NC STATE UNIVERSITY

Why Computation in Physics?

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Introductory Calculus-Based Physics for Engineers & Scientists:

Why computation?

- Authentic physics
  - Theory + Experiment + Computation
- Modeling complex systems
  - No analytical solutions typically available
- Fundamental principles
  - Time evolution (Newtonian Synthesis)
  - Vectors as tools
- 3D visualization
  - To be discussed later by Ruth Chabay

The Newtonian Synthesis

Open-ended prediction of motion into the future

$\vec{\mathrm{F}} = f(\vec{\mathrm{r}})$ Force as a function of position

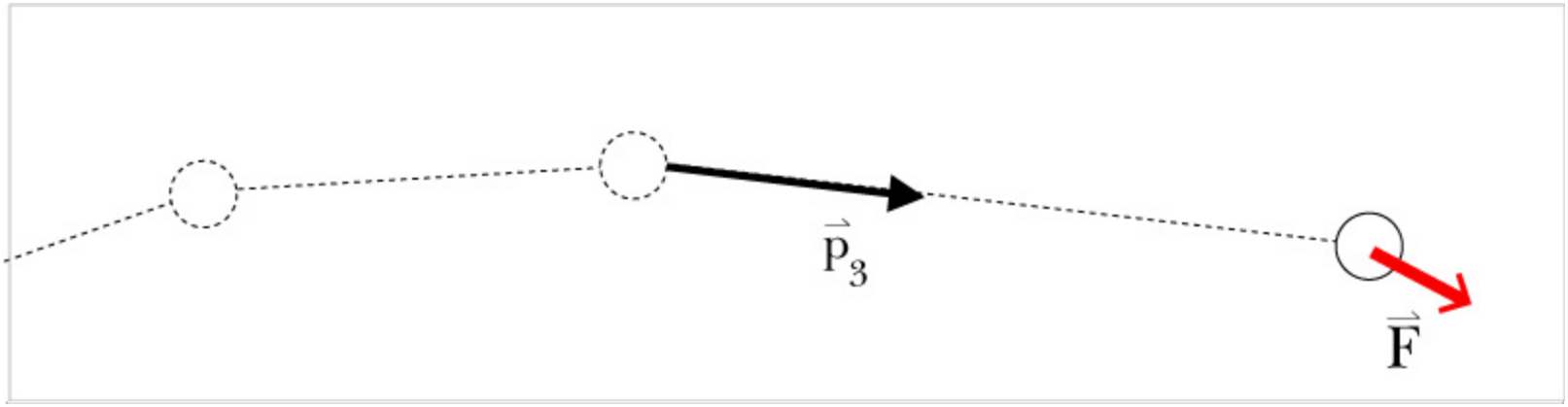
$\Delta\vec{\mathrm{p}} = \vec{\mathrm{F}}\Delta t$ **The Momentum Principle**

$\vec{\mathrm{p}} \Leftarrow \vec{\mathrm{p}} + \Delta\vec{\mathrm{p}}$ Update momentum

