Novel Laboratory Activities Emboldened by Open Source Physics

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Exploring lab activity variations with

- Tracker (video analysis and modelling)
- EJSS simulations (intro and concepts)
  - Custom, "on demand"

Iterative and never-ending explorations?

A snapshot of some of my EJSS projects,
links to OSP/Compadre as appropriate
https://phys23p.sl.psu.edu/~mrg3/interactives/EJSS_mrg/

Gravity with a twist, building on basketball toss with Tracker

Complications for a tossed ball?

Students' first guesses - drag

Soccer, Toy and Beach Balls

Curve fits with $g = 2A$

Curve fits to "top" of parabola

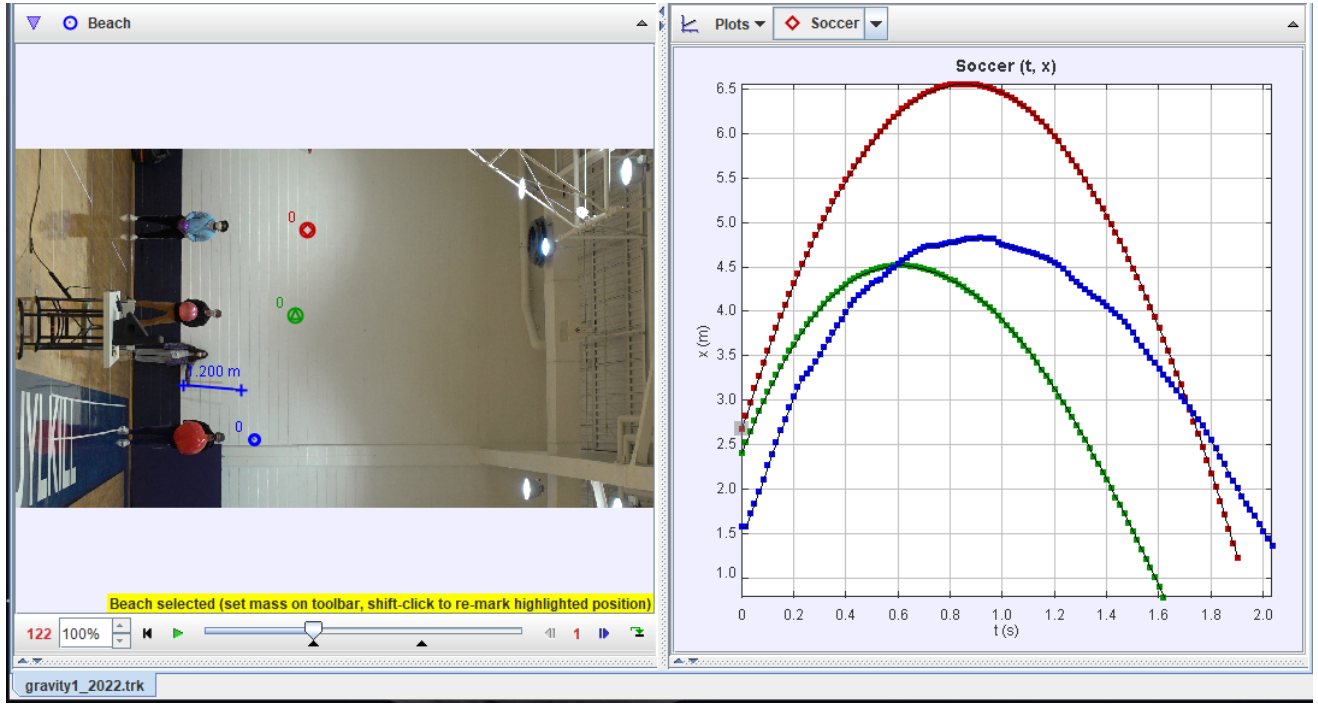
Low speed=low drag

$g_{soccer} = 10.1\ m/s^2$, modelling

$g_{toy} = 8.38\ m/s^2$, $g_{beach} = 6.40\ m/s^2$

Buoyancy is the difference!

