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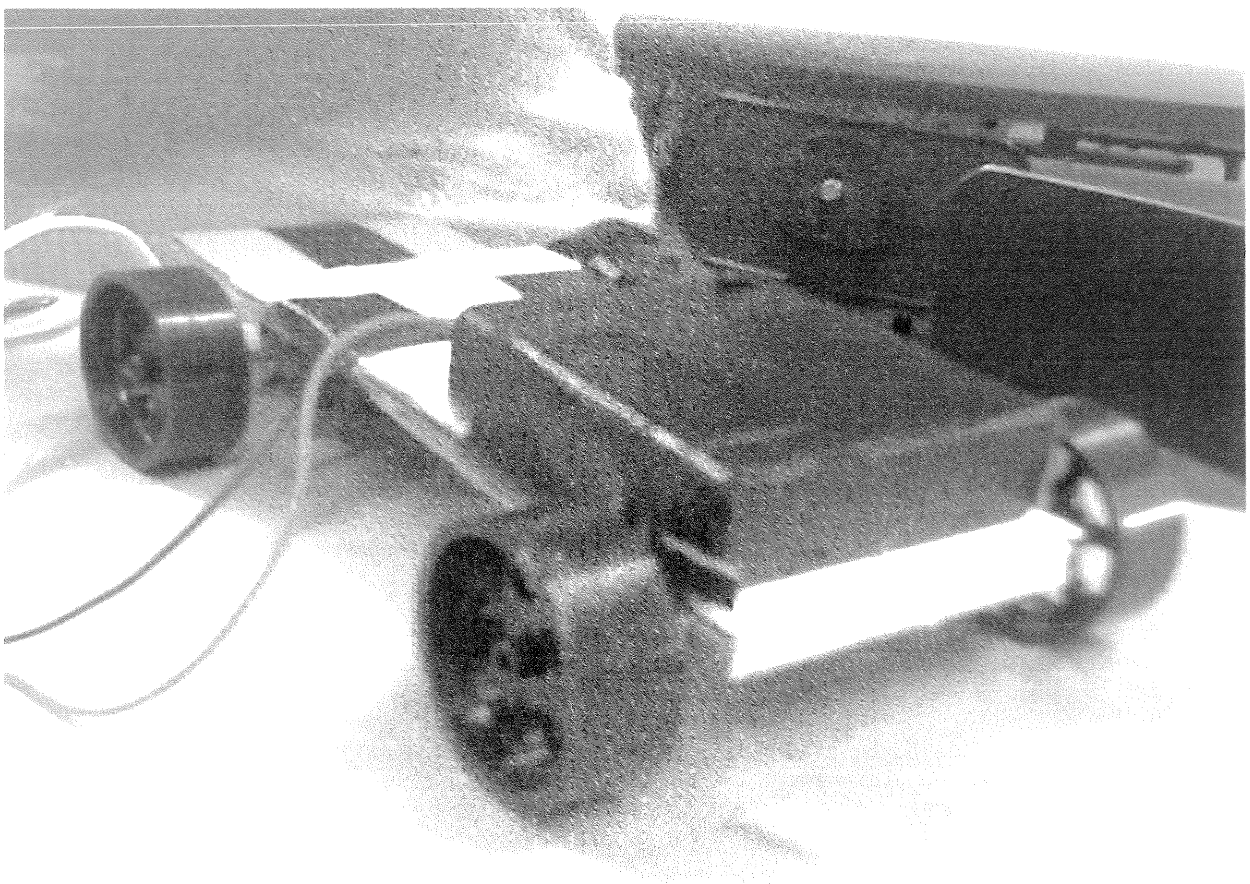
Development of Design:
<u>Our Plan</u>

