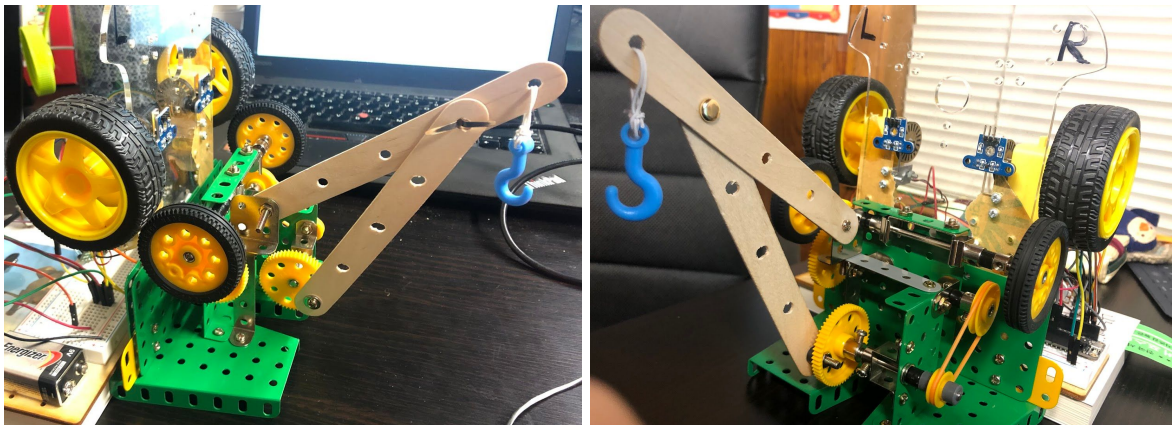
Chung Min Kim
12/08/2020

ME 102B Final Project: Lifting Spirits

Product Description

For a long time I've wanted to buy a desk toy like a Newton's cradle, but I never got around to it in the past because I was never at my home desk pre-quarantine. I found this project to be a great opportunity to make a quarantine-themed desk toy. Since these times have made my spirits a little down, I thought that it would be clever to model the product after myself: working hard, struggling sometimes, but making it through with some external help.

The final prototype combines a variety of mechanical drives (friction, gear, flexible), and a linkage in order to create a toy crane lift. The normal force to the friction drive can be manually adjusted, so I can personally adjust the torque provided to the product. My intended message is that as the toy works hard to lift, I can push it harder to help it lift better. :)

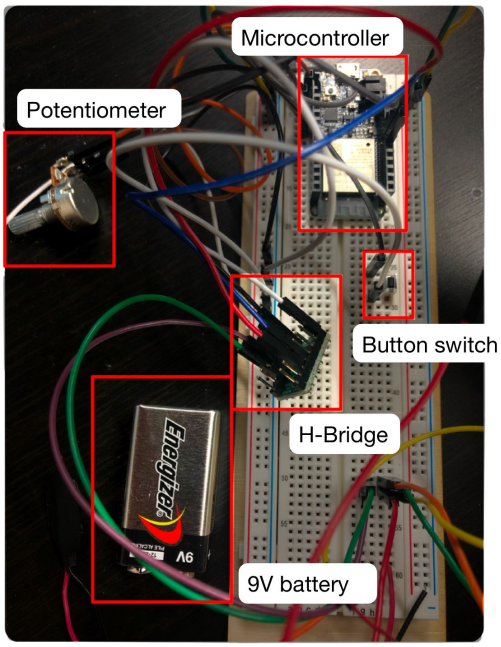


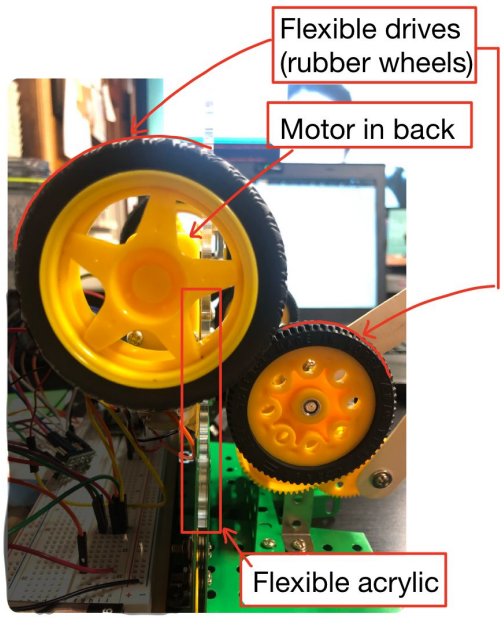
Two views of the final prototype (photos of final integrated operation)

