Gearing up for Transportation Engineering, A Summer Institute: Phase VI

By

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The numbers of female and minority students enrolled in engineering schools are increasing slowly, however there is still a relatively small percentage drawn to the field of transportation civil engineering. As a consequence, there is a need to educate young people about the profession to encourage under-represented individuals to appreciate the contributions of engineers and encourage them to become civil engineers. This summer institute project consisted of bringing middle school students, after recommendations by their teachers, to the University of Alabama in Huntsville campus to learn about engineering as a career and experience a variety of transportation engineering design topics. The participants gained knowledge about the role of engineers in society as well as learned how engineers use their knowledge in design applications. An additional program was held this year in which the alumni were invited back for more advanced research in civil engineering projects. Several UAH faulty members and Society of Women Engineer professionals acted as team mentors. As an important part of this project, local minority and female engineers served as mentors for the program. This was the sixth year of the summer program at UAH.

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Executive Summary

The numbers of female and minority students enrolled in engineering schools are increasing slowly, however there is still a relatively small percentage drawn to the field of transportation engineering. As a consequence, there is a need to educate young people about the profession to encourage under-represented individuals to appreciate the contributions of engineers and encourage them to become civil engineers. This summer institute project consisted of two programs, the first was similar to previous years where twenty middle school students were invited to the University of Alabama in Huntsville (UAH) campus to learn about engineering as a career and experience a variety of transportation engineering design topics. The participants gained knowledge about the role of engineers in society as well as learned how engineers use their knowledge in design applications. The second program involved inviting back twelve alumni from previous years to perform more in depth research in five areas of civil/transportation engineering.

Five UAH engineering faculty members, as well as professionals representing the Society of Women Engineer (SWE), NASA Marshall Space Flight Center, and the National Society of Black Engineers acted as instructors for the hands on laboratories. As an important part of this project, several minority and female engineering students served as mentors for the program.

Section 1
Introduction

Objectives

The numbers of female and minority students has been increasing overall in engineering and science (National Commission on Excellence in Education, 1983), however there is still a relatively small percentage drawn to the field of civil and transportation engineering. As a consequence, there is a need to educate young people about the profession to encourage under-represented individuals to become engineers and contribute to transportation technology.

Approach

The major goal of this program was to introduce middle school students with preference to under-represented groups, to basic engineering and transportation-related concepts. An additional approach of the project was to draft local minority and female engineers to act as team instructors and mentors. Participants used real world examples and new technologies in their hands-on activities to reinforce the concepts presented by the engineering mentors. A final comprehensive team project was used to tie all the knowledge together in a design competition.

Section 2
Background

In past years, the University of Alabama in Huntsville (UAH) and the American Society of Civil Engineers (ASCE) worked with local schools in the Huntsville, Madison County and Morgan County area and became aware that local public schools do not have any formal relationship with the engineering academic and technical community. In addition, all those school systems have a high ratio of minority students, approximately 25 percent of total enrollment. As a consequence, local county middle and “science magnet” school principals and teachers were asked to nominate students for this Summer Institute. Under-represented students, female and minorities, were given preference. This Summer Institute project consisted of bringing selected middle school students to the UAH campus to learn about various aspects of engineering and experience transportation-related design and safety topics. A committee consisting of representatives from each of the participating groups selected these participants based on potential rather than classroom grades.

This year, an additional five days were dedicated to an alumni program for students who had participated previously in this UTCA program. These students were selected based on their interest and performance in the past. This opportunity may encourage them to consider civil and transportation engineering as a career option and increase diversity of the workforce, a problem in some areas of the country (U.S. DOT, 2000).

Section 3
Methodology

Science Teaching Method

Recent efforts to reform science education in schools have led to the development of the Science/Technology/Society (STS) teaching method. Some important aspects of the STS method are that students must feel a concept is personally useful for solving specific problems, and students who learn through an experience will retain information and will be better able to apply the information later to new situations. Instructional and interactive experiences were developed with this grant to motivate interest in transportation engineering and related science topics. The program was initiated in the Gearing Up for Transportation Engineering Summer Program (GUTEP) in 2000, the current year's program contains refined laboratory activities and initiated an alumni program to keep interest levels high.

