Mars Rover Mission

Bishesh Khadka
Naperville North HS

Brian Nord
Fermilab

7/31/2013

Acknowledgements

- QuarkNet family
- SiDet Staff
- WDRS Staff
- Peers

- Nathan Lindquist

Introduction

- Naperville North High School
- Soon to be senior
- Interests: Physics, Computer Science and pedagogy

- Programming Background:
  - Intermediate Python and Beginner Java

Are we alone?

- Multiple worlds
  - Ancient Hindu Scripture
- Cosmic Pluralism
  - William Hershel, Immanuel Kant, Benjamin Franklin
- Invasion of Earth by Martians
  - H.G. Wells 1897 novel: War of the Worlds

Are we alone?

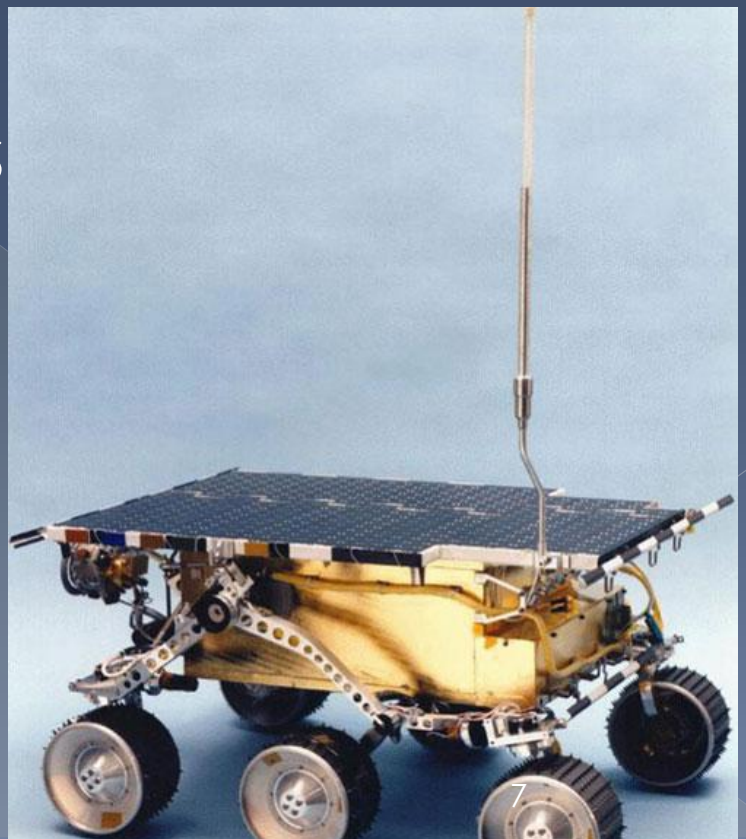
- Radio Signals
  - Nikola Tesla, 1896
  - Wow! Signal 1977
- SETI: Search for Extraterrestrial Intelligence
- Drake Equation $N = R^* \cdot f_p \cdot n_e \cdot f_\ell \cdot f_i \cdot f_c \cdot L$
  - N= number of civilizations within our galaxy with which communication is possible

Why Mars?

- Suspected to have had conditions capable of supporting life
  - Mars Ocean Hypothesis
- Prospect of alien life
- Close to home

What has been done on Mars?

- Mars Exploration Project
  - Primary Goal: Determine if life ever arose on Mars
- Unmanned explorations
- Sojourner Rover 1997
  - Proof-of-concept
  - Spectrometer



What has been done on Mars? (cont'd)

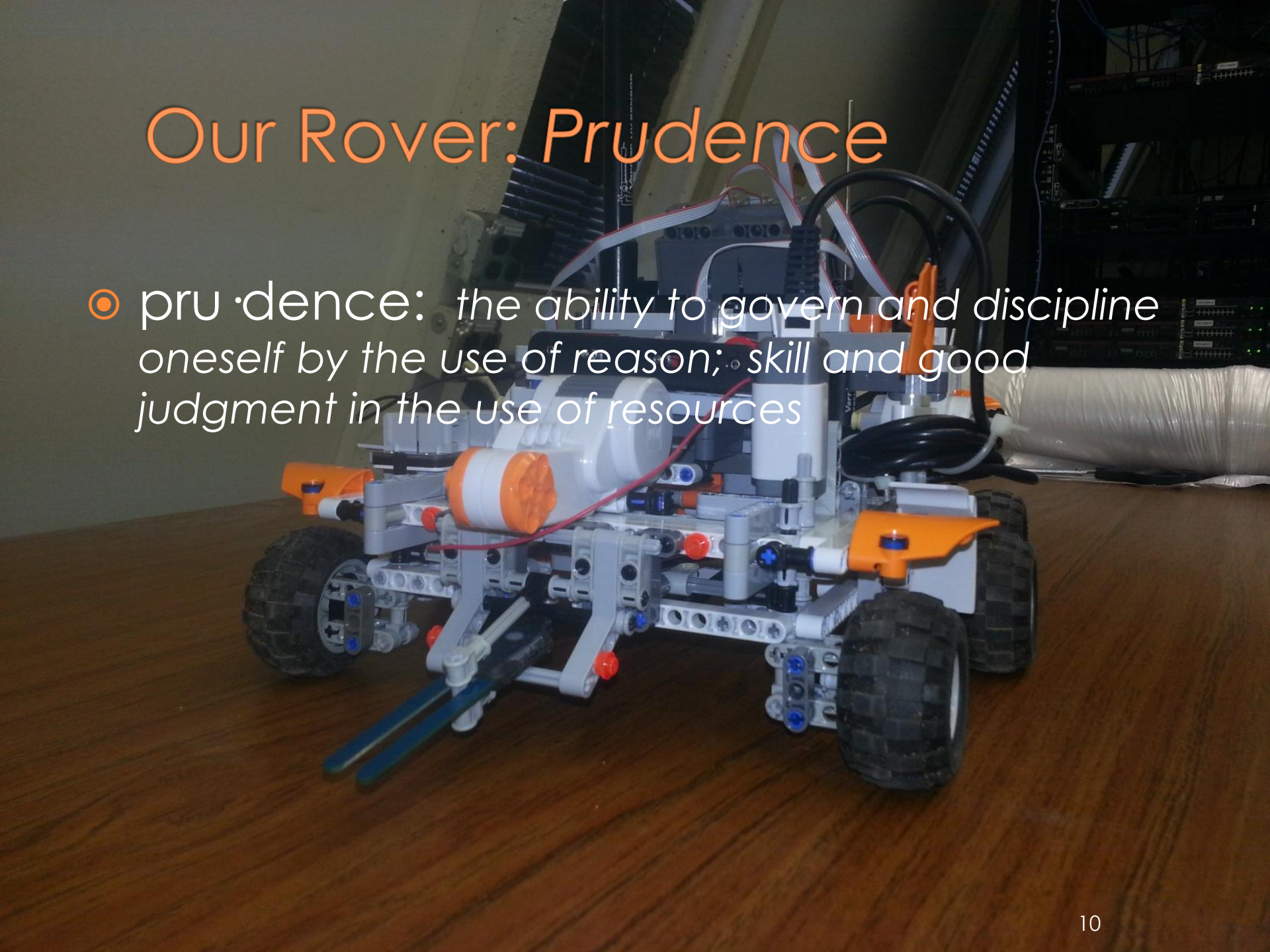
- Spirit & Opportunity Rovers 2004
  - Geology
    - Soil and Rock test for past water activity
- Curiosity Rover 2012
  - Continuation of geology
    - CheMin Lab
    - Various Spectrometers
  - More atmospheric experiments
    - REMS

