North Carolina
School of Science
and Mathematics

Interactive Web Physics

Physics Animations that Run in a Web Browser

Taylor Brockman (Brain Power Software)
Jonathan Bennett, Andy Wang, Benjamin Wu (NCSSM)

NCS-AAPT Workshop
November 16, 2019

North Carolina School of Science and Mathematics

Workshop Agenda

1. Origin story, connectivity, and tour of IWP6 - **Taylor**, 10m

2. Creating a simple animation with projectile motion - **Jon**, 10m

3. Using the IWP6 library of built-in functions to create more complex animations, specifically elastic collision - **Ben** 10m

4. Simulation with Euler's method with IWP + orbital motion challenge - **Andy** 20m

5. Q&A and Discussion about ways to use IWP - **Everybody** 10m

North Carolina School of Science and Mathematics

IWP Origin Story

1. Open Source! Founded in 1998, Java Version 1.1, 25+ Students

2. “Designer” is a key differentiator that empowers everyone to author new content. Embrace competition and evolution

3. Tech transition starting 4 years ago from Java Applet to Web, with a priority of preserving our content library of animations

4. Integration with online student systems like WebAssign

5. NCSSM Physics instructors, Winters, Bennett. Used for 10+ years in Online, AP Physics 1, Hybrid, Practice & Review, Waves & Optics

Interactive Web Physics 6

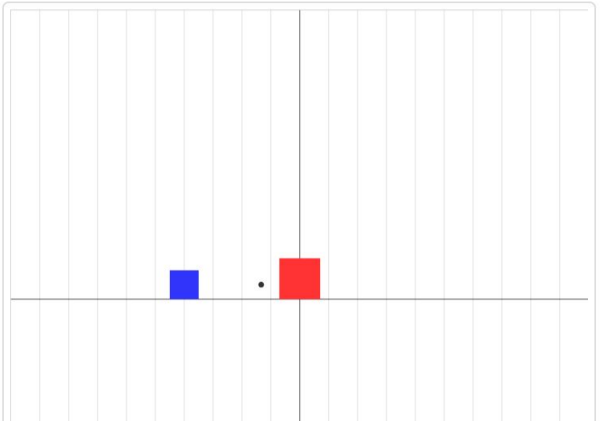
www.iwphys.org

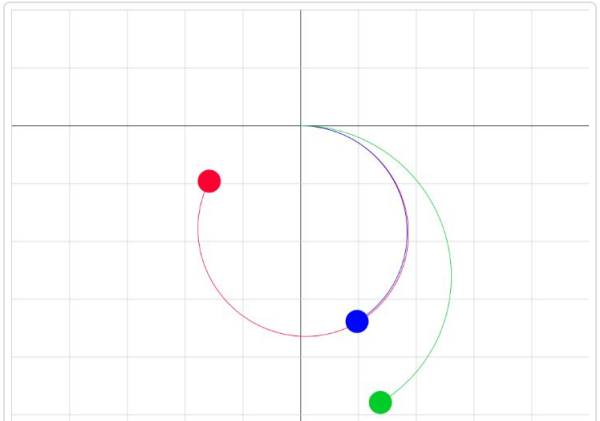
Physics animations that run in your web browser and tablets using HTML

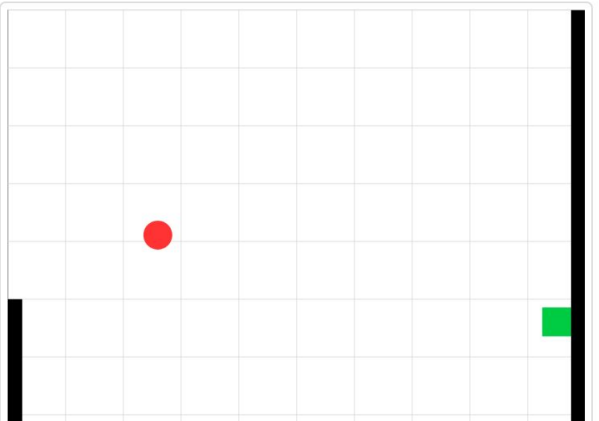
Packaged Animation Collections

Charged Particle Motion | Electrostatics | Forces | Kinematics | Momentum, Collisions, KE | Optics | Oscillations

Popular Animations





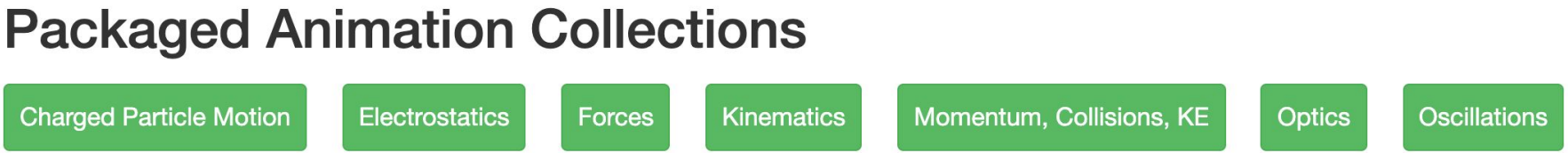


North Carolina School of Science and Mathematics

IWP Animation Library

IWP ships with a complete library of physics animations developed over the past 20 years at NCSSM.

From the homepage www.iwphys.org, click any of the green buttons to view the best of four packaged animation collections:



North Carolina School of Science and Mathematics

Connectivity

1. Wi-Fi: NCSSM Guest, Conference Specific Username + Password

2. Web: https://www.iwphys.org/, Sign In Top Right

3. IWP: Username = **ncptc1**, Password = **Peebles**
ncptc2...
ncptc70

4. Animate one of our popular animations from the home page on your own laptop. Great work, keep it up! Chrome or Firefox please.

Got Issues? You get a special visit from me while the show goes on.