The strategy of this program was to produce students who know "how to find out" and "how to examine and evaluate evidence." As discussed in the first year's UTCA final report [Leonard, et al., 2000], the following criteria were used in designing the hands-on experiments:

- The activities were designed so that the students could complete them by themselves; not demonstrations performed by the instructors for the class.
- The students had to be able to read, perform and document the experiments themselves with limited adult supervision.
- Each experiment was designed such that the results were sufficiently dramatic to keep the student's attention with a high probability of success.
- Experience has shown that middle school students work best in teams, so the activities and equipment were appropriately structured.
- In general, each experiment took approximately 1-1.5 hour including set-up and clean-up, and follow-up discussions were held to highlight concepts and results.
- Safety and good lab protocol were practiced and stressed throughout.

To accomplish these goals, students were encouraged to use the following design heuristic in their team transportation problem:

- Define the problem
- Generate possible solutions, using brainstorming and other creative thinking techniques
- Decide on a course of action
- Integrate the solution
- Evaluate the solution

This project meets UTCA goals of increasing diversity in the transportation field, and thus affects Alabama's future human resource population, by using technology transfer through focused educational activities.

Section 4
Project Results

Tasks Completed

This project had a one-year duration commencing January 2005. The following tasks were completed to achieve the desired goal of transportation education through technology transfer.

***Recruiting* –** Sent out letters to schools, made phone calls to science teachers and made follow-up contacts. Dr. Leonard made site visits to several middle schools to meet with science and math teachers for additional recruiting. The program committee got together to select twenty students for the GUTEP week and an additional twelve for the alumni program based on potential and interest levels.

***Scheduling Mentors* –** The principal investigator contacted professional organizations (National Society of Black Engineers, Society Women Engineers, American Society of Civil Engineers), college chapters of the societies, NASA Marshall Space Flight Centers, local companies (SEI Group, Boeing and Sverdrup), and Huntsville Center of US Army Corps of Engineers.

Setting-up schedule and lab experiences –

a) The principal investigator met several times with instructors to discuss objectives of each lab experience.
b) Professors were asked to update individual experiments as indicated by last year's survey results.
c) Instructors developed new six hour labs for the alumni program: GPS and Surveying (Dr. Anderson), Geotech (Dr. Schwarz), Robotics (Edgar Blevins - ISE), Composite Materials (Dr. Toutanji) and Solar Power (Dr. Leonard).
d) Ran through labs with several middle school students prior to GUTEP.
e) Finalized laboratory instructions from co-PIs.
f) Obtained supplies and collated student manuals.
g) Scheduled rooms on campus and field trips.

***Summer institute* –**Week 1: June 20-24, 2005

a) Divided students into five teams of four students to run concurrently in labs.
b) Followed schedule (see Appendix A).
c) Friday of each institute–Participants gave demonstrations and oral reports on their team's future transportation design to parents and instructors.

***Alumni institute* –** June 20-June 24 2005

a) Each instructor took student teams for a day and performed more in depth projects requiring problem solving skills.

b) Each day ended with a team discussion on topics learned and how they may be applied to transportation engineering.

Après- program

a) Thank you letters and certificates were sent to instructors and field trip sponsors.
b) Compiled participant surveys.
c) Instructors met to discuss ways to improve program for subsequent years.
d) Proposal was submitted for 2006 UTCA funding.

Deliverables

a) Completed manual for students and as a teacher resource – All five investigators were responsible for completing their laboratory experiments.
b) The manual was posted on the UAH UTCA web site in html format (http://coeweb.eb.uah.edu/cee/utca.htm).
c) Principal investigator was responsible for quarterly reports to UTCA. The final report was completed and sent to UTCA in December 2005.

Synopsis of New Civil Engineering Challenge

The GUTEP summer institute for new students was similar to previous years (see previous final reports). The new robotics experiment was added under the supervision of Dr. Blevins; it is included in Appendix B. Photos from the Summer Institute are included in Appendix C.

The new activity for this year was called the "civil engineering challenge." It was a Popsicle stick bridge and Solar Car Challenge for high school students held in the CE department at UAH in October. Letters were sent out to all county, city and private schools to participate. Over 150 students participated in the event this year. In addition to the learning experience of this event, the winning classes were awarded a class pizza party and other prizes. The teachers were sent details on the competition in early September and supplies were provided to all participants. The Huntsville and UAH chapters of the American Society of Civil Engineers provided judges and additional prizes for the winners. The general guidelines are summarized below.

