2020 NASA Academy

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Introduction

The 2020 NASA Academy was a ten week summer internship tasked with designing and simulating an autonomous vehicle. This internship was conducted virtually (due to COVID-19) with an interdisciplinary team of 15 students from various STEM majors. Through this internship, I learned about using Bekker's terramechanics models to determine required input power to wheels, designing for various environments, and balancing the design requirements of a mechanical team versus an aerospace team. Members of the Academy also had the opportunity to hear from various speakers from different research areas of NASA.

NASA Langley Research Center
https://www.nasa.gov/langley/virtualtour/

Working Virtually

Issues with different time zones and work hours for team members resulted in our official online hours of 8 am - 4 pm PST. Extensive use of Microsoft Teams and GroupMe helped with communication and organization of files. The group had daily subteam meetings and weekly advisor meetings to ensure everyone was keeping up to date. These were especially important as more difficulties arose when other team members met in person for the final 4 weeks.

Antarctica

The McMurdo Dry Valleys were investigated due to their similarity to the Mars climate and landscape. These valleys are extremely dry with large areas of rocks and ice. To get more detailed information on the various valleys and their geology, we spoke with Dr. Andrew Fountain of Portland State University.

McMurdo Dry Valleys
https://www.atlasobscura.com/places/mcmurdo-dry-valleys

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Designing

The design process included learning to design a vehicle for driving through various terrain (by using Bekker's Terramechanics), designing for specific climates and weather patterns, and balancing the needs of aeronautics and mechanical teams.

Trade studies were done to determine best designs for our vehicle while requirements were decided by both aeronautics and mechanical teams to set limits on our designs.

Bekker's Terramechanics

Bekker's Terramechanics calculations allow us to input tire and soil parameters and determine:

- Can the vehicle drive through this soil?
- What is the required power input per wheel?
- What is the required torque input per wheel?
- What degree of slope can be traversed in this soil?

Property	description
bw	wheel width
dw	wheel diameter
M	rover mass
Ww	wheel loading
po	tire contact pressure*
v	velocity
Ph	housekeeping power
e	motor-gearbox-drivetain efficiency

Tire and Vehicle Inputs

Property	description
m	moisture content
n	exponent of sinkage
kc	cohesive modulus of soil deformation
kf	frictional modulus of soil deformation
c	cohesion of soil
K	coefficient of slip
f	angle of internal friction
k	soil deformation modulus for tire

Soil Inputs

Property	description (per wheel)
z	sinkage (cool robot)
zrw	sinkage (rigid wheel)
zew	sinkage (flexible wheel)
Rc	contact resistance
Rc/W	dimensionless contact resistance
Rt	tire deformation resistance
Rt/W	dimensionless deformation resistance
R/W	dimensionless total resistance
Pr	power to overcome resistance
Pt	total required power (per wheel)
Tg/W	gross traction
Tn	net traction (per wheel)
Fd	drive force required to make headway
theta	maximum slope gradability

Vehicle Outputs