Our Mission

- Inspired by previous generations of rovers
- Purposes:
  - Quantitatively and qualitatively examine environment for life sustaining qualities.
  - Fabricate a computer-based interface from which to control and monitor aspects of the rover

Our Rover: *Prudence*

- pru·dence: *the ability to govern and discipline oneself by the use of reason; skill and good judgment in the use of resources*

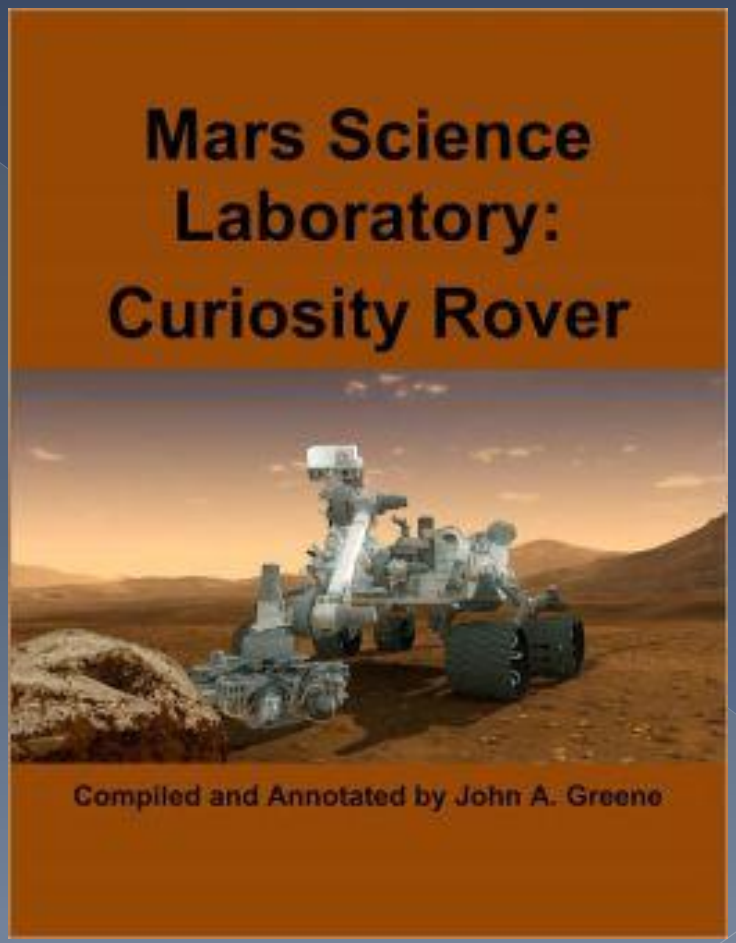


Scientific Objectives

Science	Sensor
•Quantitatively Examine: •water content in ground •atmospheric pressure •air temperature •UV levels •Qualitatively Observe: •live video stream from Rover	•Soil Moisture Sensor •Gas Pressure Sensor •Temperature Probe •UVB Sensor •Android device attached to Rover

