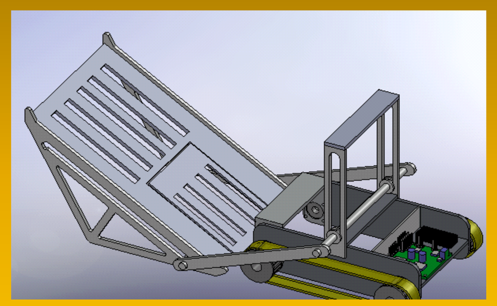

Remote-Controlled Robot with Ramp for Rock Retrieval

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Introduction

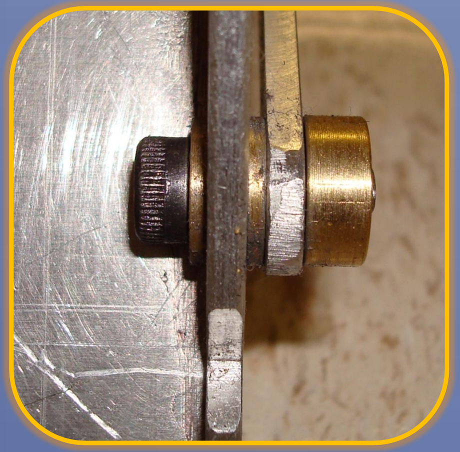
For the 2009 ASME Student Design Competition, students are required to design a vehicle simulating a Mars rover. The vehicle is intended to navigate a course and retrieve rocks within a four minute time limit. Furthermore, at the conference, there are many unknowns (such as the course flooring or the size and types of rocks), so the vehicle must be prepared to handle many possibilities.

In accordance with the concept of sending a payload into space, there are stringent restrictions on the size of the vehicle and its control equipment, requiring it all to fit in a box of 370mm x 165 mm x 165 mm interior. The scoring equation penalizes for weight and battery power.

Table 1. The scoring equation dictated most of the design decisions.

Score = Σ (R*t) +1000P - W - A - 1000T – 5s	
R	designated rock score
T	target multiplier
W	weight of the vehicle in grams
A	milliamp-hours available to the battery
T	times device touches border tape
s	seconds to complete task, maximum 240
P	bonus for parking vehicle at end of task (1 = parked, 0 = not parked)

Figure 1. The linkage and its alignment was a critical component to the success of the design (right).

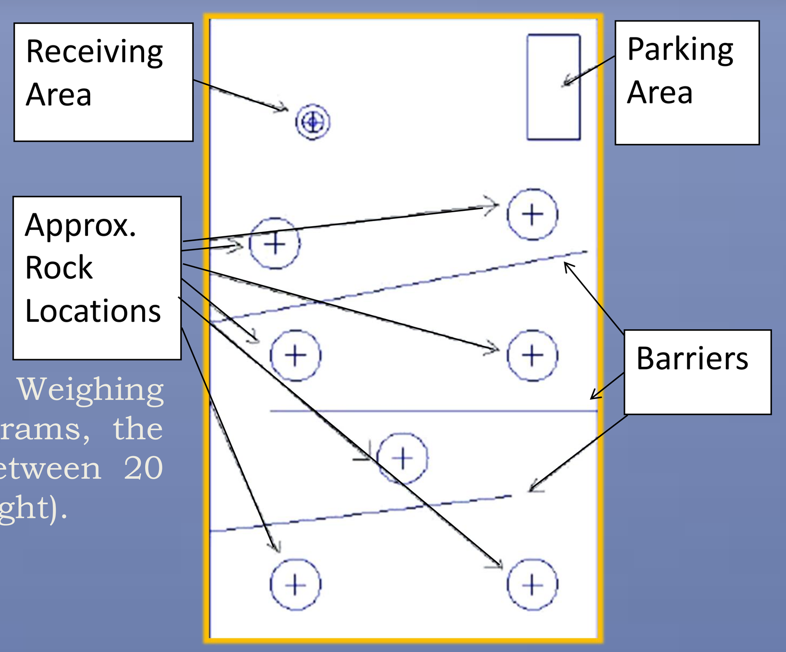


Objectives

Therefore, two objectives were identified to signal the completeness of the project and the preparedness of the vehicle for the competition:

- to design and fabricate a remotely-controlled vehicle to compete in the ASME District E Student Design Competition on April 17, 2008.
- to complete the course in under four minutes in a lab setting.

Figure 2. Marked out on any typical flooring, the course layout is a 2290 mm x 3660 mm rectangle. The barriers are 4" x 4" wood studs or two 2" x 4" studs nailed together. Weighing between 10 and 80 grams, the rocks will measure between 20 and 40 mm in width (right).



Approach

To optimize the vehicle with regard to the scoring equation, especially the milliamp-hours and weight requirements, the team chose to implement a car and ramp design. This would provide the robot with a means of climbing the obstacles and transporting the rock cargo to the designated target area without adding excessive weight or needing a large battery. A 7.4V lithium polymer battery was used to power the device, and DC geared motors with a 35:1 reduction ratio were chosen for their size and capabilities. Moreover, the team utilized tire treads to increase contact with the obstacles during scaling and to allow for zero-point turns. To control the vehicle an analog 2-channel controller was implemented. This design did not allow for speed variation, but the motor performance at the maximum allowable voltage was ideal for single-speed operation.