Graphs have hints of terminal velocity



Autotracking issues with underinflated beachball –more problem solving to do

Unintended Spin: unwanted Magnus effect

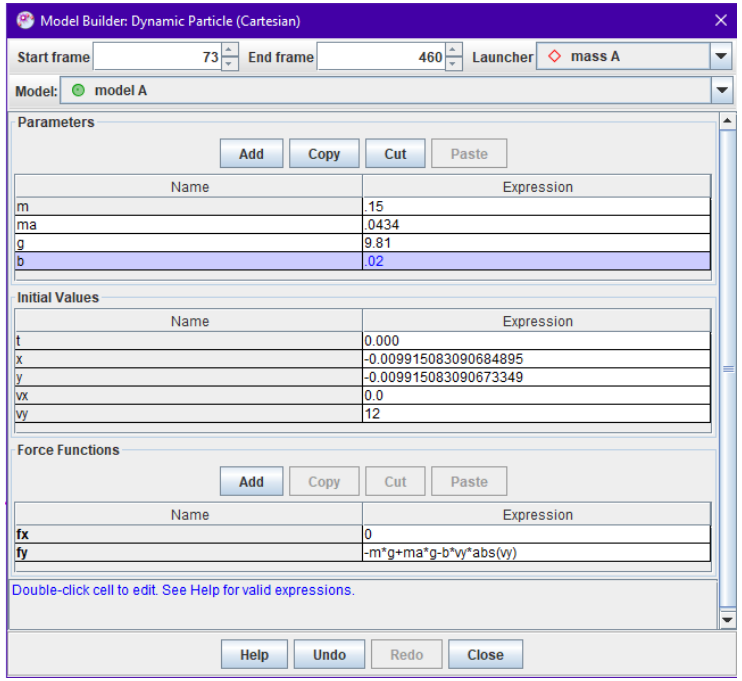
A more complete beach ball model:

Gravity, Drag, Magnus, and Buoyancy

$$(m_{ball} + m_{air})\vec{a} = -(m_{ball} + m_{air})g\hat{z} + m_{air}g\hat{z} - \frac{1}{2}C_D\rho A v\vec{v} + \rho C_{spin}\, r_{ball}^3 \vec{\omega} \times \vec{v}$$

Adding to lab activities:

- Buoyancy: $g_{effective} = \frac{m_{ball}}{m_{ball}+m_{air}} g$
- drag: $C_D = \frac{2m_{ball}g}{\rho A v_T^2}$
  - Terminal velocity and modelling
- Advanced: Tracker model full dynamics
  - $m = m_{ball} + m_{air}, m_{air} = \rho \frac{4}{3}\pi r^3$
  - v_0 from video data
  - $\mathrm{b} = \frac{1}{2}\rho C_d A, C_d \approx 0.5$



More beach ball:

Gravity, Drag, Magnus, and Buoyancy (oh, my!)