Early Stages

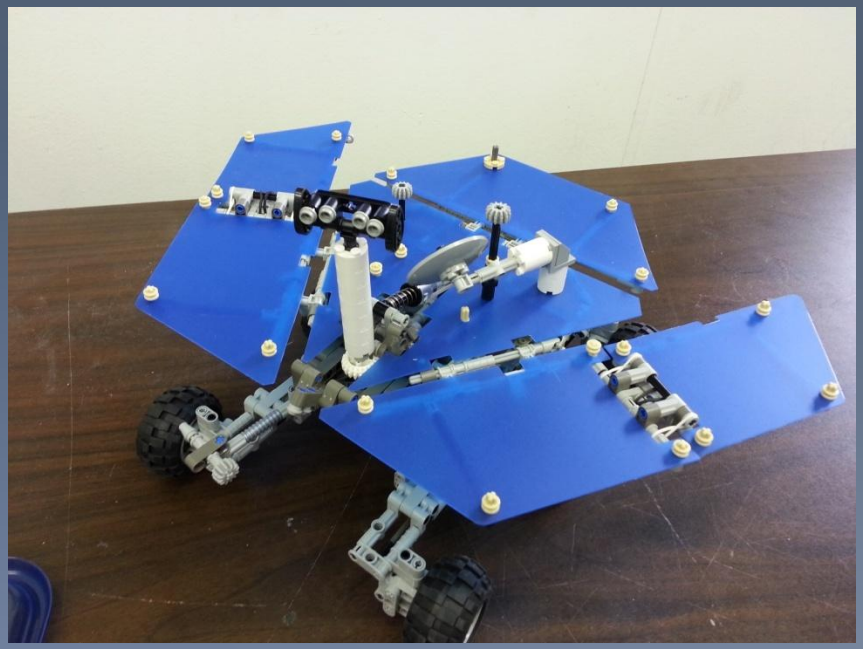
- Study of Mars



Early Stages cont'd

- Out of the box rovers

Mars Rover: Spirit Rover



Prototype #1

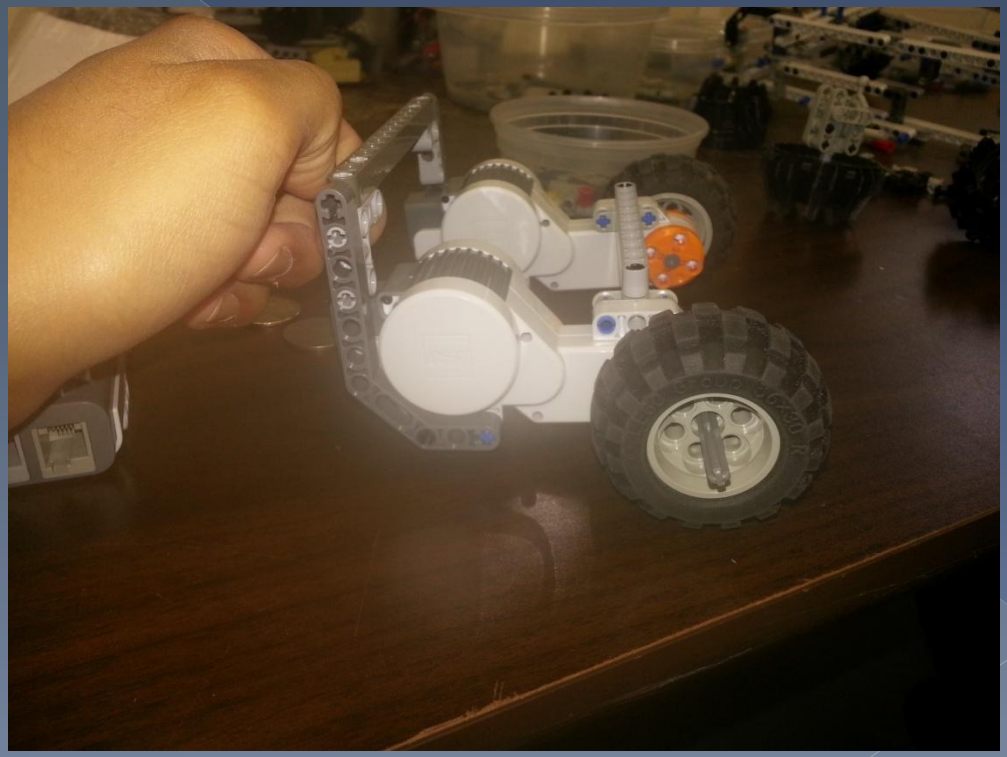
- Modified version of Spirit rover.
- Fully mechanized drive
- Autonomous operation w/ Ultra sonic sensor
- NXT-G
- Low clearance
- Bulky steering
- Very slow

Questions elicited by Prototype 1

- How do we resolve engineering issues?
- How do we integrate more robust code?
- How do we incorporate knowledge from reading onto rover?

Engineering Upgrades

- Clearance issue
  - Reorient motors, 2 in front for front wheel drive
  - Steer with differential motion of the 2 motors



Software Upgrades

- NXT G did not allow desired complexity
- RobotC and LeJOS
  - Command line based languages
  - Based on C and Java
- LabVIEW
  - Object oriented
- Decided to experiment with LeJOS and RobotC

Rover Science

- We needed various instruments that analyze Martian terrain
- Vernier Sensors

- Plethora of sensors compatible with our NXT Brick

Research and Design

- Arduino vs. NXT Brick
  - Both worked with Vernier sensors
- Experimented with LeJOS and RobotC
  - Began learning both languages
  - Languages were a bit meticulous
  - Given time crunch, needed a more efficient alternative

Research and Design (cont'd)

- Switching to LabVIEW for Mindstorms
  - Pros:
    - Systematized
    - User friendly GUI creation w/ Front Panel
    - LabVIEW is widely used in robotics and associated data acquisition
  - Cons:
    - Still a new language (to me)
    - Can only run 1 .vi(program) on NXT at a time

Research and Design (cont'd)