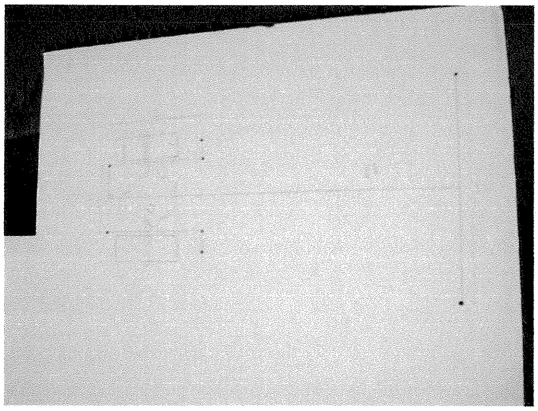
Day 1

On our first day in the lab, we built a basic car model to test the motor and the gear ratios. We taped the battery pack and the motor onto a piece of cardboard. We also started discussing and sketching ideas for possible car design (wheel types, sizes, axels, etc...). We also discussed the car competition and our overall goals. We decided that we wanted to change our gear ratio between the torque and speed competitions. We used the highest rpm gear ratio for the race, and the highest torque gear ratio for the tug of war and pulling test. We discussed materials we would need. We decided on wood for the body of our car. Why?

Why?



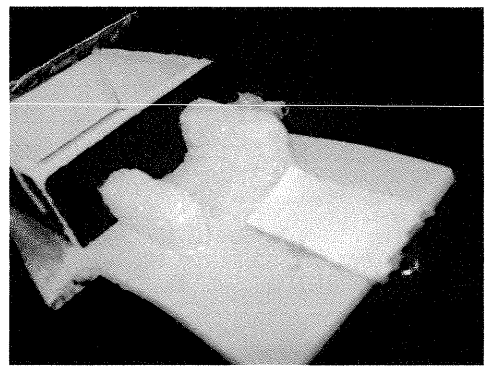
Day 2

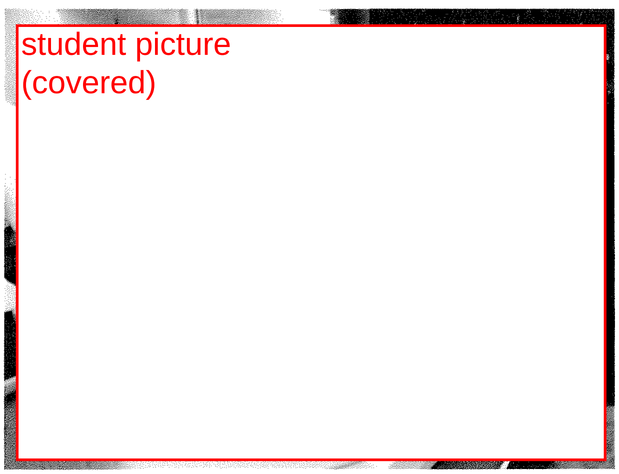


We sketched our car design onto a piece of cardboard. Originally, we were going to run the car in front wheel drive (as you can see in the sketch) because the axle was short and [we wanted the back of our car to be large.] Then, we decided to look for a long axle that would allow us to run the car in rear wheel drive (so we could have more power for the tug of war competition). We ordered a Multipurpose Aluminum (Alloy 6060) 3mm Diameter, 1 Meter Length axle. We also decided to buy two Dubro Large Scale Treaded Wheel 3-3/4" for our rear wheels. We felt that they would provide the most traction. **Cut out car body (from wood).** Since we wanted to change the gear ratio between competitions, we had to make the gear box and motor removable. Using Styrofoam we created a cradle to place the motor in (so that we could easily slip it out). [We finalized the placement of all internal instruments for the car (battery pack, motor and gear box).]

why?

How did you do this?