1. Bridge design build & race competition rules

1. The bridge will be composed of two Popsicle stick trusses joined together by a Popsicle stick deck
2. Only wood glue (e.g. Elmers) may be used to join the pieces together.
3. There is a limit of 150 individual Popsicle stick pieces used in construction and the total mass of the bridge must be less than 220 grams. Note that the total mass of the bridge will be taken into account for the final factoring.
4. Dimensions: The bridge will be supported by two vertical supports, 17 inches apart. The maximum length of the bridge is 20 inches. The outside dimension of the road deck must be less than 4.5 inches

2. Solar car challenge rules

The objective of the Solar Challenge is to design and build a vehicle that will complete a race in the shortest possible time using the available power. Teams of 4 to 5 students will experience first-hand the process of design; actually turning ideas into a working model. The winner of the competition will be the team whose vehicle is the top finisher in a series of head to head elimination rounds.

Your school will be given solar panels, motors, wheels, gears, and axles. You will need to determine materials for the body to complete the design of your car. These are the basic parts involved for your design:

1. power source: how the solar panel and motor work
2. chassis: how to build the frame of the car
3. wheels and bearings: how to make wheels that turn
4. transmission: how to transfer power from the motor to the wheels
5. body design: how the car body effects car performance

The purpose of this competition is to capture energy from the sun with the solar panel and to turn it into electrical energy. The electric motor then uses this electrical energy to power the wheels of the solar car.

Goals Met

The major goal of this program was to introduce middle school students with preference to under-represented groups, to basic scientific and engineering concepts. These groups have potential for science and engineering, but might lack role models and motivation to pursue a career in transportation engineering. The selection committee used the teacher references to rate the students (criteria were student statements of interest, teacher comments and ethnicity). Through the UTCA summer program, we were successful in recruiting 45 percent minority students (African American, Asian and Hispanic) and 60 percent female students for the first week. The alumni program was 58 percent female with 60 percent ethnic minority students for the program. The ethnicity breakdown is given in Table 4-1.

Table 4-1. Participants ethnicity information

Week 1	**Female**	**Male**	**Percent**
Total number	7	13	100%
African American	2	7	45%
Asian	0	1	5%
Caucasian	4	3	35%
Hispanic	1	2	15%
Alumni Program			
Total number	6	6	100%
African American	2	3	41%
Asian	1	1	17%
Caucasian	3	2	42%
Hispanic		0	0%

Significance and Benefits of the Program to Participants

The participants gained knowledge about the role of transportation planning, management, safety, and design in modern society. The emphasis was on how engineers use their knowledge in design applications. The last day of the Summer Institute concentrated on the team design in transportation engineering, where they combined the knowledge acquired in the laboratory experiences. A faulty member or professional acted as each team's mentor and helped them to prepare an electronic and oral presentation of their design. Students in the winning design team were awarded certificates of accomplishment and gifts at the closing ceremony on Friday. All the students received a prize of some kind, from the safety challenge, bridge design, rocket launch, etc., which helped to instill a sense of accomplishment and pride.

Since the middle school curriculum contains hard science and algebra, which are directly related to engineering, this program enhanced classroom instruction with "hands on" experience. In addition, the principal investigators and professionals that acted as team mentors also functioned as role models for minority and female students. This may help to increase the numbers of these students who will become transportation professionals. The use of UAH minority and women engineering students as lab assistants encouraged them to become involved in the community as professionals.

The program was intended to be a fun learning experience with a lot of basic information, team building skills, and hands-on laboratory experience of the latest transportation safety and management technology. On the last afternoon of the program, the students were asked to complete a program survey course. Table 4-2 shows the results. The favorite experiments were robotic cars and bridges (design and build Popsicle stick bridge). These will remain unchanged in the upcoming program. The least favorite, soils will be updated with more fun dynamic activities. The students were also asked about their enjoyment of the program and most of them answered affirmatively to questions regarding recommending this program to a friend and the fact that the field trips and experiments increased their knowledge of engineering (question #6). The last question indicates their own views about engineering as a future career for them. Approximately 90 percent thought that they might choose engineering as a profession.

