



Robotics Studio MECE 4611
Spring 2024
Assignment 1
Nicolino Primavera (ncp2136)
Submission: 1/28/24 at 8:40pm
Grace hours: 96+3:20

Concept 1 - Spider/Arachnid design

- This design is of an eight-legged robot that is inspired by spiders' physical characteristics.

Calculations for spider design:

Volume of body = $144 \text{ in}^3 \cdot \left(\frac{2.54 \text{ cm}}{1 \text{ inch}}\right)^3 = 2359.737 \text{ cm}^3$

mass of body = $(2359.737 \text{ cm}^3)(1.249 \text{ g/cm}^3)(0.10) = 292.61 \text{ g}$

* each leg is 20cm long (there are 8 total legs)

Schematic design of each leg

* based on the design, each motor is critical

the legs are cylindrical with a 2cm diameter $\rightarrow V = \pi r^2 h$
 $V = \pi \cdot (1\text{cm})^2 (20\text{cm}) = 62.832 \text{ cm}^3$ (volume of each leg)

mass of each leg = $V \cdot d \cdot 0.10 = (62.832 \text{ cm}^3)(1.249 \text{ g/cm}^3)(0.10) = 7.791 \text{ g}$

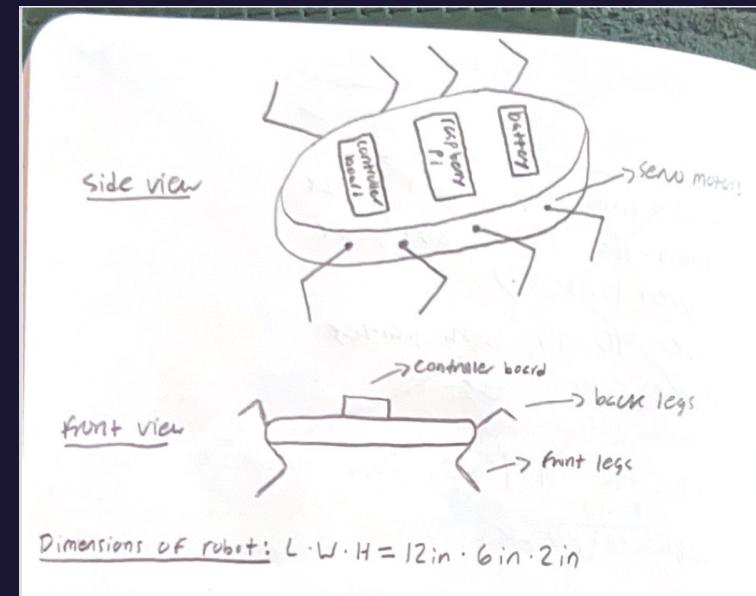
(each leg) Weight = $m \cdot g = 7.791 \text{ g} \cdot 9.81 \text{ m/s}^2 = 76.43 \frac{\text{g} \cdot \text{m}}{\text{s}^2} = 0.07643 \text{ N}$

(Weight plus servo motor) Force = $(52 \text{ g} + 7.791 \text{ g}) \cdot 9.81 \text{ m/s}^2 = 586.55 \frac{\text{g} \cdot \text{m}}{\text{s}^2} = 0.58655 \text{ N}$

Static torque for each motor = $0.58655 \text{ N} \cdot 20 \text{ cm} = 11.731 \text{ N} \cdot \text{cm}$

* The motor specification is $17 \text{ kg} \cdot \text{cm}$, which is $166.7 \text{ N} \cdot \text{cm}$
 since: $(11.731 \text{ N} \cdot \text{cm}) \lll 166.7 \text{ N} \cdot \text{cm}$

Conclusion: the design is well within motor specifications



Walking distance

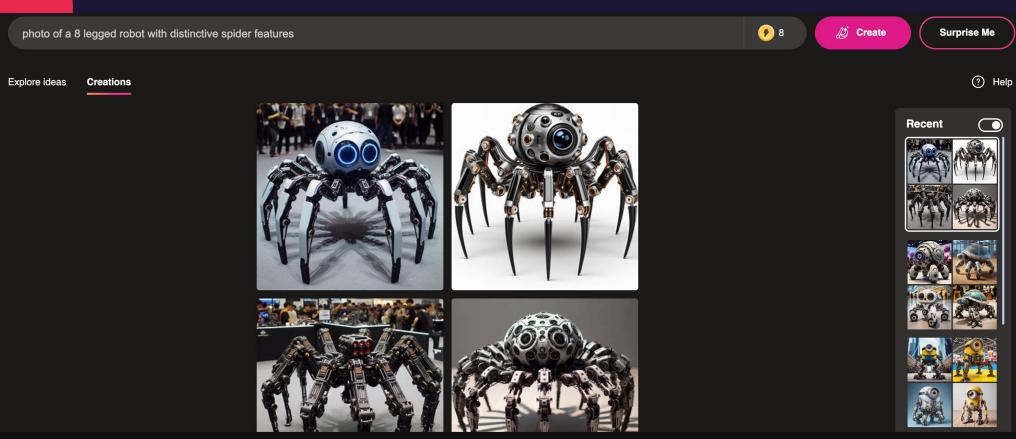
each motor

Power = $\frac{\text{Work}}{\text{time}}$, Work = Force \cdot distance = $8(586.55 \frac{\text{g} \cdot \text{m}}{\text{s}^2})(10 \text{ m}) = 46924 \frac{\text{g} \cdot \text{m}^2}{\text{s}^2} = 46.924 \text{ N} \cdot \text{m}$

