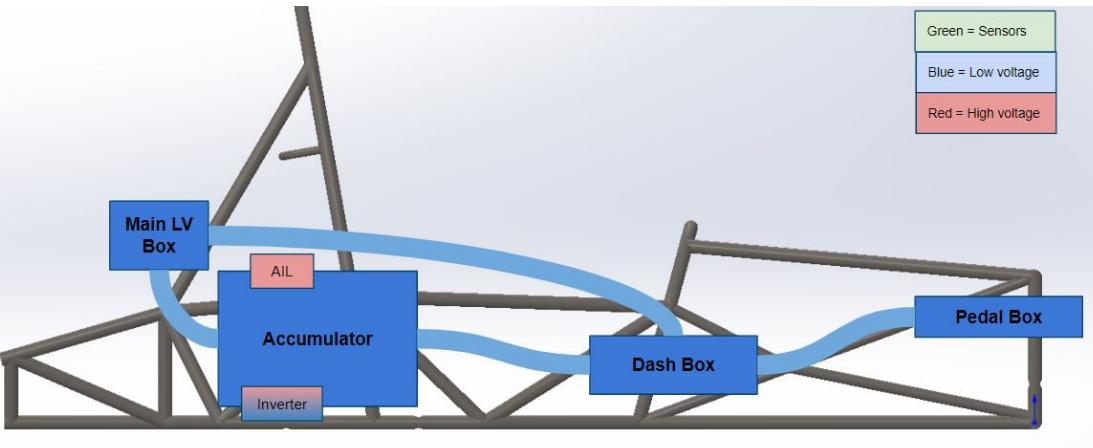


Systems Management Integration

Design integration, plumbing/wiring, power management, schematics. Are sensitive items protected? Proper use of data? Do systems compliment another? Are progressive project management/ organization methods evident? Special communication tools utilized? What testing/development tools have been used or created?

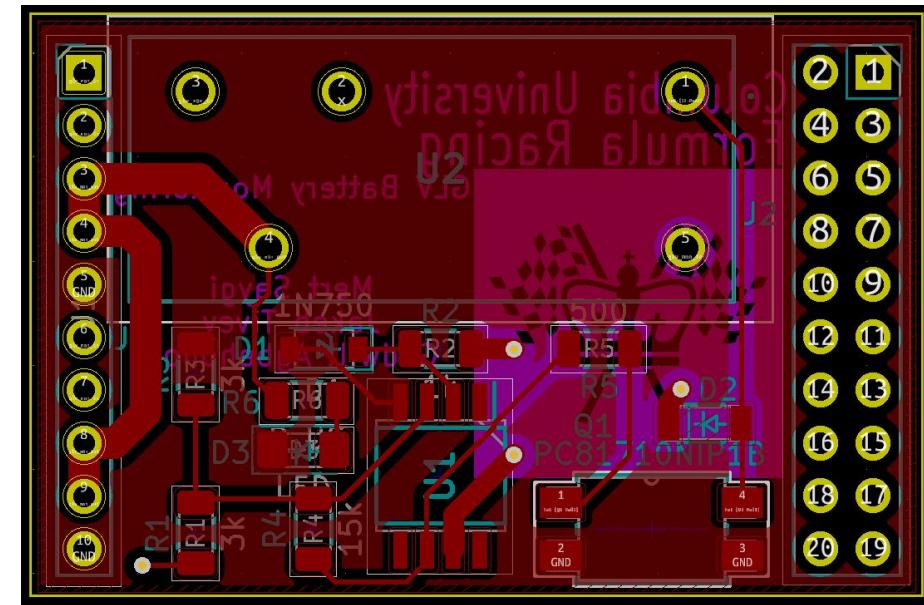
Wiring Harness and Power Management

EV Integration



- Decentralized and modular LV circuits allow for subsystem testing and redesign to happen in parallel
- 4 MCUs (one per LV enclosure and one in Accumulator) all responsible for nearby peripherals and subsystems -> allows for shorter individual wire lengths
- A CAN Bus allows for communication between MCUs and subsystems

