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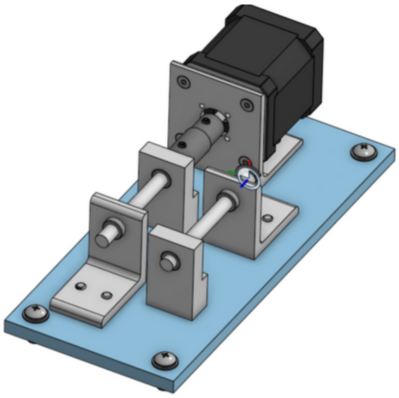
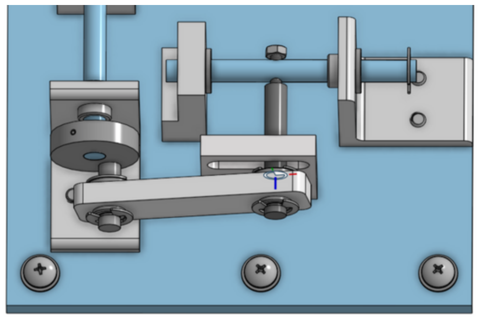
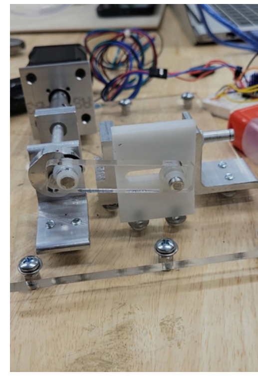
MOTION TRANSMISSION MECHANISM







What?

- Design and fabricate a device that can consistently transmit motion from a motor-driven rod to a stationary rod.
- Be wary of **material choice** and **mechanical fastening mechanisms.**

How?

- Used **Onshape** and **SolidWorks** to design a **slider-crank** transmission.
- Created Drawings with **GD&T**, **exploded views**, and **Bill of Materials**.
- Created parts using the **mill**, **lathe**, **bandsaw**, and **laser cutter**.

Results

- The design fulfilled its purpose as it converted the angular rotation of the motor-driven rod to linear movement of the other.
- Ran for 20 minutes with no alignment issues or locking.

QUBE MOTOR CONTROLLER DESIGN

What?

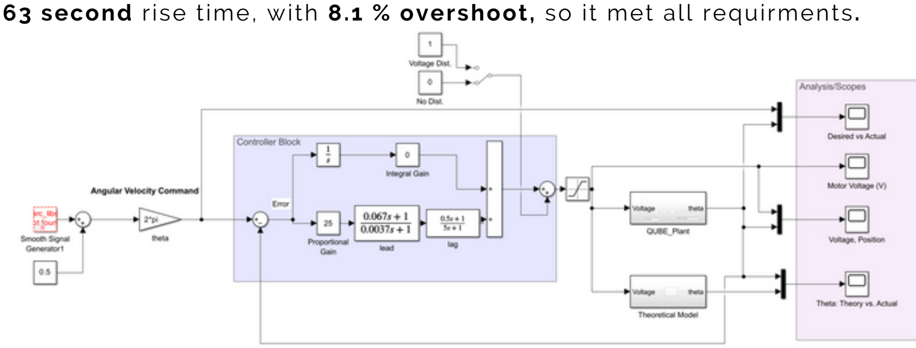
- Control the position of a **QUBE servo motor** using a **lead-lag controller**.
- Specifications to be met: Rise Time < 0.1 seconds, Steady State Error < 0.05 radians to unit step reference and disturbance inputs, and Overshoot < 20%.

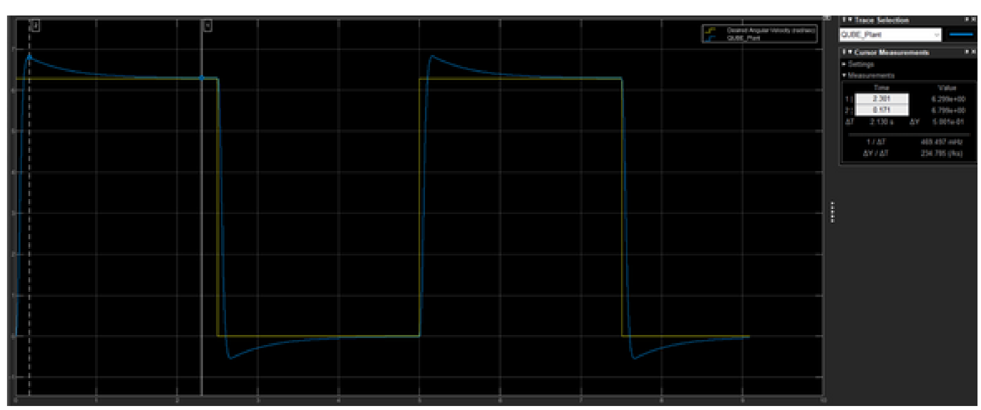
How?

- Designed using **Control System Designer** on **MATLAB,** and **Simulink** with motor specifications.
- Used knowledge of **feedback control systems**, including **Bode, Root Locus, Nyquist**, and **step responses.**
- Used equations for lead-lag controllers, to place the max phase lead near the crossover frequency, increasing phase margin and bandwidth.

