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Hopkinauts Mars Rover Team

A group of undergraduate students at Johns Hopkins University who are designing and building a medium-scale Mars rover to compete at the University Rover Challenge (URC), a global, collegiate-level competition.

ROVER BASE

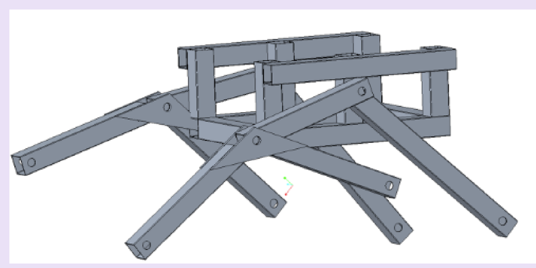


Figure 1. Original CAD of the rocker-bogie and frame

OBJECTIVES:

- Design a robust six wheel rocker-bogie frame that can remain stable on diverse and extreme terrains, including steep inclines, uneven terrain, and large drops
- Incorporate a differential bar system to further improve stability of the rover, specifically reducing the amount of roll and pitch that the rover experiences
- Develop and build a versatile electronics housing that can serve as a modular mounting point for other systems

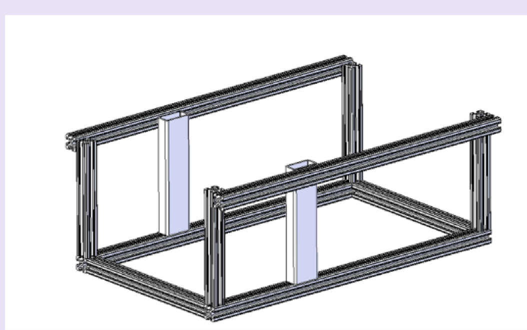


Figure 2. Current CAD for the frame

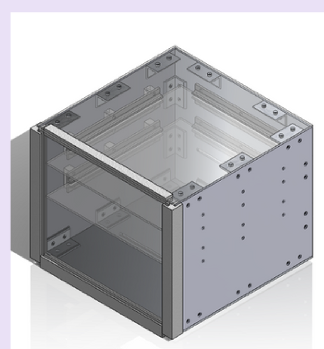


Figure 3. Current CAD for the electronics box

COMPONENTS:

- Aluminum frame assembled using 80/20 t-slotted framing and brackets
- Aluminum square tubing and custom designed sheet metal brackets for the rocker bogie
- Electronics housing box made of acrylic and aluminum
- Differential bar attached to both sides of the frame and to the back of the electronics box to serve as an additional attachment point while improving mobility

NEXT STEPS:

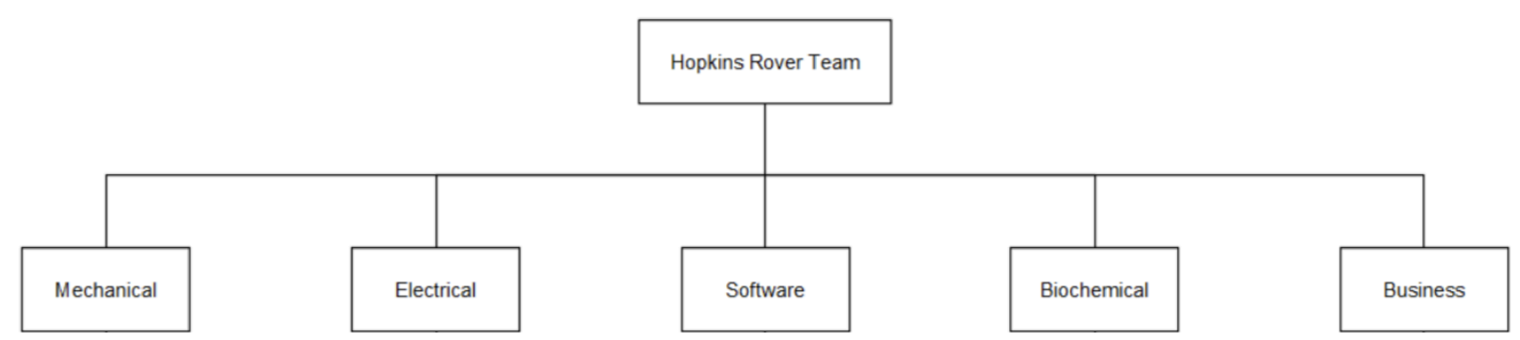
- Test the rocker-bogie design on various terrains with the 3D printed wheels attached
- Design a gear box to attach to the wheel shafts
- Choose motors that are most applicable to the objectives of the rover
- Build and design an electronics box to store all electrical components