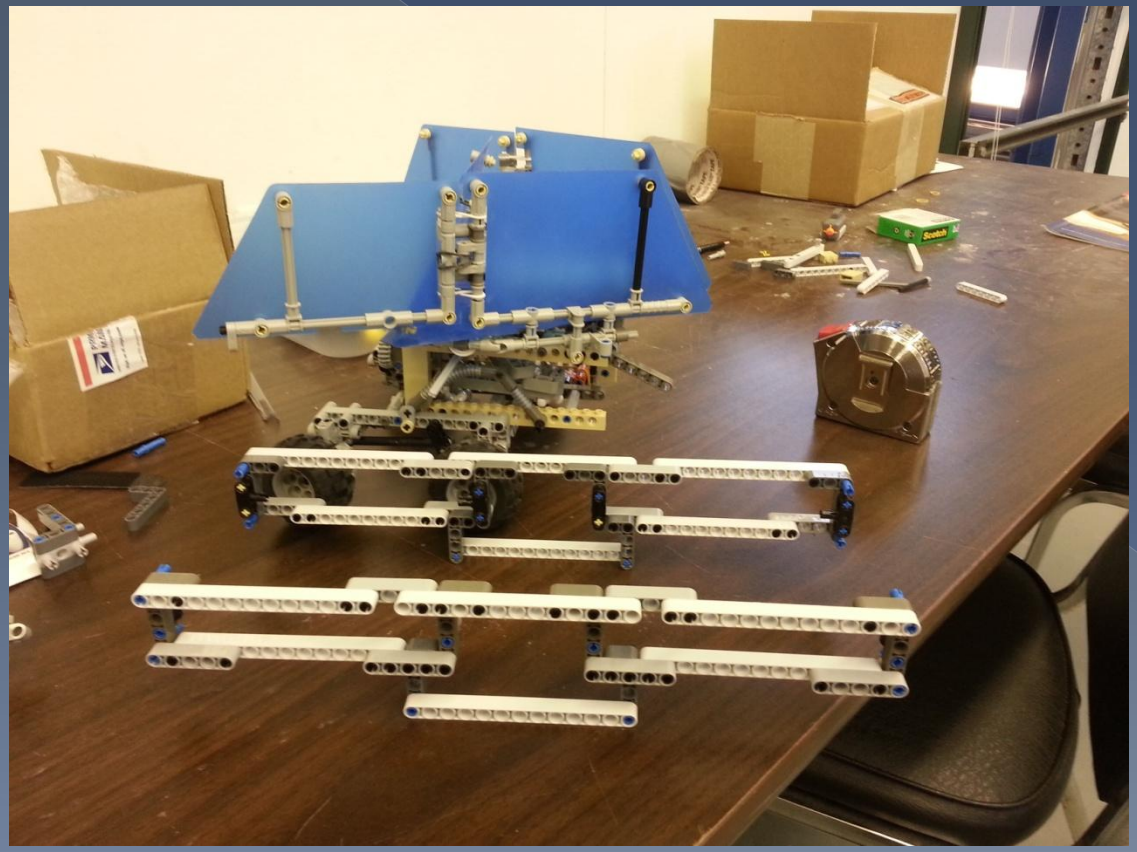
- Instruments for final version
  - Weather station sensors
    - UVB
    - Gas Pressure
    - Temperature probe
  - Chem lab sensor
    - Soil moisture
  - Drive
    - Motors
    - Ultrasonic sensor
  - Power supply
    - Solar panel
    - Rechargeable battery
  - Utility
    - Motor and sensor multiplexer

Research and Design (cont'd)

- Environment
  - The idea
    - Martian terrain will consist of portable "cage" and buckets of red clayish dust and various rocks
  - The reality
    - Dusty and rock like
    - Simulate it with some sand, gray gravel, and rocks found at Fermilab's warehouse