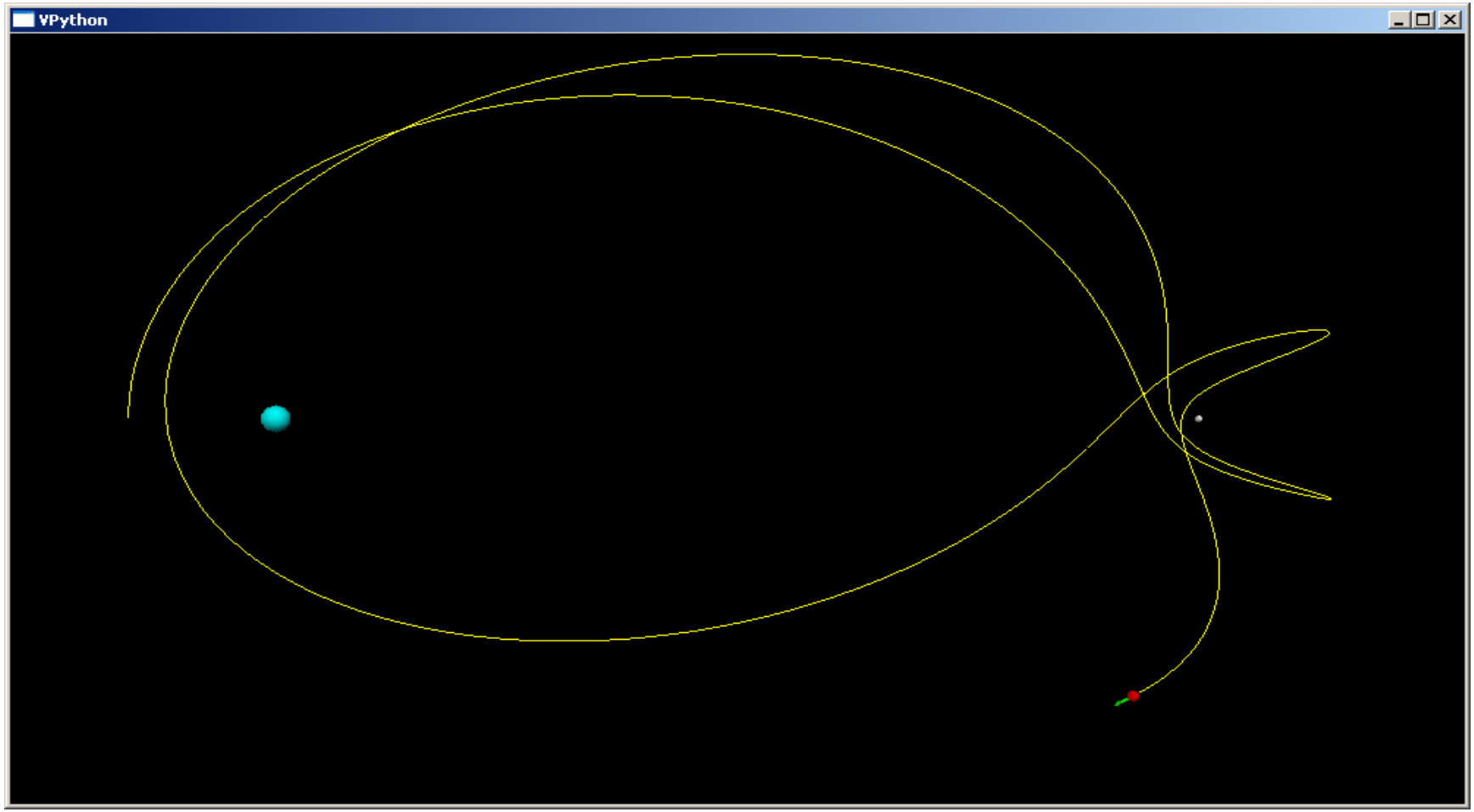
$\vec{\mathrm{r}} \Leftarrow \vec{\mathrm{r}} + \vec{\mathrm{v}}\Delta t$ Update position