INTRO TO PROJECT

Interdisciplinary engineering student organization that encourages students from any major and experience level to join the team and help build the rover. Students can choose to join one of the five subteams: Biochemical, Electrical, Mechanical, Software, and Business. Within each subteam, members work in small groups to design a system, part, or procedure that will be used to build the rover. While the students work closely with those within their subteam, they also collaborate with the other subteams to encourage knowledge sharing among the groups and to help everyone understand that this is a collaborative effort that relies on the progress of every group.

We plan to continue our work during the 2024 summer and 2024-25 school year to compete in 24-25 URC!

OUR GROUP STRUCTURE:



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CAROUSEL SCIENCE TESTING SYSTEM

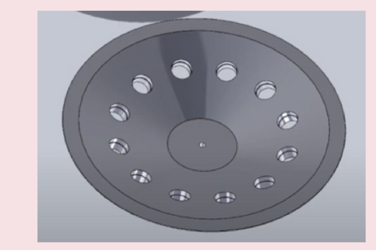

Figure 1. First draft of the carousel

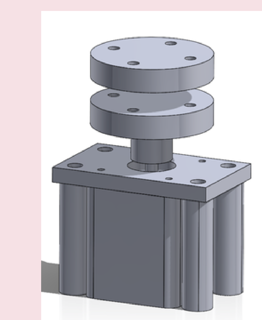

Figure 2. Motor-carousel connection stand

OBJECTIVES:

- Create system to complete the Science Mission at URC
- Create part that holds up to 12 test tubes
- Design a system that holds, organizes, and mixes multiple types of soil with chemical tests
- Program a motor to collect each soil sample in its corresponding test tube and centrifuge the materials
- Use cameras to analyze the soils based on color changes from different chemical tests

Figure 3. 3D print of the carousel (first draft) and the circuit to connect the stepper motor and Arduino

COMPONENTS:

- 3D printed carousel to hold 12 test tubes
- 3D printed carousel-to-motor connection pieces
- 12 V Stepper motor
- Funnel
- Box made of acrylic and aluminum
- Camera, hall effect sensor, and photo-interrupter sensor

NEXT STEPS:

- Use a spectrometer in addition to the camera to help with analysis
- Paint/Add markers to the carousel to differentiate the test tubes after centrifuging for organized analysis
- Improve or edit the stopping procedure after centrifuging
- Add a mesh to the funnel to use consistent grain sizes
- Finalize designs for an arm to collect soil

BIOCHEM

OBJECTIVES:

- Test various chemical tests that detect the existence of organic molecules in substances
- Determine which tests require the fewest materials and show the greatest color change when the corresponding macromolecule is detected
- Finalize the list of chemical tests to use for URC
- Create a procedure for testing and analyzing the soils

NEXT STEPS:

- Optimize chlorophyll extraction methods and detect wavelength that absorption will occur using a Nanodrop
- Buy a spectrometer to more accurately measure the colorimetric changes quantitatively
- Troubleshoot and run the whole process on the centrifuge
- Narrow down the test to 3-4 main ones
- Work on developing a camera that can analyze the soil and rock matter

COMPONENTS:

- Chemical Tests: Lugol's, Benedict's, Sudan III Stain, Biuret, Bromothyl blue, Indophenol , Ethanol emulsion
- Chlorophyll Procedure:
  - Grind the leaf and soak with 15-25 milliliters of isopropyl alcohol for 15 minutes
  - Place a coffee filter over the top of the funnel and push it down into the funnel. Collect 10-15 milliliters of the filtered extract
  - Measure fluorescence using a microscope GFP filter