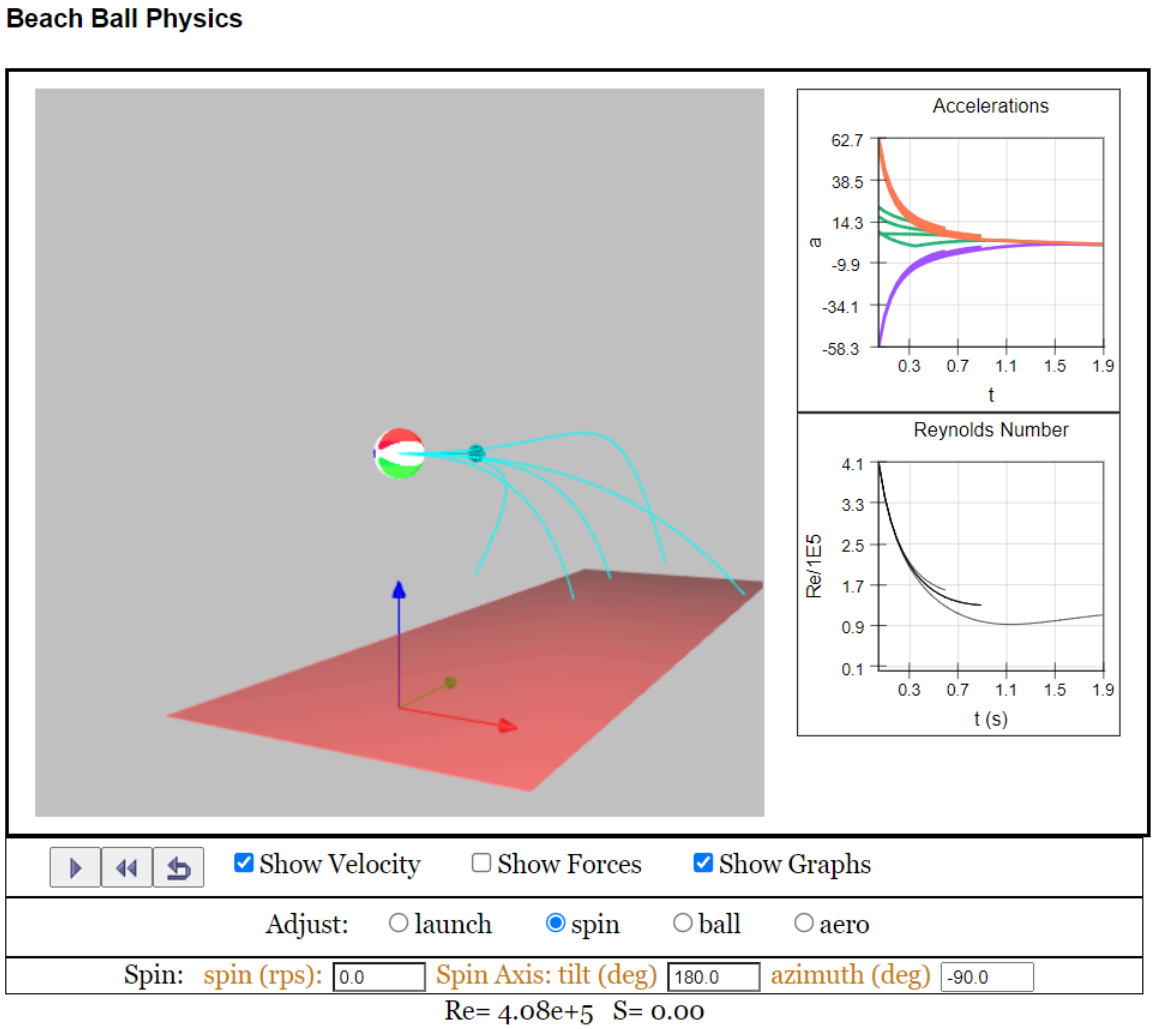
$$(m_{ball} + m_{air})\vec{a} = -(m_{ball} + m_{air})g\hat{z} + m_{air}g\hat{z} - \frac{1}{2}C_D\rho A v\vec{v} + \rho C_{spin}\, r_{ball}^3 \vec{\omega} \times \vec{v}$$

Tracker Video analysis:

- Side views, top views with drone
- Curve ball, sinker, floater
- Collisions!

Modelling In EJSS

- compadre.org ID=15165



Rubber Band “Bungie Jumps”

Ideal Springs and beyond

Design contest:

- Closest to ground without impact
- Closest to predicted first bounce

Tracker Video Analysis

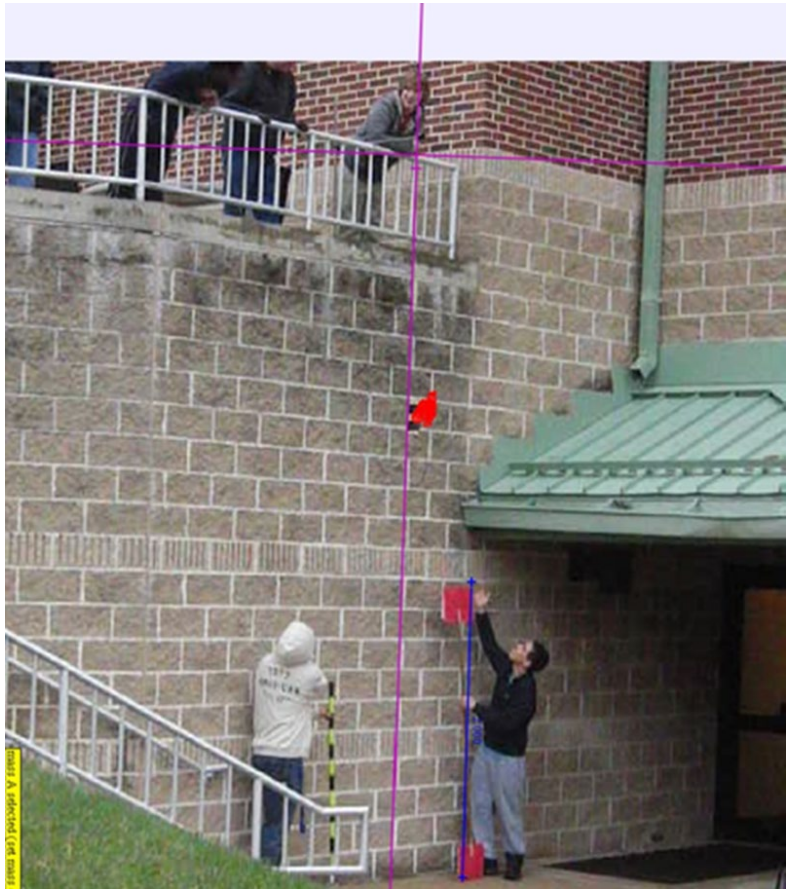
- Site measurements
- Contests winner determination
- Model validation