North Carolina School of Science and Mathematics

Workshop Agenda 2

1. Origin story, connectivity, and tour of IWP6 - **Taylor**, 10m

2. Creating a simple animation with projectile motion - **Jon**, 10m

3. Using the IWP6 library of built-in functions to create more complex animations, specifically elastic collision - **Ben** 10m

4. Simulation with Euler's method with IWP + orbital motion challenge - **Andy** 20m

5. Q&A and Discussion about ways to use IWP - **Everybody** 10m

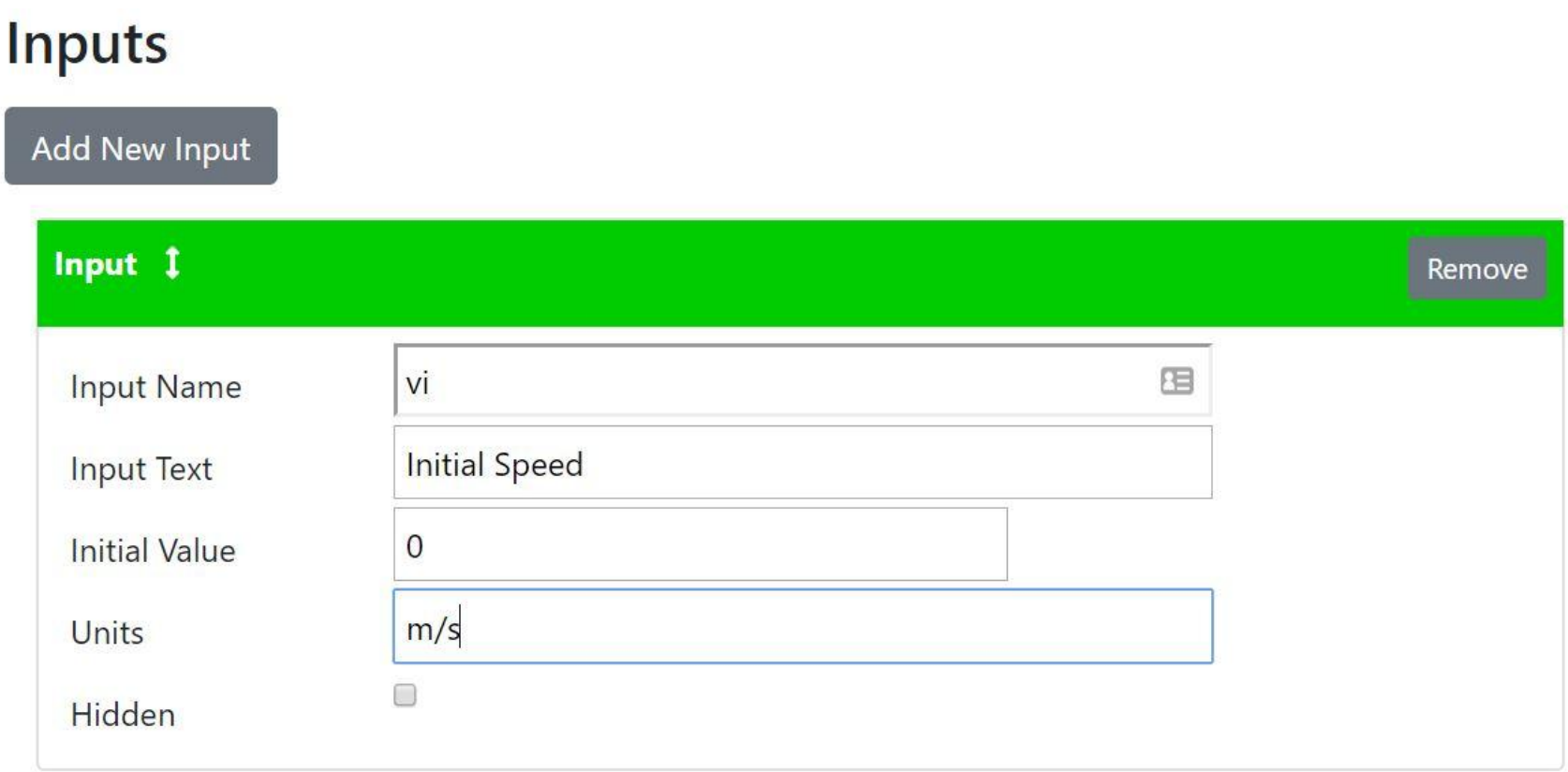
North Carolina School of Science and Mathematics