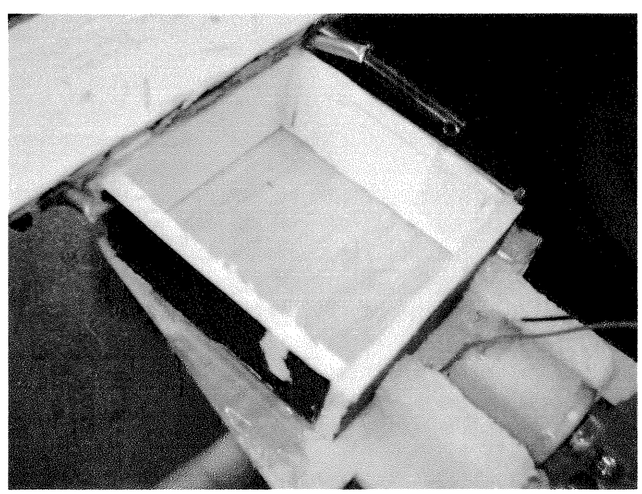


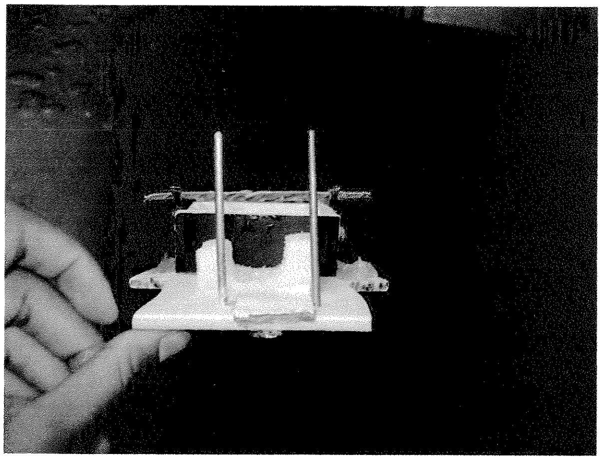
Day 3

We cut out the wood body based on our sketch. Since we had to replace the batteries before the race we made another cradle to hold the battery pack. It was made out of poster board and hot glued to the wood body. Last lab we made a cradle for the motor, but the gear box still had to be removable. To solve this we nailed two axles into our wood body so we could easily slide the gearbox on and off of the car (see picture to the left). Our rear wheels [came in,] but our axle

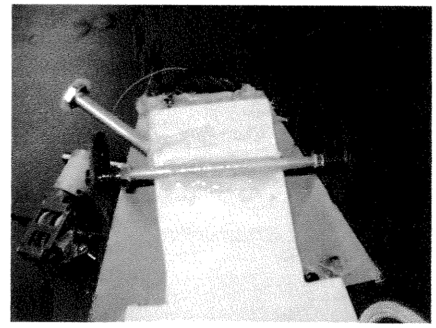
Picture is on the right...

what does this mean?





hadn't arrived as yet. However, we were able to attach our front wheels and axle. We did this by gluing a hollow axle to the front of the car, then we put a smaller axle through the hollow axle. The small, plastic front wheels were then attached to the inside axle.



Day 4

Our rear motor axle still had not come in, so we changed our car design. As opposed to using a triangular body design, we had to shorten the back so that the wheels would fit on the short axle that came with the gear box (see picture to the right). We also epoxied half of the motor to half of the gear box. This was so that the motor gear would always mesh with the gear in the gear box. **Plastic pieces** came with the gear box kit that attached to the ends of the axle. We hot glued these **plastic pieces** to the rear wheels. We also change the way that the gear box was attached to the car body. Instead of using the two metal rods, we used nails with removable nuts on the other side so that we could take off the gear box to change the ratio (see left image).

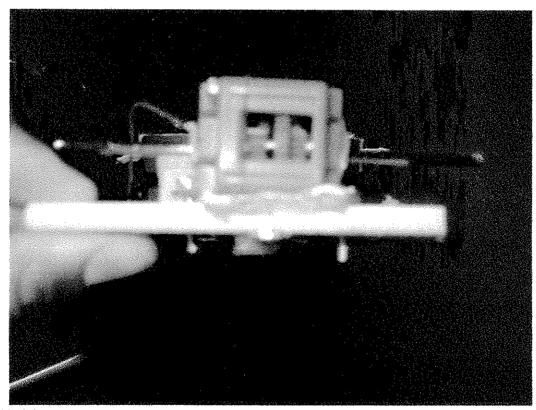
Which picture?

