Final 185 Laboratory: All-Terrain Vehicle Contest

All Terrain Vehicle - Goal

- Design and build a small vehicle
  - drive systems
  - steering
- Teams of 3 (hopefully)
- Parts
  - 3 screwdrivers per group
  - kits provided
- Drive in competition on an obstacle course

Final Project Objectives

- Transform a cordless power screwdriver into a functional all terrain vehicle that competes on a grueling obstacle course
- 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!

Preparation

- Cordless Screwdriver Dissection
  - Reverse engineer mechanical components
  - Intuitive “feel” for how it was designed
  - Recorded functionality

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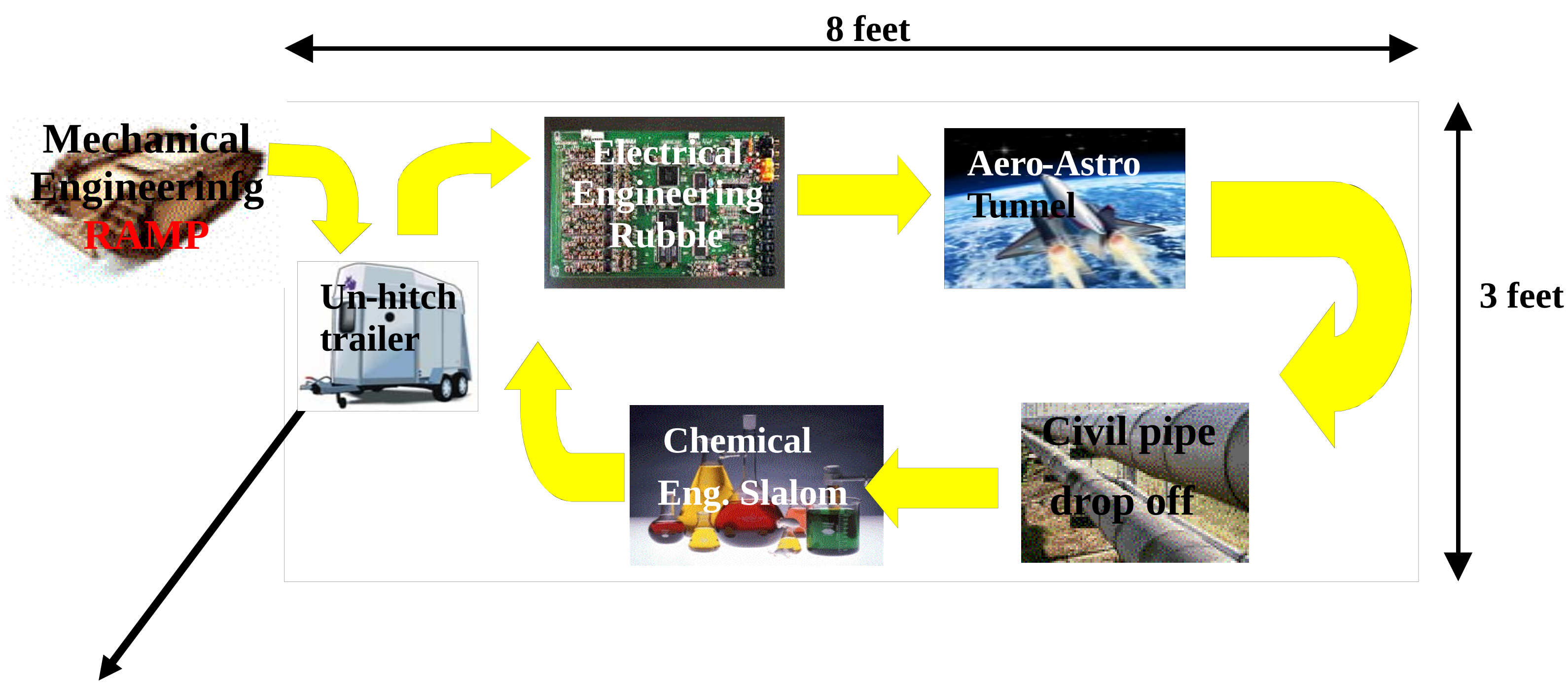
- Cordless Screwdriver Dissection
  - Reverse engineer mechanical components
  - Intuitive "feel" for how it was designed
  - Recorded functionality
- Motor Specification
  - Characterized speed-torque curves for motors
  - Calculated motor constants
- Lecture/textbook material on motors, gears, etc.

