Lab 7: All Terrain Vehicle and Obstacle Course

Introduction

You have spent the last week reverse engineering your cordless screwdrivers and learning about the function of its basic parts. Over the remaining weeks you will be working in teams of 3-4 to transform these screwdrivers plus some additional parts into an All Terrain Vehicle (ATV) that will have to conquer a grueling obstacle course. The design of your ATV will be driven by the performance, design, and manufacturing requirements outlined below and during lecture. The goal is to successfully design an ATV that will overcome all the obstacles on the course while collecting as many points as possible. Your designs will therefore need to result in simple, rugged, creative, maneuverable, quick, and powerful machines. The parts you will use will come from your cordless screwdrivers, a kit that you will receive in the first week and a budget of $80 to be spent on gears.

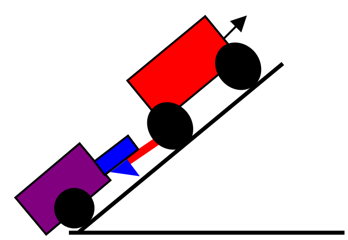
Final Project Objectives

- Transform a cordless power screwdriver into a functional all terrain vehicle Learn to design with gears while implementing drive and steering systems
- Implement a design that meets performance requirements
- Understand basic electro-mechanical components
- Learn to make a complex SolidWorks assembly from subassemblies and using some of SW's advanced assembly features
- Work in teams!!
- Have fun!!!!

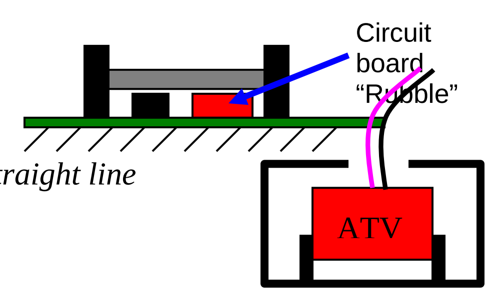
Contest

The goal of the contest is to acquire as many points as possible by successfully overcoming the obstacles on the course. The obstacles were cleverly constructed to represent various disciplines in the wonderful world of engineering. These obstacles include:

- Mechanical engineering:
  Performance objectives - power and maneuverability
  - Task is to go up a ramp onto the course while having to tow a heavy trailer and unhitching the trailer (as demonstrated in lecture)



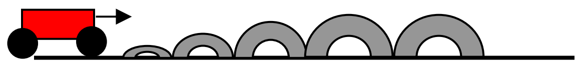
- Electrical engineering:
  Performance objective - clearance
  - Task is to traverse over circuit board rubble



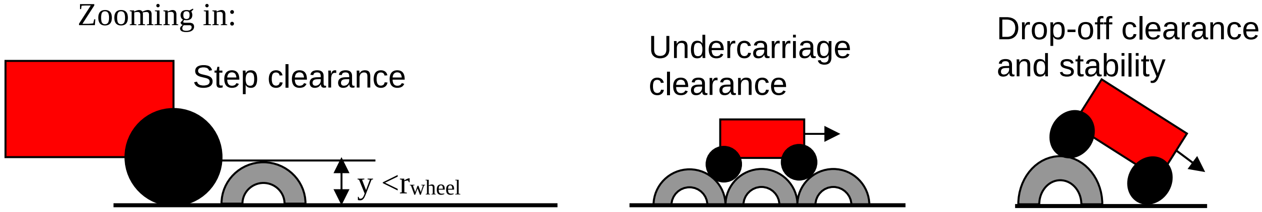
- Aero-Astro engineering:
  Performance objectives – size, ability to drive in a straight line

- o Task is to travel through a "tunnel" that will have a slot on the top for your wires