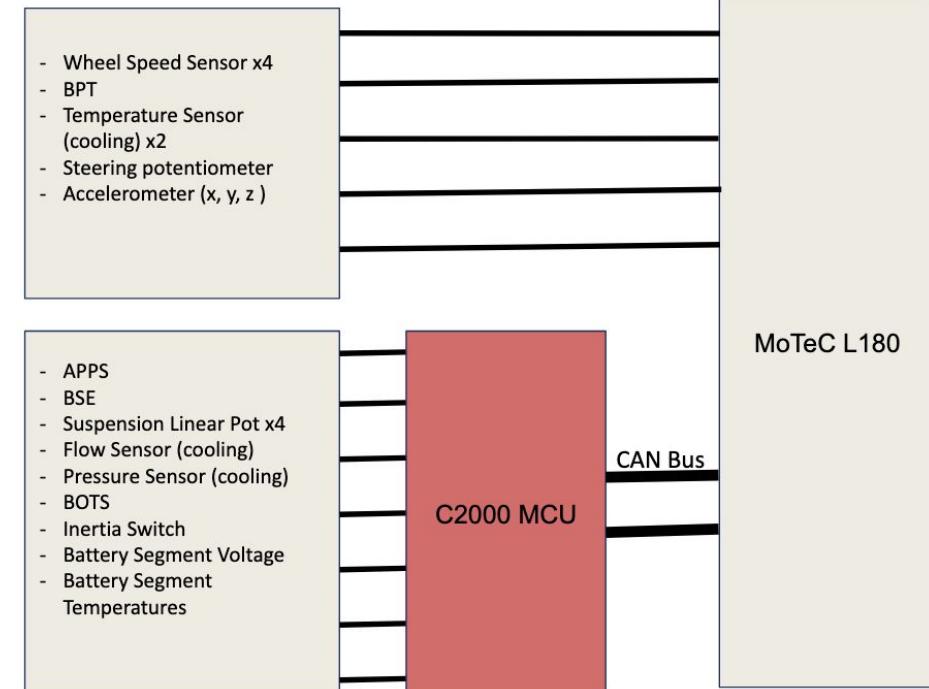
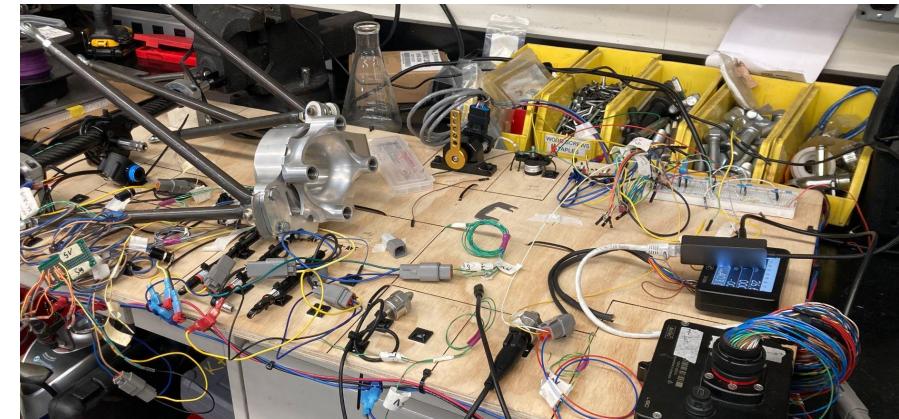
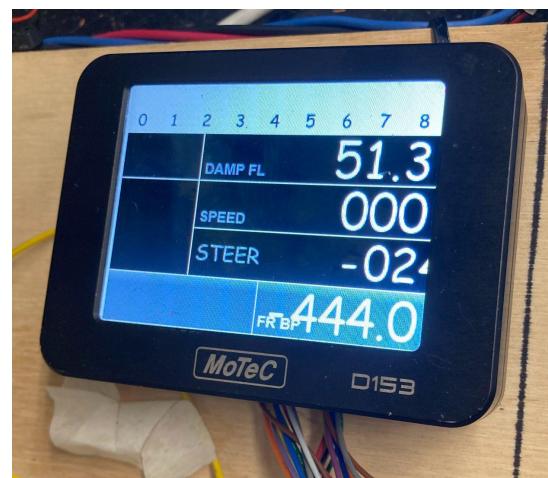
Power Management



- Shorai 12V, 12Ah battery for low-power LV systems
- Subsystems fused in each enclosure
- A Low Voltage Battery Monitoring Board (pictured above) ensures that the battery does not discharge below the rated 12V to ensure a long lifetime

