Machine Control Design Project

Elevator

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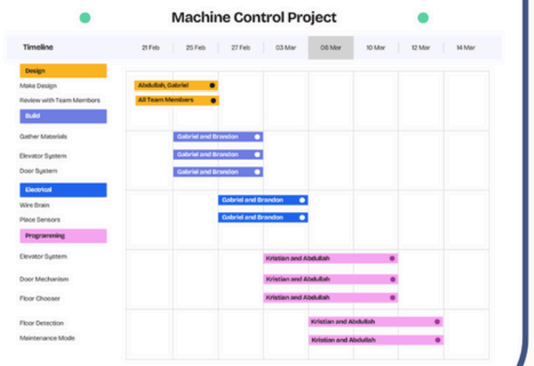
Project Management

Project Management Sheet

Task	Steps to Completion	Responsibility	Due Date
Make Design	1. Use CAD to construct a design of the elevator with a functioning elevator and door system 2. Find a way to introduce a biomechanical element to the elevator 3. Promise amount of materials	Abdullah, Gabriel	2/25
Review Design	1. Review design with team 2. Ensure design meets all criteria and constraints of the project	All Team Members	2/25
Gather Materials	1. Analyze the CAD design and gather as much of the materials as possible 2. Prioritize obtaining as many of the motors and other sparse materials before they get taken	Gabriel and Brandon	2/25
Build Frame	1. Build a rough frame of the elevator with each of the floors 2. Make sure there is enough room for people to take things in and out and build around it	Gabriel and Brandon	2/25
Wire the Brain	1. Attach each of the wires to the brain	Gabriel and Brandon	2/25
Code Doors	1. Find a way to make the doors open and close	Kristian and Abdullah	3/6
Code Elevator System	1. Make a code for the elevator that is able to smoothly pull the shaft up and down without jamming 2. Adjust code if necessary when applied to the build	Kristian and Abdullah	3/6
Build Door Mechanism	1. Look at the CAD design 2. Test if it can be built in real life 3. Adjust if necessary, otherwise build off of the model	Gabriel and Brandon	3/6
Place Sensors	1. Look at the CAD design 2. Test if it can be built in real life 3. Adjust if necessary, otherwise build off of the model	Gabriel and Brandon	3/6
Code Floor Chooser	1. Code a button press on a certain floor to make the elevator go to that floor	Kristian and Abdullah	3/10
Code Floor Detection	1. Code the sensors to stop the carriage when seen on a curtain floor	Kristian and Abdullah	3/12
Code Maintenance Mode	1. Code mode where lights turn on, elevator goes to floor, and all doors open.	Kristian and Abdullah	3/12