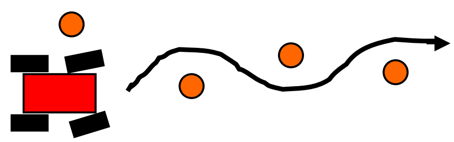
- U-turn
  Performance objective - turning radius
  - o Task is to change direction on the course
- Civil Engineering:
  Performance objectives - clearance, power, durability
  - o Task is to step-up onto the horizontal pipes, drive over them, and drop-off the other side



Zooming in:



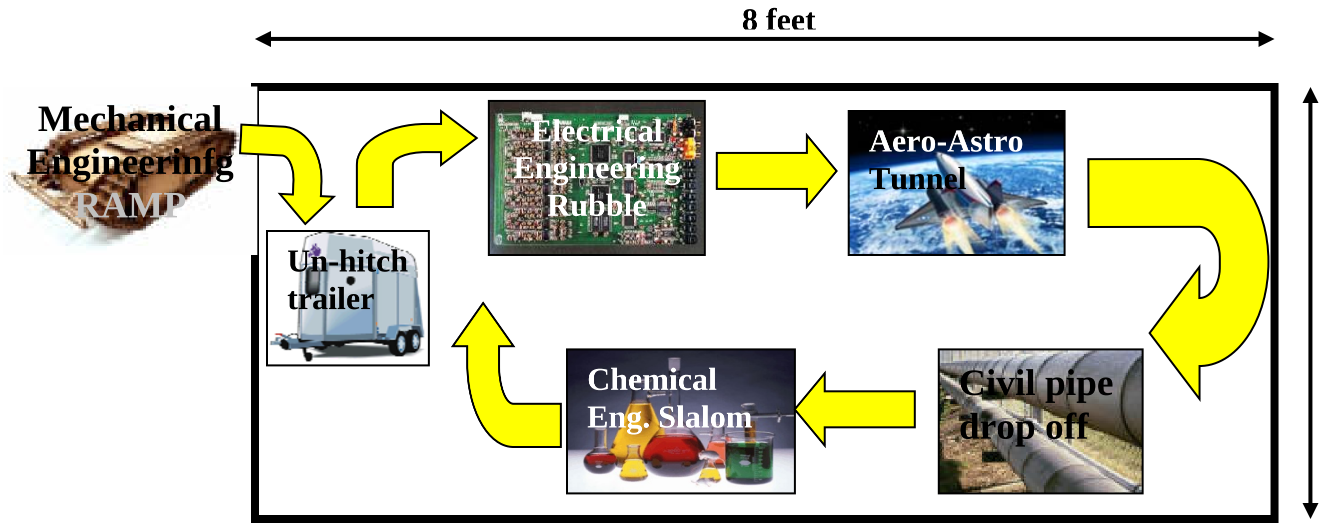
- Chemical Engineering:
  Performance objective - maneuverability
  - o Task is to complete a beaker/funnel slalom course



Each team will be allowed 2.5 minutes for combined set-up and take-down of their ATV's. Each team is then allowed 5 minutes to complete as many obstacles as possible, or until 3 "lives" are spent. If the ATV can't overcome an obstacle or gets stuck, that is considered a "life". There will be several check-points in the course where you can start after losing a "life" (instead of having to go all the way back to the beginning). Each obstacle will have a clearly marked entryway and exit. After you complete the course once, you may then proceed directly to the entryway of any obstacle by driving along the center bypass lane to collect more points until time or "lives" are fully depleted.

The ATV must begin at the bottom and drive up a ramp towing the trailer and weight provided. Once at the top of the ramp, the ATV must then unhitch the trailer before continuing on the course. The vehicle will then drive in a clockwise direction around the course entering and exiting each obstacle and passing through the checkpoints. The wires for your device will be held up by a teammate so that they do not interfere with the operation of your vehicle. Team members will have to ensure that the wires have the appropriate slack (AKA the slacker), without exerting force on the vehicle. The driver will operate the vehicle using the remote controller, and the other team members will serve as strategists and advisors to the driver.