Steps to Create a Simple Animation

1. Inputs
2. Solids
3. Time Range, Window and Graph Window Settings
4. Outputs
5. Save and Play

North Carolina School of Science and Mathematics

Setting up Inputs



North Carolina School of Science and Mathematics

Setting up Solids

Solids

Add New Solid

Solid ↕ Remove

Solid Name: pumpkin

X Path: (•) Parametric ( ) Euler

X = vi*cos(2*pi*theta/360)*t

Y Path: (•) Parametric ( ) Euler

Y = vi*sin(2*pi*theta/360)*t - 4.9*t*t

Shape: Circle

Height: (•) Parametric ( ) Euler

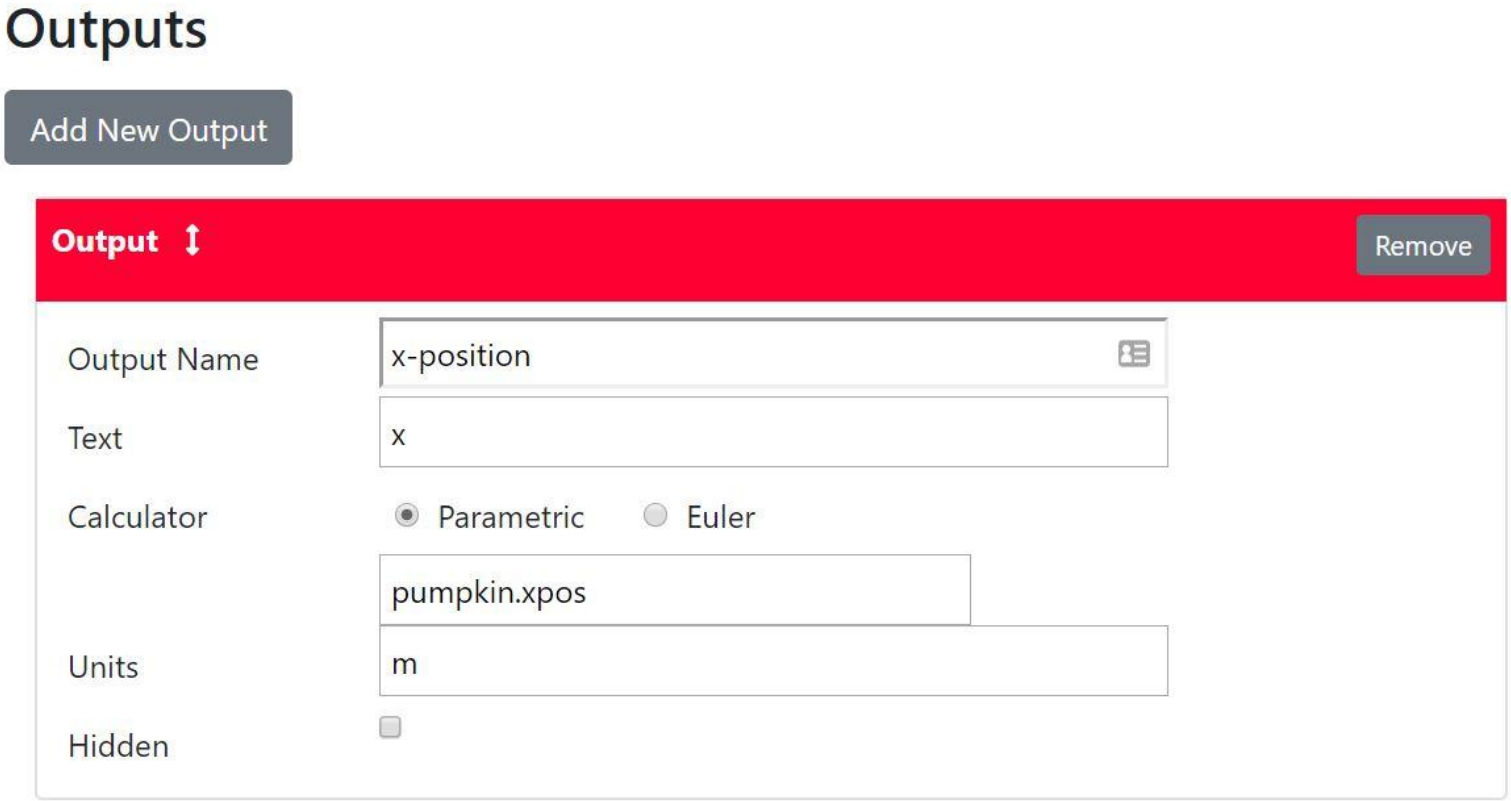
H = 1

Width: (•) Parametric ( ) Euler

W = 1

North Carolina School of Science and Mathematics

Setting up Outputs



North Carolina School of Science and Mathematics

Setting up Time, Window, Graph

Author Information

Username	anonymous
Email	
Name	
Organization	

Time Range

Start	0
Duration	100
Change	0.1
Fps	20

Description

This is a demo animation - a punkin chunkin !

Window

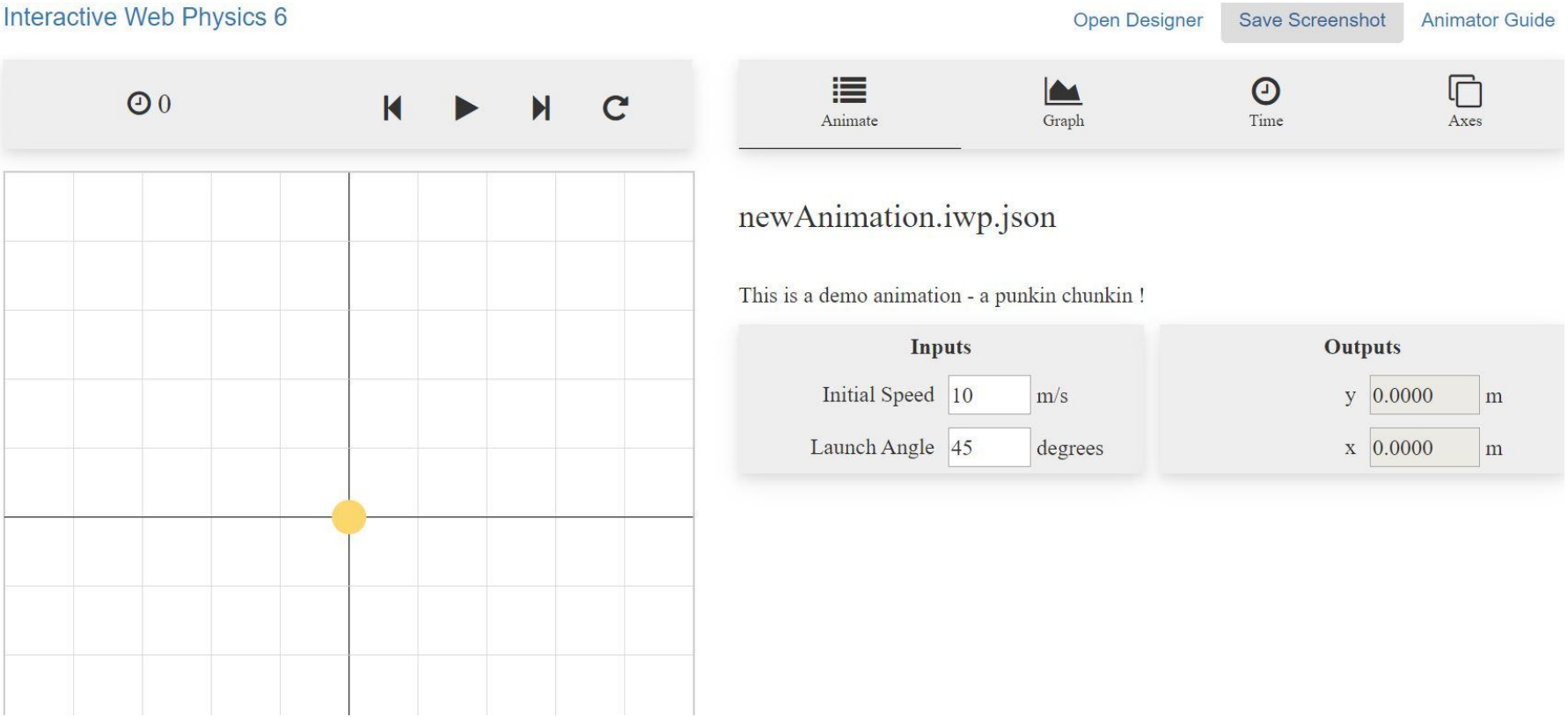
X Min	-10
X Max	10
X Grid	2
X Unit	meters
Y Min	-10
Y Max	10
Y Grid	2
Y Unit	meters