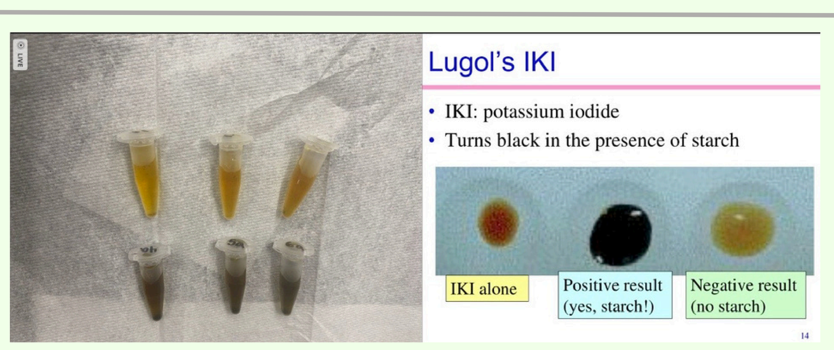

Figure 1. Added varying volumes of soil to the microcentrifuge tubes and control solution for the top 3 tubes and 0.05 ml starch additive for the bottom 3 tubes. a positive result color change was shown for the bottom 3, and not the top 3.

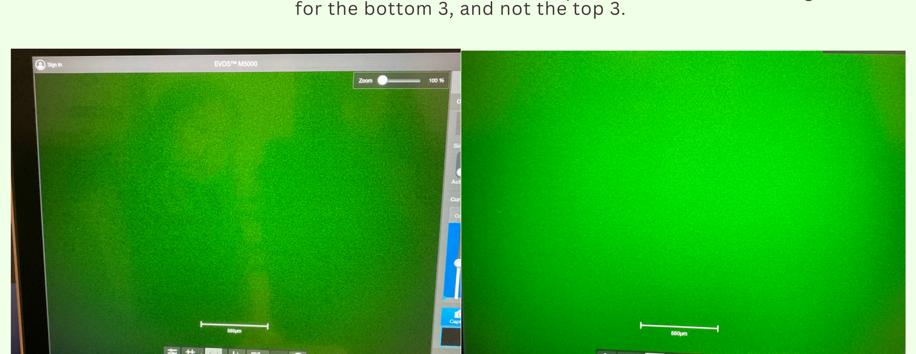

Figure 2. Followed protocol from left for chlorophyll procedure. The GFP filter in the microscope showed a brighter fluorescence for 5 mL of 100% acetone versus 10 mL of 80% acetone.

WHEELS & TESTING RIG

OBJECTIVES:

- Design several wheel candidates to use on the rover that can traverse various terrains (sand, soil, gravel, large rocks)
- Create a testing rig (Fig. 1) to collect wheel performance metrics
- Experimentally determine a relationship between wheel dimensions and performance metrics

PROPOSED METHOD:

1. 3D print two wheel designs (Fig. 2 & 3) using PETG and nylon
   a. Each wheel printed **3** times at **25%** **and 30% and 40%** scale
2. Test bed was filled with rocky material
3. Each wheel mounted to testing rig and with the motor was run
4. The resultant force from the wheel mounted plate recorded using an S-type load cell
5. Results analyzed and compared to determine which wheel design is best for our rover