First Draft of Prudence

- Chassis

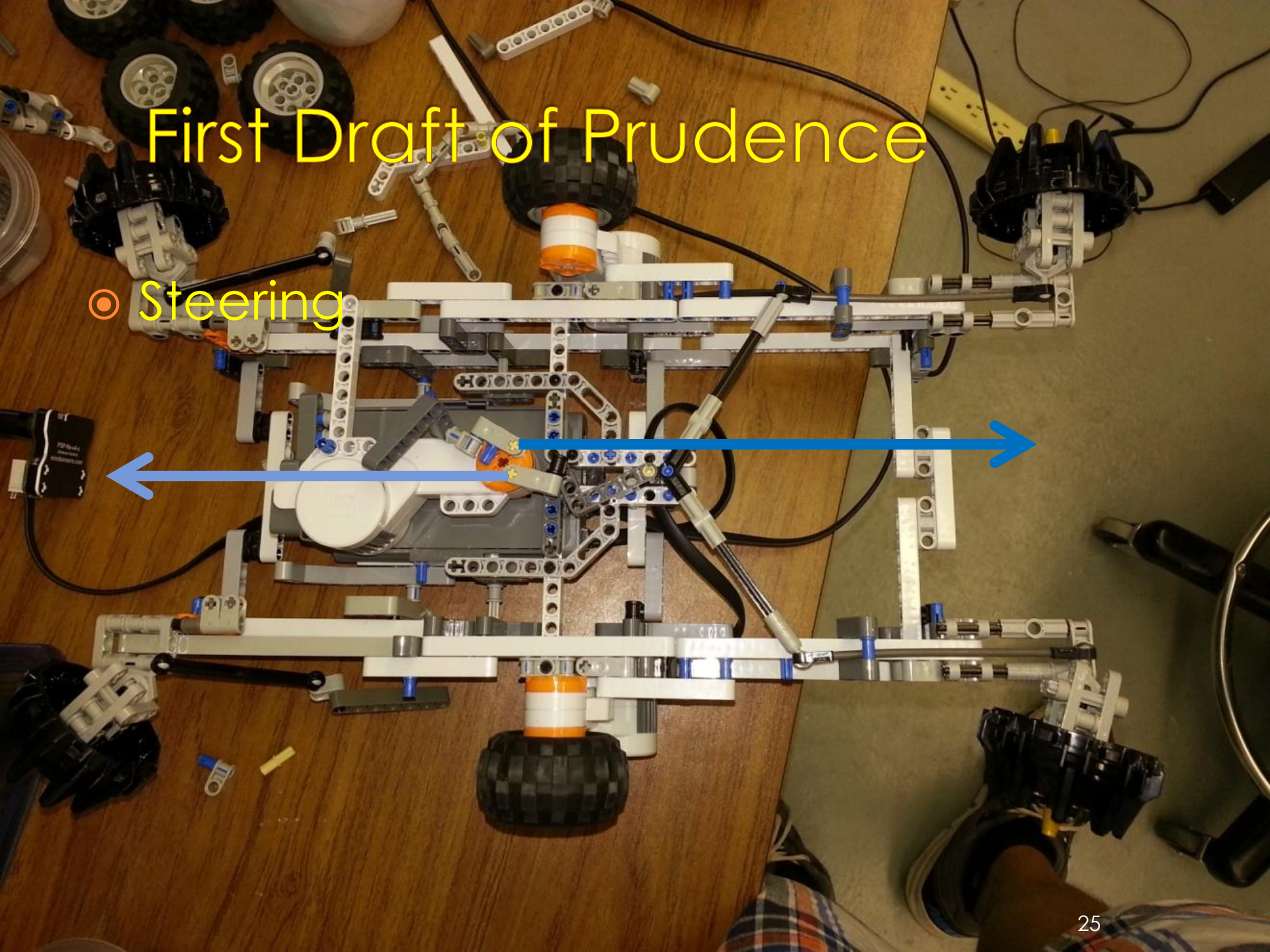


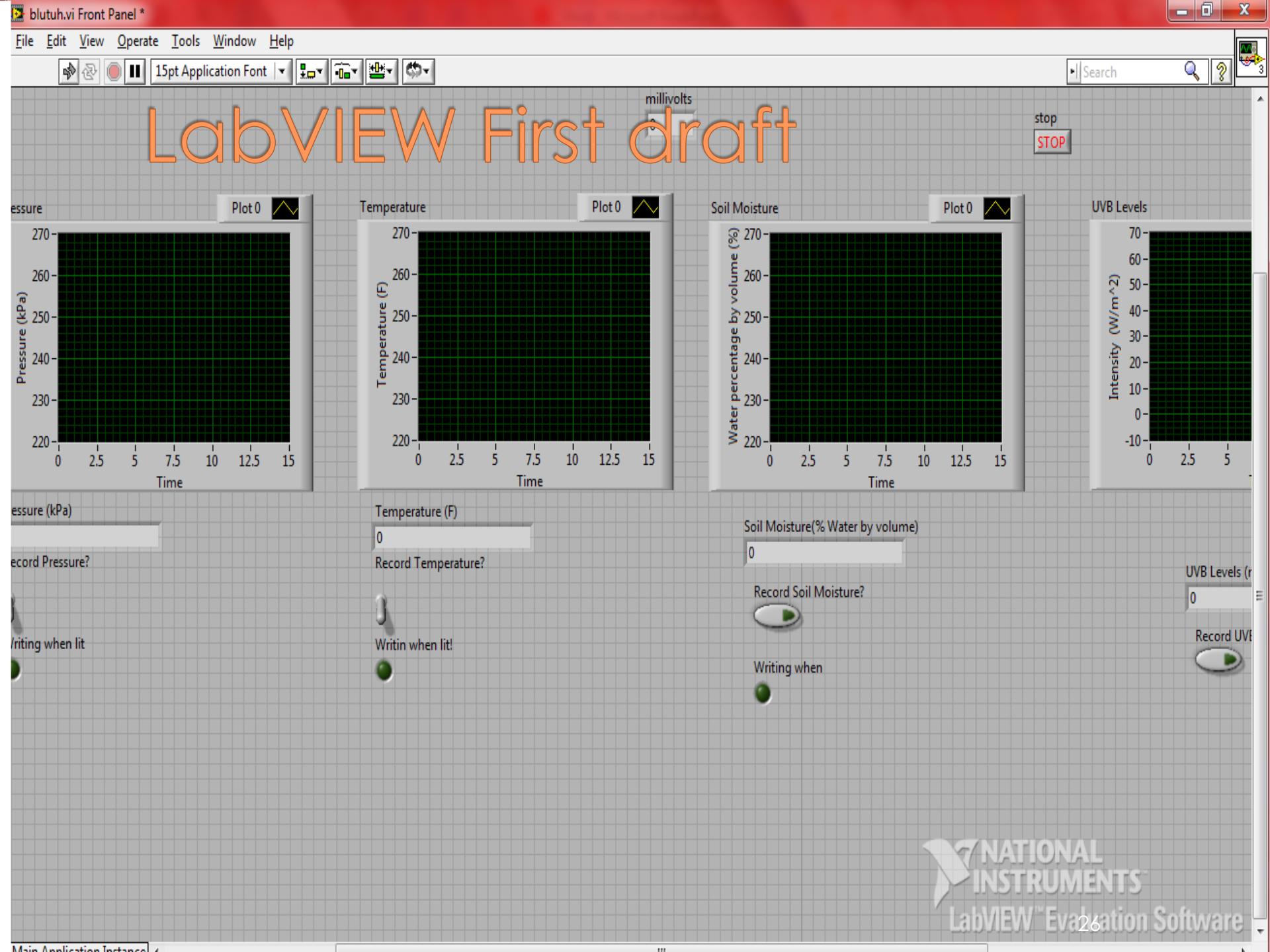
First Draft of Prudence

- Instruments

First Draft of Prudence

- Steering



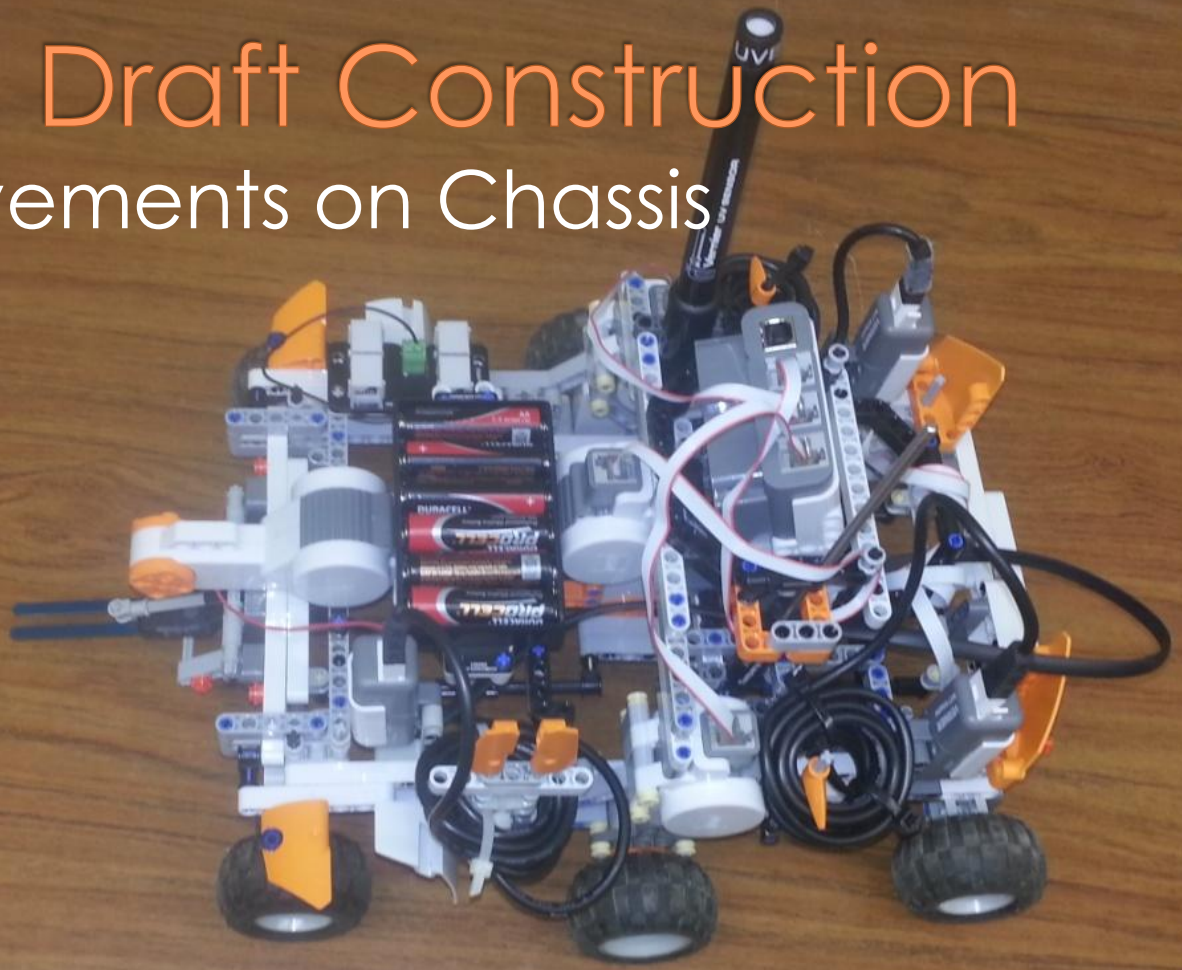

blutuh.vi Front Panel *
File Edit View Operate Tools Window Help
15pt Application Font
Search
LabVIEW First draft
millivolts
stop
STOP
essure
Plot 0
Pressure (kPa)
Time
Temperature
Plot 0
Temperature (F)
Time
Soil Moisture
Plot 0
Water percentage by volume (%)
Time
UVB Levels
Intensity (W/m^2)
essure (kPa)
ecord Pressure?
/riting when lit
Temperature (F)
0
Record Temperature?
Writin when lit!
Soil Moisture(% Water by volume)
0
Record Soil Moisture?
Writing when
UVB Levels (r
0
Record UVI
NATIONAL INSTRUMENTS
LabVIEW Evaluation Software
Main Application Instance