Results

- For the **lead**, the pole and zero were **-120** and **-20**, respectively, and for the **lag** they were placed at **-0.36** and **-2**, respectively. A **gain of 25** was also used.
- Steady State Error to Unit Reference was **0.015 rad**, and **0.0491 rad** to Unit Disturbance (disturbance response not shown here). Response also had a **0.063 second** rise time, with **8.1 % overshoot,** so it met all requirments**.**





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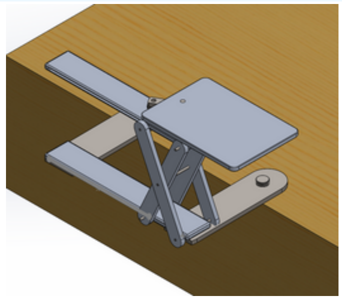
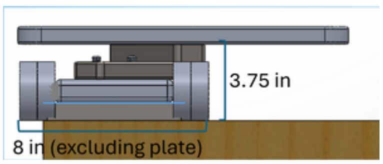
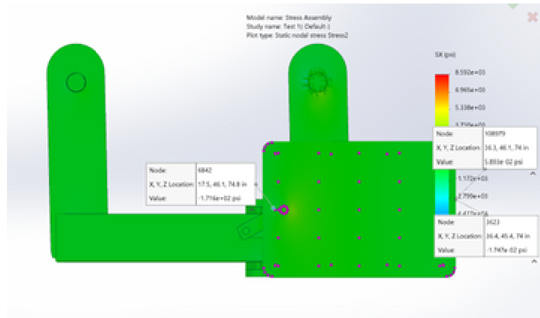
BED LEG LIFTER FOR INDIVIDUALS WITH PARAPLEGIA







What?

- Design and analyze a leg lifter for Individuals with Paraplegia.
- Must use 14x20 in. plate and fit below a given mattress and above the lower base.
- Side profile must be within 8x4 in.
- Must hold a 200 lb. uniform load (very conservative).

How?

- Used **SolidWorks** to design model.
- Used a **scissor lift** and **4 bar linkage** to rotate plate, and legs over bed.
- Used **Mechanics of Materials**, **Airy Stress Functions**, and **Roark's Plate Equations** to estimate stresses and deflections of the 14x20 in. plate.
- Used **FEA** to determine true values and to compare to theory.

Results

- The fixed edge and opposing free edge were analyzed.
- The theoretical model fit closely with the FEA model

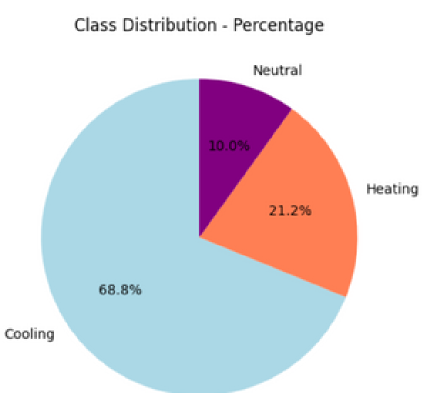
At Fixed Edge:

Model	σ_x	σ_y	τ_{xy}	$\delta(deflection)$
Theoretical	-172 *psi*	0 *psi*	28 *psi*	0 *in.*
FEA	-171.6 *psi*	5 *psi*	20 *psi*	0 *in.*

At Free Edge:

Model	σ_x	σ_y	τ_{xy}	$\delta(deflection)$
Theoretical	176 *psi*	0 *psi*	–	0.045 *in.*
FEA	174.7 *psi*	8 *psi*	–	0.071 *in.*

ANALYZING BUILDING OPERATIONAL MODES USING MACHINE LEARNING



What?

- Using synthetic building data, create optimized **Machine Learning** models to classify the operational mode of the building, in a given hour.
- This is a **3 class (multiclass) classification** problem.
- Classes are heating, cooling, and neutral.

How?

- Used **Python programming**.
- Used **Target Engineering** to manufacture classes based off hourly energy thresholds.
- Handled **imbalanced** data using **SMOTE**.
- Used **Feature Selection,** and **Hyperparameter Tuning** to tune models.
- Used **Logistic Regression**, **KNN**, and **Decision Tree** models.
- Evaluated models using **F1**, **recall**, and **precision**, through **classification report.**

Results

- Tuned Decision Tree and KNN models performed well with metrics above 0.7-0.8.
- Improved Neutral Classification across models significantly.

LR Test Set Performance:

	precision	recall	f1-score	support
Cooling	0.99	0.95	0.97	7236
Heating	0.87	0.98	0.92	2229
Neutral	0.62	0.62	0.62	1047
accuracy			0.92	10512
macro avg	0.83	0.85	0.84	10512
weighted avg	0.93	0.92	0.92	10512

Decision Tree Test Set Performance:

	precision	recall	f1-score	support
Cooling	1.00	0.95	0.97	9045
Heating	0.97	0.95	0.96	2786
Neutral	0.69	0.92	0.79	1309
accuracy			0.95	13140
macro avg	0.88	0.94	0.91	13140
weighted avg	0.96	0.95	0.95	13140

KNN Test Set Performance:

	precision	recall	f1-score	support
Cooling	0.99	0.97	0.98	7236
Heating	0.93	0.94	0.94	2229
Neutral	0.73	0.80	0.76	1047
accuracy			0.95	10512
macro avg	0.88	0.91	0.89	10512
weighted avg	0.95	0.95	0.95	10512