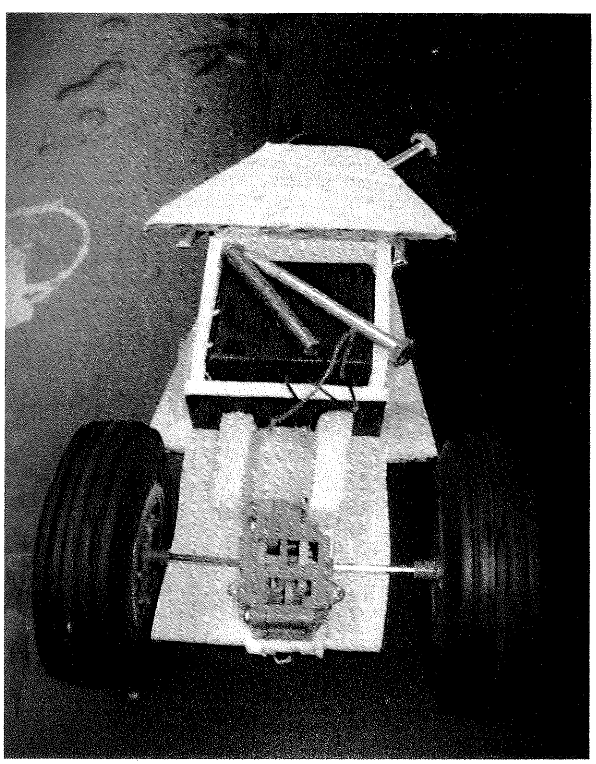
Why bold?

Day 5

We put everything together. We glued a thin piece of cardboard to the car so that the motor would be at the right level for the gearbox. We also added weight to the car by epoxying metal rods to various places, so that the car would be the right weight. We also epoxied the metal hook to the back end of our car. We also tested our car (for speed and pull). We tested all four different gear ratios.

What is the right weight?





Data

gear ratio	torque (N)	time (s)
344	4.5 N	
114	4.25	23
38.2	4	8
12.7	2	4.3

During our speed tests, we found that our car pulled to the right, so we added metal bumpers to the right of the car. Then, during one of the tests our front axle (along with the front wheels) came off. Because of

How?

this, we decided to reattach the axle tilted to the left. This made the car run straight.

Manufacturing Process:

As our designs began to take physical form we realized we would have to make some changes. We began our first lab by making a prototype car. With the materials we were given on the first day (without ordering special parts) we built a mockup of a working vehicle. Using the simplest components we were able to make a moving, working, car prototype. After looking at the initial speeds and power levels of the given transmission, this car helped us to decide more details about the design of our actual model. Over the next few weeks we refined our design on paper and finally began to build. Our original idea involved a chassis that was much wider in the back than in the front. We also decided we wanted to leave the original gearbox intact without adding new gears. However, we ran into a problem involving the axle running through this gearbox. None of the various axles we were given fit with the right dimensions into the gearbox and the original axle was too short to support the wide breadth we wanted for our wheels. At this point, around week two, we ordered a new axle of the correct size for our back wheels. However, several weeks later, we still did not receive the axel. We halted our manufacturing plan until it became clear that the axel would not arrive in time for the first deadline. We realized that we could not move any further in our plans without a longer axle. At this point we decided to change our design to incorporate the materials we already had. We reduced the span of the back wheels from six inches to two and a half inches and cut the base of our car down accordingly. Now we could successfully use the original axle and gearbox with some changes to our initial design. Another problem we encountered was the task of making the car drive straight. It was difficult for us, given our new smaller width, to have the car travel in a line during the speed trial. Though it took some time, we adjusted the angle of the wheels to negate any turning motion. As another

what kind of details?

why?

Proofread!

how?

precaution involving this issue, we added a new component to our design. We attached two metal bolts protruding in front of each wheel on the side the car turned to. The point of these bumpers was to protect our car in the event of a collision. This plan helped to work as a failsafe, making sure our car would not be destroyed in a crash even if it did not drive straight as intended.

Our team worked well together to manufacture our car quickly and efficiently. By the end of the first lab period we able to make a complete working car. Without our quick building skills we would not have been able to complete this task when at the last second our materials did not arrive. Our plans and design changed several times, but because of our ability to work together and innovatively use given materials we successfully completed the task in the given amount of time.