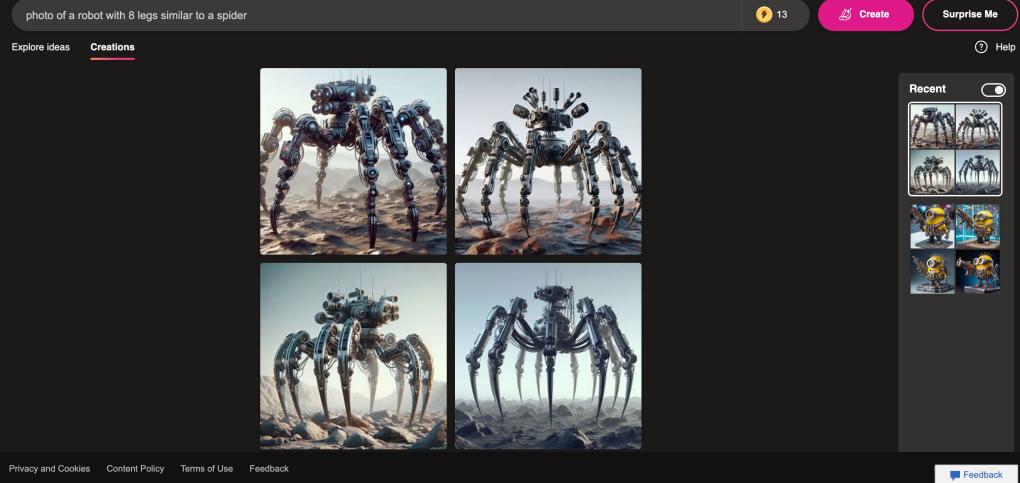
Power = $30 \text{ W} = 30 \frac{\text{N} \cdot \text{m}}{\text{s}}$

time = $\frac{46.924 \text{ N} \cdot \text{m}}{30 \text{ N} \cdot \text{m/s}} = 1.56 \text{ s}$ * take 1.56s to walk 10 meters

Concept 1 - Spider/Arachnid design using AI

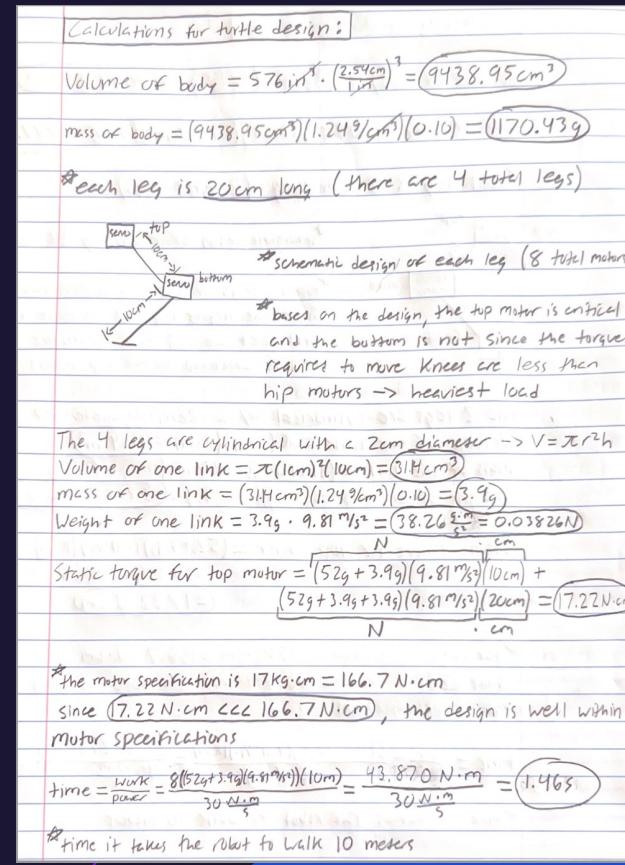
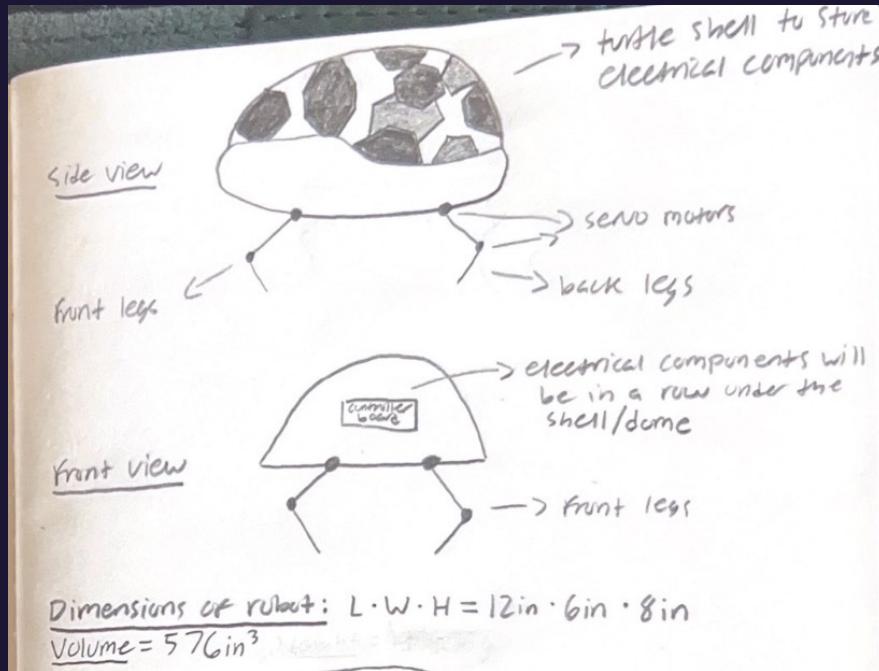


- I used the generative AI models to improve my designs and sketches.
- They helped me position joints and servo motors in spots I wouldn't have initially chosen.



Concept 2 - Turtle/Quadruped design

- This design is of a four-legged robot that is inspired by turtles' physical characteristics.



Concept 2 - Turtle/Quadruped design using AI

photo of a 4 legged robot with distinctive turtle features like a shell

Explore ideas Creations

The interface shows a search bar with the query "photo of a 4 legged robot with distinctive turtle features like a shell". Below it, there are two rows of two images each, displaying various quadruped robots with shells. A sidebar on the right is titled "Recent" and shows a grid of smaller thumbnail images. At the bottom left, there are links for "Privacy and Cookies", "Content Policy", "Terms of Use", and "Feedback".

