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Lab 2

I. Introduction

This report aims to determine the results of dropping a 1kg mass into a vertical mine shaft at the equator and whether it can accurately measure depth using fall time. We use findings from air drag, gravity, Earth's rotation, and planetary density to determine the impacts on the mass's motion.

II. Calculation of fall time (including drag and variable g).

Three scenarios

- No drag
    - 28.5s fall time
- Variable gravity
    - 29.1s fall time
    - Gravity weaken with depth, which slows fall
- Variable gravity and drag
    - 52.3s
    - Drag significantly delays impact

Drag was calibrated by assuming the test mass reaches a terminal velocity of 50 m/s

III. Feasibility of depth measurement approach (including Coriolis forces).

Coriolis force cause drift, the Earth's rotation can push the mass sideways when it is falling

Shaft wide is 5 meters

- No drag
    - Displacement 32.7m
    - Collision time 22.4s
    - 2.8km depth
- Drag
    - Displacement 18.2m
    - Collision time 19.8s
    - 2.1km depth

The mass hits the shaft wall so it is not feasible. Shaft might need to be widened to over 30m.

IV. Calculation of crossing times for homogeneous and non-homogeneous earth.

n=0

- Time to center is 21.4 minutes
- Speed is 7.9km/s
    - This matches orbital velocity

n=9

- Time to center is 16.2 minutes
- Stronger gravity closer to core

Moon's Density 3344kg/m^3

- 27.4 minutes

V. Discussion and Future Work

Approximations

- Earth and Moon are perfectly spherical
- Ignored shaft wall friction
- Simplified density

Improvements

- Use accurate density models
- Add centrifugal force that might affect the mass's movement

- Model the shaft's shape and geometry

Figures

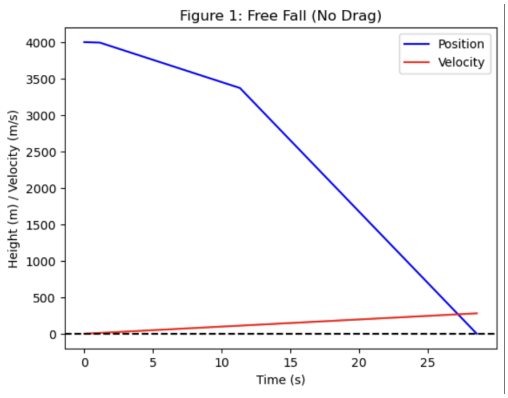

Figure 1: Free Fall Validation

Numerical and theoretical results match

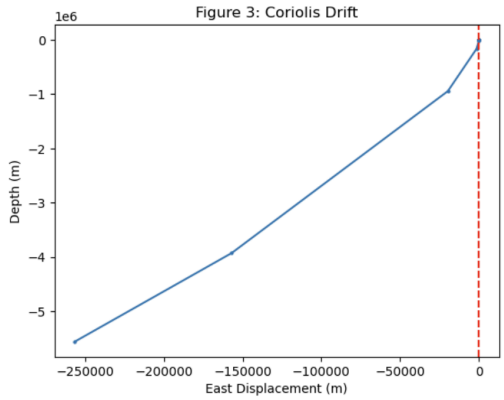

Figure 3: Coriolis Drift

Displacement is east

This shows that this method does not work

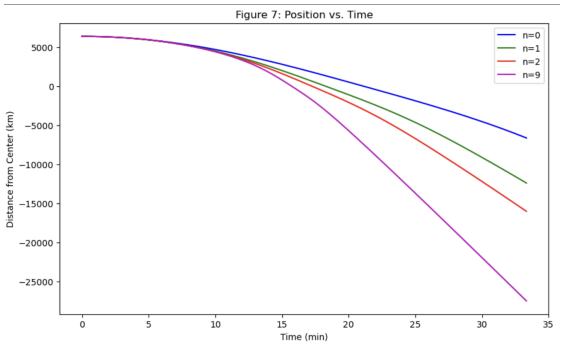

Figure 7: Density Impact on Fall Time

Crossing time between uniform and dense core of Earth

This highlights the impact of density