Data and Communication

- A MoTeC L180 data acquisition module is used to store data from sensors
- To increase the number of sensors that can connect to the MoTeC and to act on sensor data in real time some sensors are routed to an MCU and transferred to the MoTeC over the CAN bus
- A testing board for all of our sensors and the MoTeC was used to test the data acquisition system in parallel with car development
- A MoTeC D153 display screen is mounted on the dashboard
- Critical information (ie. battery pack voltage and velocity) will be displayed to the driver

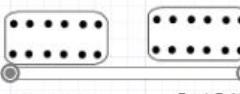


Wiring Harness Software: RapidHarness

- Creates a digital mockup of wiring harnesses and the connections on the car
- Harnesses are created from connectors and wires and can store the data about each of its wires within said harness
- Devices are used to show an electrical component that has a connection to a harness (i.e. PCB Boards)
- Harness and devices make up a system, which can use signals created by the harnesses and devices to show a complete connection net of the system
- RapidHarness allows for easier and more localized access to wiring schematics and other data regarding the wiring harness for testing and presentation

Dash_to_Main Harness (Main C to Dash D)

Notes	From	To	Conductor	Color	Gauge
PWR_12V	MainC.1	DashD.1	W5.Red	■ Red	18 AWG
PWR_GND	MainC.2	DashD.2	W11.Black	■ Black	18 AWG
SDS+	MainC.3	DashD.3	W6.Blue	■ Blue	18 AWG
SSOK_SIG	MainC.4	DashD.4	W7.Blue	■ Blue	18 AWG
CANH	MainC.5	DashD.5	W8.Green	■ Green	18 AWG
CANL	MainC.6	DashD.6	W9.Green	■ Green	18 AWG
CAN_GND	MainC.7	DashD.7	W10.Black	■ Black	18 AWG
APPS_SIG	MainC.8	DashD.8	W12.Green	■ Green	18 AWG
APPS_5V	MainC.9	DashD.9	W13.Red	■ Red	18 AWG
APPS_GND	MainC.10	DashD.10	W14.Black	■ Black	18 AWG



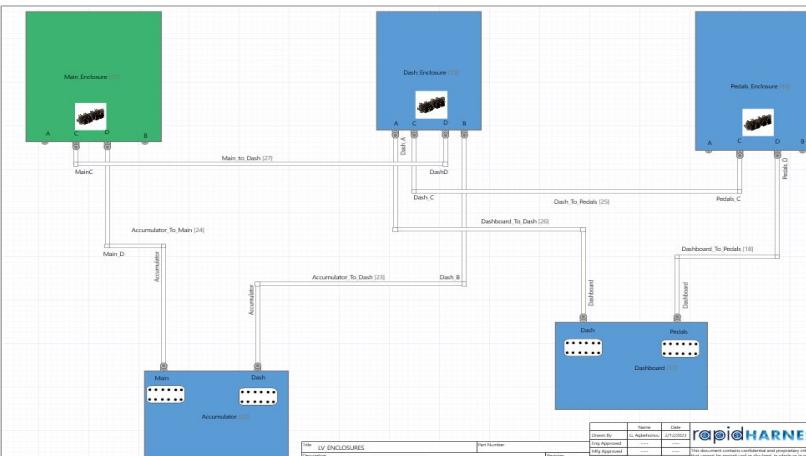
Notes	From	To	Conductor	Color	Gauge
PWR_12V	DashD.1	MainC.1	W5.Red	■ Red	18 AWG
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CANL	DashD.6	MainC.6	W9.Green	■ Green	18 AWG
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APPS_SIG	DashD.8	MainC.8	W12.Green	■ Green	18 AWG
APPS_5V	DashD.9	MainC.9	W13.Red	■ Red	18 AWG
APPS_GND	DashD.10	MainC.10	W14.Black	■ Black	18 AWG