Kits

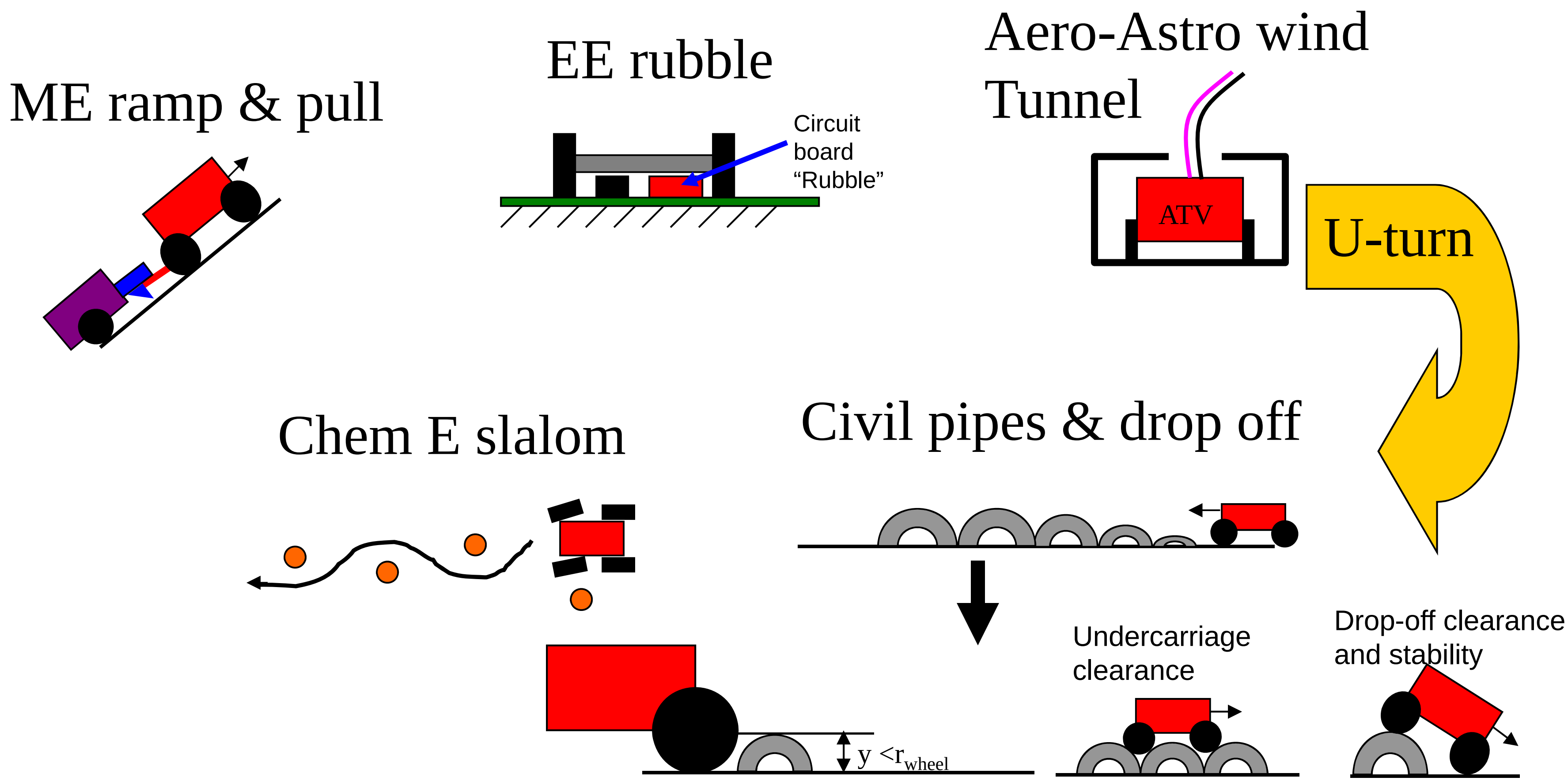
- Screwdrivers, **limit: three (3) to a team**
- Black acetyl (Delrin) stock, **limit: one (1) 12” x 12” x 1/4” thick piece**
- Molded spur gears from the gear catalog page attached, **limit: $80 value**
- Axel rod 0.2500” diameter, **limit: one (1) 36” length**
- Rubber wheels with plastic bushings, **limit: four (4)**
- White acetyl (Delrin) rod 1/4” diameter, **limit: one (1) 6” length**
- Dowel pins 1/16” diameter by 3/8” long
- Switches/screwdriver housing
- Other: Wire (lamp cord), 18 AWG, Cable ties, Electrical tape, 4-40 screws