First draft issues

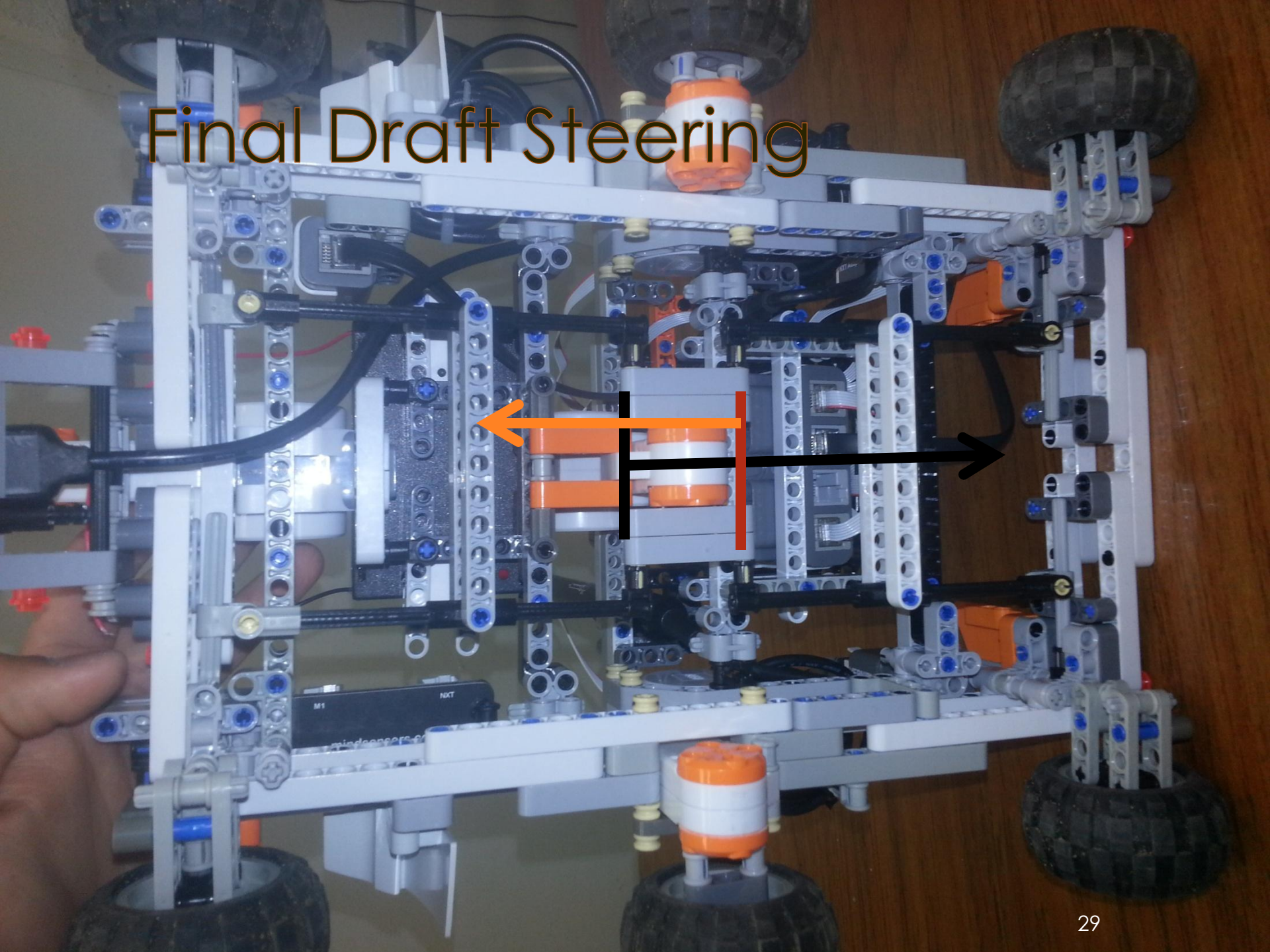
- Over weight
- Steering
- Traction
- Remote control Program
  - LabVIEW could only run one program at a time
- Solar Panel's rechargeable battery

