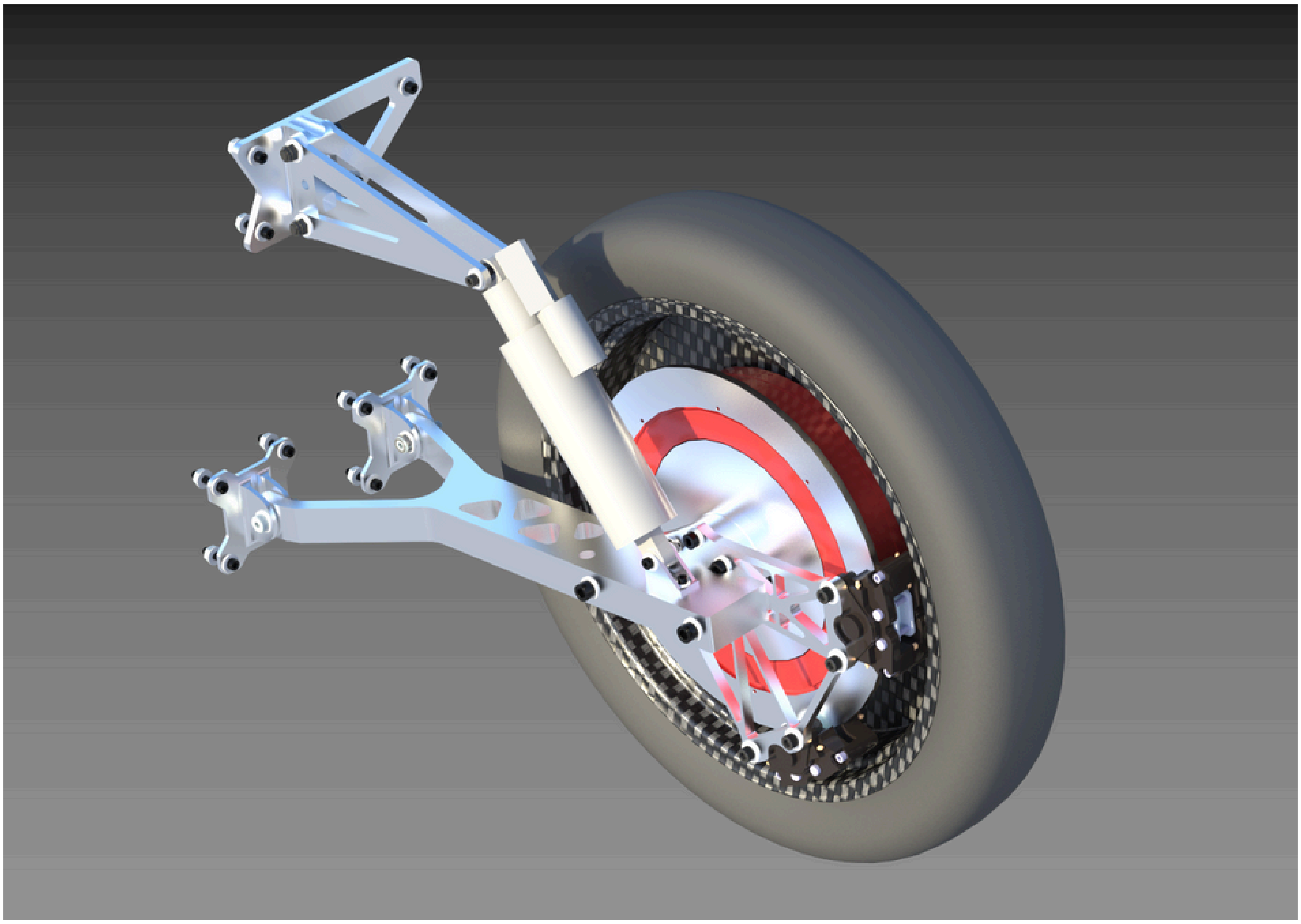
Engineering Portfolio

Pallab Layak

Click to find my LinkedIn



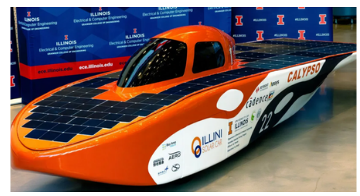
Quick Overview

Graduating Senior in Mechanical Engineering at the University of Illinois at Urbana-Champaign (UIUC). Student advisor and former lead mechanical engineer for the **Illini Solar Car Team**. **Tutor for Mechanical Engineering** courses at UIUC. Research assistant from this semester in **non-Newtonian Fluid Mechanics and Rheology research lab.**

About Me

Hi, I'm Pallab!

I am passionate about analytical and practical problem-solving for contemporary problems. I enjoy collaborating with people from various walks of life, learning and growing together.



I would love to apply my Mechanical Engineering knowledge to the renewable energy sector, automotive industry, medical fields, and cutting-edge research in fields including (but not limited to) robotics and electric vehicles. Using my knowledge and experiences to make the world a better place is my life's ultimate goal.

In my free time, I love solving Rubik's Cubes and other 3D puzzles. In fact, I got my first Rubik's Cube as a Christmas gift in first grade. I taught myself how to solve it almost 15 years ago and today I can solve one in less than 10 seconds (click **here** to watch!). Now, I own a collection of 20+ Rubik's cubes and puzzles and hope to design my own 3D puzzle one day.

Please take a look at some exciting engineering projects I've had the opportunity to work on and feel free to reach out to me about anything!