3 feet



Performance Constraints

During the first week of this lab you will be allowed to make measurements of the obstacle course so that you can determine the performance constraints for your ATV. The course will also be made available during lab section times if needed. Specifically you will need to determine:

- Ramp angle and width
- Hitch dimensions for the hitch/ATV interface and for the unhitching of the trailer once up the ramp
- Trailer weight
- Clearance height
- Size constraints (fit on ramp and in tunnel)
- Turning radius and rate
- Obstacle “step” size

Kits (what each team will be given)

- Cordless screwdrivers, **limit: three (3)**
- Black acetyl (Delrin) stock, **limit: one (1) 12” x 12” x 1/4” thick piece**
- Molded spur gears from the gear catalog page attached, **limit: $80 value**
- Axel rod 0.2500” diameter, **limit: one (1) 36” length**
- Rubber wheels with plastic bushings, **limit: four (4)**
- White acetyl (Delrin) rod 1/4” diameter, **limit: one (1) 6” length**
- Screws, 4-40, pan head, Philips, 3/8”, 1/2”, 5/8” long
- Dowel pins 1/16” diameter by 3/8” long
- Wire for the remote control
- Electrical tape

Design and Manufacturing Constraints

Chassis and Motor Mount Bracket

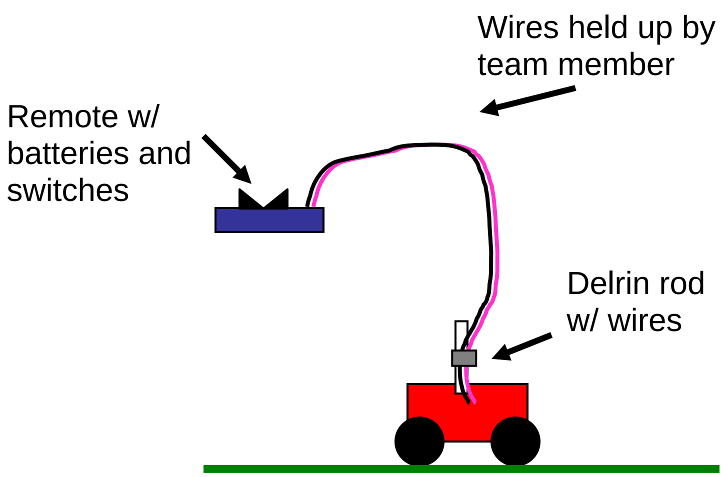
- You will need to use substantial bracing on the chassis structure to keep joints rigid. Examples will be given in lab.
- The motor should be mounted using the two machine screw holes on its face, as well as a close-fitting hole for the motor boss cylinder.

Wheels, Gears, Shafts and Axels

- The 0.2500” axel rod will be used for wheel axles and gear shafts.
- Wheels will be press fit onto the bearings that are pinned to the shafts with the 1/16” dowel pins as will be demonstrated in lab.
- The Delrin chassis walls will serve as bushings and thrust bearings for wheel axles and gear shafts as demonstrated on the cart.
- The gears are designed to be press fit on to the 0.2500” steel rod.
- If used, the 10-tooth pinion gear can be attached to the motor shaft with epoxy.

Wiring

- You will be able to use up to 3 switches (one for each motor) to use on your remote control. The batteries and switches should be mounted on the remote controller. You will be given wire to connect your remote to the corresponding ports on your ATV.
- The ATV should have the 6” long Delrin rod press fit vertically into the chassis to serve as a departure point for the wiring. Cable ties can be used to direct the wiring along the ATV chassis and up the Delrin rod



Other Guidelines

- The cable ties, wire and electrical tape are for electrical hookup only and not for mechanical structure.
- Only parts in the kit may be used.
- All critical chassis features must be cut on the lasercutter. This means you cannot band saw slots and notches in the chassis after the fact. You must plan ahead.
- TFs will make the decision of whether a chassis feature isn’t “critical”

SolidWorks Requirements

- Separate subassemblies should be used for each logical group of parts as discussed in lecture. Subassembly examples are: wheels + bearings pinned on a shaft; the chassis base + walls + top; the motor + motor mount bracket + pinion gear; etc.
- Shaft holes should be drawn as in context features.