do it again

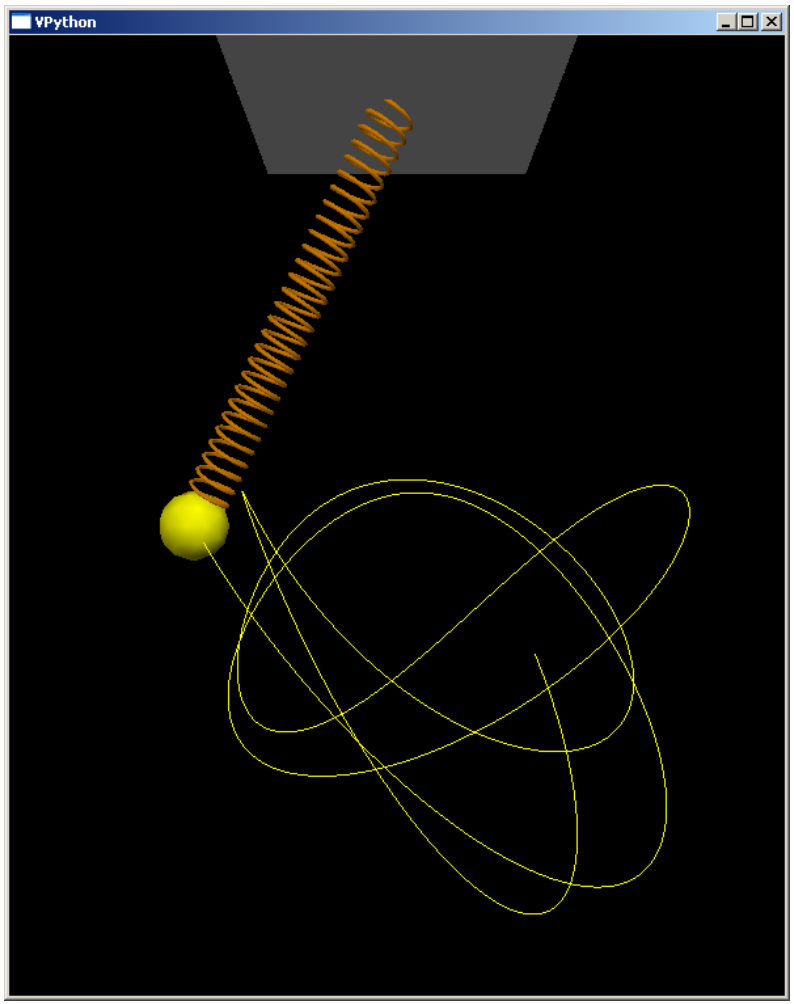
The Momentum Principle



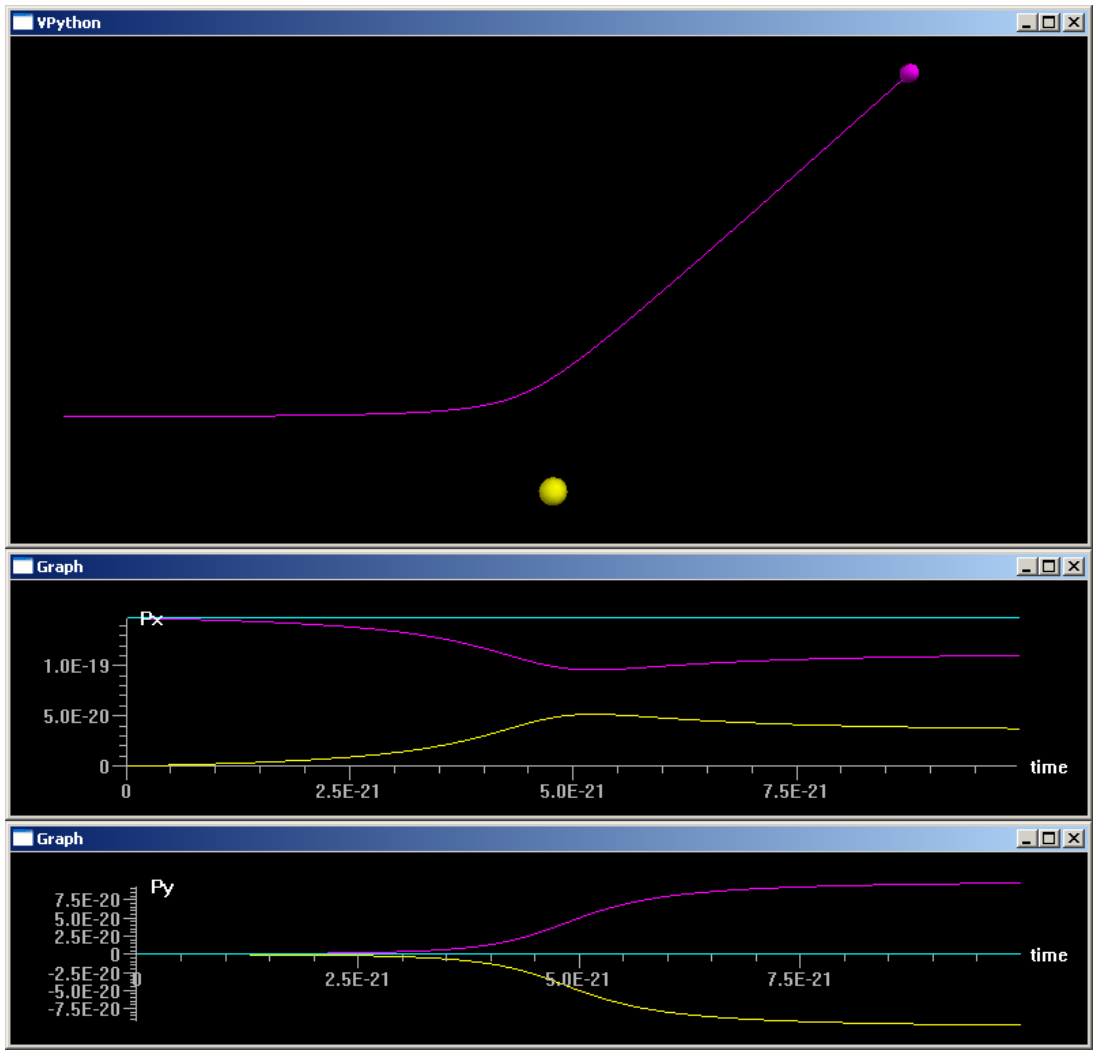
Student program: 3-body orbit



Student program: 3D spring-mass



Student program: Rutherford scattering (alpha particle incident on a gold nucleus), with graphs of momentum



Why Programming?

- No black boxes
  - Student codes all the physics
- Same fundamental principles invoked in different situations
- Links multiple representations
  - Equations
  - Code (symbolic, not numeric)
  - 3D animation of motion / visualization
  - Graph

Computational Labs

- compadre.org:
  search for VPython computational labs