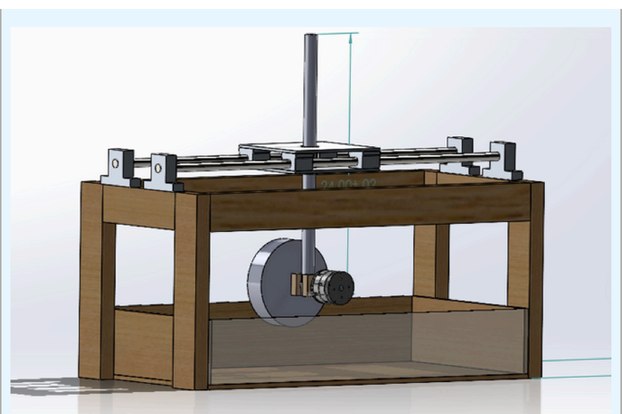

Figure 1. Testing Rig CAD

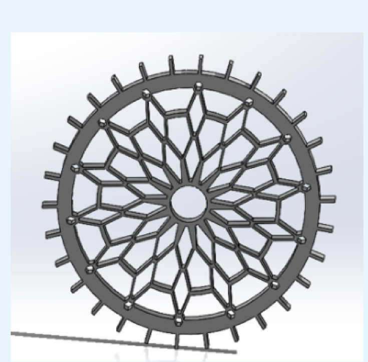

Figure 3. Custom wheel design

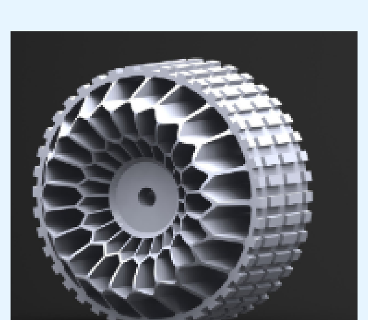

Figure 3. Open source wheel design

COMPONENTS:

- Wood frame to support all other components of testing rig
- Plywood testing bed to hold various terrains
- Acrylic viewing wall to qualitatively observe how the wheels displace the terrain
- Aluminum mounting plates for the wheels and motor
- Linear guide rails so wheel can be observed moving across the terrain
- 3D printed wheels
- Terrains including:
  - Sand
  - Soil
  - Gravel
  - Large rocks
  - Small rocks

NEXT STEPS:

- Repeat this experiment with new, improved wheel designs
- Repeat this experiment with different terrains
- Repeat this experiment to obtain DBF/traction data with the wheels under differing loads
- Choose final wheels to put on rover

SOFTWARE

OBJECTIVES:

- Learning ROS (Robot Operating System)
- Used ROS to control a Turtlebot, kindly lent to us by Dr. Whitcomb
- Built "rover junior" to let members continue programming the different movements without the actual rover
- Using Python with the GPIO Zero package to control motors on "rover junior"
- Used OpenCV, Yolo V8, Raspberry Pi to detect Aruco tags with pose estimation

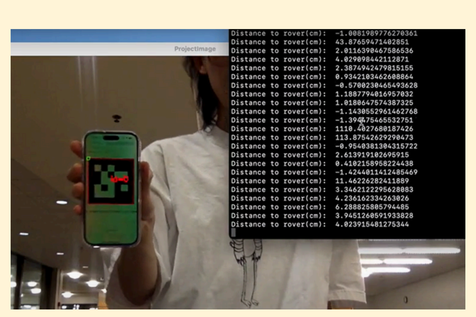

Figure 2. Aruco tag detection testing

Figure 3. YOLOv8 hammer detection preparation

Figure 4. Turtlebot used to begin learning ROS and how to program a robot to move in preparation to code the rover

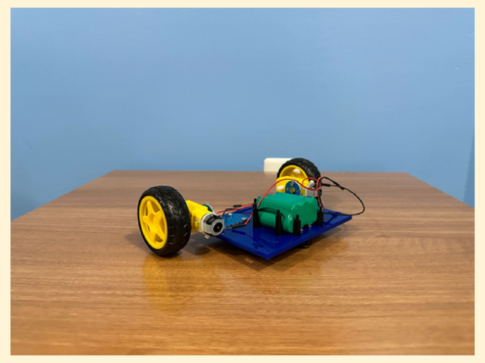

Figure 1. "Rover junior" without wheels, which is used by the Software subteam to test movement control and codes

NEXT STEPS:

- Continue learning and finish setting up the YOLOv8 to create an image detection model for an orange hammer and a water bottle
- Continue setting up the Raspberry Pi with ROS to control "rover junior"
- Create an interface with the GPS module to "rover junior" to autonomously move from one location to another
- Learn to use the Gazebo simulator in ROS for path planning