Graph Window

X Min	0
X Max	10
X Grid	2
Y Min	-5
Y Max	5
Y Grid	2

North Carolina School of Science and Mathematics

Finished Animation !



North Carolina School of Science and Mathematics

Workshop Agenda 3

1. Origin story, connectivity, and tour of IWP6 - **Taylor**, 10m

2. Creating a simple animation with projectile motion - **Jon**, 10m

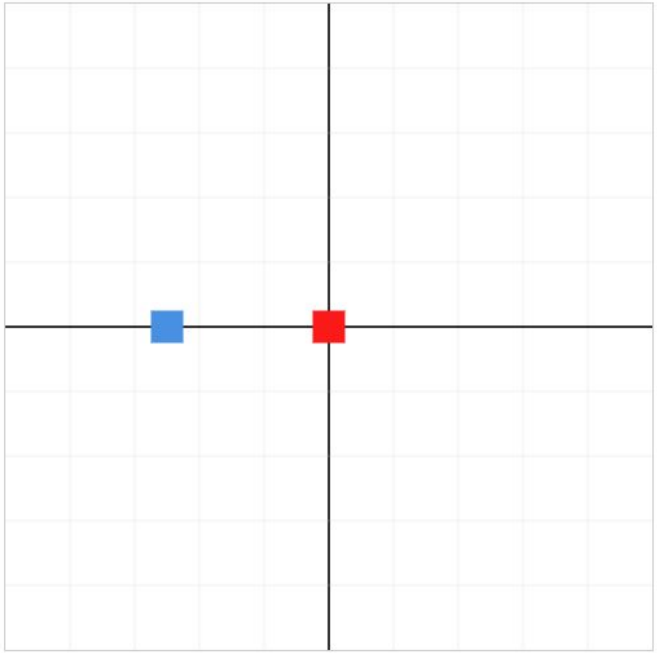
3. Using the IWP6 library of built-in functions to create more complex animations, specifically elastic collision - **Ben** 10m

4. Simulation with Euler's method with IWP + orbital motion challenge - **Andy** 20m

5. Q&A and Discussion about ways to use IWP - **Everybody** 10m

North Carolina School of Science and Mathematics

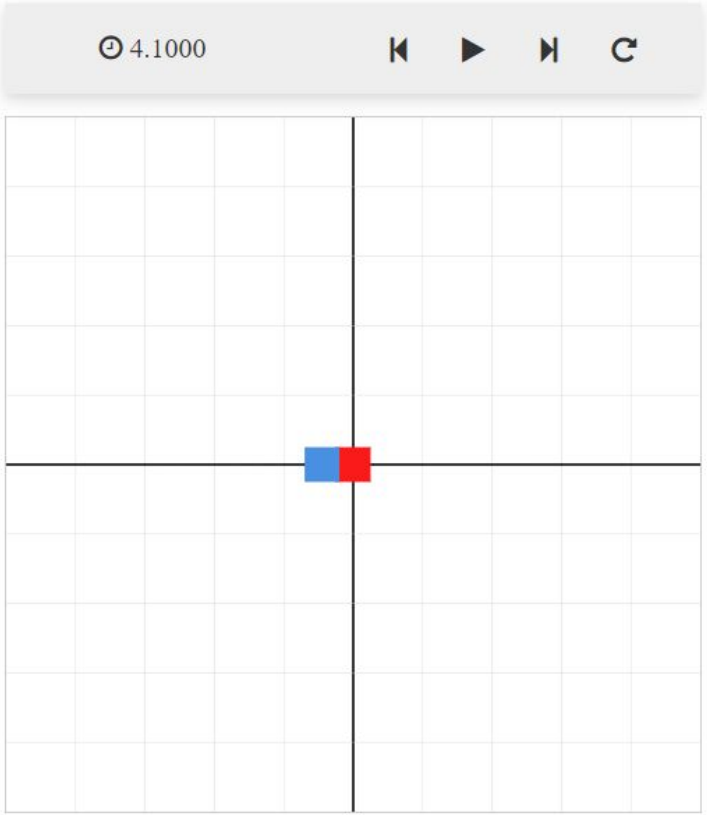
Creating an Elastic Collision Animation (10m)



- GOAL: Animate an Elastic Collision between the blue box traveling to the right and the red box initially at rest
- Will make use of the parametric calculator and the step function