Contest: the course



Note: there will be a bump for you to maneuver over that will unhitch the trailer = extra points (otherwise done manually)

The Performance Objectives



Contest: The course cont.

- Second week (after screwdriver dissection) the course will be available in the lab to make the necessary measurements for your designs
- These include:
  - Ramp angle and width
  - Hitch dimensions and unhitching information
  - Trailer weight
  - Clearance heights
  - Size constraints
  - Turning radius and rate
  - Obstacle step size

Rules of the Game

- 2.5 minutes for combined set-up/take-down of your car
- 5 minutes of drive time OR 3 “lives” whichever comes first
- Must begin at bottom of with ramp and pull trailer to top (not counted in time)
- Must un-hitch trailer before doing rest of course
- Complete course in clockwise fashion
- Earn points for each obstacle completed (they have different point values)

Rules of the Game cont.

- Complete all obstacles once, then repeat any obstacles you like (minus ramp)
  - but must drive to entrance point and complete obstacle to end point
- Team with the most points wins!

Design Process: Steering example

Goal (turn ATV on obstacle course)

Performance Objective (min obstacle course turning radius?)

Factor of safety/error margin

Performance Specifications (r < objective radius)

Physics, geometry, math

Design Specifications (wheel angle, car length)

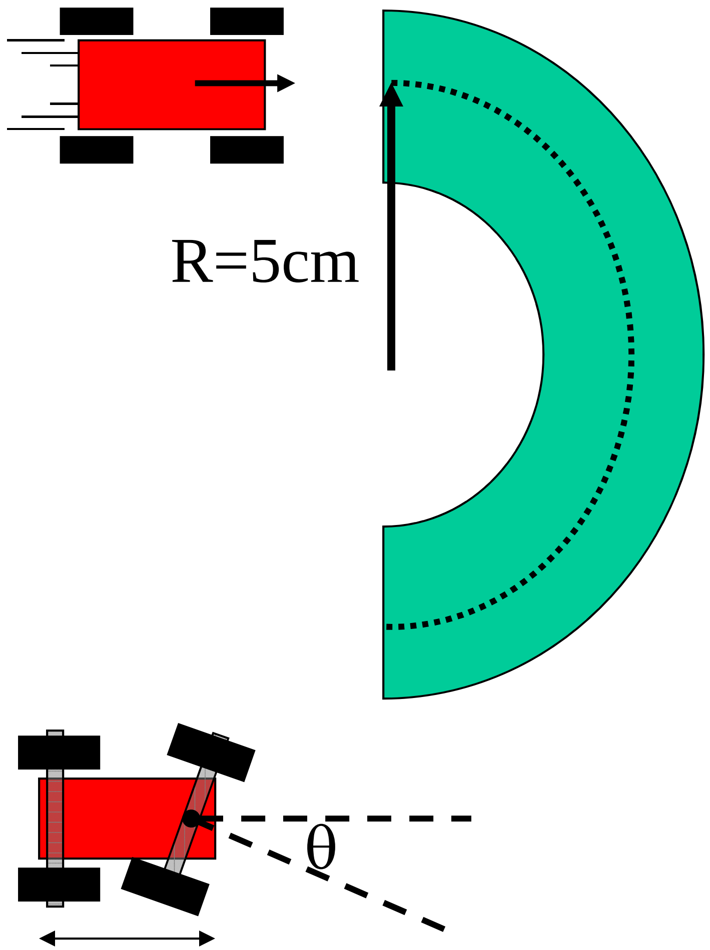
Design & manufacturing constraints

Physical Design Solution (actual components)

Build it

Prototype, Test, Contest (YOUR ATV CAN TURN!)