Gantt Chart



Design Brief

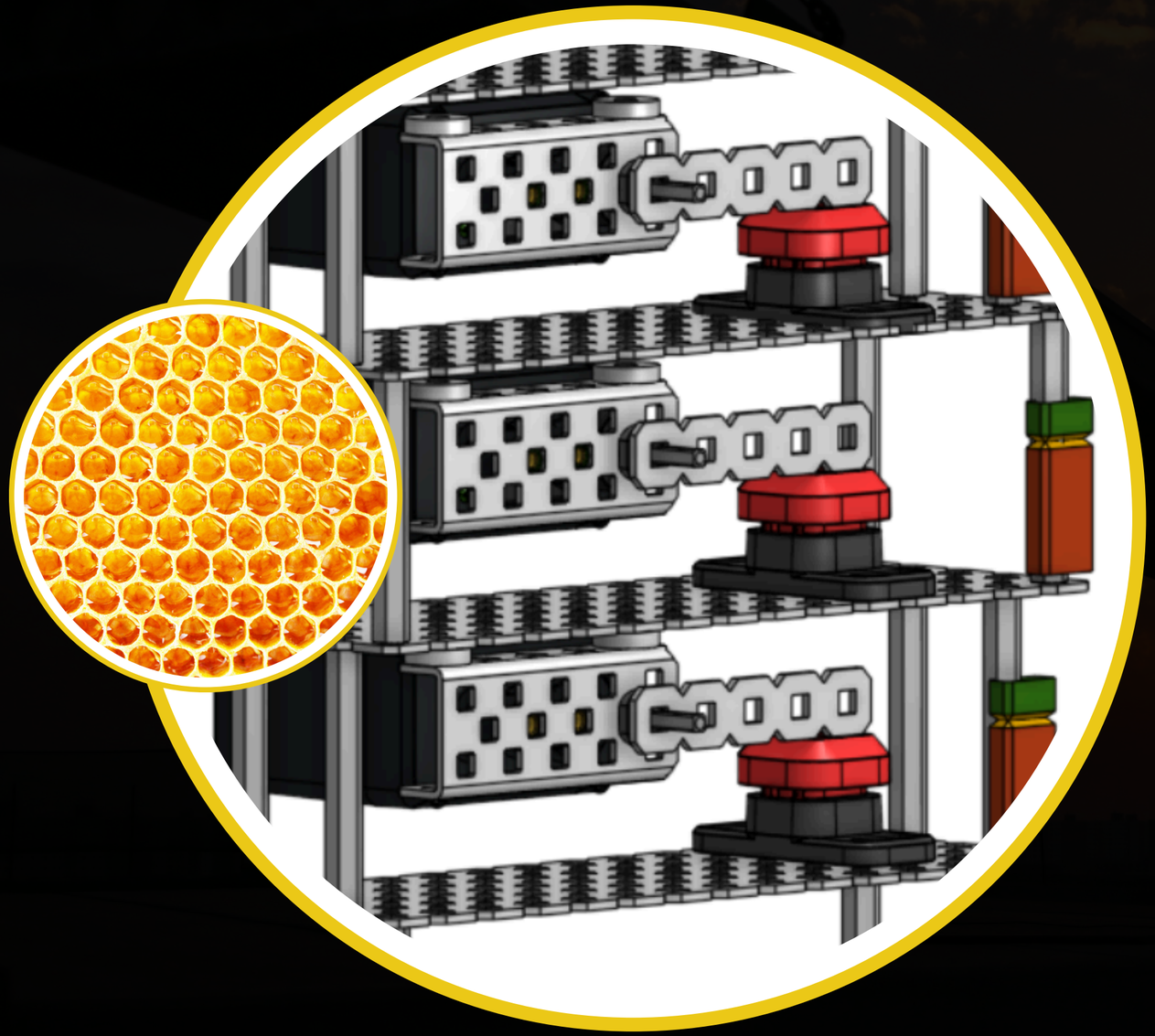
Design Brief

Created by: Abdullah Khaled, Kristian Little, Gabriel Garabedian, Brandon Chiou

Client:	Contractors 4U
End User:	Elevator Company
Designer(s):	Kristian, Brandon, Abdullah, and Gabriel
Problem Statement:	A company would like to begin producing residential elevators. Your team must design the control system and a prototype of an elevator that can go between three floors in any order.
Design Statement:	We have to design, build, and test a working prototype of an elevator that can go to any floor; display its current floor; contain safety mechanisms that return the elevator to ground floor after a user-determined amount of time and gates to prevent users from entering the elevator shaft; and include a "maintenance mode."
Criteria & Constraints:	Criteria: • Carriage must go to any floor in any order • Display the elevator's current floor • Each floor must have a way for someone to call the elevator to that floor. • Users, once in the elevator, must be able to choose their desired floor to go to • Return to ground floor after user-determined period of time • Include a "Maintenance Mode" where the lights blink and all doors open Constraints: • Prevent residents from entering elevator shaft • Doors must not interfere with other floors • Order of carriage should not matter

Throughout our project, managing our resources, communicating with our peers, and determining the best course of action were vital to the success of our group. As such, we implemented various methods to ensure our group completed the project before the deadline.

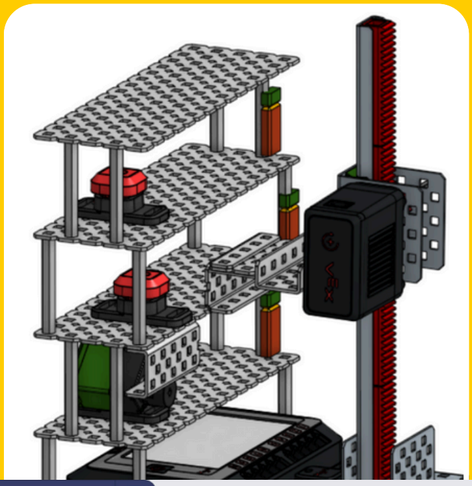
- **Project Management Sheet**: We used a project management sheet to determine what tasks needed to be completed, when they needed to be done, and who was responsible for each task.
- **Gantt Chart:**: The Gantt chart allowed us to visually display deadlines and resources throughout the project.
- **Design Brief:** As customary with most projects, we created a design brief that clearly stated the problem, criteria, and constraints we had to complete to have a successful project.
- **Decision Matrix:** Our team collaborated on the decision matrix to determine how we could complete the project's criteria while keeping both the project's and our constraints.