PALLAB LAYAK

MECHANICAL ENGINEERING AT THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

playak2@illinois.edu

https://www.linkedin.com/in/pallab-layak/

(447) 902 - 0861

AUTOFEEDER IMPROVEMENT - SENIOR CAPSTONE

FINAL VIDEO → HERE

What?

- Created improvements for autofeeder system that palletizes cam lobes for camshaft manufacturing.
- Goals:
  - **<3.75s** cycle time
  - **99%** uptime
  - **<5 minute tooling changeover** for different cam profiles.

How?

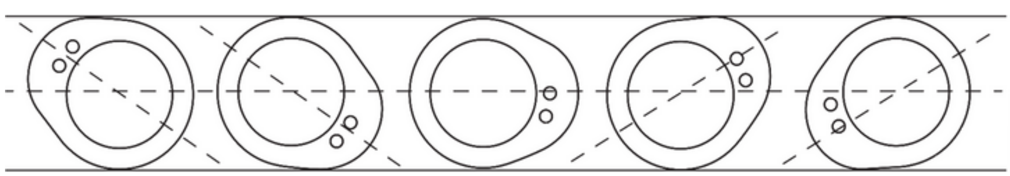
- Created high-fidelity prototype for offsite testing and rapid prototyping in **Creo**.
- Designed **sheet metal** vibration fixture to funnel lobes into narrowing conveyor section.
- Performed **dynamic load analysis** and **fatigue analysis** on fixture using **hand-calcs** and **FEA**.
- Implemented a **roller-bearing gripper** to passively orient lobes.

Results

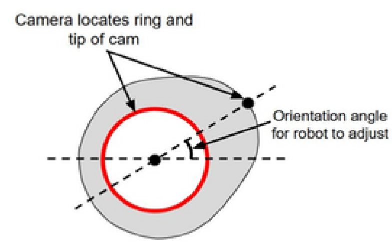
- By decreasing angular variability of lobes, **failure rate was reduced to 0 in 1000 lobes**.
- Cycle time **reduced by 0.5s**.
- No tooling changeover required.
- Won 1st place in ~40 groups for best prototype :)

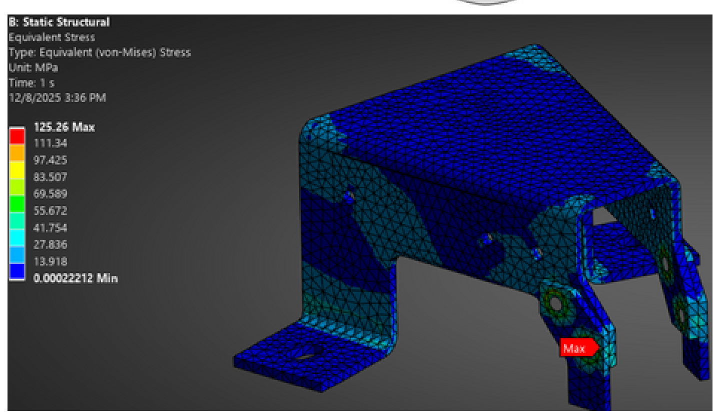
Conveyor Belt → Gripper → Camera → Robotic Arm → Pallet

Autofeeder processes



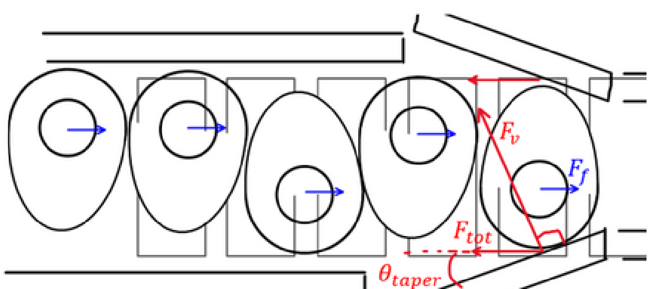
Minimizing angular variability with narrow walls



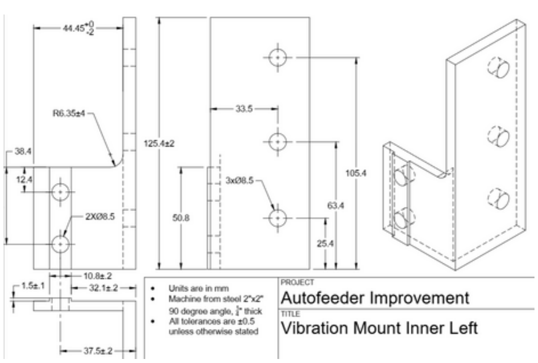


FEA for vibration fixture

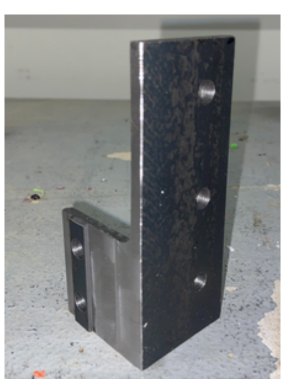
****Calculation Sneak Peak****



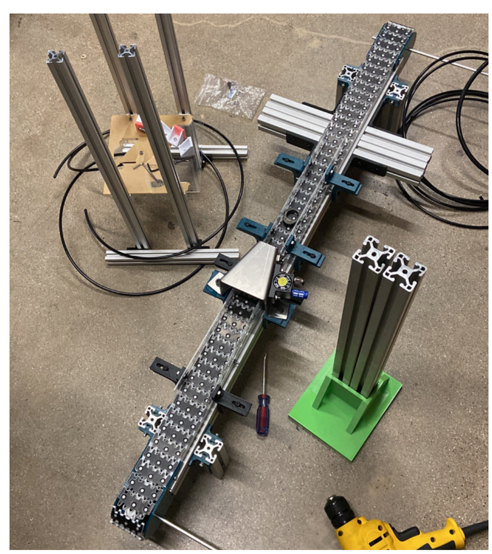
Force diagram for jamming of narrowing conveyor section



