Apollo Lab Summary

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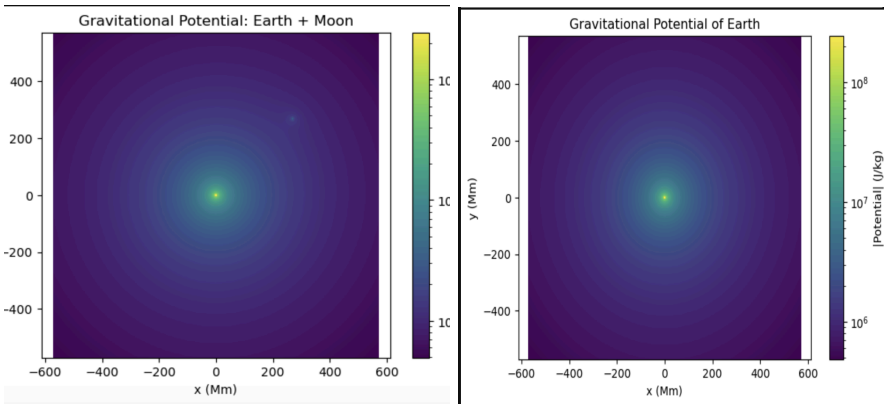
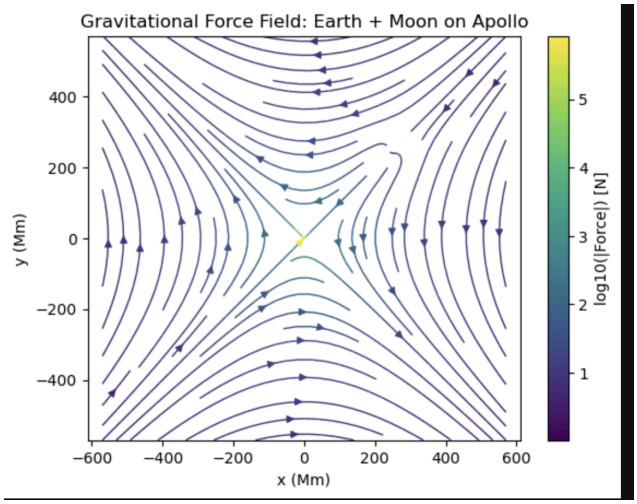
I. Overview

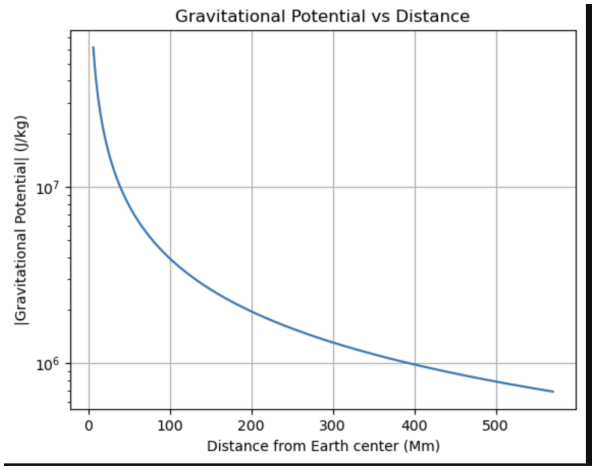
This summary models gravitational fields and rocket motion for Apollo 11 using Newtonian physics and the Tsiolkovsky rocket equation.

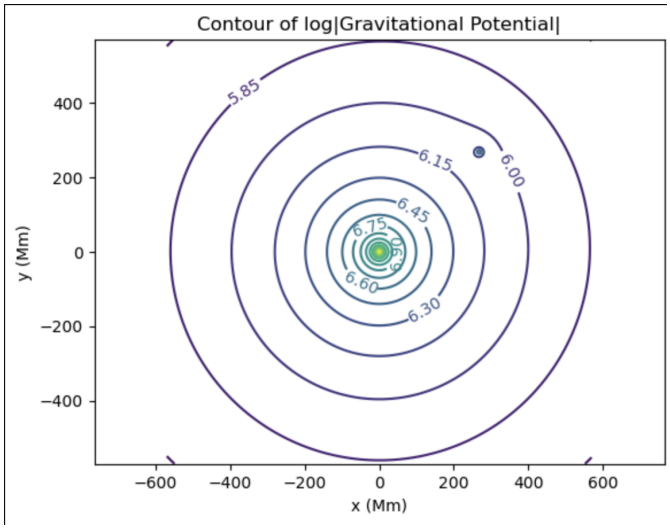
II. Gravitational Potential

- **1D Plot**: Potential drops rapidly with distance from Earth.
- **2D Earth Plot**: Radial symmetry shown with a color map.
- **Earth-Moon**: Adding the Moon shows a saddle point and Lagrange region.




Gravitational Force Field: Earth + Moon on Apollo
y (Mm)
x (Mm)
log10(|Force|) [N]


Gravitational Potential vs Distance
|Gravitational Potential| (J/kg)
Distance from Earth center (Mm)


Contour of log|Gravitational Potential|
y (Mm)
x (Mm)
5.85
6.00
6.15
6.30
6.45
6.60
6.75

III. Gravitational Forces

Using $\vec{F} = -\frac{GMm}{r^2} \hat{r}$, we plotted the net force on the Apollo module.

- **Streamplots**: Show forces curving toward Earth and Moon; magnitudes color-coded.

IV. Rocket Performance

With: $\Delta v(t) = v_e \ln(\frac{m_0}{m(t)}) - gt \quad ; \quad h = \int_0^T \Delta v(t) dt$

Inputs:

- $m_0 = 2.8 \times 10^6$, $m_f = 7.5 \times 10^5$, $\dot{m} = 1.3 \times 10^4$, $v_e = 2400$

Results:

- Burn time $T \approx 161.5$ s
- Altitude $h \approx 96.3$ km

NASA test: 160 s and ~70 km. Discrepancy likely from drag.

V. Conclusion

Assumptions:

- Point masses, no drag, constant gravity

Future Work:

- Include drag, simulate full trajectory, add relativistic effects

Results support Apollo mission under simplified models.

End of Summary