Advantages for participants

- fun and enjoyable exposure to science, engineering and transportation technology topics
- development of thinking and problem-solving skills
- learn what civil engineers do and their contributions to society
- meaningful and immediate experimental learning
- fuel for their natural curiosity
- self-directed learning opportunities in team design
- increased self-esteem from completion of institute
- multiple exposure to difficult topics and inter-relationships to transportation issues
- opportunity to learn within academic facilities – may take away fear of technology
- diversity of mentors help students feel comfortable at institute

Table 4-2 Participants' survey results

Survey Questions	**Responses**	
1. What was your favorite experiment?	bridges, robotic cars	
2. What was your least favorite experiment?	Soils	
3. What was your favorite field trip?	HSV Shuttle bus	
	Yes	**no**
4. Would you recommend this program to a friend?	95%	5
5. Would you attend a similar program again	90%	10
6. Do you feel like the field trips and experiments contributed to your learning *experience?	95%	5%
7. Is one (or both) of your parents engineers?	35%	65%
8. Did the program increase your knowledge of what transportation engineers do?	100%	0
9. Would you consider becoming an engineer?	90%	10%

UAH Student Involvement

The project employed four undergraduate student assistants and two graduate students (both minorities and females) to help in designing the projects, documenting plans, laboratory set-ups, and assist with the participating middle-school students at the Institute. Other university students acted as laboratory volunteers through the Society of Women Engineers, American Society of Civil Engineers and National Society of Black Engineers student chapters.

Section 5
Project Conclusions

Education and Technology Transfer Activities

The team members completed the lab activities' manual (both teacher instruction and student activity guides) for implementation at school visits and for next year's program. A web page was posted through UAH - UTCA home pages to allow on-line access.

Research relevance and impacts to Alabama

This project addressed the mission and several major goals of the UTCA. In addition to providing **educational experiences** for minority students within Alabama, the project focused on **diversity issues**. This program has the potential to affect the future workplace (human resources issues) since the students may wish to become involved in working on transportation-related safety research at an early age and thus may gravitate towards the profession as they mature. The project also addresses the **technology transfer** goal of the UTCA since student assistants, mentors and participants were exposed to state of the art technology within the university curriculum.

After the program was finished the students completed a survey and all thought that the program was fun and educational. Most of them did not know what transportation engineers did prior to coming to UAH and were surprised at all the variations. Finally, they would all recommend the program to their friends.

Recommendations for Next Program

The survey results will be helpful in composing next year’s summer program. The least favorite lab will be updated with new material and an additional lab will be added. The new activity, “CE challenge”, which was held in the fall for local high school freshman was not as well attended as hoped (only five schools), so we will discuss ways to improve turn-out.

Section 6
References

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U.S. DOT, Bureau of Transportation Statistics, 2000. *Education and Careers in Transportat*ion, http://www.bts.gov/edu/68.html.

APPENDIX A

"GEARING UP FOR TRANSPORTATION ENGINEERING SUMMER INSTITUTE"

2005 SCHEDULE

Field Trips (Thursday)

Past Modes of Transportation

Huntsville Train Depot & Museum – Church St

Current Modes of Transportation

Huntsville Shuttle Service (Mass Transit)
Huntsville Traffic Office – Sign shop, Intelligent Transportation System

Hands-On Sessions (4 Groups of 5 students each)

Title (coordinator)	Room
1. Traffic Simulation - (Dr. Mike & Shalana)	TH S242
2. Space transportation - (Dr. Kate & Emily)	TH S208 & 206
3. Construction Materials -- (Dr. Sam & Eugene)	TH S207
4. Engineering Shapes - (Dr. Mike & Shalana)	TH S206
5. Alternative Energy/Boats (Shalana & Eugene)	TH S203
6. Bridges - (Dr. Lois & Emily)	TH S208
7. Geotechnical Materials --(Dr. Lois & Emily)	TH S224
8. Transportation Safety - (Dr. Kate, Vana))	TH S201
9. Robot Cars (Shams, Shalana & Emily)	TH N104