Engineering drawing for fixture mounting bracket



Brackets I machined on a manual mill



High-fidelity prototype setup

Further details upon request! :)

PALLAB LAYAK

MECHANICAL ENGINEERING AT THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

playak2@illinois.edu

https://www.linkedin.com/in/pallab-layak/

(447) 902 - 0861

COMPOSITE CHASSIS ANALYSIS AND OPTIMIZATION - ILLINI SOLAR CAR

What?

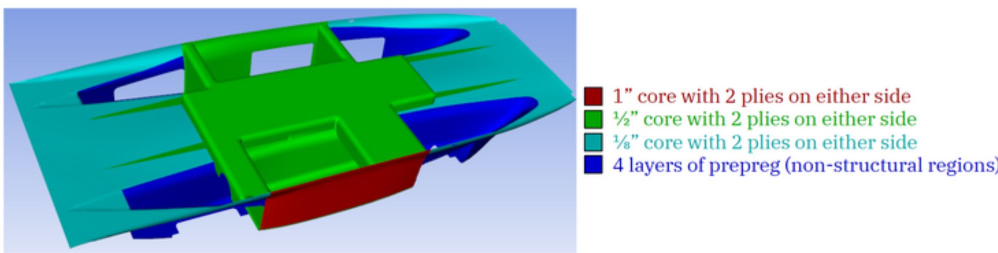
- **Analyzed composite chassis** to satisfy load cases based on competition regulations.
- **Ensure safety** of driver in the event of an impact.
- Created **5 custom load cases** to satisfy.
- **Optimized** composite layup plan to **minimize overall weight** of chassis and aero-shell.

How?

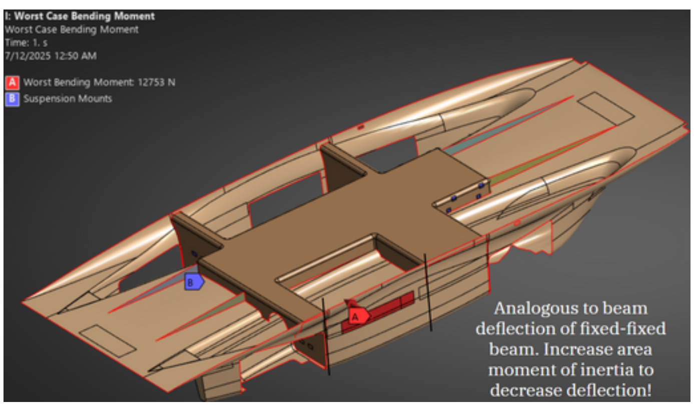
- Utilized **ANSYS Composite PrepPost (ACP)** to assign **material properties** and **composite stackups.**
- Used **beam-bending equations** to estimate maximum deformation and required stiffness.
- Set up load cases in **ANSYS Static Structural** and observed **deformation** and **stress distribution.**
- **Iterated** until optimal results were obtained.

Results

- Weight of composite chassis reduced by **30%** from previous generation.
- Overall weight of ~ **50 kg**.
- Deformation < 25 mm and no yielding (satisfied regulations).
- **Topology optimization** will be used to further reduce weight.
- Physical panel testing will be used to **validate analysis**.
- Learn more from [this report](#).



Thickness plot for shell and chassis

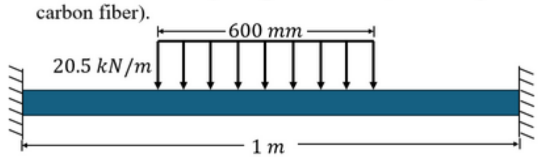


Example of ANSYS Static Structural setup

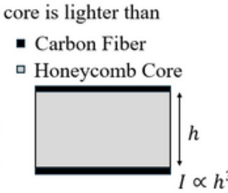
Calculation Sneak Peak

Regulation:
Drive occupant cell cannot deform more than 25 mm under 5G side loading.

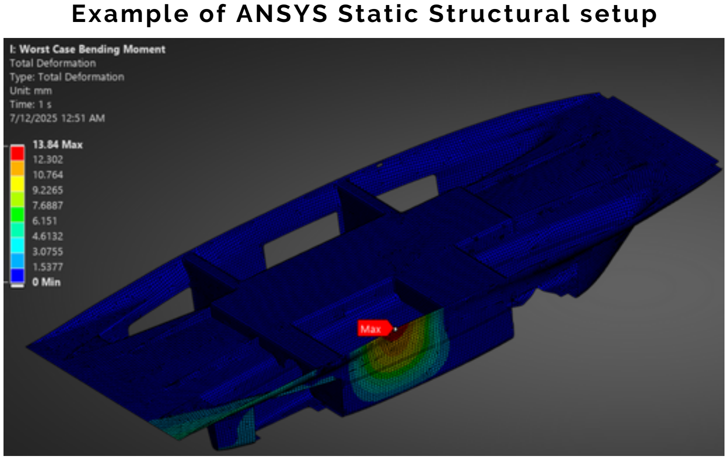
We know:
Deflection (δ) $\propto \frac{1}{EI}$, Bending Stress (σ) $\propto \frac{1}{I}$
Increasing E would require adding layers of carbon fiber.
Aim to maximize I by using thicker core (since honeycomb core is lighter than carbon fiber).