North Carolina School of Science and Mathematics

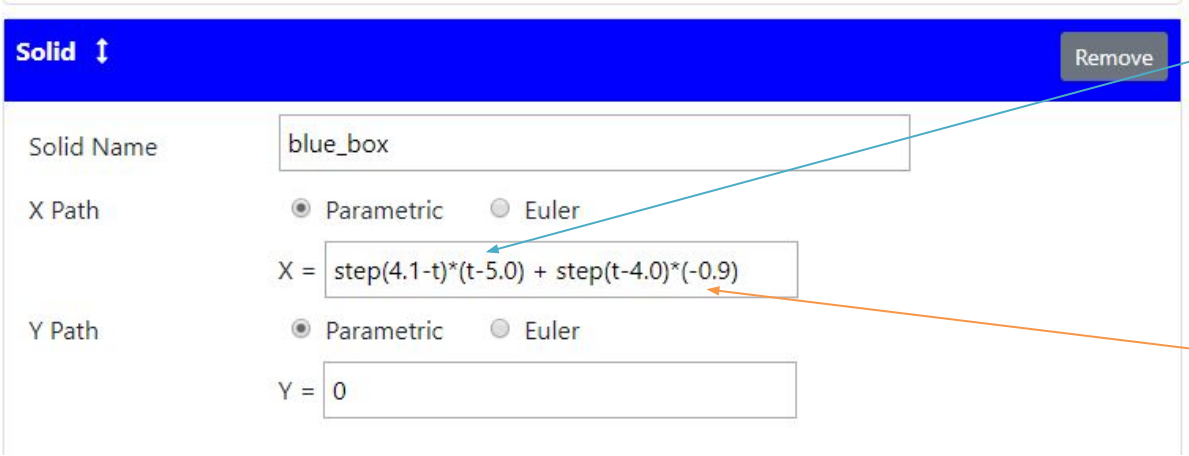
Example



- step(x) = 0 if $x \leq 0$
- step(x) = 1 if $x > 0$
- Boxes collide at x = -0.9m and t = 4.1s
- Using the step function we can parametrize the path for the boxes before and after the collision

North Carolina School of Science and Mathematics

Example, cont.

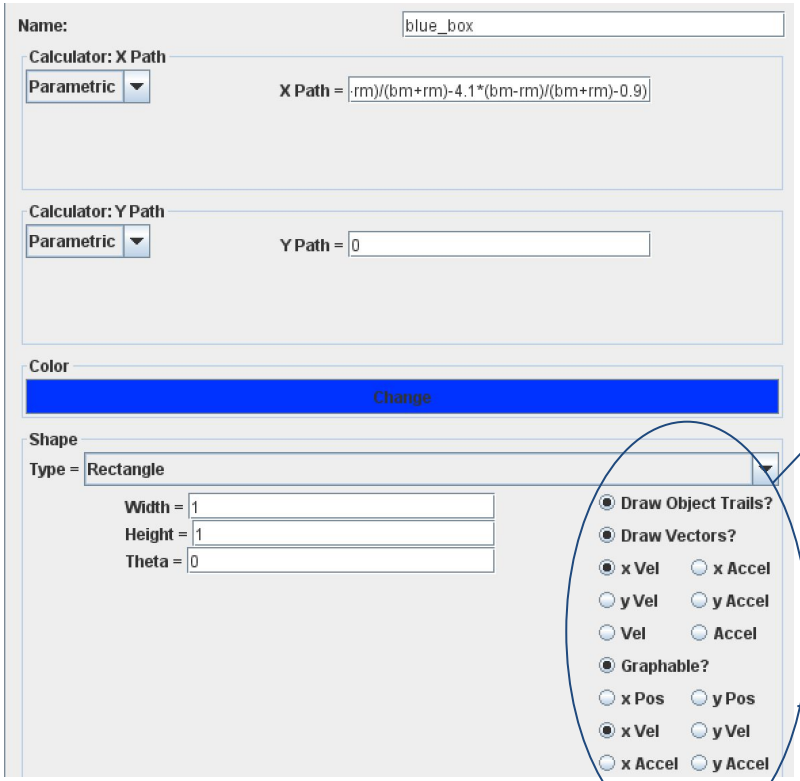


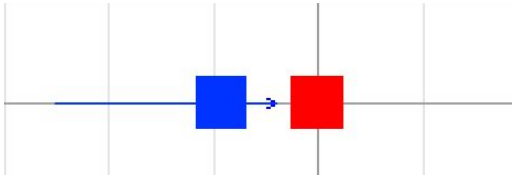
- For t < 4.1 the blue box starts at -5.0 m and moves right at a speed of 1.0 m/s
- For t ≥ 4.1 the blue box stays at the position -0.9m where it collided with the red box

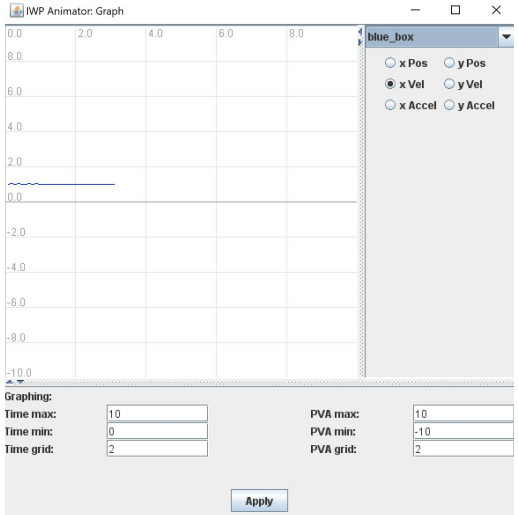
$$X = step(4.1-t)*(t-5.0) + step(t-4.0)*(-0.9)$$