Design Process Example: turning your ATV



1. Goal: turn ATV
2. Performance Objective:

   follow course radius = e.g. 5cm

3. Performance Specification:

   turning radius = e.g. 4.5 cm

4. Design Specification

   chassis length and wheel angle = ???

Overall Design

- Steering System
  - Design solution: # wheels, orientation, …
  - Determine turning radius
  - Determine turning rate and gear ratio needed to achieve that
- Drive System
  - Determine power requirements
  - Speed specification
  - Gear ratio needed to accomplish these
- Overall Chassis Configuration

Power Calculation Example: Lifting a Mass with a Winch

- Goal: Design a winch that lifts a given mass as quickly as possible
- Performance Objective
    - Maximize velocity for a given mass
- Design Specification
    - Since Power=mgv and m and g are given…

      we want to maximize power.
    - Power from the motor = $\tau\omega$
    - Max motor power (for a given V) **P_{max} = (given by motor specs)**
    - For maximum power output, we want to operate the motor at the torque/speed point for max continuous power

Power Calculation Example

1. Find the τ and ω corresponding to the motor's P_{max}.
2. Calculate $v = P_{max}/mg$
3. Calculate the winch $\omega_{winch} = v/r_{spool}$
4. Calculate the gear ratio $VR = \omega_{motor}/\omega_{winch}$
5. Determine the gear stages that provide this gear ratio.

Design Details: chassis and motor

- Chassis attachments/joints must be made to be rigid! Add extra bracing, etc.
- Chassis parts will be fastened together with 4-40 allen screws: thru holes lasercut, tapped holes done on drill press
- DO NOT put shaft holes in your initial SW parts. These will be added using SW's in-context features. This will make your lives easier and will ensure proper gear train positioning
- Motor mount:
  – Create a bracket to mount motor using circular protrusion and 2 screws on motor face

Design Details: axles, shafts, wheels, gears

- Use ¼" aluminum rod for all axels and gear shafts
- Gears will press fit onto shaft
- Wheels will press fit onto bearings that will be pinned to shaft
- Delrin chassis serves as bearing
- Use the existing screwdriver pinion gear

Design Details: wiring

- Batteries and switch from screwdriver will be used in the screwdriver housing as a ‘remote control’
- A 6” long ¼” diameter Delrin rod will act as a departure point for your wiring
- 15’ of wire will connect to the motors and into the remote controller
- Solder wires to switches, motors

Manufacturing Details

- Tape and ties are for electrical purposes only
- ALL critical chassis features must be cut on the laser cutter
  - Design for Manufacture!!!

SolidWorks

- Use Subassemblies!
  - Better organize collections of parts
  - Facilitate division of labor
  - Simplify the full assembly
- In-Context Features
  - Simplify shaft hole placement
  - Automatic update if shaft placement changes

Teams and Grading

- Final report will include:
  - Individual time reports
  - Division of labor
- General grading criteria:
  - 25% Mechanical construction quality
  - 25% Design process and approach
  - 25% SolidWorks Model
  - 25% Performance

Schedule/Deliverables

- WEEK 1: Power Screwdriver dissection (individual project)

1. Worksheet completed.

Schedule/Deliverables

- WEEK 2: Concepts, foam core prototype, gear order

1. BOM for gears you would like to order (up to $80 worth).
2. Three (3) team concept hand sketches (overall design including steering and drive train solutions), one (1) foam core + wood etc. prototype of said concepts, and one (1) 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.

Schedule/Deliverables

WEEK 3: SolidWorks Assemblies and complete Bill of Materials

A hard copy (submitted in class) 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.

Schedule/Deliverables

WEEKS 4-contest: Fabrication and Testing

During regular semester – work in lab. During Reading Period, work

Tips

- Control is key
  - Best speed?
  - Best driver?
  - Design a changeable gear ratio?
- Testing is ESSENTIAL
- Good fabrication can make the difference
  - Great design can perform poorly
  - Mediocre design can perform well

Logistics:

- Pset 5 due next Mon. (out today)
- Teams will be assigned this week
- Please be in class on Monday – team-based brainstorming exercise
- Final Contest – During Final Exam Slot (May 7, 2pm)