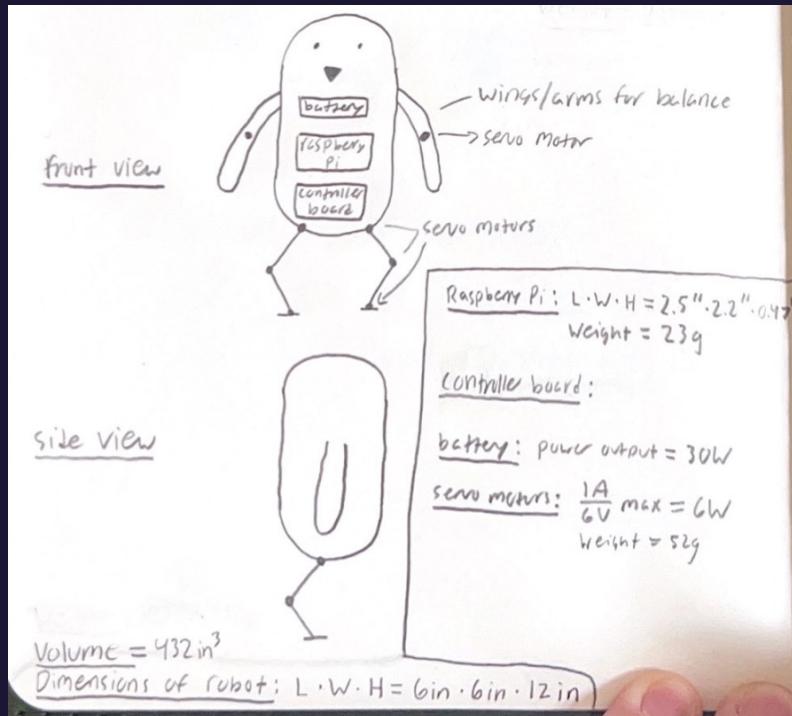
photo of a robot with 4 legs similar to a turtle

Explore ideas Creations

The interface shows a search bar with the query "photo of a robot with 4 legs similar to a turtle". Below it, there are four large, detailed images of quadruped robots with metallic shells and complex mechanical designs. A sidebar on the right is titled "Recent" and shows a grid of smaller thumbnail images. At the bottom left, there are links for "Privacy and Cookies", "Content Policy", "Terms of Use", and "Feedback".

Concept 3 - Penguin/Bipedal Robot design

- This design is of a two-legged robot that is inspired by penguins' physical characteristics.



Calculations for Penguin design:

Volume of body = $432 \text{ in}^3 \cdot \left(\frac{2.54 \text{ cm}}{1 \text{ in}}\right)^3 = (7079.217 \text{ cm}^3)$

mass of body = $(7079.213 \text{ cm}^3)(1.249 \text{ g/cm}^3)(0.10) = (877.82 \text{ g})$

* each leg is 20 cm long (2 total legs)

schematic design of each leg (2 total)

top * schematic design of each leg (2 total)
 hip top
 knee knee
 10cm 10cm
 feet feet
 * top motor is critical and bottom two are not
 since the torques required to move the knee
 and feet are less than hip motors → heaviest
 load is attached to the hip motors

The 2 legs are cylindrical w/ a 2cm diameter → $V = \pi r^2 h$
 Volume of one link = $\pi (1\text{cm})^2 (10\text{cm}) = (31.4 \text{ cm}^3)$
 mass of one link = $(31.4 \text{ cm}^3)(1.249 \text{ g/cm}^3)(0.10) = (3.9 \text{ g})$
 Weight of one link = $(3.9 \text{ g})(9.81 \text{ m/s}^2) = (38.26 \frac{\text{N}}{\text{s}^2}) = 0.03826 \text{ N}$

Static torque for top motor = $(52 + 3.9g)(9.81 \text{ m/s}^2)/(10\text{cm}) +$
 $(52 + 3.9g + 3.9g)(9.81 \text{ m/s}^2)/(20\text{cm})$
 $(= 17.22 \text{ N}\cdot\text{cm})$

* the motor specification is $17 \text{ kg}\cdot\text{cm} = 166.7 \text{ N}\cdot\text{cm}$
 Since $(17.22 \text{ N}\cdot\text{cm} \ll 166.7 \text{ N}\cdot\text{cm})$, the design is well within
 motor specifications

time = $\frac{\text{work}}{\text{power}} = \frac{6(52g + 3.9g)(9.81 \text{ m/s}^2)(10\text{cm})}{30 \text{ N}\cdot\text{m/s}} = \frac{32.90274 \text{ N}\cdot\text{m}}{30 \text{ N}\cdot\text{m/s}} = (1.097s)$

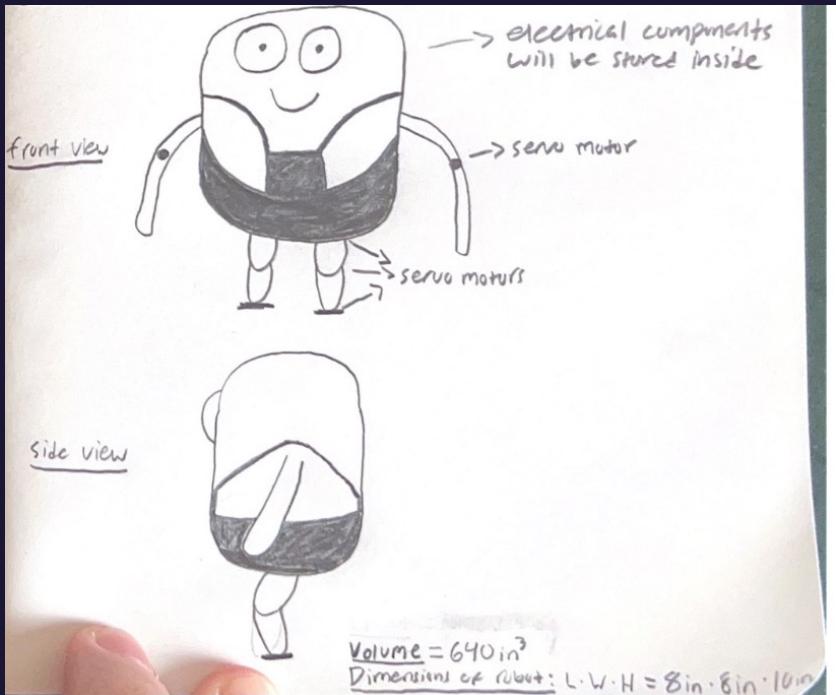
* time it takes the robot to walk 10 meters

Concept 3 - Penguin/Bipedal Robot design using AI

The image shows two screenshots of the Microsoft Bing AI Image Creator interface. The top screenshot shows the initial search results for "photo of a 2 legged robot with distinctive penguin features". It displays four images of real-world robots with penguin-like features: two white and black bipedal robots, one blue and black penguin-shaped robot, and one white and black penguin-shaped robot. The bottom screenshot shows the final generated image, which is a highly detailed 3D rendering of a white and black bipedal robot designed to look like a penguin, standing on a rocky beach. The interface includes a sidebar for "Recent" images and various search and creation tools.