North Carolina School of Science and Mathematics

Graphing, Trails, Vectors

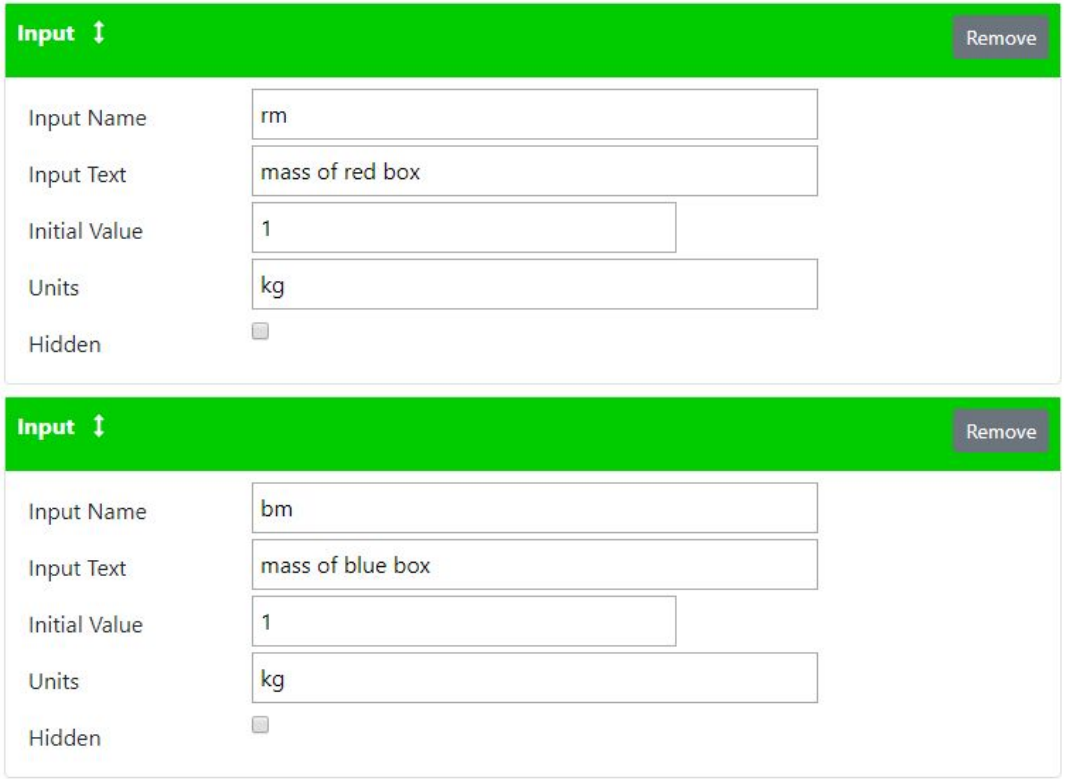






North Carolina School of Science and Mathematics

Creating Inputs (mass)



North Carolina School of Science and Mathematics

Making the Elastic Collision

$$v_{\text{blue},f} = \left(\frac{m_{\text{blue}} - m_{\text{red}}}{m_{\text{blue}} + m_{\text{red}}} \right) \cdot v_{\text{blue, i}}$$

$$v_{\text{red},f} = \left(\frac{2 \cdot m_{\text{blue}}}{m_{\text{blue}} + m_{\text{red}}} \right) \cdot v_{\text{blue, i}}$$

- Initial velocity of the blue box set to 1.0 m/s
- We can modify the step function to incorporate the formulas to the left

North Carolina School of Science and Mathematics

Making the Elastic Collision, cont.

Blue Box X-Path

- step(4.1-t)*(t-5.0) +

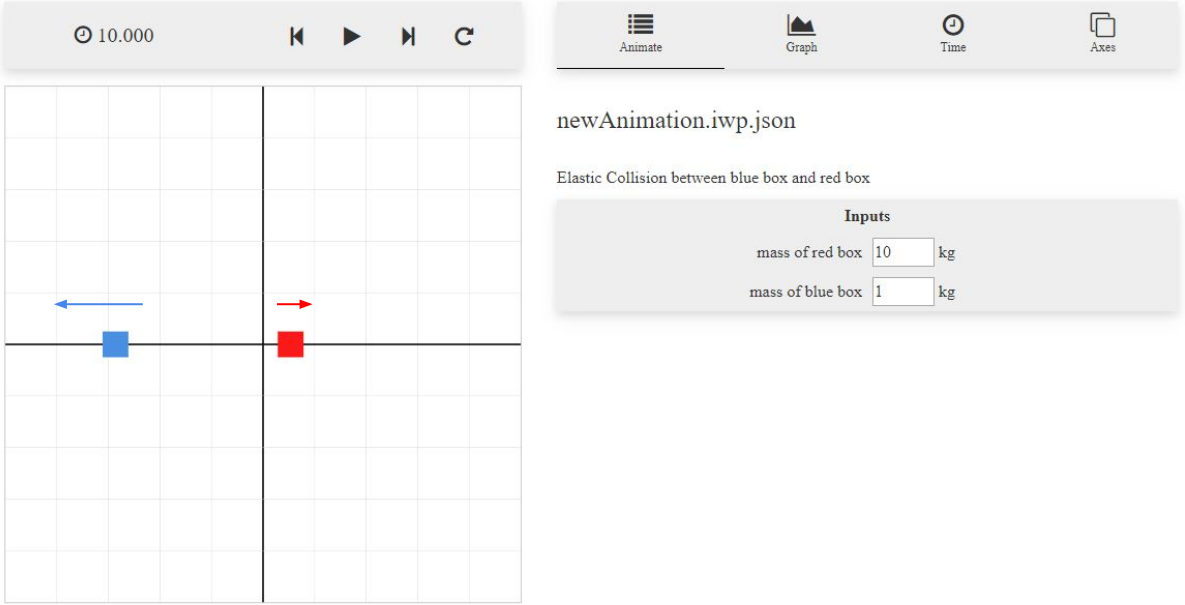
  step(t-4.0)*(t*(bm-rm)/(bm+rm)-4.1*(bm-rm)/(bm+rm)-0.9)

Red Box X-Path

- step(t-4.0)*(t*(2*bm)/(bm+rm)-8.2*bm/(bm+rm))

