Week 1: Inclined Plane and Classical Dynamics

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April 28, 2025

Weekly Focus

This module introduces Newton's Second Law applied to inclined planes, basic dynamics, and connections to calculus-based motion analysis.

Topics Covered

- Free-body diagrams for objects on inclines
- Decomposition of forces: gravitational, normal, and frictional
- Root-finding and modeling from Burden & Faires
- Probability intersections from Asimow & Maxwell
- Calculus-based derivations of kinematic equations

Calculus Derivations

$$
\begin{aligned}
v(t) &= \frac{dx}{dt} \quad \text{(velocity)} \\
a(t) &= \frac{dv}{dt} \quad \text{(acceleration)} \\
x(t) &= x_0 + \int v(t)\,dt = x_0 + v_0 t + \frac{1}{2}at^2 \\
v^2 &= v_0^2 + 2a(x - x_0)
\end{aligned}
$$

GRE-Style Problem Set

- Q1: A 2.0 kg block slides down a frictionless incline of 30°. What is the acceleration? Use $a = g\sin\theta$.
- Q2: Derive time of flight and max height for a projectile using integrals.
- Q3: Use Newton-Raphson to find t such that $x(t) = 5$ for $x(t) = x_0 + v_0 t + \frac{1}{2}at^2$.
- Q4: If $F(t) = 5t$, find velocity for a 1 kg mass.
- Q5: Find normal/tangential acceleration components for $y = \sin(x)$.

Computational Physics with Python

These exercises emphasize algorithmic thinking applied to classical systems.

Euler Method for Inclined Plane Motion

Simulate motion of a block sliding down an incline using Euler integration.

Vector Field Plotting

Use Python to visualize gravitational field vectors over a 2D grid.

Files Included

- incline_diagram.py
- incline_diagram.ipynb
- free_body_diagram_block_on_incline.svg
- bisection_method.py
- combinatorics_simulation.py