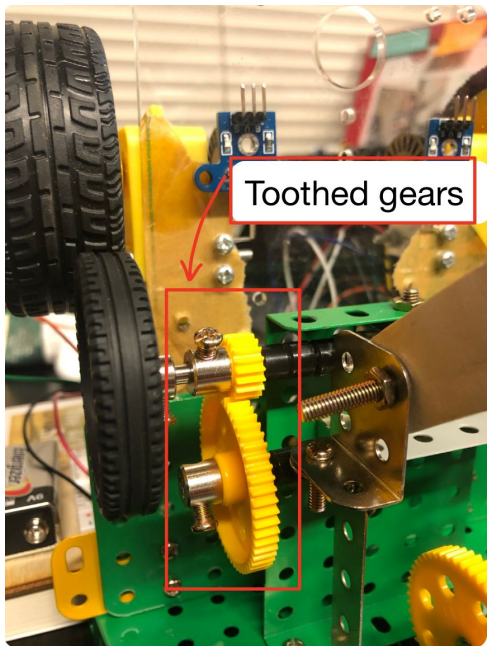
Parts description list

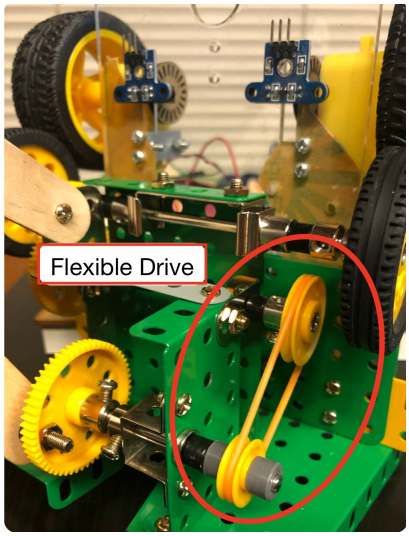
Main elements	Component parts
Electronics	9V DC motors (2x), microcontroller, button switch, H-bridge, potentiometer
Flexible drives	Big rubber wheels (2x), small rubber wheels (2x)
Gear drive	Two gears (gear ratio ~2:1)
Flexible drive	Two pulleys (gear ratio ~1:2), rubber band
Linkage	Popsicle sticks (2x), brass fasteners

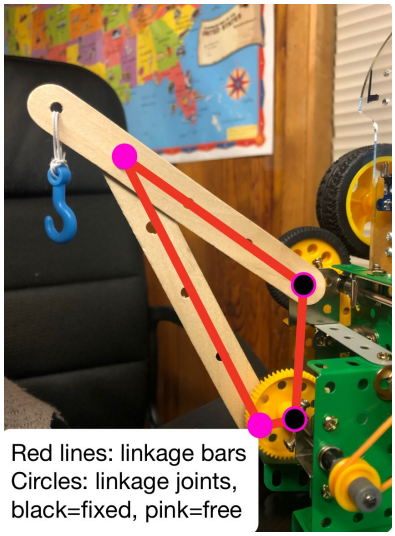
Multiple shafts, shaft collars, nuts+bolts, and metal plates (fastening parts) were also used in the process. Most of my non-lab kit parts were from a kid's engineering building kit and a class lab kit, so the exact specifications + cost are unknown. The electromechanical components transmit power in the order listed above in the five descriptive figures on the next page.











Top, from left: electronics, friction drive, gear drive; Bottom row: flexible drive, four-bar linkage

For the friction drive, gravity pulls the flexible acrylic plate (which is attached to the two motors and the big rubber wheels) towards the small wheels, which provides the normal force required for the driving friction force. The friction force also pushes the plate away, which makes the power transmission rate very low without extra normal force applied externally.

The combined gear ratio of gear drive and flexible drive is 1:1 - it was mainly placed for my own learning experience. The flexible drive, similar to friction drive, messes with the power transfer. The output of the toothed gear drive is fixed to the same shaft as the flexible drive's input pulley.

Finally, the flexible drive's output pulley drives the gear attached to the four-bar linkage. This gear contains two linkage joints, one fixed and one free. The linkage bar joining them is along the gear's radius. This bar serves as the crank to the crank-rocker mechanism. The rocker is the bar with the hook attached to it.

