OF 3

Build a new kind of biomimetic sensor:

Identify a living organism, or the sensory system of a particular organism. Design a concept for a new type of sensor that mimics that organic system. [You can use organic material]

Present at a concept diagram that explains:

1. who is the user?
2. what is the task accomplished?
3. Why is it unique?
4. Outline the technological / fabrication methods that you would use to accomplish this.