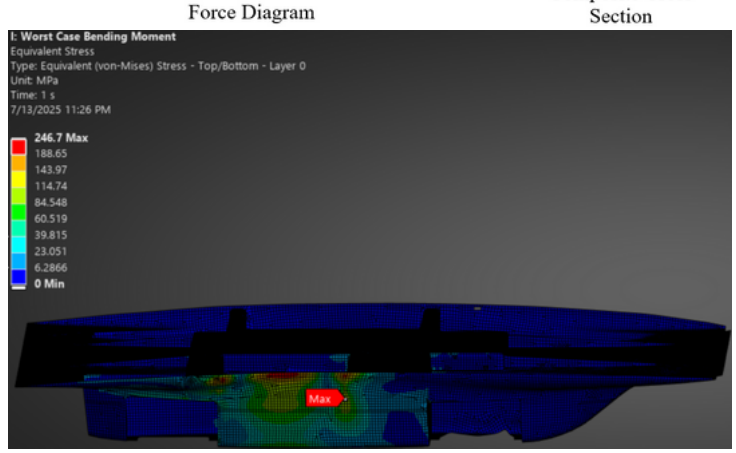
Force Diagram



Composite Cross Section



Deformation results for a load case



Stress results for a load case

PALLAB LAYAK

MECHANICAL ENGINEERING AT THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

playak2@illinois.edu

https://www.linkedin.com/in/pallab-layak/

(447) 902 - 0861

REAR SUSPENSION REDESIGN - ILLINI SOLAR CAR

What?

- Redesign trailing arm rear suspension for Solar Vehicle.
- Primarily focused on lower trailing arm mounts but contributed to all component designs.
- **Optimize weight** with minimum FoS = 1.25 (based on fatigue calculations from S-N Curve)
- Previous design had minimum safety factor = 4.50.

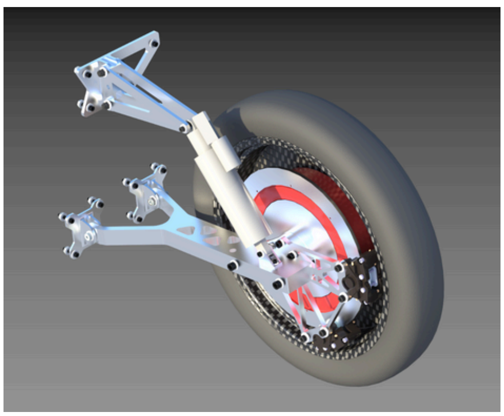
How?

- Designed in **NX.**
- Used **free-body diagrams** to calculate reaction forces on each component.
- Performed **Finite Element Analysis** and **topology optimization** in **ANSYS.**
- Performed **lug analysis** at clevis.
- Researched into **bolt preload** for analysis.
- Performed **worst case tolerance stackup analysis** for **thrust bearing, clevis and trailing arm** in assembly ensuring clearance.

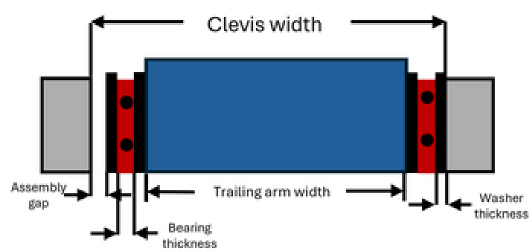
Results

- Designed on tight timeline- less than **1 month.**
- Weight of design was reduced by **40%.**
- **Minimum safety factor = 1.28.**

****Calculation Sneak Peak****



Clevis width = Assembly gap + 2 (Bearing thickness) + 4 (Washer thickness) + Trailing arm width



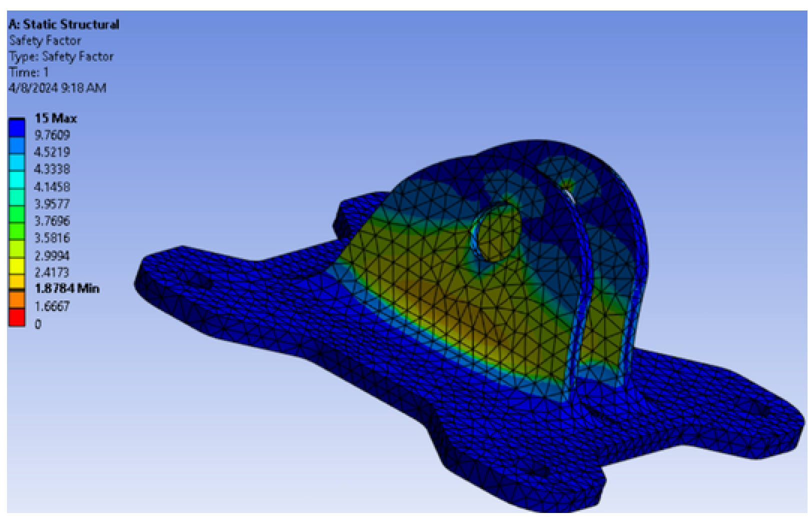
Worst Case Stackups:

Maximum Clevis Width = 0.80825 in

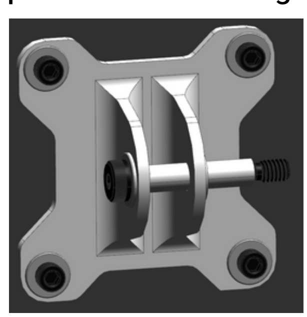
Minimum Clevis Width = 0.77445 in

Clevis Width = 0.791 ± 0.017 in

ANSYS FEA



Optimized Final Design



PALLAB LAYAK

MECHANICAL ENGINEERING AT THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

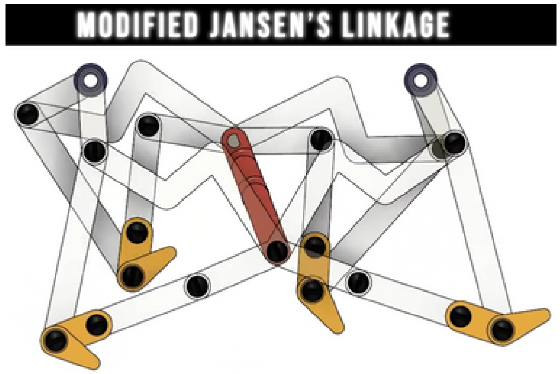
playak2@illinois.edu

https://www.linkedin.com/in/pallab-layak/

(447) 902 - 0861

STRIDER - INCLINED WALKER ROBOT

-Click here to watch!



What?

- **Design, prototype and assemble** a walker robot that can climb up a 30 degree incline on grassy/muddy terrain.
- Minimum required speed of 4 m/min.
- Given a motor and a battery pack.

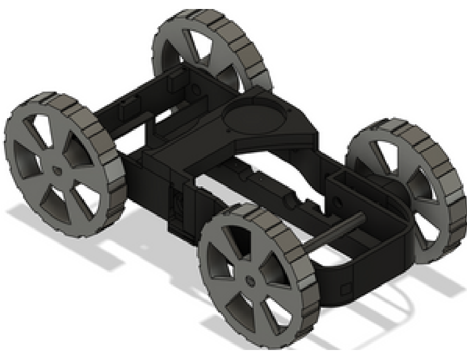
How?

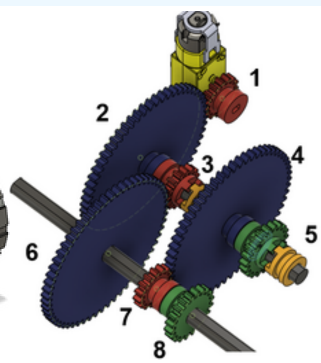
- Performed **PVA analysis** to create **linkage** system.
- **Bevel gears** used to transmit rotation from motor to linkage.
- Linkage **laser cut** from Delrin to minimize friction.
- Performed gait analysis and **CG analysis** to verify design.

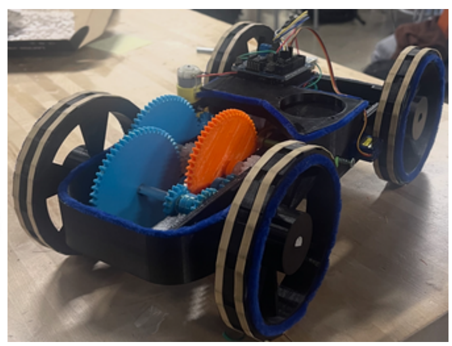
Results

- 18 m/min speed achieved.
- 2^{nd} fastest robot in the class.
- Designed for 3d printing for **rapid prototyping** and iteration.
- Hand calculations allowed for **optimizing gear ratio** to maximize speed.

LIGHT RUNNER - MANUAL TRANSMISSION RC CAR







What?

Create a car that is controlled by an IR remote that can:

- Lift **2 kg** up a **20 degree** incline.
- Drive at **1 m/s** average speed.
- **Shifts gears** with only **one servo**.
- Can shift between low, high and reverse gear smoothly.
- Costs less than **$15** to make.

How?

- Performed **gear ratio calculations** based on motor power and rpm to create **drivetrain**.
- Performed **bending stress analysis** on gear teeth,
- **Barrel cam** for converting rotational to translational for shifting.
- Machined metal D-shafts.
- Used **Arduino Uno**, **l298n motor driver**, and **IR sensor** to control the car.

****Calculation Sneak Peak****

$$P = T_{stall}\omega_{@6V}$$

$$\frac{r_2}{r_1} = \frac{T_2}{T_1} = \frac{\omega_1}{\omega_2}$$

High torque gear ratio: 16:1

High speed gear ratio: 1:1

Results

Car was able to:

- Lift **4.6 kg** up a **20 degree** incline.
- Drive at **1.05 m/s** average speed.
- **Shifts gears** with only **one servo**.

PALLAB LAYAK

MECHANICAL ENGINEERING AT THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

playak2@illinois.edu

https://www.linkedin.com/in/pallab-layak/

(447) 902 - 0861

COMPOSITE PLUG DESIGN AND MANUFACTURING - ILLINI SOLAR CAR

What?