DAILY SCHEDULE

	Monday 20th	**Tuesday 21st**	**Wednesday 22nd**	**Thursday 23rd**	**Friday 24th**
9-10	Introduction History of Transportation	Exp 8, 4	Exp 5, 2	HSV Shuttle RR museum	***Concrete BB*** Team Design Project
10-11:30	Team Building	**Exp 8, 4**	Exp 5, 2		
11:30-12	*Lunch - Pizza*	*Lunch – Subs*	*Lunch – Hamburgers*	*Lunch – picnic*	*Lunch – Pizza*
12 -1:45	Exp 3, 7	Exp 1, 6	Exp 9	City Eng.	Design Competition
1:45- 2:00	Break	Break	Break		
2:00-3:45	Exp 3, 7	Exp 1, 6	Exp 9	Break	Awards
4:00	Depart	Depart	Depart	Soccer	Depart

APPENDIX B
Copy of New Experiment

9. Robotics

Designing, Building and testing a robotic automobile ☺

In this experiment you will use a LEGO Robotics kit to build a working robotic auto and then race it against the other teams.

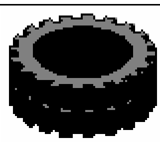
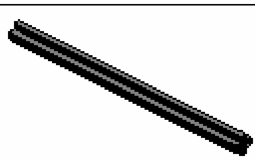
What are robots?

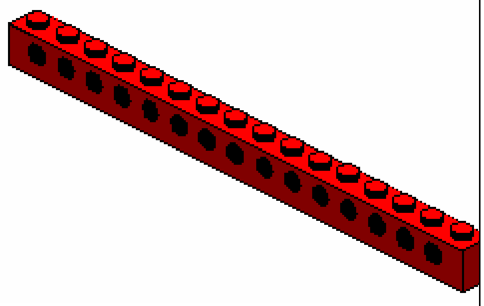
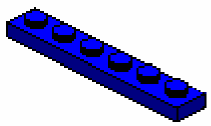
A Robot is a "reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through various programmed motions for the performance of a variety of tasks." The word 'robot' was coined by the Czech playwright Karel Capek from the Czech word, robota, for forced labor or serf. The first industrial modern robots were the Unimates developed by George Devol and Joe Engelberger in the late 50's and early 60's. Now robots are used in many applications that are hazardous or inaccessible to humans, including space travel and explorations.

9a Design/Build

Easy Steps to Build a Sturdy Car using components found in the LEGO Robotics Kit.
STEP 1: Build a basic frame for the car

The frame of a car is made from:

	Tire	Wheels are made from tires and axel hubs
	Hub	Hubs are the center part of tires
	Bushing	Bushings keep
	Axle	Wheels are attached (using the hubs) to the axle

	Beam	Beams form the structure of the car and can support the photo
	Plates	Plates form a base for the motor

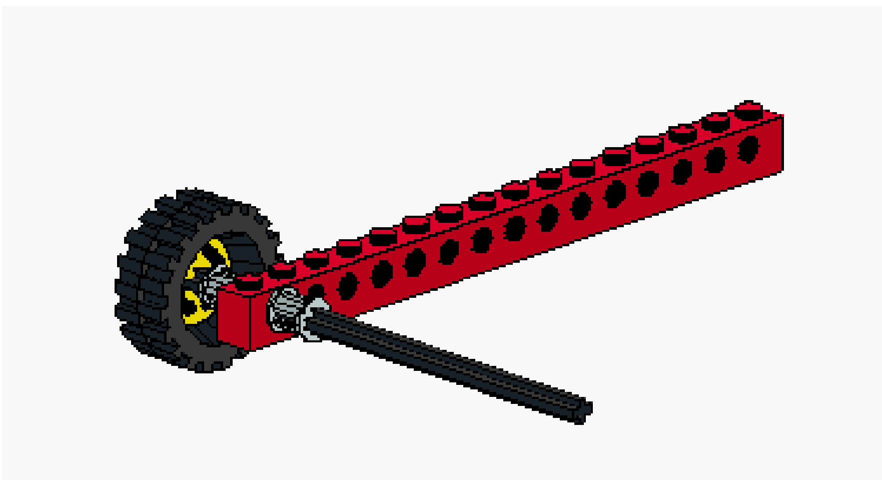


Figure 1: Partial Car Frame

Bushings are put on each side of the beam to keep the tires from sliding back and forth. They should be close to the beam but not TOO close. If they are too close the axle will not be able to turn (and hence the car will not be able to move).