Concept 4 - Despicable Me Minion design

- This design is of a two-legged robot that is inspired by the Despicable Me minions' physical characteristics.



Calculations for minion design :

Volume of body = $640 \text{ in}^3 \cdot \frac{(2.54 \text{ cm})^2}{(1.24 \text{ g/cm}^3)} = 10487.72 \text{ cm}^3$

mass of body = $(10487.72 \text{ cm}^3)(1.24 \text{ g/cm}^3)(0.10) = 1300.48 \text{ g}$

* each leg is 20 cm long (2 total legs)

hip [servo motor] top knee [servo motor] knee [servo motor] feet [servo motor]

* schematic design of each leg (2 total)

* top motor is critical and bottom two are not since the torques required to move the knee and feet are less than hip motors → heaviest load is attached to the hip motors

The 2 legs are cylindrical w/ a 2cm diameter → $V = \pi r^2 h$

Volume of one link = $\pi (1\text{cm})^2 (10\text{cm}) = 31.4 \text{ cm}^3$

mass of one link = $(31.4 \text{ cm}^3)(1.24 \text{ g/cm}^3)(0.10) = 3.9 \text{ g}$

Weight of one link = $(3.9 \text{ g})(9.81 \text{ m/s}^2) = (38.26 \text{ g-m}) = 0.03826 \text{ N}$

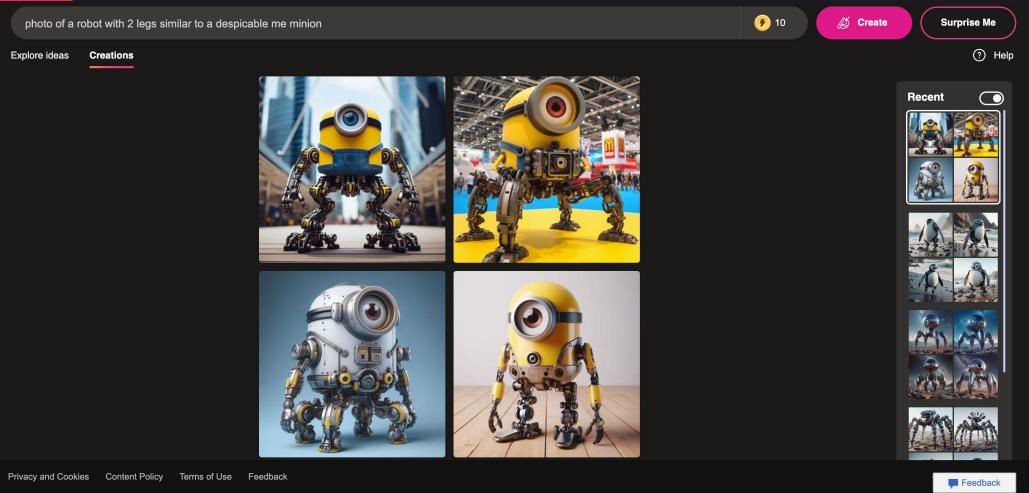
Static torque for top motor = $(52 + 3.9g)(9.81 \text{ m/s}^2)(10\text{cm}) + (52 + 3.9g + 3.9g)(9.81 \text{ m/s}^2)(20\text{cm})$
 $= 17.22 \text{ N}\cdot\text{cm}$

* the motor specification is $17 \text{ kg}\cdot\text{cm} = 166.7 \text{ N}\cdot\text{cm}$
 Since $(17.22 \text{ N}\cdot\text{cm} < 166.7 \text{ N}\cdot\text{cm})$, the design is well within motor specifications

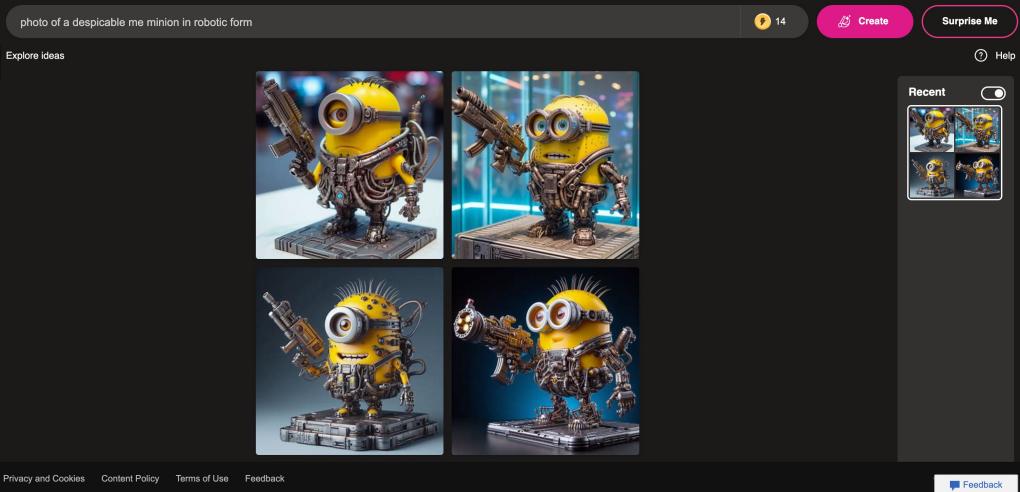
time = $\frac{\text{work}}{\text{power}} = \frac{6(52g + 3.9g)(9.81 \text{ m/s}^2)(10\text{cm})}{30 \text{ N}\cdot\text{m/s}} = \frac{32.90274 \text{ N}\cdot\text{m}}{30 \text{ N}\cdot\text{m/s}} = 1.097 \text{ s}$

* time it takes the robot to walk 10 meters

Concept 4 – Despicable Me Minion design using AI



- The minion in the bottom right corner is exactly what I look to do.



