Syllabus

The Rover Decal will focus on design, testing, and implementation of a fully functional rover prototype (including mechanical, electronics, and software). Students will be exposed to the basics of CAD Design, FEA, Electronics, and controls with the end goal a complete rover.

There will be a total of five assignments each of that build off of each other which culminate with the final prototype build. The assignments will start with CAD designs of each subsystem before bringing everything together into a full prototype. Once this first iteration has been built, each group will be tasked with making one modification/improvement to their design based on what they learned from the build process.

Meetings will be held twice a week for roughly 1.5 hours each (exact days and times TBD). The meeting focuses will alternate between Mechanical and Electrical oriented topics. The first meeting of each week will typically focus on new mechanical topics and introducing/developing the skills needed for the assignments (includes FEA, designing for manufacturing, part definition/selection, etc.). During this meeting, electronics groups will either be following along, working on a guided practice, or working on the rover design. The second meeting of the week will generally focus on software, electronics, and control. Mechanical groups will have a similar set of options as the electronics groups did during the first meeting.

Focus areas will be in mechanical/electrical design and fabrication, graphical user interface development, and bare metal control code. See accompanying week by week schedule as well as the assignments at the end for more details.

An 80% attendance rate and satisfactory work on the rover prototype are required to pass.

Grading

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Attendance</td>
<td>5%</td>
</tr>
<tr>
<td>Participation</td>
<td>10%</td>
</tr>
<tr>
<td>Assignment 1</td>
<td>20%</td>
</tr>
<tr>
<td>Assignment 2</td>
<td>15%</td>
</tr>
<tr>
<td>Assignment 3</td>
<td>10%</td>
</tr>
<tr>
<td>Assignment 4</td>
<td>30%</td>
</tr>
<tr>
<td>Assignment 5</td>
<td>10%</td>
</tr>
</tbody>
</table>
Schedule

Meeting 1
Syllabus Day: Basic introduction of the decal and about the sponsoring team (AIAA Rover). Highlevel intros of each design program we will be using and run through of the week to week schedule.

Meeting 2
Pick apart previous rover designs and discuss pros/cons/challenges encountered. This includes going through the old CAD files as well as looking at the final hardware to compare differences and unseen design challenges.

Meeting 3
Introduction to CAD (SolidWorks) and working with global datums. At the end of the meeting we will assign our global datums to the project (will be used for design basis and integration), define project criteria/outcomes, and form subsystem teams.

*First Assignment Assigned (Due Meeting 9).*

Meeting 4
Basics of motors and motor control. Types of motors, how to control them (motor drivers, PID loops), encoders, feedback, and correction algorithms using feedback.

Meeting 5
Introduction to FEA using Solidworks and Ansys (Needed for Assignment 2).

Meeting 6
Assignment work session and introduction to designing for manufacturing. Compare current results and ensure that global datums are still being met. Brainstorm new solutions to any problems that have come up as a group and define new build criteria. Introduce the idea of designing of manufacturing and analyze current CAD work to see areas of improvement.

Meeting 7
Feedback and adaptive controls using numerous sensors (sensor fusion), protocols, and design structures. How to design/create circuits and what programs are available for testing.

Meeting 8
Advanced assemblies in SolidWorks such as setting up motion, assemble/disassembly views and movies, and rendering.
Meeting 9
All things communication and networking. Electrical and software components behind UART, I²C, analog, bluetooth, WIFI, and using long range antennas (all needed for the competition). Will go over the limitations and advantages of each type as well as examples/resources on how to use them.

Second Assignment Assigned (Due in Meeting 13).

Meeting 10
Advanced simulations in SolidWorks and Ansys. Focus on dynamic stresses in moving parts and how to test common motion cases. (Examples: Lifting camera mast, moving over various sized rocks, impacts, etc.)

Meeting 11
Assignment 2 check-in and work session. Help with FEA simulations and circuit diagrams. BOM’s should be 90% and first parts ordered by this point.

Meeting 12
Interfacing and controlling many sub-circuits, sensors, and controls into a single microcontroller (such as an arduino or PSoC4/5LP). Will focus on buffer circuitry needed to step up power requirements as well as to protect the microcontrollers inputs/outputs from damage.

Meeting 13
Setting up files and drawings for machining. Get material that needs to be waterjetted setup with drawing and email ME Shop the DXF/PDF files.

Third Assignment Assigned (Due in Meeting 19).

Meeting 14
Merge all portions of rover into single assembly file. Make sure global datums are still present and that all desired degrees of freedom still work. Setup and run FEA simulations on entire package to ensure that there are no weak joints.

Meeting 15
Assignment 3 work session. Extra session allotted in order to ensure enough working time to fix bugs and ensure that all fits are checked with correct analysis.