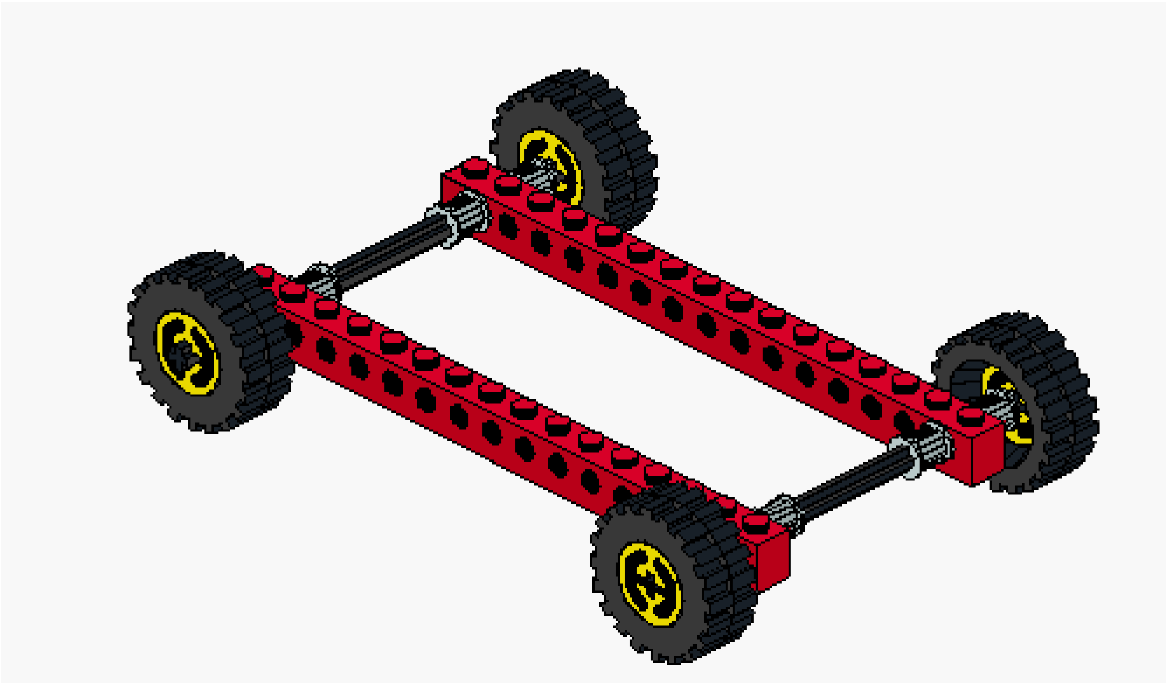


Figure 2: Sturdy Car Frame

It is important that the frame be as rectangular and symmetric as possible. If there is more friction on one side the car will tend turn in that direction.

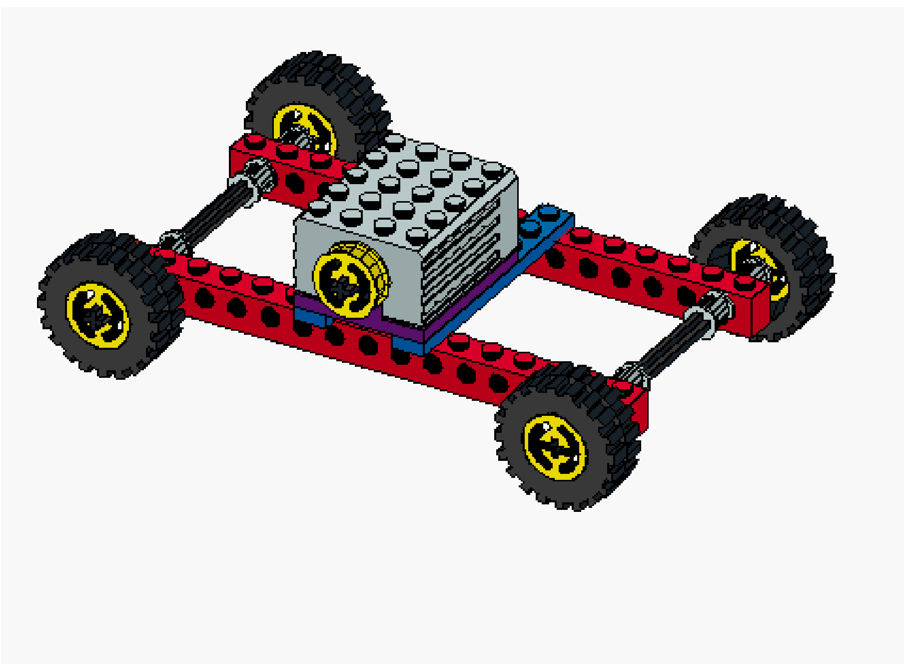


Figure 3: Add Motor to Car

You can attach the motor to the frame using flats.