Rubric Checklist

- At the end of the assignment, list all the rubrics and points you believe you should receive, along with page numbers to support your claim.
- 5 Points Title slide complete (slide 1)
- 5 Points overall aesthetics, layout and formatting of the slides
- 5 Points posting a sketch of your robot on the discussion board at least 24h in advance of the deadline (slide 12)
- 5 Points Comment (constructively) on at least three other's postings (slide 11)
- 5 Points showing three robot designs from an AI-generator (e.g. StableDiffusion) along with the prompt (slides 3, 5, 7, 9)
- 5 Points 3D sketch, with key dimensions and labels (slides 2, 4, 6, 8)
- 5 Points shading and shadows (slides 4 and 8)
- 5 Points weight estimate, gait and stability analysis (slides 2, 4, 6, 8)
- 5 Points power estimates (including estimated run time) (slides 2, 4, 6, 8)
- 5 Points including Computer, controller, battery labels (slides 2, 4, 6, 8)
- 5 Points showing in multiple poses (slides 2, 4, 6, 8)
- 10 Points showing generative AI assistance (slides 3, 5, 7, 9)

Comment (constructively) on at least three other's postings

Nico Primavera 2 days ago

Great sketches! I had a similar idea to the crab except I called it spider and used 8 legs.

Comment Edit Delete ...

Add comment

Aleksandr Vankov 2d

Thank you, I look forward to seeing your design with 8 legs. I thought of some myriapods with so many legs, but ended up with crab.

Reply ...

Nico Primavera Now

Nice Grogu! I also used animated movie characters for inspiration

Comment Edit Delete ...

Nico Primavera 26m

I like your turtle design! I had a similar idea

Reply Edit Delete ...

Nico Primavera 17 hours ago

Nice designs! I particularly like the 4 legged one.

Comment Edit Delete ...

ED Discussion Board post

The screenshot shows a Safari browser window with the following details:

- Address Bar:** edstem.org
- Tab Bar:** Google Calendar - Week of Janua..., M (2) - nicolinoprimavera@gmail.co..., Robotics Studio Design Drawings..., ROBOTICS STUDIO - Section 1, (6) MECE 4611 S1 – Ed Discussion
- Page Title:** ed MECE 4611 S1 – Ed Discussion
- Left Sidebar:** Courses (MECE 4606, MECE 4611 S1), Categories (General, Sketches, CAD design, Working robot, Simulation), and a message about 36 others online.
- Search Bar:** Search and Filter dropdown.
- Post List:** A list of posts under the category "Sketches".
 - Pair (General, KashafJabbar 21h): Concept Sketch #1 Guanjie(Bill) Zhao (Sketches, Guanjie Zhao 21h)
 - Concept Sketch #1 (Sketches, Aileen Liu 22h)
 - Prelim Concept Sketches 1-3 - James Vic... (Sketches, James Vickery 23h)
 - Concept Sketches - Nico Primavera (Sketches, Nico Primavera 23h)
 - Concept Sketch (Sketches, Rishabh Dhotrekar 24h)
 - Concept Sketches 2&3 -Zelin Tao (Sketches, Zelin Tao 1d)
 - Concept Sketches (Sketches, KashafJabbar 1d)
 - The Griddy (Sketches, Daksh Garg 1d)
- Post Preview:** Nico Primavera's post titled "Concept Sketches - Nico Primavera #21".
 - Author:** Nico Primavera (Profile icon N)
 - Time:** 23 hours ago
 - Category:** Sketches
 - Views:** 61
 - File:** HW1 - Sketches.pdf
 - Message:** Hi all,
Attached are a few of my sketches. I used spiders, turtles, penguins and minions for inspiration. I am not the best artist but I hope you can still see what I was going for.
 - Actions:** Comment, Edit, Delete, ...
- Comments:** 3 Answers.
 - Alexa Ocel (Profile icon A): I really like the turtle shell design to enclose the electrical components, nice work.
Comment, ...
 - Nico Primavera (Profile icon N): Thank you!
Reply, Edit, Delete, ...



Robotics Studio MECE 4611

Spring 2024

Assignment II

Nicolino Primavera (ncp2136)

Submission:

Grace hours: 99:20 + 1:15 hours

Bob the Minion

General Robot Rendering

Electrical Component Specifications

Dimensions (L x W x H):

- Raspberry Pi 3A+ = 2.56 x 2.2 x 0.47 in
- Battery Pack = 1.1 x 3.35 x 5.7 in
- LX-16A Metal Servos = 1.38 x 0.97 x 1.78 in
- Small Servo Controller Board = 4.7 x 3.1 x 1.2 in
- 10A Stepdown DC to DC Buck Converter = 3.74 x 2.24 x 1.22 in
- DROK DC Converter = 3.23 x 2.05 x 1.26 in
- Raspberry Pi Camera = 0.98 x 0.90 x 0.35 in

Mass (grams):

- Raspberry Pi 3A+ = 50g
- Battery Pack = 190g
- LX-16A Metal Servos = 52g
- Small Servo Controller Board = 62.4g
- 10A Stepdown DC to DC Buck Converter = 9.072g
- DROK DC Converter = 68g
- Raspberry Pi Camera = 3.4g

3D Printed Component Specifications

Dimensions (L x W x H = Volume):

- Oval Base: 6.5 x 6.0 x 0.3 in
- Motor Harness (from Solidworks: Evaluate→Mass Properties): V=7.81 in³ , SA=39.29 in²
- Thigh Link (from Solidworks: Evaluate→Mass Properties): V=3.65in³ , SA=27.39 in²
- Foot Attachment (from Solidworks: Evaluate→Mass Properties): V=0.401in³ , SA=5.92in²
- Foot (from Solidworks: Evaluate→Mass Properties): V=1.02in³ , SA=12.03in²

Mass (grams): mass = volume (L x W x H) x density (1.24 g/cm³) x infill percentage (0.10), 1in³ = (2.54cm/1in)³

- Oval Base = 23.774g
- Motor Harness = 15.87g
- Thigh Link = 7.42g
- Foot Attachment = 0.815g
- Foot = 2.073g