LV_ENCLOSURES

Connection Signal Net

Device / Harness	Endpoint	Signal
Accumulator	Dash.1	DCDC_ON
Accumulator_To_Dash	Accumulator.1	
Accumulator_To_Dash	Dash.B.7	
Dash_Enclosure	B.7	
Accumulator	Dash.2	RTD_DASH
Accumulator_To_Dash	Accumulator.2	
Accumulator_To_Dash	Dash.B.8	
Dash_Enclosure	B.8	RTD_SIG
Accumulator	Dash.3	LED_SDC
Accumulator_To_Dash	Accumulator.3	
Accumulator_To_Dash	Dash.B.4	
Dash_Enclosure	B.4	LED_SDC_ACC
Accumulator	Dash.4	CURRENT_SENS
Accumulator_To_Dash	Accumulator.4	
Accumulator_To_Dash	Dash.B.6	
Dash_Enclosure	B.6	CT_ACC
Accumulator	Dash.5	BPT_SIG
Accumulator_To_Dash	Accumulator.5	
Accumulator_To_Dash	Dash.B.12	
Dash_Enclosure	B.12	BPT_SIG_ACC
Accumulator	Dash.6	SDS_OUT
Accumulator_To_Dash	Accumulator.6	
Accumulator_To_Dash	Dash.B.11	
Dash_Enclosure	B.11	SDS_OUT

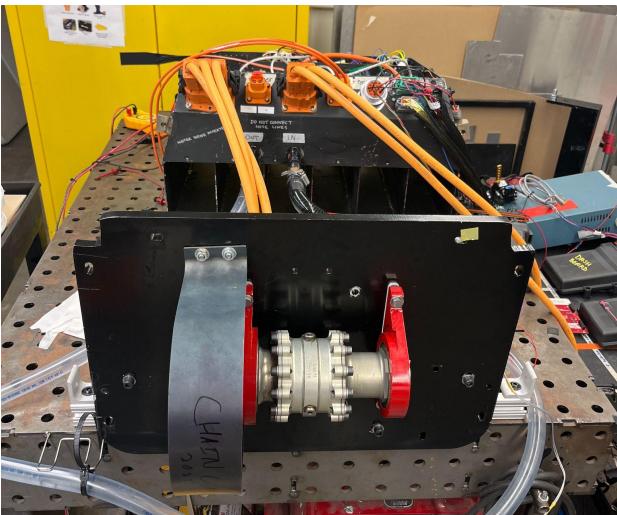
LV_ENCLOSURES System



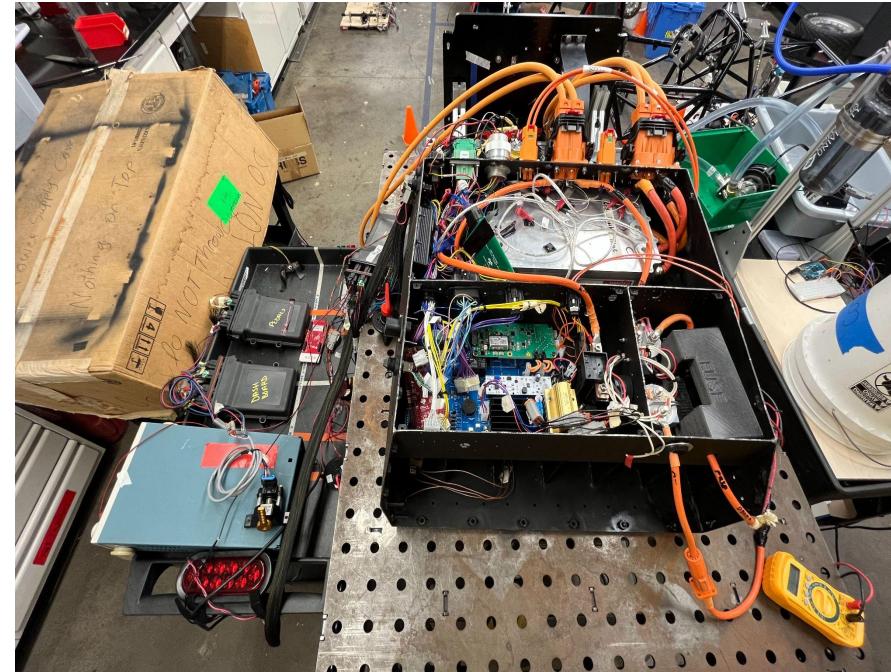
Isolated Testing

- Subteams (ie. cooling, HV, LV) had specific testing carts for a pipelined testing program and easy integration and troubleshooting off the chassis
- This allowed us to isolate problems such as the motor plate flexing and the AIRs not flipping due to high resistance in the shutdown loop
- PCBs designed for standalone testing without the need of integrated sensors and systems