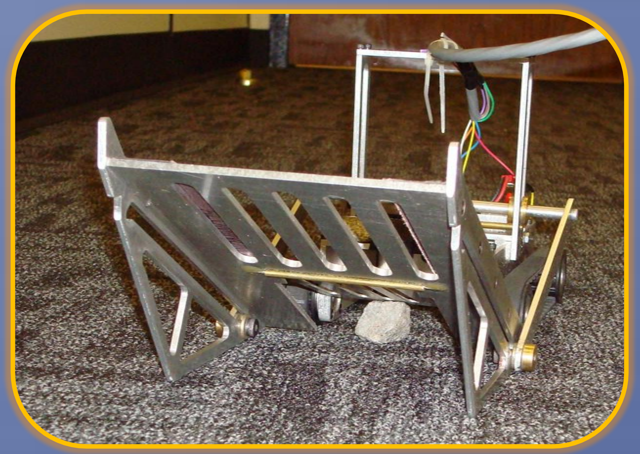
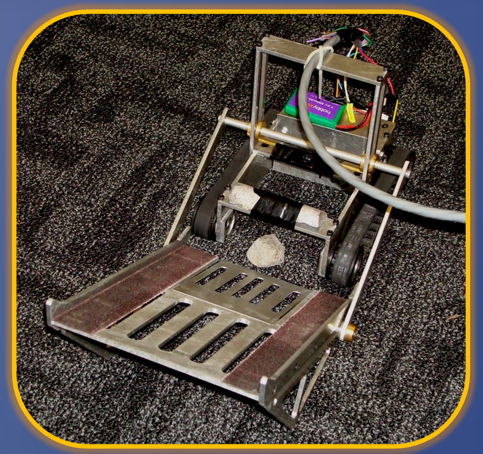


Figure 3. For when the ramp is in front of the rock collection area in the car, there is a one-way gate that allows the rocks to enter it when the ramp goes over it (left). **Figure 4.** This gate also keeps the rocks from escaping before the vehicle goes over the 4" x 4" again (right).



Results

The vehicle is able to scale barriers, collect rocks, and deposit them in a target. Weighing 1446 grams total, the robot is capable of speeds of 2 ft/s with a battery of 300 mAh. Tested on both carpet and tile, the vehicle completed the course in less than four minutes with the quickest time of two minutes and twenty-two seconds.

Table 2. Results of Practice Runs

Run	Time	Border Touches	Parked?	# of Rocks	Flooring Type
0	3:15	0	Yes	7	Tile
1	3:45	0	Yes	7	Tile
2	3:30	1	Yes	5	Tile
3	2:22	0	Yes	7	Tile
4	3:33	2	Yes	5	Carpet
5	3:40	4	Yes	7	Carpet

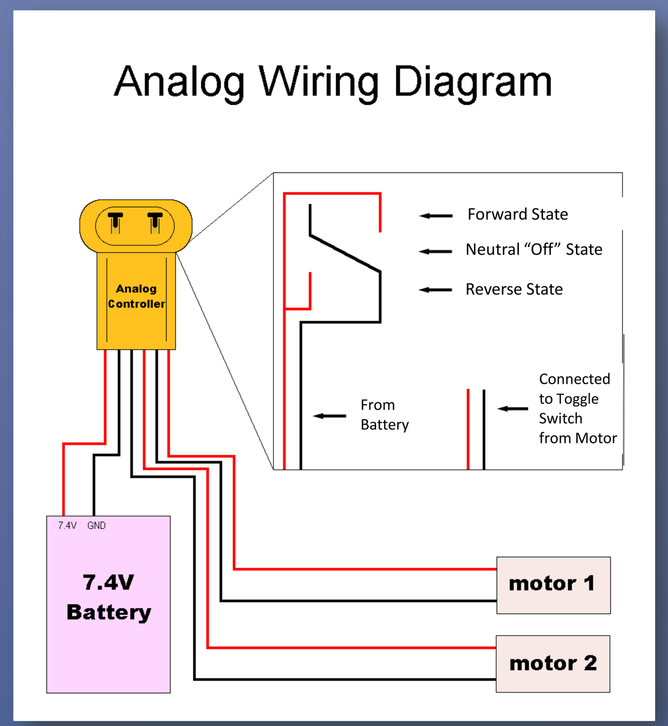


Figure 5. The wiring diagram of the analog controller. With an umbilical cord design, all wires must pass through a multi-pin connector (above).

Conclusion

As can be seen from the results, a Mars-rover-like vehicle has been constructed which can scale the course obstacles and collect rocks. Meeting all of the requirements for the competition, the vehicle is also registered to compete. With some practice, the vehicle should have a competitive edge at the conference.

Acknowledgments

Special thanks goes to the team advisor, Dr. John Matsson, and the ORU technician, Mr. Randy Iwanaga, for their assistance in the development of the project.

Additionally, immense gratitude is owed to the ASME Mid-Continent Section for the generous grant for this project.

Figure 6. Starting from left to right, the sequence of photos demonstrates how the vehicle is able to surmount the 4" x 4" obstacles on the course. The robot approaches the board with the ramp first. When the ramp is stopped by the lumber, the linkage is forced to slide vertically, allowing the car half to drive up the ramp. As the car continues over the obstacle, the ramp is pulled over behind it (above).