GrabCAD Designs for Components - Citations

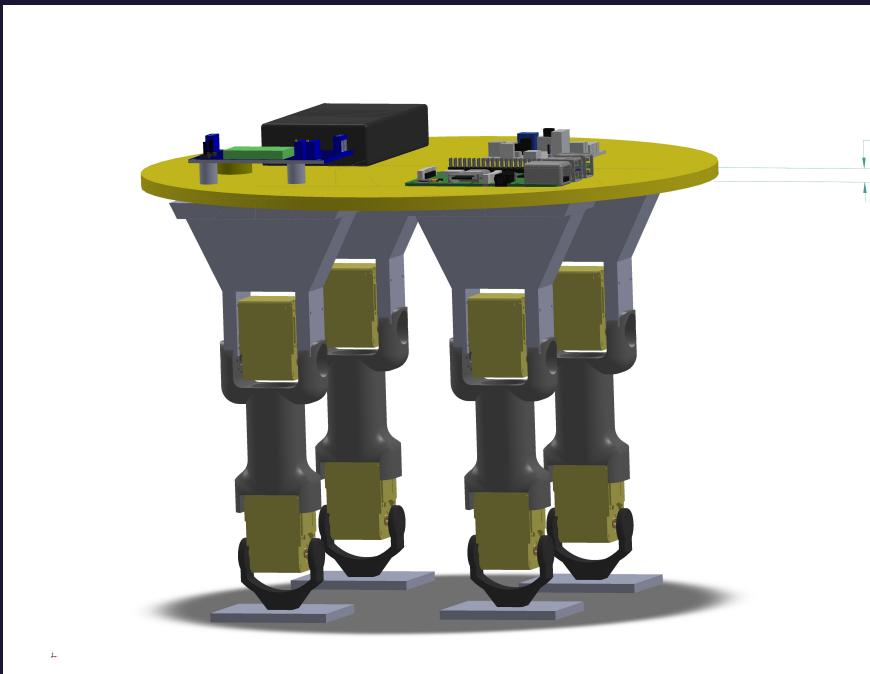
Incorporated in preliminary design

- LX-16A Metal Servos: <https://grabcad.com/library/lewansoul-lx-16a-bus-servo-1>
- Small Servo Controller Board: <https://grabcad.com/library/lewansoul-lx16a-controller-board-1>
- Battery Pack: <https://grabcad.com/library/talentcell-rechargeable-12v-3000mah-lithium-ion-battery-pack-1>
- DROK DC Converter: <https://grabcad.com/library/drok-dc-converter-5-3-32v-to-1-2-32v-1>
- Raspberry Pi 3A+: <https://grabcad.com/library/raspberry-pi-3-4>
- Motor Harness: <https://grabcad.com/library/robot-skeleton-and-modular-motor-harness-1>
- Thigh Link: <https://grabcad.com/library/leg-piece-2>
- Foot: <https://grabcad.com/library/lewansoul-lx-16a-motor-connector-1>

Did not incorporate these yet

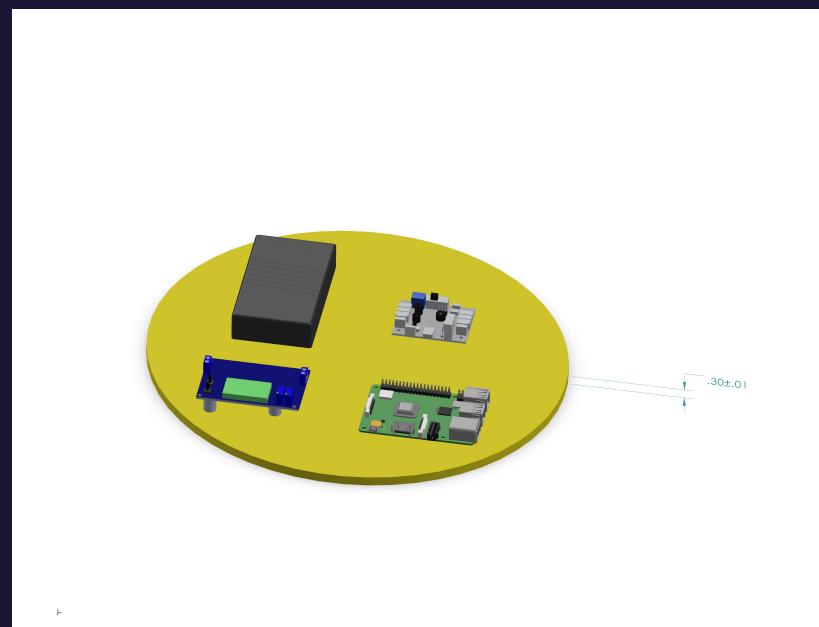
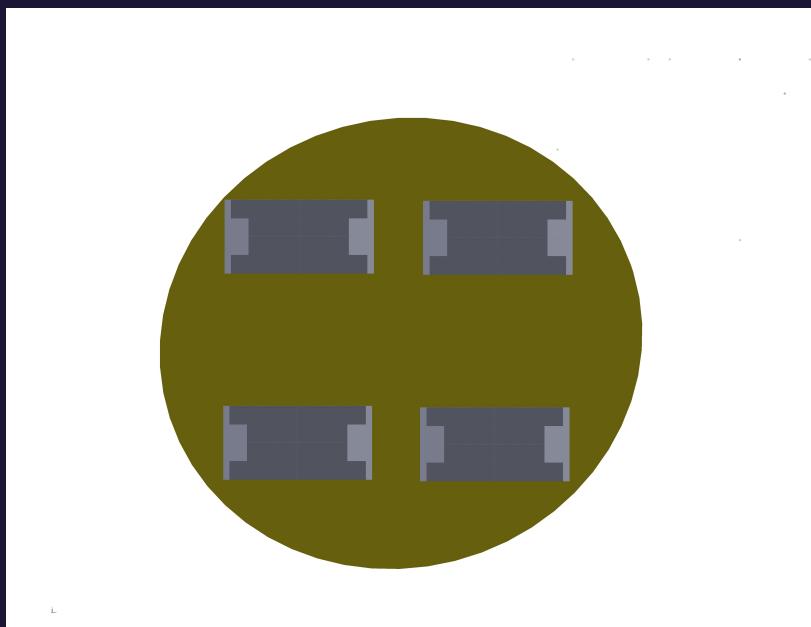
- IMU (Adafruit): <https://www.thingiverse.com/thing:4602596>
- Raspberry Pi Camera: <https://grabcad.com/library/raspberry-pi-camera-module-v2-1>
- Mini USB Microphone: <https://grabcad.com/library/raspberry-pi-camera-module-v2-1>
- Motor Wheels: <https://grabcad.com/library/motor-shaft-adapter-for-lx-16a-1>

