Pseudo-situation: Lulay Industries, LLC is seeking a new vehicle design. It is to have good speed on flat level terrain, and also be able to pull loads up a steep incline. They have asked students to develop the vehicle through prototype demonstration. In ME401, the students will design a functioning small-scale proof-of-concept prototype. Lulay Industries will host a competition to evaluate the various proof-of-concept designs and select a winner based on prototype’s performance.

Objective: design a vehicle prototype composed entirely from the supplied LEGO Mindstorm kit (plus a small amount of cardboard). The vehicle must be capable of meeting the following two criteria:

- High speed in the flat track event
- Sufficient speed in the steep-incline pull event (as defined below)

The vehicle must be capable of carrying up to 1 kg (10N) of weight.

Safety Requirement:
Safety is a critical design criterion for this project. The vehicle must not tip when placed on a 30 degree incline (as if it were traversing sideways across the incline).

Cost
Economics is always an engineering criterion. For this event, teams will be “charged” 10 points for each gear or sheave used.

Weight and size
Weight is often an important criterion; especially with transportation vehicles. For this event, teams will be penalized 1 point for each gram over 430 grams that the vehicle weighs. Size is often a criterion for vehicles as well. The entire vehicle must fit inside a 10X8X6 inch volume.

Dynamic events:
1) The first event (flat track) will measure the time required for the vehicle to travel 45 feet across the competition room floor (Shiley 301). It will not be carrying payload for this event.
2) The second event (hill pull) will measure the time required to traverse plywood (about 6.5 feet in length) inclined at 15 degrees. The vehicle may be empty or it may contain up to a 1 kg load (or loads in between of 200g, 500g, or 700g).

Scoring for the dynamic events will use the following algorithms:

Flat Track Score = 100 X (t_{\text{longest}} - t_{\text{yours}}) / (t_{\text{longest}} - t_{\text{shortest}})

- $t_{\text{shortest}}$: fastest time by any vehicle
- $t_{\text{yours}}$: time for your vehicle
- $t_{\text{longest}}$: the lesser of: a) slowest time by any vehicle; b) 4*$t_{\text{shortest}}$
Hill climb: Scoring for this event is “all or nothing” – 150 points will be awarded to teams completing the hill climb in 15 seconds or less and zero points for times greater than 15 seconds.

Failure to complete either event will result in a score of zero for that event. Details as to the weight to be pulled will be released after the final Design Decision Documents have been submitted; therefore, the final DDD should discuss how the design might vary depending upon the weight to be pulled. In other words, what gear ratio, tires, etc. would be used if the vehicle had no load as compared to having heavier loads. It is reasonable to expect to have several different designs; each one being better than the others for specific weights. Only one gear ratio may be used for both events (same ratio for both events). It must be the same ratio from the motor to the ground (so using different wheel diameters or different gears within the competition violates this requirement).

Limits: only parts from the assigned LEGO Mindstorms may be used, and from that only one motor may be used. Only the batteries provided may be used. If you have problems with your battery charge, please contact Jared (EE Technician). The same drive ratio (motor, gears, drive tires, etc.) must be used for both the hill-climb and flat track events. In other words, only one gear “speed” – you may not “shift” gears between events in any capacity. In addition to the LEGO materials, you may use up to one piece of cardboard, 6x6 inch maximum, to place the weights on in vehicle. In other words, you may use cardboard for the truck bed. Other than supporting the weights directly, the cardboard cannot be used for any other purpose. Cardboard will not be provided.

Deliverables:
~ February 11: Submit a Project Plan (described by the ME481 Project Plan – link on course web page). This is to be your project as you see it as a student in ME401. In other words, don’t pretend you are working for a company that will actually build a vehicle. The vehicle to be designed, tested, fabricated in ME401 will use LEGO mindstorms kits. Actual expenses will be zero. For the Project Plan, identify 4-6 milestones (including dates) and at least one or two tasks to complete each milestone. Creating the plan must be a team activity where all members agree upon the tasks, milestones and dates. This should NOT be viewed as a “hoop to jump through.” Planning is a very important part of every engineering project and should be taken seriously. By the process of creating the plan, the team has the opportunity to better understand what really does need to be accomplished, how to accomplish it, and when it needs to be accomplished. After creating the plan – use it! Hold yourself and each other accountable for following it as closely as possible.

~February 25: resubmit the revised Project Plan (if needed)

~Due March 4: submit a Design Decision Document focusing on analysis to determine appropriate gear ratio for hill climb and validation testing. Specifically, through analysis determine what gear ratio should be used to carry 200g load successfully up the incline. Test to validate analysis (aka, validation testing). It should also contain a brief but detailed test plan
used for the validation testing. Include photos of testing. NOTE: DDD’s are NOT like formal reports (although, formal reports may include many DDD’s). They are more like homework assignments.

Also, submit/resubmit updated tables (criteria, milestones, and task schedule).

~Due March 25: submit a DDD - through analysis, determine range of gear ratios which will successfully complete the hill climb while carrying the five different loads (0 to 1kg). Validation testing with at least three different loads should be completed and included in this DDD. Include analysis and validation testing for the flat track event. Include photos documenting test work. Submit/resubmit updated tables (criteria, milestones, and task schedule)

~April 8 – Final report. One page text maximum, plus tables, figures, all previous DDD’s, action item log and decision log. Include a new table that duplicates the criteria table but adds a column which concisely describes what was done to design and demonstrate each specific criterion was met or not met. On appropriate criteria, it simply could reference the DDD that demonstrates accomplishing the criterion. This report should include a table defining what gear ratios should be used based on the potential weights to be carried (0g, 200g, 500g, 700g, 1kg). Different gear ratios may be selected for different loads to be carried. Results of testing should be included. Include a sketch or photograph of your design.

~April 20, Competition: An in-class competition will be held to determine which teams best satisfied the requirements. The configuration of the vehicle used in competition must match the configuration described in the final report for the given weight to be pulled; therefore, it must be clear in your report what the design would be for all possible weights (0 up to kg). “Awards” will be given to the top teams in the form of extra homework points as follows:

- First Place: 40 homework points.
- Second Place: 20 homework points
- Third Place: 10 homework points
- Fourth Place: 5 homework points

Be sure to charge the Mindstorm battery before the competition and bring the entire kit (box) with you. We will collect them immediately after the competition.

Project Management: each team is to maintain an action item log and decision log throughout the project. Each team member will act as the lead engineer at various times throughout the project. The lead engineer will be responsible for at least one meeting (creating agenda, etc.). The lead engineer will also be responsible for weekly email updates to all stakeholders (the instructor and team members). The course web page shows the schedule for who will be the lead engineer and when.