Terramechanics

- Origin and nature of lunar soil
- Soil mechanics
- Rigid wheel mechanics
Substitute Lectures

- F 9/19 1:00-2:15
- F 9/26 1:00-2:15
- F 10/3 1:00-2:15
- M 10/6 2:00-3:15
- W 10/15 2:00-3:15
- M 10/20 2:00-3:15
- M 10/27 2:00-3:15
- F 11/7 1:00-2:15

All lectures in ITV 1111
Lunar Regolith

• Broken down from larger pieces over time

• Major constituents
  - Rock fragments
  - Mineral fragments
  - Glassy particles

• Local environment
  - $10^{-12}$ torr
  - Meteorites at $>10^5$ m/sec
  - Galactic cosmic rays, solar particles
  - Temperature range $+250^\circ F - -250^\circ F$
Regolith Creation Process

- Only “weathering” phenomenon on the moon is meteoritic impact!

- Weathering processes
  - Comminution: breaking rocks and minerals into smaller particles
  - Agglutination: welding fragments together with molten glass formed by impact energy
  - Solar wind spallation and implantation (miniscule)
  - Fire fountaining (dormant)
**JSC-1 Simulant**

- Ash vented from Merriam Crater in San Francisco volcano field near Flagstaff, AZ
- K-Ar dated at 150,000 years old ± 30,000
- Major constituents $\text{SiO}_2$, $\text{TiO}_2$, $\text{Al}_2\text{O}_3$, $\text{Fe}_2\text{O}_3$, $\text{FeO}$, $\text{MgO}$, $\text{CaO}$, $\text{Na}_2\text{O}$, other <1%
- Represents low-Ti regolith from lunar mare
- MLS-1 simulant (U.Minn.) preferred for simulation of highland material
Soil Pressure vs. Deflection
Derivations

Displacement Energy $\frac{E}{A} = \int \frac{F}{A} dz = \int P dz$

If we sink to a depth $z_0$,$$
\frac{E}{A} = \int_0^{z_o} P dz = \int_0^{z_o} k z^n dz = k \frac{z_0^{n+1}}{n + 1}
$$

Total Energy $\frac{E}{A} = \frac{E}{A} bd = k \frac{z_0^{n+1}}{n + 1} bd$

Given a force resisting rolling $\equiv R$, the energy required to roll a distance $d$ is

$E_{\text{roll}} = Rd$

$E_{\text{roll}} = E_{\text{displacement}} \Rightarrow Rd = \frac{E}{A} bd$

Generic case:

$P = k z^n; \frac{E}{A} = k \frac{z_0^{n+1}}{n + 1}; R = k b \frac{z_0^{n+1}}{n + 1}$