Renderings – Full Robot

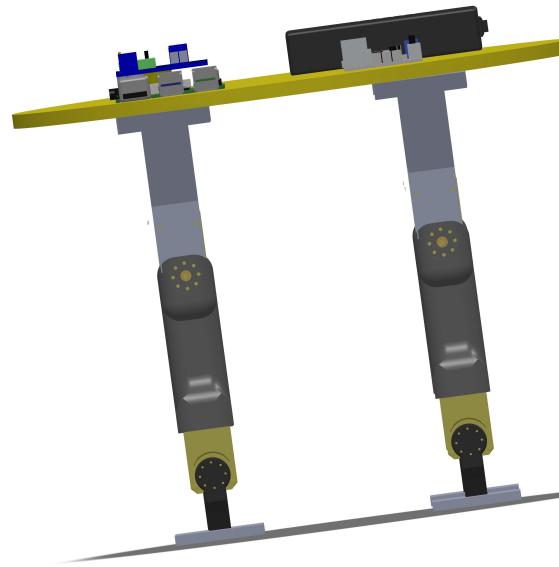
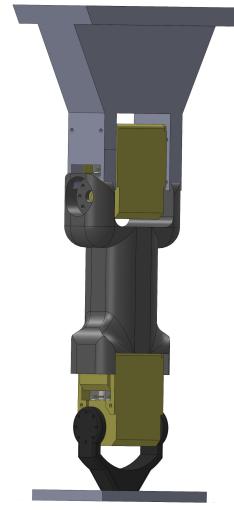


- So far, I have completed the legs and base designs of the robot
- Next step will be to incorporate the Despicable Me Minion features
- The robot legs are approximately 10 in long and the oval base is 6.5 by 6.0 in
- The electrical components will be covered in the final design
- Based off my initial calculations it will take ~1.5 seconds to walk 10 meters
- The motors are positioned to be able to walk forwards and backwards
- I opted for four legs instead of two for increased stability and so the robot can support more weight

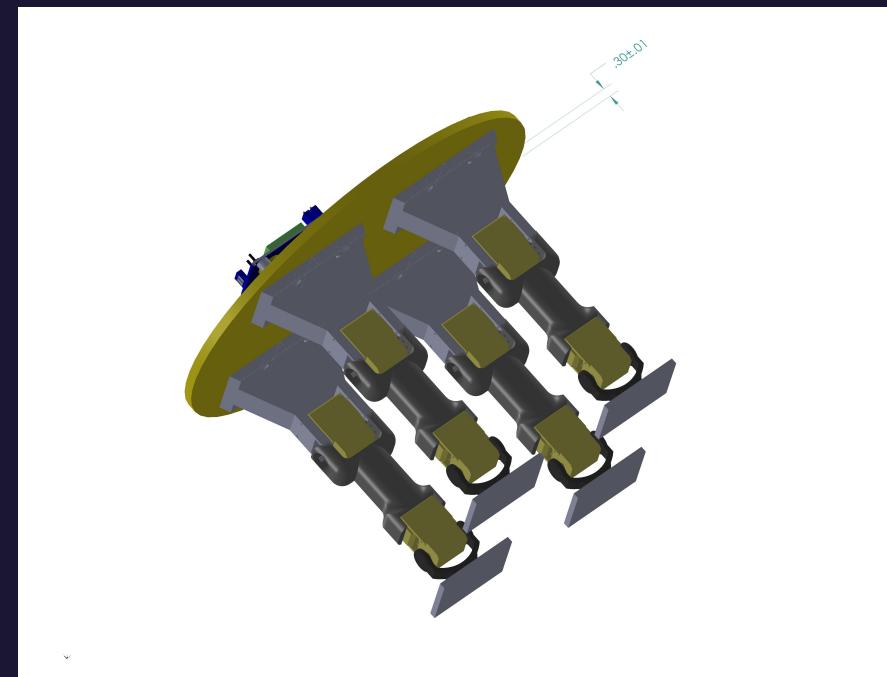
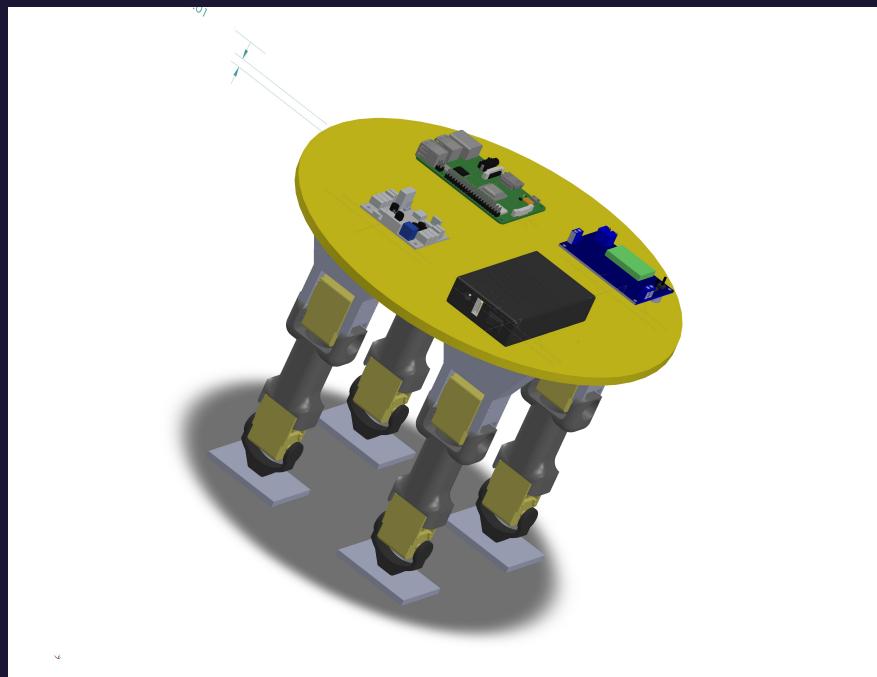
Renderings – Aerial View