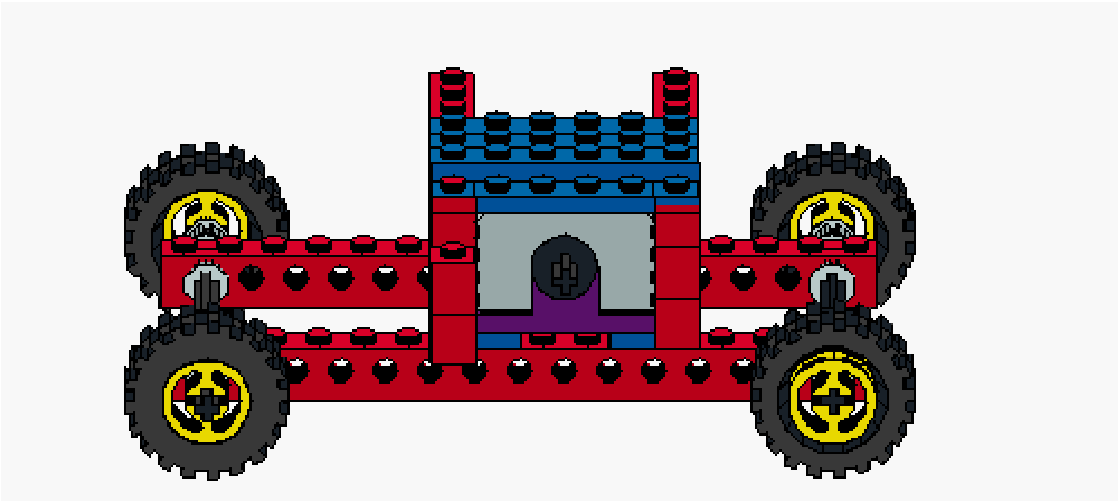


Figure 4: Car with Motor boxed in

To keep the car from breaking when it is dropped you need to box the motor in on all sides so it's supported in all directions.

9b.Drag Race

You are to design, build, test and race a robot to travel across an established horizontal distance in the least amount of time. The fastest robot to cross the finish line is the winner. The contest rules are listed below.

1) The entire robot begins behind the starting line.
2) The timer says 'on your mark, get set, go' and begins the timer.
3) A robot is triggered to begin its program by one of the builders.
4) The surface will be a smooth floor. The starting and finishing line will be marked.
5) The timer will stop when any part of the robot reaches the finish line.
6) If a robot has a false start, they may try once more with a 2 second penalty. (two false starts will result in no time score for a trial.)
9) A robot gets 2 trials. The faster of the two trails will be used to determine ranking.
10) The robot may use rubber bands as structures, but not to provide power.
11) The robot must be made for the components provided in each kit.
12) A robot leaving the race track will not receive a time score for that trail.

Note: These rules may be modified if needed.

Hints:

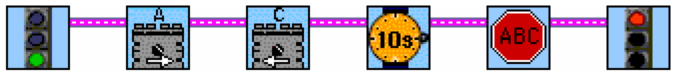
Build a robot that does not turn. A longer robot, with wheels farther apart will usually go straighter.

Experiment with different wheels.

Make your robot as light as possible.

Example Drag Race Robolab Program

When the program begins the robot moves forward at the highest power level. One motor turns clockwise and the other turns counter clockwise. After 10 seconds, all motors stop. This program will be preloaded on each Robolab Controller.



More Information?

http://robotics.nasa.gov/students/challenge.htm
http://asimo.honda.com/asimos_origin.asp?bhcp=1
http://www.ceeo.tufts.edu/robolabatceeo/

APPENDIX C
Photos from GUTEP 2005

C-1. Alumni Week - solar cars experiment

C-2. Geotechnical lab

C-3. Week 1 – GUTEP participants