The only components ordered were:

Vendor	Item Name/Description	part/order #	quantity	unit price	Total
Tower Hobbies	*Dubro Large Scale Treaded Wheel 3-3/4" (1)*	*LXD796*	*2*	*$11.69*	*$23.38*

Calculations and Analysis of Performance:

Power = F * v

F = Power / v

m * a = Power / v

m * dv/dt = Power / v

v dv = Power/ M * dt

v ^ 2 / 2 = Power / M * t

v = (2 * Power / M * t) ^ .5

dx / dt = (2 * Power / M * t) ^ .5

dx = (2 * Power / M * t) ^ .5 dt

$x = 2 / 3 * (2 * Power / M) ^\wedge .5 * t ^\wedge 1.5$

$15 / 2 * 3 / (2 * 8 / (21.2 \text{ ounces} * .02834 \text{ kg / ounces})) ^\wedge .5 = t ^\wedge 1.5$

$t = 2.68s$

This time was calculated by using the constant power of 8 watts, and assuming that all of this power is put into force pushing the car forward. This is one of the major flaws of the calculation, as there is a significant amount of power lost through our not flawless gearbox. Additionally, there is also a maximum velocity of the motor, and the car will not continue to accelerate forever. Air resistance also comes into play, but not on an extremely large scale for the speed of our cars. One factor that also came into it was the fact our car's axle was bent, so we had extreme difficulty getting it to drive straight, which caused it to bump into a wall and lose time on race day. We had planned on this, as our car drove in a very inconsistent manner, so we attached a bumper to bounce of the wall, which helped reduce the negative affect of the bump, but not completely get rid of it.

Max Velocity

$1/322 \text{ (Gear Ratio)} * 8000 \text{ (RPM)} * 3.75\pi \text{ (in/R)} * 2.54\text{cm/inch} * 1\text{m}/100\text{cm} * 1 \text{ M} / 60\text{s}$

$.1239 \text{ m/s}$

$vf/2 * F\_0/2 = power$

$F\_0 = 4 \text{ power} / vf$

$F\_0 = 4 * 8 / .1239$

$F\_0 = 258 \text{ N}$

$= 72 \text{ Ounces}$

This value is off largely due the fact the process of calculating it does not take into account force normal. When we pushed down on our car, it was able to push much more than it would without this force. The force calculated here is only the force if there was an infinite force normal, which we do not have. When we tried different gear ratio, other than between the 12 and the next highest, 30 something, there was not a large change in force. All of the three higher gear ratios had about the same, which was double of the gear ratio of 12 which we had used for the race. This shows how after a certain point additional force does not make a difference without either more traction or a greater force normal. Another source of error again stems from the flawed gear box and motor, which do not put out the same out of energy as put in, and lose a lot, especially with very large torque favored gear ratios.

	Race	Pull
Car	4.70s	15.5 ounces

Our car performed well in the competition. We had one of the fastest race times of any group, despite bumping into the wall. We had spent a lot of time both trying to get our car to go straight, and to minimize the affect when it did not. We only bumped into the wall once on our first and good trial, but still finished with one of the best times. If our car had not collided, we might have had the best time. On our second trial, we completely hit into a wall and did not finish, which was disappointing after seeing how well we could have performed without colliding into a wall. We performed in the middle of the pack for the tug of war, but the race was definitely our superior event, which makes sense as we had spent all of our budget on large race wheels. We were able to change our gear ratio, though our motor wiring had become disconnected when we collided with the wall on our second race trial. However, despite this we were able to fix it and compete in the tug of war. During the tug of war, we lost our first game, then won three games in the losers finals before finally losing. This made sense considering we were right in the upper middle of the force test. All in all, we performed very well, but could have improved.

The single biggest change to make to our design is to get it to drive straight. One of the biggest reasons that is was not was because the axle bent, so we would need either replaceable straight axle, or an axle made of a material that was less bendable. By driving straight, we could have cut at least a ½ a second off of our time. This would have put us into first place by itself. Some other changes would be a better gear box, and a different set of tires for the pull competition. We would want smaller tires with better traction for the pull competition, as one of the biggest problems with how much we could pull was the tires slipping. We could also make our car more aerodynamic, but that was not a large issue for the scale of this race. Another possible idea would be to use capacitors or resistors to draw more energy from the batteries, and increase the voltage of the motor. While this would likely burn out the motor much quicker and not be very efficient, it would help get a faster top speed, which is what we are aiming for, not efficiency in the long run.