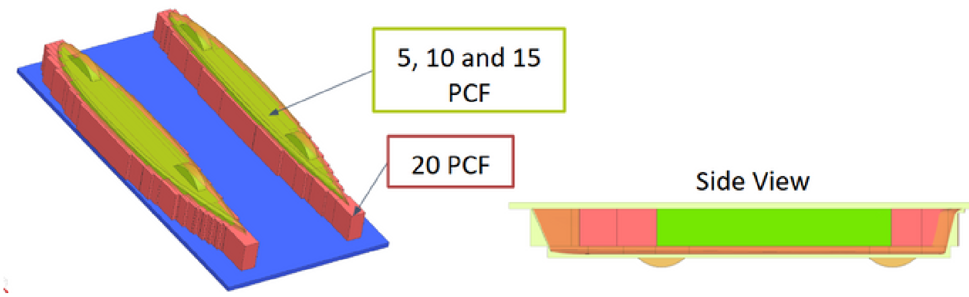
- Designed a preliminary **6.5ft x 16ft** HDPU foam mold assembly for composite aero-shell.
- Created procedure for reference geometry transfer between mold and final part.
- **Carbon fiber layup** on male plug to create female mold.

How?

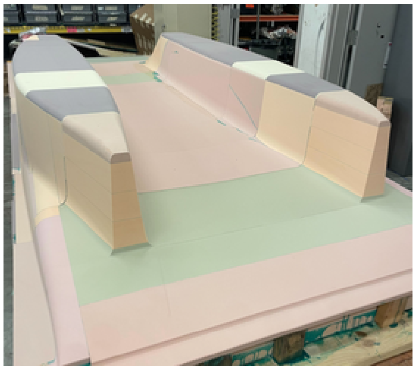
- Designed foam mold assembly in **NX.** Minimized cuts required by tracking with spreadsheets and slides.
- Created foam molds using **planers**, a **track saw** and elaborate gluing setups.
- Outsourced mold manufacturing with **5-axis CNC**.
- **Post-processed mold** for layup.
- Machined **100+** inserts for reference geometry transfer on **manual lathe.**

Results

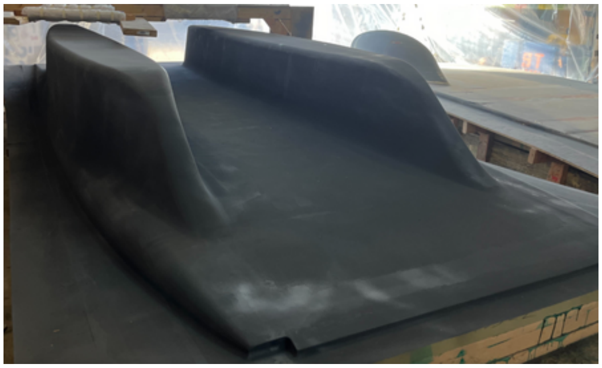
- Created using existing resources - **no additional materials purchased**.
- Reference geometry successfully transferred from male to female mold.
- Mold layup completed successfully.



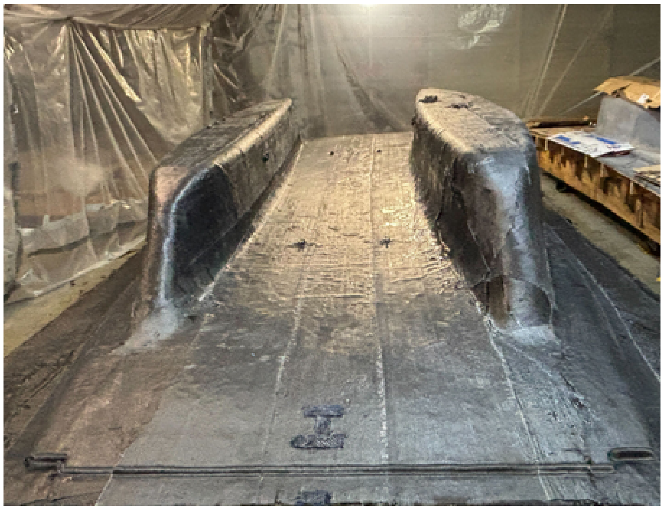
Preliminary Foam Assembly



Final Machined Plug



Plug Prepped for Layup



Layup Complete!

Inserts Machined for Hole Transfer

PALLAB LAYAK

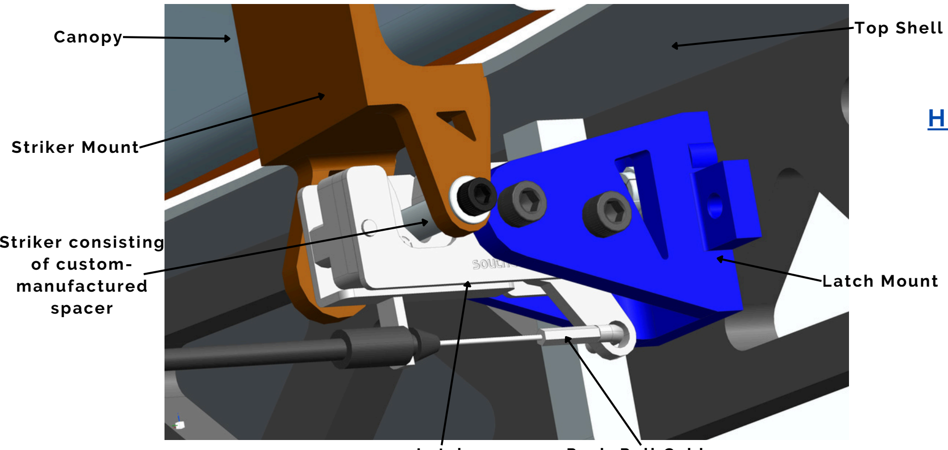
MECHANICAL ENGINEERING AT THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

playak2@illinois.edu

https://www.linkedin.com/in/pallab-layak/

(447) 902 - 0861

LATCHING SYSTEM - ILLINI SOLAR CAR



Canopy Latching System Assembly in NX

Here is a video showing that the system works!