**Drivetrain
Test Bench**



HV and LV Test Cart



Cooling Test Cart



Development Tools: GitHub and GrabCad

The screenshot shows the GrabCAD Workbench interface. At the top, there's a navigation bar with icons for clock, file, user, search, and settings, followed by links for 'Download Desktop App', 'Help', and 'Log out'. Below the navigation bar is a toolbar with 'New', 'Download project', and 'Upload' buttons. A sidebar on the left lists project categories: 'CFER-23', 'CMM', 'EV22 (OLD)', 'EV23 (COMP)' (which is highlighted in red), 'EV24', 'Misc', and 'Partner Space'. The main area displays the 'EV23 (COMP)' project with a warning message: '⚠ We're saying goodbye to Workbench on June 1, 2023. Read details here'. It shows a list of folders: 'Controls', 'Dynamics', 'Frame Body Aero', 'High Voltage', 'KiCad Files', 'Low Voltage', 'Powertrain', 'temporary redesign files', and '~Other'. At the bottom, there's a summary for 'eCUFR-2023 Full CAD.SLDASM': Size 164.4 MB, Type SLDASM, Version V9, Last modified 09 Feb 2023 at 12:14 am, and Modified by Knickerbocker Motorsports.

GrabCad:

- Store and version control all CAD models

GitHub:

- Store and version control all electrical schematics, PCB designs and software
- Desktop Application allows for instant update of project folders on local device

The screenshot shows a GitHub repository page for 'columbia-fsae / KiCad2023'. The repository is private. The top navigation bar includes 'Code', 'Issues', 'Pull requests', 'Actions', 'Projects', 'Security', 'Insights', and 'Settings'. Below the navigation bar, it shows 'main' branch, '1 branch', and '0 tags'. The 'Code' tab is selected, showing a list of recent commits:

- Rosnel14 fixed pads on DBR and DAR (3068772 yesterday, 129 commits)
- CUFR-Footprint-Library.pretty v5 edits w/ Bert (5 days ago)
- ESF Schematics ESF folder fixes (last month)
- High Voltage fixed pads on DBR and DAR (yesterday)
- Low Voltage Created GLVMB v6 (3 days ago)
- .DS_Store sdc update (2 weeks ago)
- .gitignore Added Demo (5 months ago)
- CUFR-Full-Library.lib LV-fixes (3 months ago)
- README.md Update README.md (7 months ago)

On the right side, there are sections for 'About', 'Releases', and 'Packages'. The 'About' section notes 'All KiCad files for EV 2023' and lists 'Readme', '1 star', '2 watching', and '0 forks'. The 'Releases' section says 'No releases published' and 'Create a new release'. The 'Packages' section is currently empty.

Communication: Slack and Google Suite

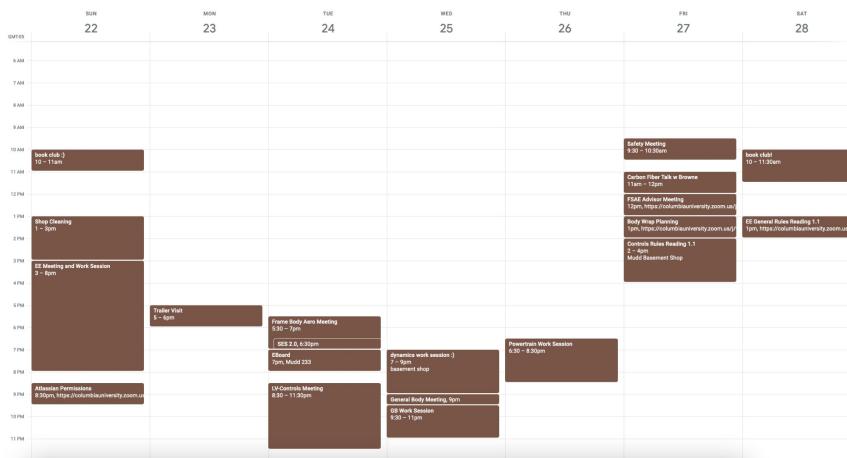
Slack:

- Fast and urgent messaging
- Topic-specific channels
- Integrated with apps for productivity

A screenshot of the CU Formula Racing Slack interface. The left sidebar shows various channels like #general, #calendar, and #controls. The #general channel is active, displaying a message from Vedhas Banaji at 3:47 AM: "Motor is filled with water !!! Please do not touch the cooling connections to the motor. They are sensitive. If for any reason the cooling connections need to be removed, contact me or @Vedhas Banaji." Below the message is a photograph of a mechanical assembly with yellow and red components. The message was posted in #ev-powertrain yesterday at 3:18 AM.