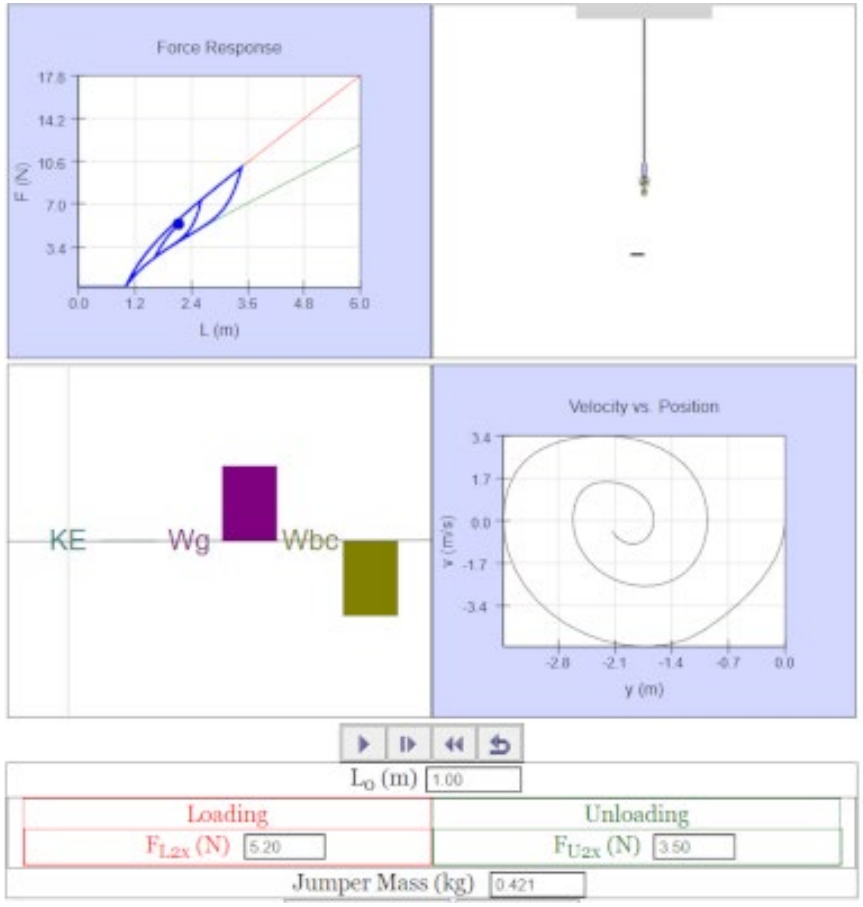
Elastic Hysteresis, Work and Energy

- Measurement Methodology
  - Pasco force and motion sensors
- Models and EJSS simulation