What?

- **Design** a latching system to secure:
  - Top shell to bottom shell.
  - Canopy to top shell.
- **Minimize costs** by using resources that we already had.
- Incorporate buttons as the "user-interface" with the latching system. **Human-centered design** was used to do so.

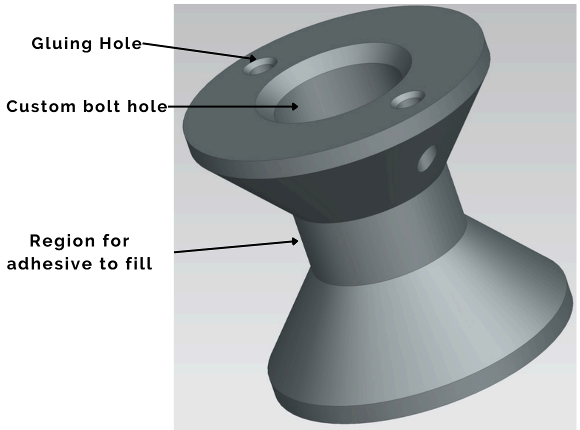
How?

- **3-D printed** latch and striker mounts.
- Striker mount was glued onto the canopy. Latch mount was slotted and bolted into triangular chassis cutouts.
- Used **rapid prototyping** to test fit.
- **Push-pull cables** were used and customized along with **mechanical buttons** to activate the latch.
- Striker consisted of a bolt and custom-made spacer I manufactured on the **lathe.**
- Top shell latch system was made in a similar manner.

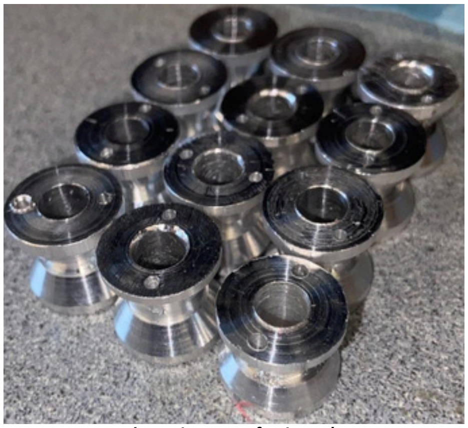
Results

- Completed within 4 days.
- Latch systems successfully survived the entire race.
- **$0** cost because the project was designed to use existing resources.

INSERTS FOR CARBON FIBER - ILLINI SOLAR CAR



Inserts designed in NX



Inserts manufactured

What?

- **Design** and **manufacture** custom diameter inserts to bolt components through carbon fiber.
- Ensure that the inserts can be glued.

How?

- **Design** in NX and made engineering drawings using **GD&T.**
- Manufactured in-house using the **manual lathe** and **mill.**
- Created a setup to test whether the inserts withstand their required load cases.

Results

- Manufactured more than 30 custom inserts.

PALLAB LAYAK

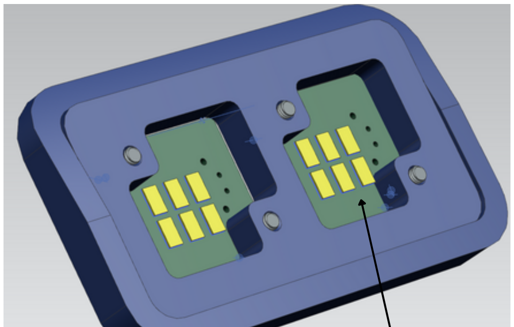
MECHANICAL ENGINEERING AT THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

playak2@illinois.edu

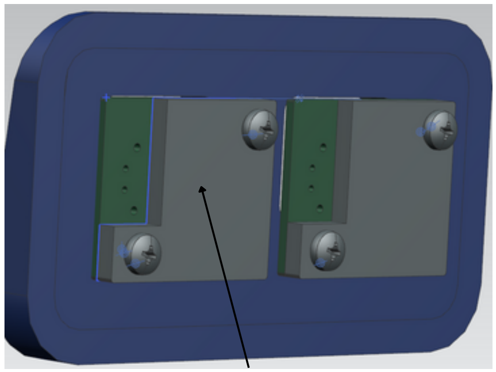
https://www.linkedin.com/in/pallab-layak/

(447) 902 - 0861

HEADLIGHTS - ILLINI SOLAR CAR



Headlight + Turn indicator PCB



Aluminum Heat Sink with hole for PCB connectors

Lights shining bright while driving in the night!

What?

- **Design, manufacture** and **assemble** a system to incorporate the headlights and front turn indicator into 3rd generation solar vehicle.
- Maintain safe temperatures by attaching a heat sink to the PCB.

How?

- Designed on **NX,** importing PCB components from **KiCAD.**
- **3D-printed** holder for headlight.
- **Waterjet** Aluminum heat sinks to prevent overheating.
- Performed **heat transfer hand calculations** to determine thickness and area of heat sink required.
- Headlight cover **SLA printed** polished, and sprayed for clear finish.

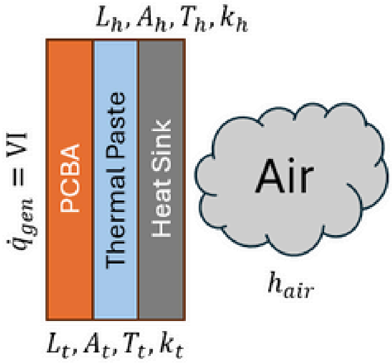
Results

- Headlight system successfully incorporated satisfying all rules and regulations.
- Heat sink dissipates sufficient heat.