Google Calendar:

- Displays designated meeting
- Allows for integration of systems to take place in parallel with individual subteam developments



Google Drive:

- File sharing: notes, competition documents, testing plans, data sets, reference documents, and more

A screenshot of the Columbia University Formula Racing Google Drive. The top navigation bar shows "My Drive > FSAE > Columbia University Formula Racing". Below the navigation are four main folder icons: "Admin", "Electrical Systems", "Mechanical Systems", and "Engineering Resources". Under each main folder, there are sub-folders and files. For example, under "Admin", there is a file named "Columbia FSAE Drive Organization". Under "Electrical Systems", there is a file named "Columbia FSAE System Le...". Under "Mechanical Systems", there is a file named "FSAE Drive Guide". Under "Engineering Resources", there is a file named "Note Taking Guide".

Management Tools: Jira

Jira allows our team to coordinate project work on subteam, system, and component level. Task dependency can be tracked as well as progress. Updates can be communicated.

The image shows two screenshots of the Jira interface. The left screenshot is the project dashboard for 'FSAE Car Tasks 2022-23'. It features a summary section with metrics: 30 done (in the last 7 days), 145 updated (in the last 7 days), 35 created (in the last 7 days), and 43 due (in the next 7 days). Below this is a 'Status overview' pie chart showing 13% Done. The right screenshot is a 'Timeline' view for the same project, showing tasks from September to November. A specific task, 'HV: Battery Pack', is highlighted. The timeline shows various tasks like 'Check temperature plugs', 'Validate BMB v5', and 'Order assembled BMBs' with their respective start and end dates and dependencies. A detailed view of the 'HV: Battery Pack' task is shown on the right, listing subtasks such as 'Check temperature plugs' and 'Validate BMB v5' with status indicators like 'IN PROGRESS' or 'DONE'.

Onboarding & Knowledge Transfer

The team invests heavily in new member recruitment and retention for long-term success of our car and engineering program.

We use Confluence as a wiki to easily share information.

Process:

- Subteam-level introduction meet & greets
- “Shopping” Period with open work sessions
- Becoming an official member guarantees you access to club-wide events
- Year-long support program by the executive board
- Workshops, Office Hours, & Teaching Presentations

A screenshot of a Confluence page titled "Tutorials". The page lists various resources under "Resources (in addition to Workshop recordings)":

- Aero Guide
- Aerodynamics Teaching Presentation
- Ansys Fluent CFD Tutorial
- APPS/RTD Teaching Presentation
- Battery Management System (BMS) Teac...
- Bert's PCB Guide
- Brakes Calculation Guide
- Brakes Teaching Presentation
- CFD
- Controls Team Guide
- CUNIX Guide
- Drawings
- Drivetrain Teaching Presentation
- Engine and Accumulator Teaching Pres...
- EV Shutdown Circuit Teaching Presen...
- FSAE Drive Guide
- Google Calendar & Slack Guide
- GrabCAD Tutorial
- How to add CUFR to your LinkedIn
- Intro to EV
- KICAD
- Master CAM Tutorial

Join the team!

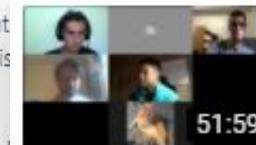
Welcome to Columbia University Formula Racing

Thanks for your interest in joining our team! We design, build, and compete with two race cars (one internal combustion engine (IC) and one electric (EV)) at formula racing-style events for college students, and we need ALL hands on deck.

Below, you'll find links to forms you can use to sign up and places where you can learn more about us.

1. Attend our info sessions

Interest Meetings are no commitment you can help with, and hear about this



SolidWorks Workshop #2
Add description

Info session meetings and slides are l

▶ Past Info Sessions: (click toggle a



Intro to Engineering Design
Relevant Links: - Slides:
[https://docs.google.com/p...](https://docs.google.com/p)

2. Join our team slack an

If there are any projects or systems tha slack channels to learn more! Once yo and directly message all of our subte



Intro to Engineering Design
Relevant Links: - Slides:
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