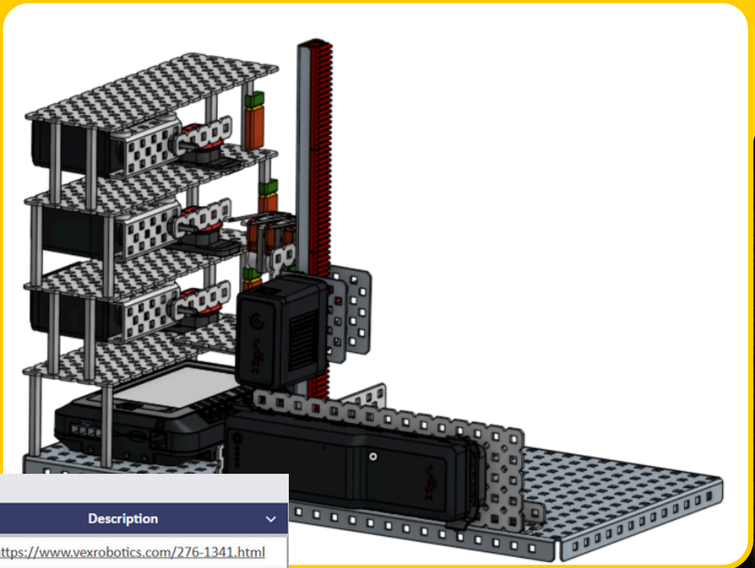


Research & Biomimicry

After we determined the criteria and constraints of our project, we looked at previous designs and specific concepts we wanted to use in our design. Additionally, we had to include an aspect of biomimicry in our design, We decided to use bee hive modularity through a repeating pattern of supports and door placements that allows for modular construction of each floor of the building. In doing so, our build process was expedited and gave our group ample time for testing, iteration, and debugging. Moreover, by using a modular design, we could scale our programming based on the number of floors we install on the elevator.

Generate Concepts





MCP Bill of Materials

Item	Name	Qty	Part Number	Description
1	15 x 30 Base Plate (276-1341)	1	276-1341	https://www.vexrobotics.com/276-1341.html
2	Rack Gear v2 (276-4782)	4	276-4782	Rack Gear v2
3	Rack Gearbox Bracket v2 (276-5771)	2	276-5771	Rack Gearbox Bracket v2
4	V5 Smart Motor (18:1) (276-4840)	1	276-4840	https://www.vexrobotics.com/276-4840.html
5	3" Standard Shaft (276-1149)	1	276-1149	https://www.vexrobotics.com/drive-shafts.html
6	12T Gear (276-2169-001)	1	276-2169-001	https://www.vexrobotics.com/gears.html
7	1 x 2 x 1 x 10 Aluminum C-Channel (276-2289)	1	276-2289	https://www.vexrobotics.com/v5-structure.html
8	5 x 5 Aluminum Plate (276-2311)	1	276-2311	
9	Linear Slide Track (276-1926-001)	1	276-1926-001	Linear Slide Track
10	2" Long #8-32 Standoff (276-2013)	16	276-2013	https://www.vexrobotics.com/standoffs-8-32.htm
11	5 x 15 Aluminum Plate (276-2311)	4	276-2311	
12	V5 Bumper Switch (276-4858)	3	276-4858	https://www.vexrobotics.com/276-4858.html
13	LEDs	3		
14	V5 Distance Sensor (276-4852)	1	276-4852	https://www.vexrobotics.com/276-4852
15	Paper	1		
16	V5 Robot Brain (276-4810)	1	276-4810	https://www.vexrobotics.com/276-4810.html

To generate our first prototype, we used CAD software (Onshape) to create a design based on previous designs made along with the unique design aspects we decided on, such as a modular elevator floor design, a rack and pinion carriage system, and scissor doors. Next, we created a Bill of Materials for our design and assembled the design. Some design changes we made through our iterations were:

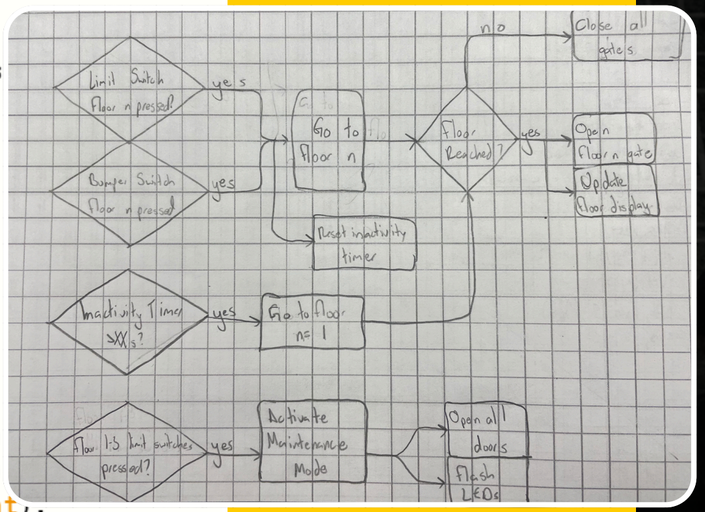
- Change from servos to motors because of insufficient 3-wire ports
- Change from gearbox bracket to 2x2 angle bracket for rack and pinion support due to insufficient materials
- Shift of bumper floor selectors to opposite side due to insufficient space
- Addition of limit switch selector panel on carriage for selection in elevator carriage
- Addition of battery holder since there was previously no designated space for battery

Programming

```
/* Set the elevator speed in rpm based on the distance
   With a max speed of 5000 rpm */
int goToHeight(double floorDist) {
  double kP = 3.0;
  elevatorMotor.setVelocity(
    max(
      calculateElevatorSpeed(kP, getDis
      5000
    ),
    rpm
  );
  elevatorMotor.spin(reverse);
  return 0;
}

/* Open the door of the floor based on
int openDoor(int floor) {
  floorOneDoor.setVelocity(50, percent)
  floorTwoDoor.setVelocity(50, percent)
  floorThreeDoor.setVelocity(50, percent);

  if (floor == 1) {
    floorOneDoor.spinToPosition(60, degrees);
    return 1;
  }
  if (floor == 2) {
    floorTwoDoor.spinToPosition(60, degrees);
    return 2;
  }
  if (floor == 3) {
```



Our programming process followed three steps. First, we modeled the inputs and outputs of our system using flowcharts and pseudocode. Next, we translated our models into C++ code. Finally, we debugged and optimized our code to ensure we met the criteria to the best of our abilities.
Some highlights of our programming included:

- The use of a feedback controller using absolute distance to determine elevator height
- Manually writing of math functions (i.e. abs, max) for use throughout
- Modularity using methods so debugging occurred in isolation and documentation was easier
- Version control using GitHub repositories

Final Design

Shown is our final design for our project. We were able to meet all criteria theoretically but were unable to make the LEDs blink due to faults with the VEX Brain. To combat this, we decided on a system of colors and text on the Brain screen as a replacement. The final design included:

- Carriage movement to any floor independent of current floor using P controller
- Automatic gates based on carriage distance to floor (±5mm)
- Floor selection using bumper switches on the floors and limit switches on the carriage despite carriage size constraints
- “Maintenance Mode” that allowed technicians to easily access the elevator

Process and Design Reflection

LEARNING

I learned how to research and brainstorm an effective design, implement that design using CAD design software, create a detailed BOM for ease of assembly, efficiently program an elevator that meets the design criteria, program an elevator using a proportional controller, and display telemetry that effectively communicates the status of the elevator, and communicate with my team members to ensure our project stayed on schedule.

IMPROVEMENTS

Some potential improvements to the design included:

1. Increase rigidity of elevator gear rack
2. Make the LEDs function correctly
3. Create a more noticeable display when the floor is reached

Some potential improvements to our team's dynamics included:

1. Communicate more often (e.g. through email to keep each other updated during absences)
2. Explain our thought process while we are working to determine the most effective path forward
3. Document our process more (i.e. take more pictures and videos throughout the initial build and programming stages).

Quick Links

Project Management Models

CAD and Technical Drawings

Bill of Materials

GitHub Repository

Videos and Media