North Carolina School of Science and Mathematics

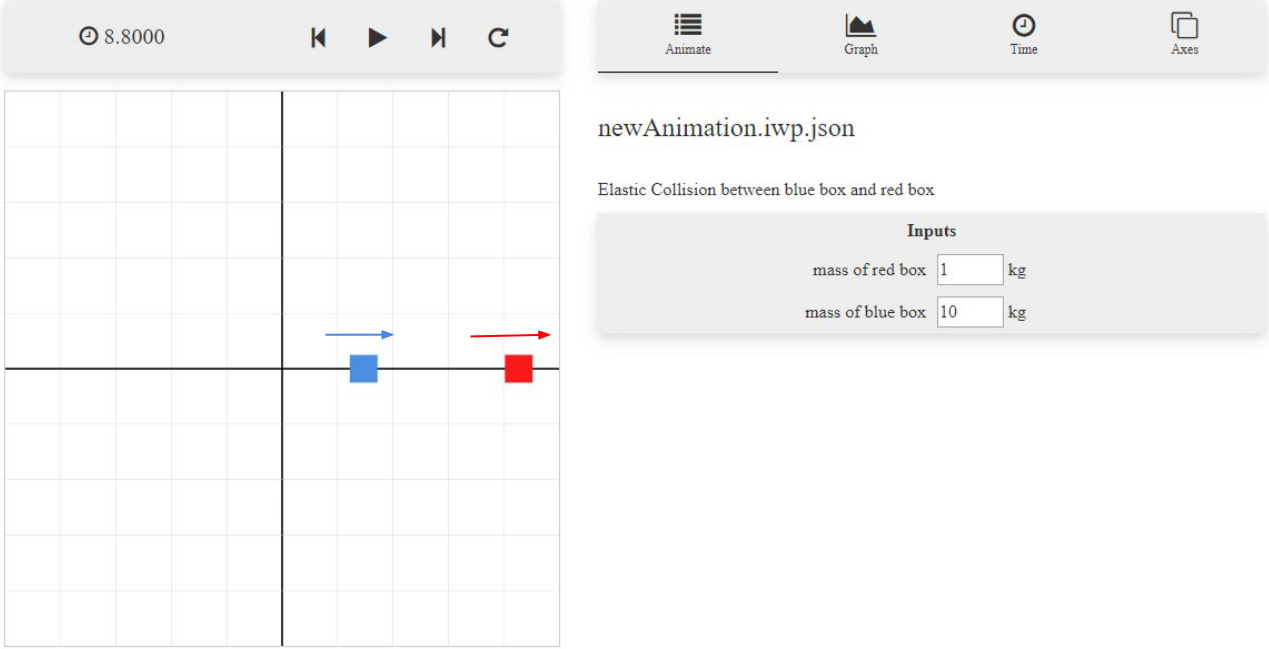
Making the Elastic Collision, cont.



red box has greater mass than blue box

North Carolina School of Science and Mathematics

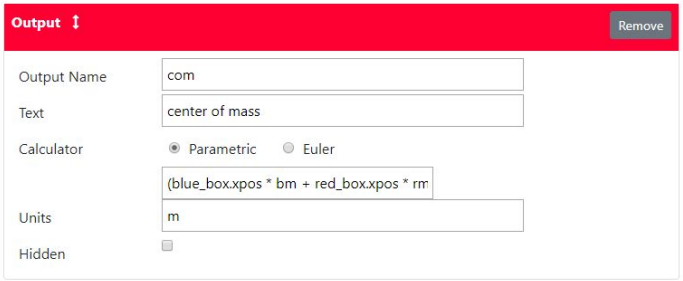
Making the Elastic Collision, cont.

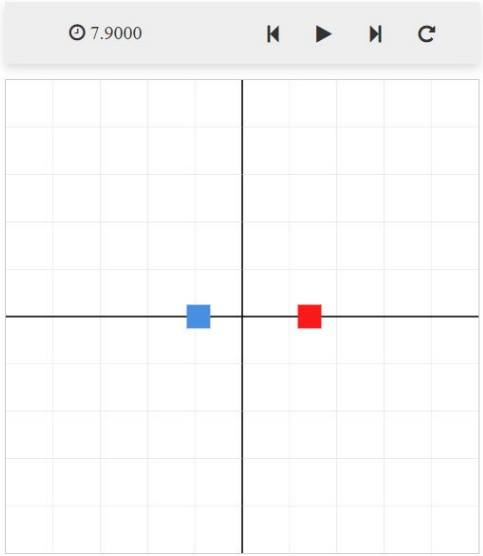


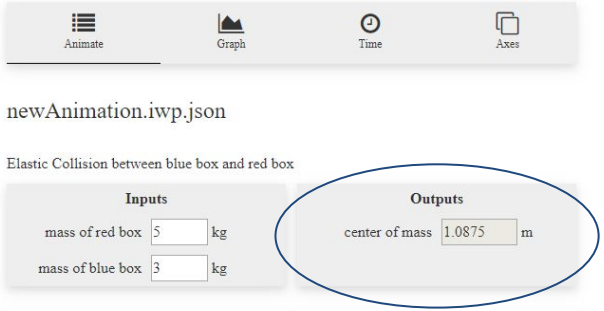
blue box has greater mass than red box

North Carolina School of Science and Mathematics

Outputs







North Carolina School of Science and Mathematics

Workshop Agenda 4

1. Origin story, connectivity, and tour of IWP6 - **Taylor**, 10m

2. Creating a simple animation with projectile motion - **Jon**, 10m

3. Using the IWP6 library of built-in functions to create more complex animations, specifically elastic collision - **Ben** 10m