Final Draft Construction

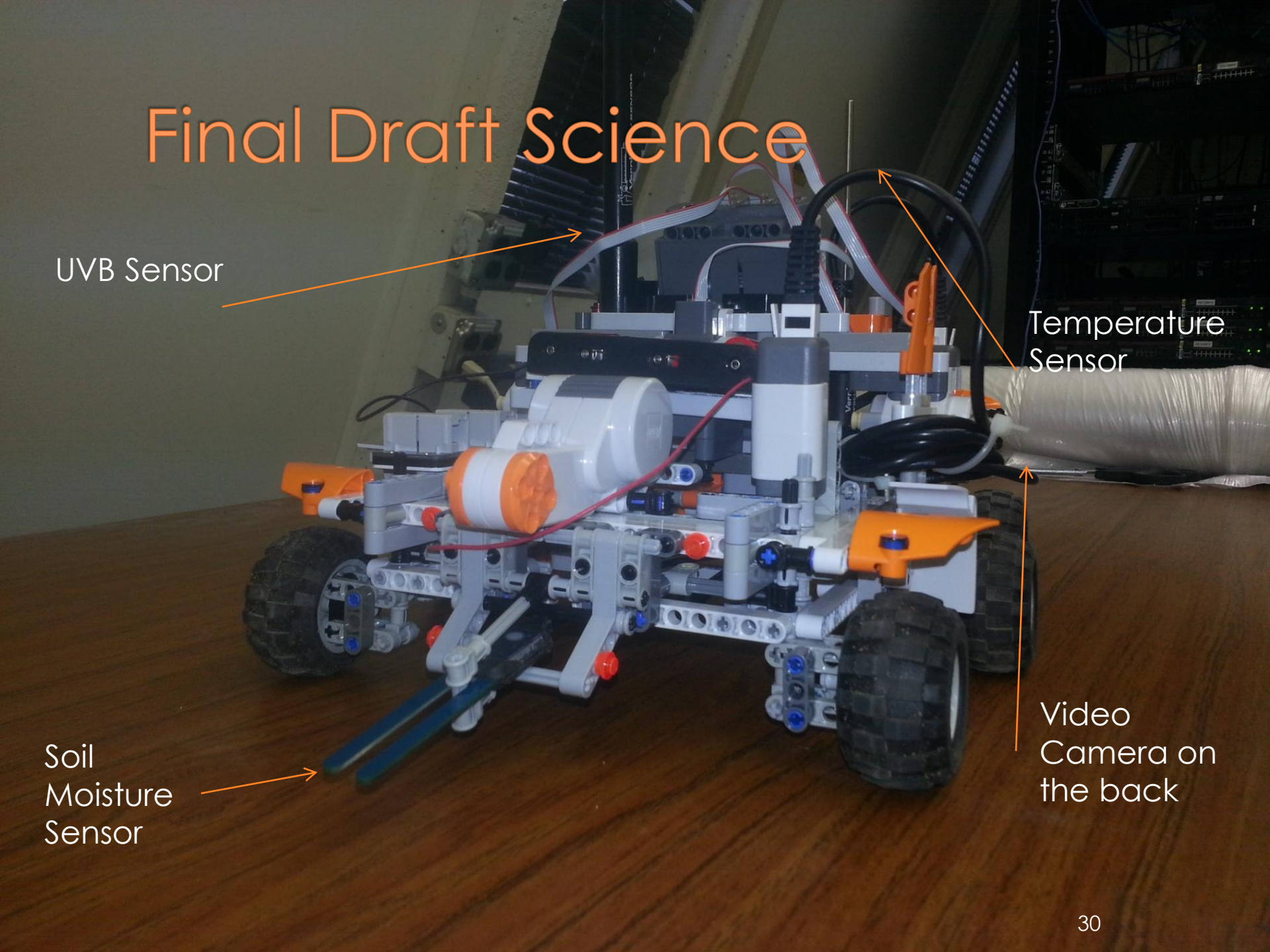
- Improvements on Chassis



Final Draft Steering



Final Draft Science



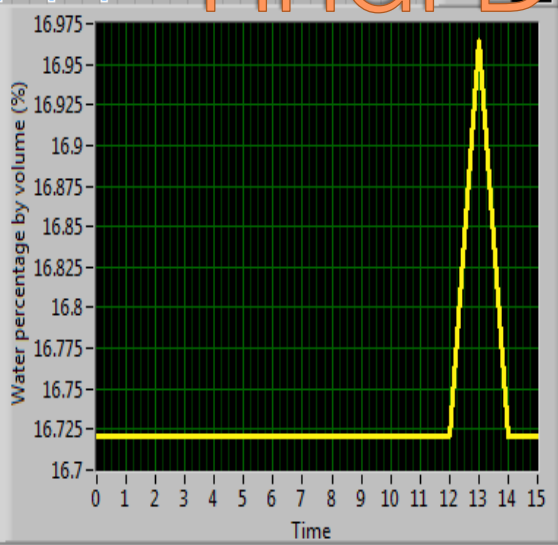
Mission Control.vi Front Panel *

File Edit View Operate Tools Window Help

15pt Application Font

Final Draft Code

Soil Moisture



Soil Moisture(% Water by volume)

16.7204

Record Soil Moisture?

Writing when lit

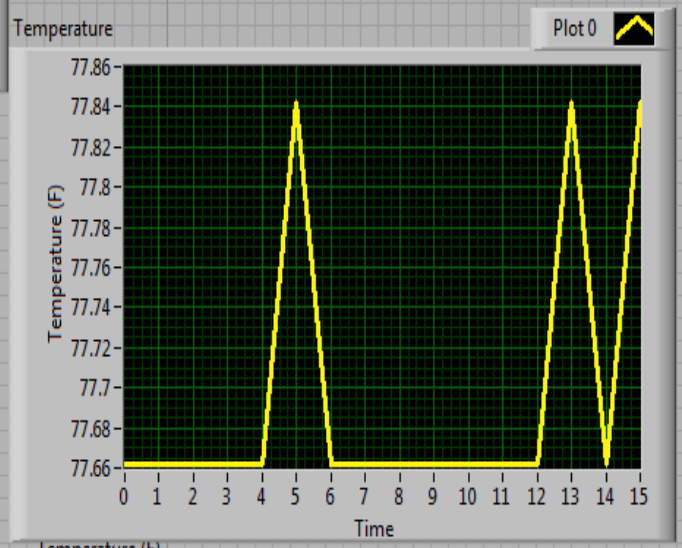
Spin Clockwise

Spin Counter Clockwise

Backup

Forward

Temperature



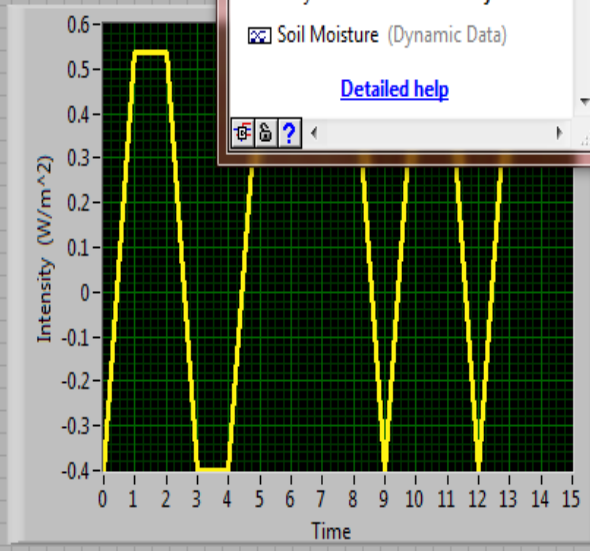
Temperature (F)

77.6617

Record Temperature?

Writing when lit!

UVB Levels



UVB Levels (mW/m^2)

-0.398

Record UVB?

Writing when lit

Context Help

Soil Moisture

Returns a dynamic data type with the values you entered in the **Array**

Soil Moisture (Dynamic Data)

Detailed help

Data?

Final Draft Autonomous Rover

Mission Accomplished! (Final package)

What was our task?

- Construct a Mars Rover using LEGO Mindstorms with potential to utilize as a medium of pedagogy that complies with Next Gen Science Standards.

Classroom

- Multifaceted teaching/learning process
  - Math, Science and Engineering
  - Humanities
    - Teamwork, planning, project management

What we learned

- Circumvention of various road blocks
  - Engineering
    - Gear Systems
      - Steering
    - Weight distribution
    - Traction
  - Software
    - New language learned: LabVIEW

What we learned con't

- Plan project with the question stem: "What will it do?"
  - Versatile with the "How to" part
  - Generic questions, then branch off to specifics
  - Graphically organize plans
- Recording logs of work accomplished
  - Blog: www.fermimachines.wordpress.com
- Learn from similar, previous endeavors

Conclusion

- A practical method of understanding some of the functions of the universe is to study machines.

The Bigger Picture

- Open ended projects encourages "autodidacticism"
- A bit of motivation, curiosity and prudence is all that is required to endeavor on an open ended project.