Renderings - Leg Design



Renderings – Full Robot



Next Steps

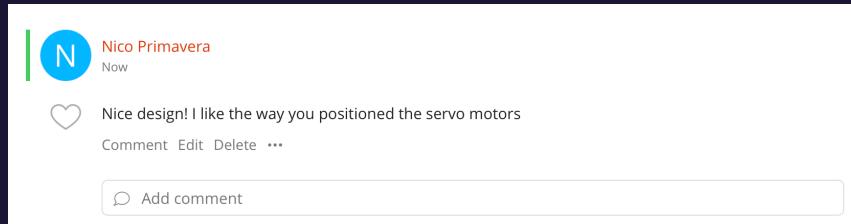
- Finalize leg design by adding fasteners, mounts, bearings, cables, through-holes, cable fasteners, surface texture, etc.
- Find the best way to incorporate the minion design found on GrabCAD
 - Extruded cut of minion design found on GrabCAD
 - Shrink-wrapping ("Monokoting")
- Find the best place for a camera
- Decide if an IMU is necessary (probably not since 4 legs will provide stability)



Rubric Checklist

- 5 Points Title slide complete (Slide 13)
- 5 Points overall aesthetics, layout and formatting of the slides (All slides)
- 10 Points posting some rendering of your robot on the discussion board at least 24h in advance of deadline, and commenting constructively and positively on at least three other's postings (show screenshots) (Slide 23-24)
- 10 Points 3D Renderings in perspective (Slides 17-20)
- 10 Points Key components included (Slides 17-20)
- 10 Points organic shape (no/few straight edges) (Slides 17-20)
- 10 Points photorealistic rendering (Slides 17-20)
- 10 Points context rendering (Slides 17-20)
- 10 Points animation
- 10 Points exploded view (Slides 17-20)
- 10 Points key specs listed including speed (Slides 14-15)
- 10 Points multiple poses shown (Slides 17-20)
- 10 Points detail close-up shown (Slides 17-20)
- 10 Points side views with main dimensions (Slides 14-15, 17-20)
- 10 Points sharing a relevant CAD component on GrabCAD or Thingiverse (show screenshot)

Comment (constructively) on at least three other's postings

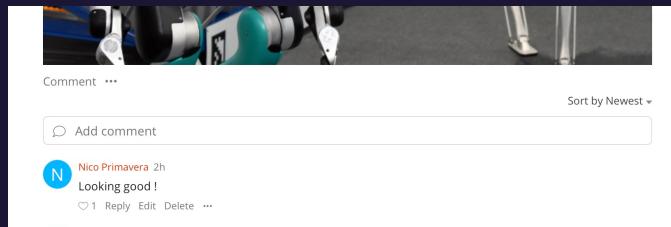


Nico Primavera
Now

 Nice design! I like the way you positioned the servo motors

Comment Edit Delete ...

 Add comment



Comment ...

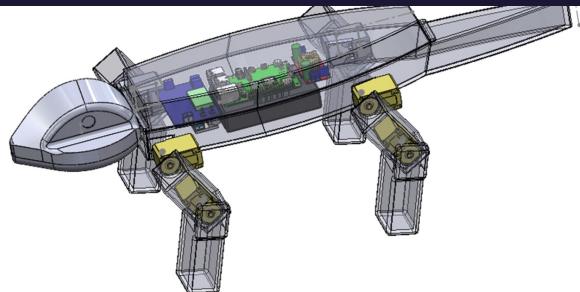
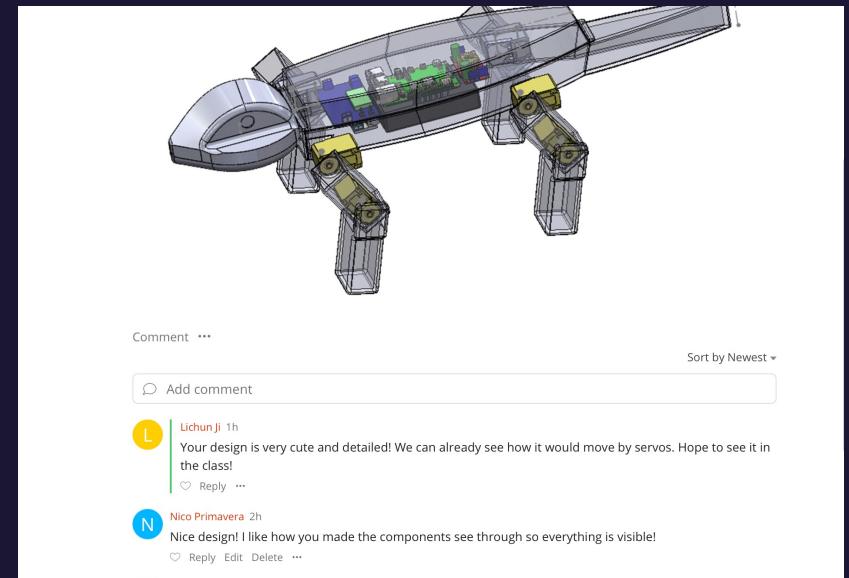
 Sort by Newest ▾

 Add comment

 Nico Primavera 2h

Looking good!

 1 Reply   ...



Comment ...

 Sort by Newest ▾

 Add comment

 LichunJi 1h

Your design is very cute and detailed! We can already see how it would move by servos. Hope to see it in the class!

 Reply ...

 Nico Primavera 2h

Nice design! I like how you made the components see through so everything is visible!

 Reply   ...

ED Discussion Board post

Preliminary CAD Model #57



Nico Primavera

1 minute ago in CAD design



STAR



WATCHING



3 VIEWS



Hi all,

Attached is my preliminary CAD model. I am still working on a few things but this is the general concept. My end result is a four legged minion. I have created the base so far, and I found this great minion design on GrabCAD that I am hoping to use. I am not sure of the best way to cut and scale everything from GrabCAD so if anyone has any ideas please let me know. As of right now I am planning on cutting the top half of the minion design and using it as a cover.

Minion example.pdf

Side View of the Robot.pdf

Comment Edit Delete ...

Add comment