compadre.org

- ID=14319 Hooke’s Law Model
- ID=15165 Elastic Hysteresis

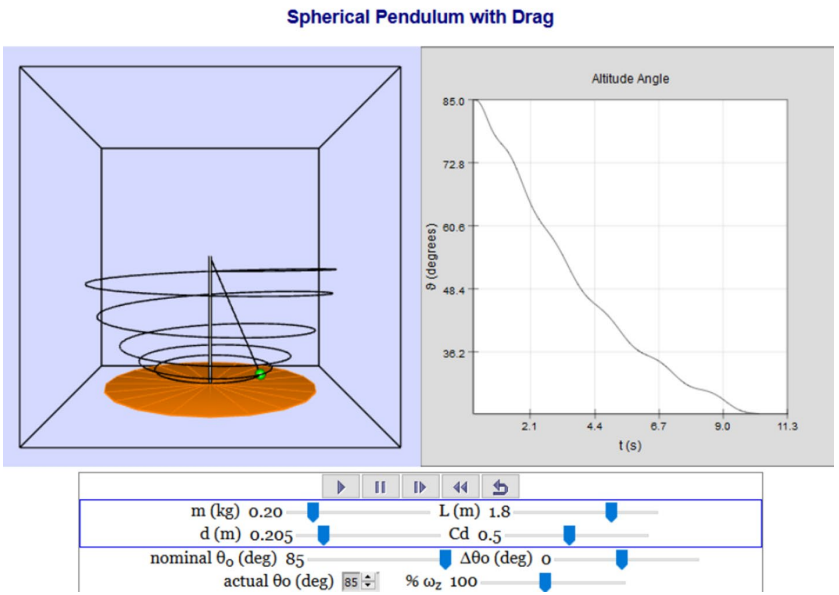


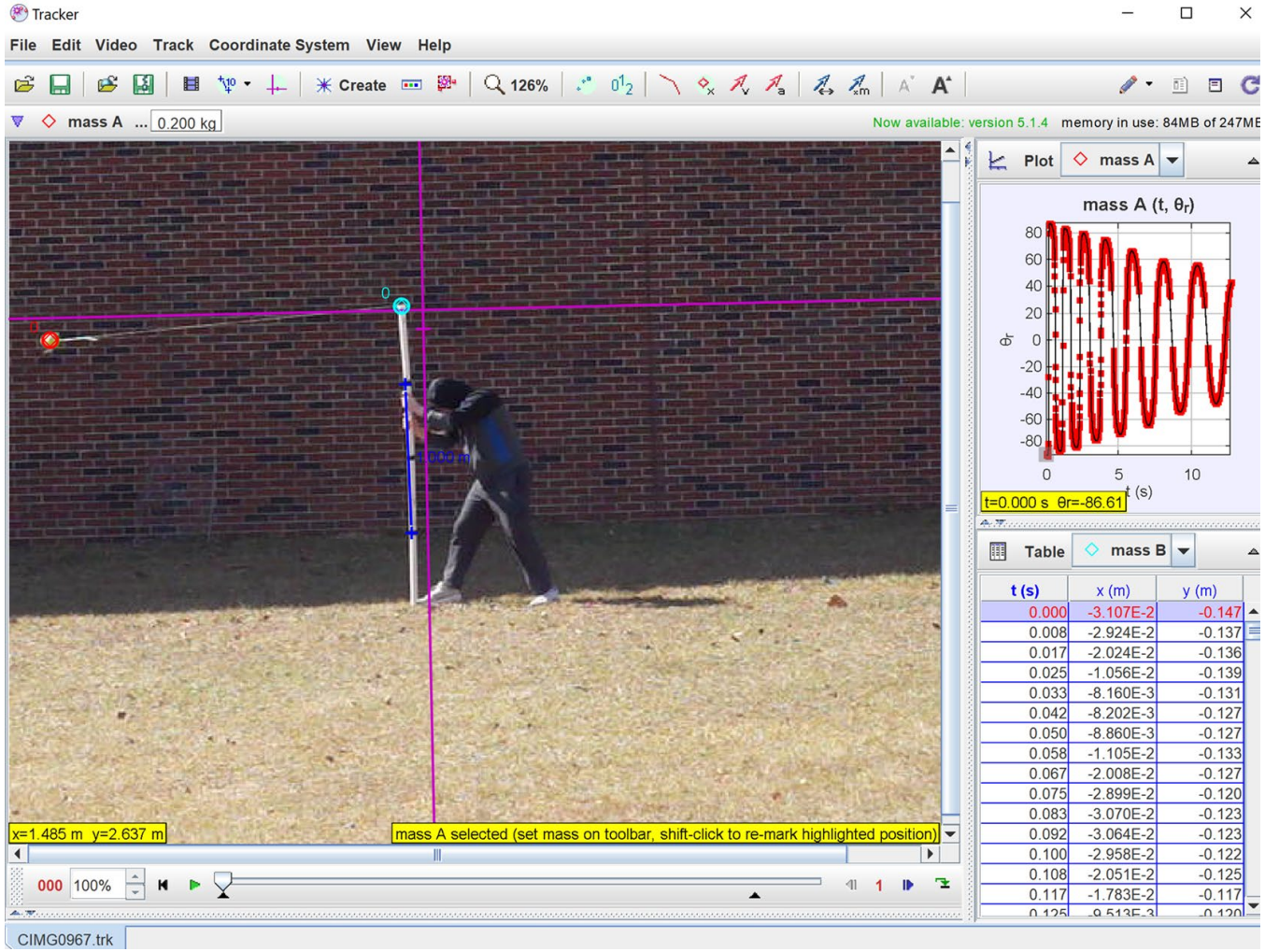


Visceral Conical Pendulum

Another Hands on Experience for Tracker Video

- Measurement Methodology
- Models and EJSS simulation and proof of concept
- Early Stages





Student Participation (honors projects+) involving OSP

2009-2021

- Ticcard Bowser
- Cody Wiscount
- Ryan Chesakis (multiple)
- Justin Bastawrose
- John (Austin) Bayliff
- Christopher Hillman
- Carlos Rivera
- Shane Hall
- Benjamin Blake
- Quentin Moyer (multiple)
- Hunter Snyder
- Ryan Vidal
- Phillip Plasky
- Kelsey Shaffer
- Baylee Colburn
- Jesse Foran (multiple)
- Travis Barrow (multiple)
- Samuel Petersen
- Lauren Gober
- Stephen Byron
- Robin Bozeman
- John Cabarcas
- Zilong Wang
- Yuxuan Cai
- Dylan Miller
- Caleb Reedy
- Jonathan Stacey

Other EJSS/EJS Modelling

- Amusement Park Physics (lots)
- Quick Virtual Activities (Covid and remote learning)
- Game Physics Demo
- Physics of Medical X-Rays
- Math
  - Predator-Prey population dynamics
  - Differential Equations direction fields

https://phys23p.sl.psu.edu/~mrg3/interactives/EJSS_mrg/

OSP Personal Impact *

- New avenues of exploration for all students
- Students involved in developing new activities
- Indulge instructor's curiosity and creativity

*This talk does not even begin to address the impact of other authors' OSP simulations and activities on my curricula