Tips

- We will be compiling the data from the motor spec lab so that you will all have the same information from which to base your design
- Note that your steering and speed/rate control WILL BE POOR! Do not expect otherwise.
- KEEP YOUR DESIGNS SIMPLE!!!! Elegant solutions are simple ones…
- Utilize team members – divide and conquer!
- Try to put the weight due to the cart over top of the wheels to increase the normal force and prevent wheel slippage on the ramp.

Grading Criteria

Item	**% worth**
Mechanical	25
Quality of chassis joints (slotted, stable, aligned, fit)	
Motor mount (uses face screw holes, adjustable)	
Shaft mounts (good fit, spin freely or fixed securely)	
Wheel-axel joints (fixed with pin)	
Wiring (proper terminals, secured with ties)	
Gears (well aligned, smooth running)	
Assembly (easy to assemble)	
SolidWorks Model	25
Sketches (fully defined, simple)	
Design for mfg. (only remove material)	
Subassemblies (fully mated)	
Assembly (fully mated, in context features, equations)	
Drawing of one chassis wall (fully dimensioned, clear)	
Check for Interference	
Design	25
Design specifications (complete)	
Concept sketches (convey design concepts, creative)	
Form core prototypes (rudimentary test of design concepts)	
Drive system (drives forward/reverse, meets speed/torque specs.)	
Steering system (meets turning radius and turning rate specs.)	
Chassis (structurally sound, simple construction)	
Performance	25
Score in final contest	

Deliverables (keep on top of these, this is going to be a lot of work!)

WEEK 1: Concepts, foam core prototype, gear order

1. **DUE in class, Mon. April 11th:** Foam-core model #1. This model should be a "complete" model, incorporating all that you think needs to be designed into your ATV.
2. **DUE at the beginning of lab, Apr. 12th or 13th:** Foam-core model #2, incorporating any fixes suggested by Prof. Dollar from the in-class review. This should be your "final" design. OK to reuse the same parts from model #1 if appropriate. Three (3) team concept hand sketches (overall design including steering and drive train solutions – one sketch per page, with pros and cons for each), and a complete list/table of design specifications (blank chart will be provided) including: drive train gear ratio, drive train gear stages to achieve this ratio, steering gear ratio, steering gear stages, chassis clearance, turning radius, turning rate, approximate weight, approximate overall dimensions (length, width height), maximum operating power, maximum operating horizontal speed, and the maximum operating torque at wheels. BOM for gears you would like to order (up to $70 worth).

WEEK 2: SolidWorks Assemblies and complete Bill of Materials

3. **DUE at the beginning of lab, Apr. 19th or 20th:** Both a hard copy and an electronic submission to the ClassesV2 drop box of a SolidWorks full assembly and a separate SolidWorks assembly view for each subassembly of your Initial prototype ATV. A complete Bill of Materials. One per team. You will begin cutting your pieces this week.

WEEK 3: Construction of Initial Prototype

4. **Continuation of Prototype Fabrication**

WEEK 4: Construction of Initial Prototype

5. **DUE MONDAY May 2 at Noon in Mason B7:** Checkpoint for physical prototype. Bring ATV to lab to demonstrate a working drive train and steering solution. One per team.

WEEK 4: CONTEST and final report

6. **DUE Saturday May 7, 2pm (in Mason B7):** ATV CONTEST!!!! Submit final SW parts and assemblies to ClassesV2 drop box. One per team.

7. **DUE TUESDAY May 10 by 5pm in box outside Prof. Dollar's office (Becton 215):** Final team report and individual design notebooks due. Details on what the final report should include will be distributed at a later date, but will include labor division and individual time spent on the lab so keep track of these.