Meeting 16
Advanced topics in manufacturing and things to consider for future iterations of the rover. Topics include outsourcing, simple prototyping using additive manufacturing (3D printing), and CNCing.
Meeting 17
Control and visualization of an arm working in 3D. Will focus on benefits and drawbacks of one-to-one joystick-motor mappings vs. algorithmic mapping of a single joystick to multiple motors to execute complex tasks.

Meeting 18
Introduction of other CAD softwares and drafting tools. Intro to packages such as Autodesk, CREO, Blender, etc.

Meeting 19
Circuit fabrication and analysis workshop. Will be working with software suites for the creation and analysis of custom PCB’s and circuits. Programs include Eagle, SPICE, OrCAD, PCBWeb, etc.

*Fourth Assignment Assigned (Due in Meeting 24).*

Meeting 20
Different types of analysis in Ansys and Solidworks. Includes example analysis for heat, fluids, magnetic, and electric cases with both transient and steady state conditions.

Meeting 21
Assignment work session. Ensure that all the pieces are coming together and that any design problems are addressed early. Have mechanical and electrical cross reference designs to ensure that builds are still going as planned.

Meeting 22
Advanced pathing algorithms and AI on the rover (autonomous path traversal). Essentially, this will show how to setup and follow a specified path based on GPS, wheel RPM, and visual queues.

Meeting 23
Assignment work session. Ensure that all parts are coming together and that final integrations are going well.

Meeting 24
Does it work? If not, what happened? Can it be finished in this period? If it does, drive it around everywhere, find/define areas of improvement for the final assignment.

Meeting 25
No Meeting: Thanksgiving Break
Meeting 26
General touch ups on current rover prototype. Does it still work after break? If not what broke? Get the final assignment squared away/started in order to finish on time.

*Fifth Assignment Assigned (Due in Meeting 29).*

Meeting 27
Final group meeting before demonstration of refactored and finalized prototype. Groups will share thoughts on the course and what can be done to improve it for following semester/years. (Private group feedback link will also be emailed out).

Meeting 28
No meeting (Start of RRR week).

Meeting 29
Final project demonstration and pizza party.

**Deliverables**

**Assignment 1 (Due in Meeting 9):**
CAD Iteration 1: Students should form groups of 3-5 and draw out the design for a specific subsystem. This subsystem should be either an arm, a drivetrain, or a chassis (list may be expanded based on thoughts in meeting).

Electronics Specification: Electronics/software should form similar groups and will tag along with a mechanical team and work to build in the control hardware and criteria to coincide with the rover design (this includes wiring, what movements or measurements are desired, and how to achieve them).

All teams must also submit a writeup of how their design fulfills the URC tasks (pdf provided) as well as any pitfalls or alternative ideas that they can think of.

**Assignment 2 (Due in Meeting 13):**
CAD Analysis: Provide FEA and Ansys analysis for each of the parts and subsytems created in Assignment 1. These should take the form of max and min strain figures as well as the logic behind why you made your choices.

Circuit Diagrams: Electronics teams will finish compiling lists of needed sensors/electronics as well as the resources needed to program/use them. and the circuits needed to drive them.

Software Layout: Front end groups will begin modules for a multi-panel graphical interface which will support basic addition of windows and panels. This module must have the ability
to easily insert new panels, control variables, change cameras, and/or change the visual appearance. The backend groups will continue working with electronics teams to define how the sensors will interact and what control code will be needed.

Mechanical and Electrical groups will need to submit their BOM ASAP to facilitate ordering the materials and troubleshooting any problems that arise.

**Assignment 3 (Due in Meeting 19):**
CAD Iteration 2: Redo Assignment 1 with considerations for the analysis in Assignment 2. Additionally, make a Bill of Materials (BOM) and drawings for all parts that need to be machined.

Bare Metal Layout: As parts come in, use manufacturer datasheets to check correct functionality using the provided test circuit layouts (and any provided/found test suites or code). Once checked, build the predefined circuit (from assignment 2) and check functionality again.

GUI Layout: Using the multi-paned GUI design from assignment 2, add inputs for 3 cameras, multiple tabs for control variables, a 3D arm graphic, and pathing inputs (used for the autonomous traversal mode).

Large material purchases (such as stock metal, bolts and/or fasteners) and the rest of the electronics will be ordered at the start/middle of this assignment.

**Assignment 4 (Due in Meeting 24):**
Build: Using CAD models and the generated drawings from the previous assignments, build the prototype rover. Electronics teams will continue building their circuits and integrating into the final computer system. GUI team will finish the control stick inputs as well as modules for single stick arm control and the AI path finder explained during the meetings (also part of the competition spec).

**Assignment 5 (Due in Meeting 29):**
Project Writeup:

1. What went well?
2. What didn’t go so well?
3. If you could start over what would you do differently?
4. If we kept going what would you try to improve?
5. Any advice for future classes?

In addition to answering these questions, please provide a list of changes to the initial design (end of assignment 3) that you made or wish you had made.