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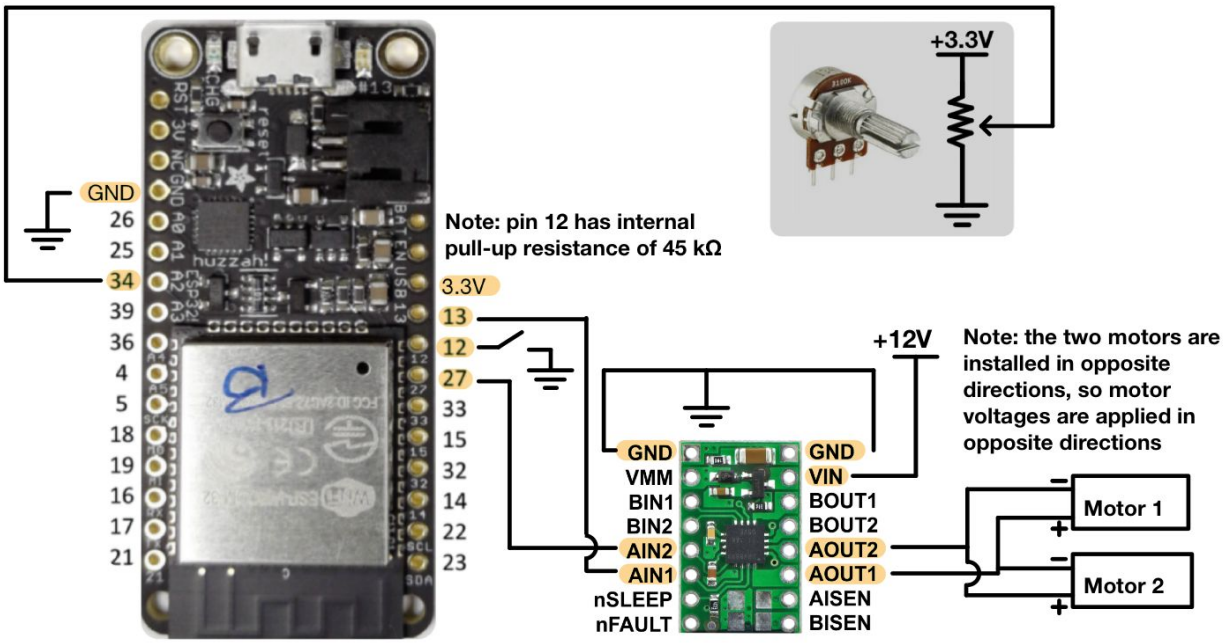
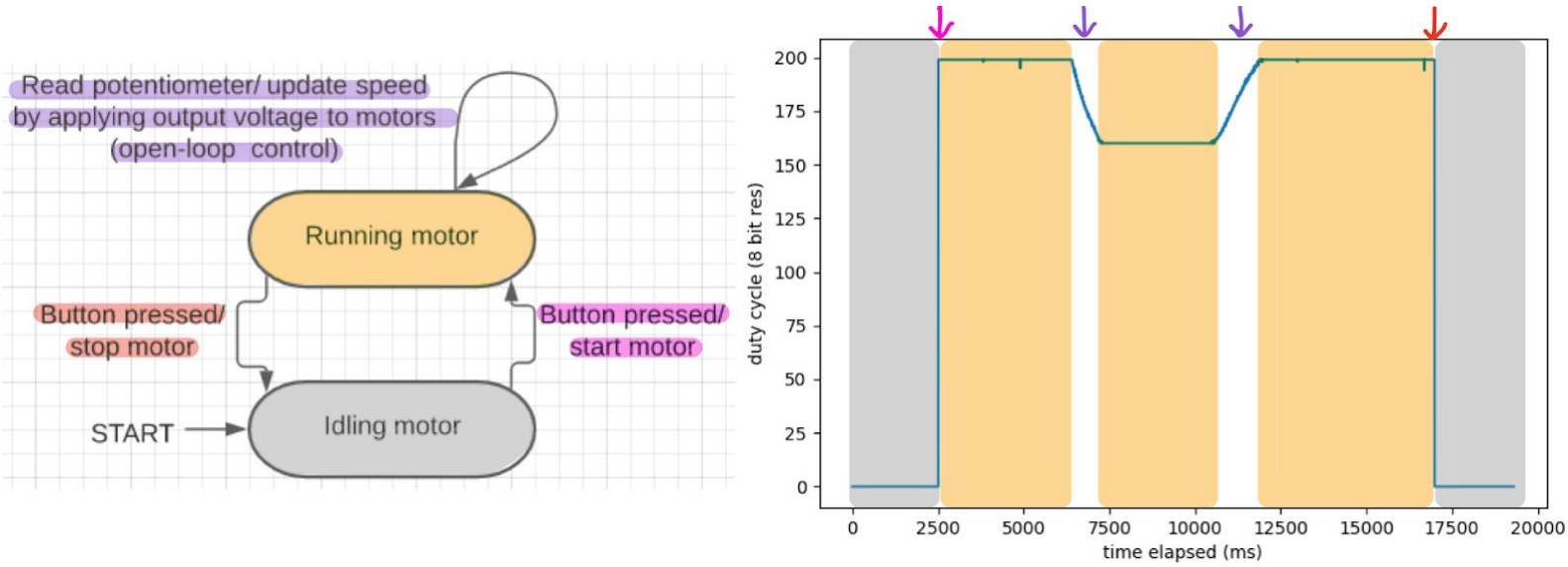
Circuit diagram



Finite state machine diagram



Finite state machine + example system behavior

The machine uses open-loop control to control the two motors with the same signal (the directions inverted, as described in circuit diagram previously). I chose this control scheme since my project does not require precise values - it only needs adjustable speed. The potentiometer value is polled during the microcontroller's main loop, and this value is linearly mapped to a motor duty cycle range. The button press events are caught with interrupts.