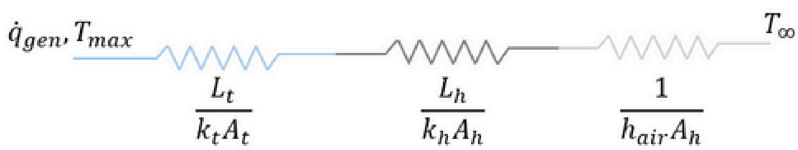
Calculation Sneak Peak

Goal:

Estimate heat-sink thickness ensuring temperature of PCBA doesn't exceed T_{max}



Resistor diagram for 1D SS heat flow:



(Assuming cross-sectional area of heat sink ≈ surface area)

$$T_{max} - T_\infty = VI\left(\frac{L_t}{k_t A_t} + \frac{L_h}{k_h A_h} + \frac{1}{h_{air} A_h}\right)$$

Solve for L_h to determine required thickness!

PALLAB LAYAK

MECHANICAL ENGINEERING AT THE UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

playak2@illinois.edu

https://www.linkedin.com/in/pallab-layak/

(447) 902 - 0861

RESEARCH - EMBEDDED 3D PRINTING

What?

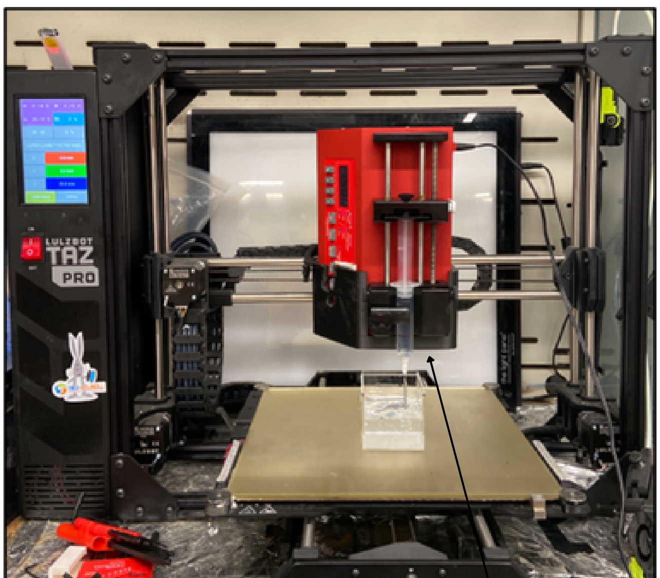
- Design structures to show the capabilities of **embedded 3-D printing**- printing a fluid within another fluid.
- Incorporating an **automatic** extrusion systems to provide accurate results.
- Conducted numerous experiments to determine rheological properties.

How?

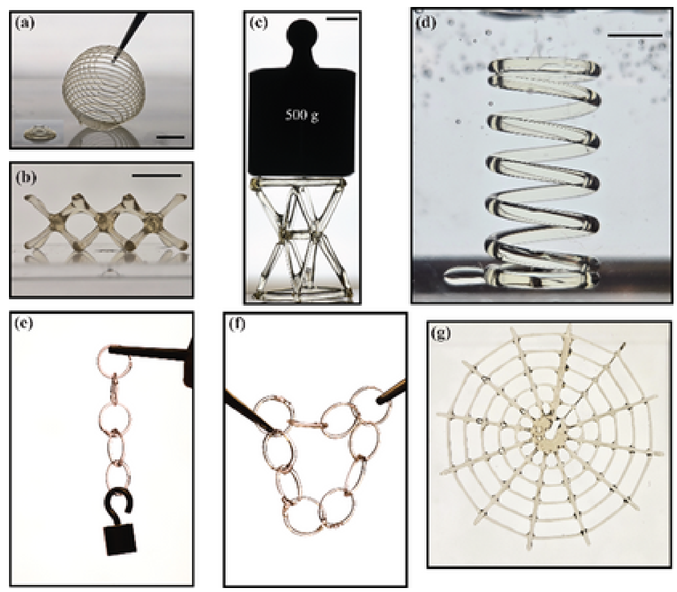
- Used **Python** and researched 3-D printer G-Code to create 9 shapes.
- **3-D printed** custom housing for extrusion pump.
- Automated printing using **Arduino Nano** to connect printer output to pump input.

Results

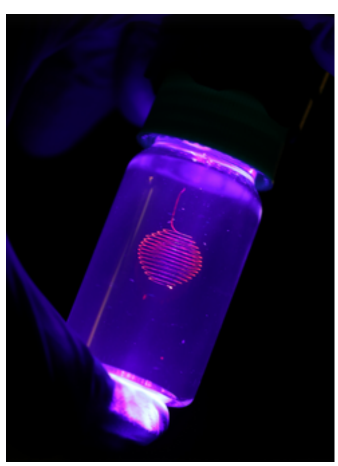
- Structures depicting the "wireframe" printing ability of embedded 3-D printing.
- **100+ hours** of printer monitoring saved by automating the printing.
- Currently **co-authoring** a paper on the rheology of hagfish slime.
- Writing another paper this summer focused on **embedded 3-D printing.**



Custom attachment for pump to printer



Numerous structures printed via embedded 3-D printing. Toolpath G-Code generated using Python Scripts



Embedded 3D printed spiral using UV ink