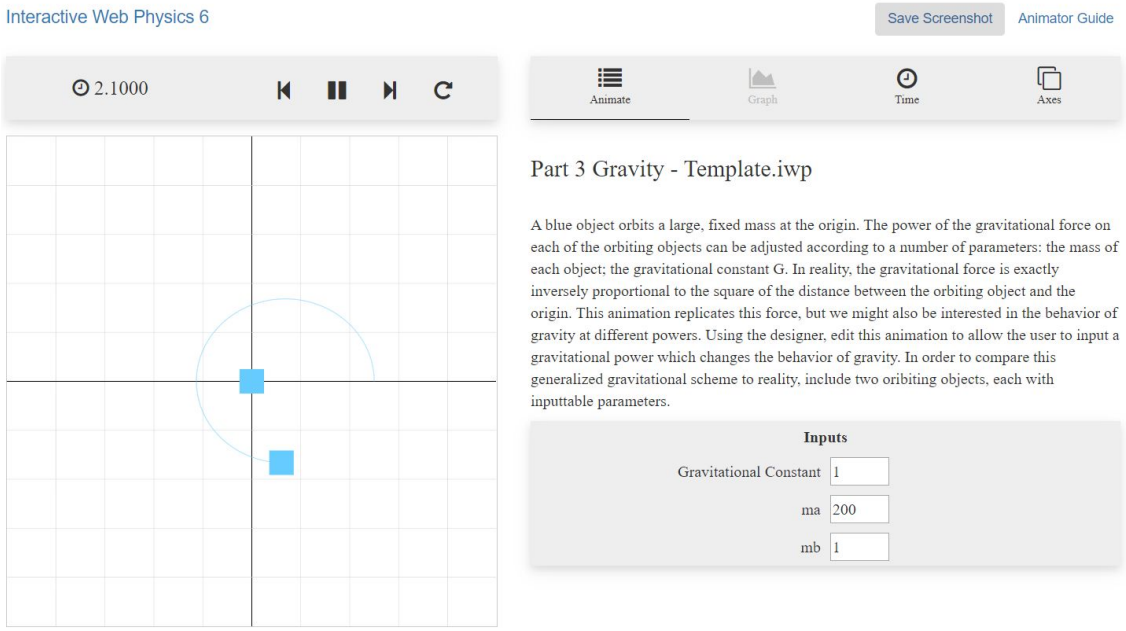
4. Simulation with Euler's method with IWP + orbital motion challenge - **Andy** 20m

5. Q&A and Discussion about ways to use IWP - **Everybody** 10m

North Carolina School of Science and Mathematics

Animating Gravity with Explicit Methods (20m)

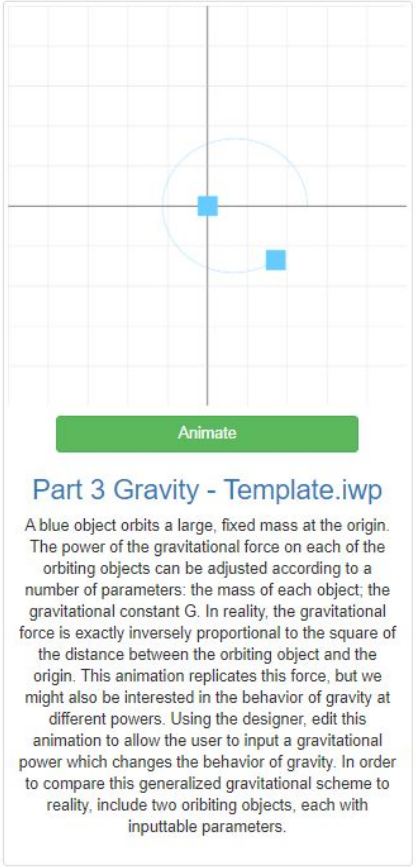
- GOAL: Experiment with an animation template of an object orbiting a fixed point
- New techniques:
  - Euler's Method
  - Object attributes



North Carolina School of Science and Mathematics

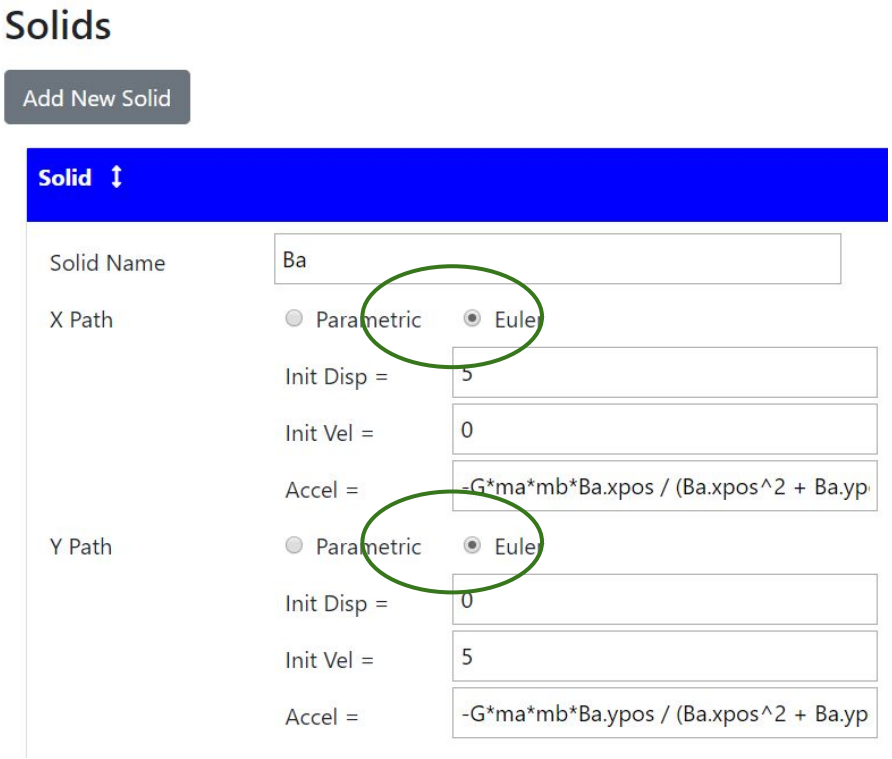
Animating Gravity with Euler's

- Template Features:
  - Orbit and origin solids with trails
  - Mass and gravitational constant inputs
  - x- and y-acceleration for orbiting objects using Euler's



North Carolina School of Science and Mathematics

Euler's in IWP



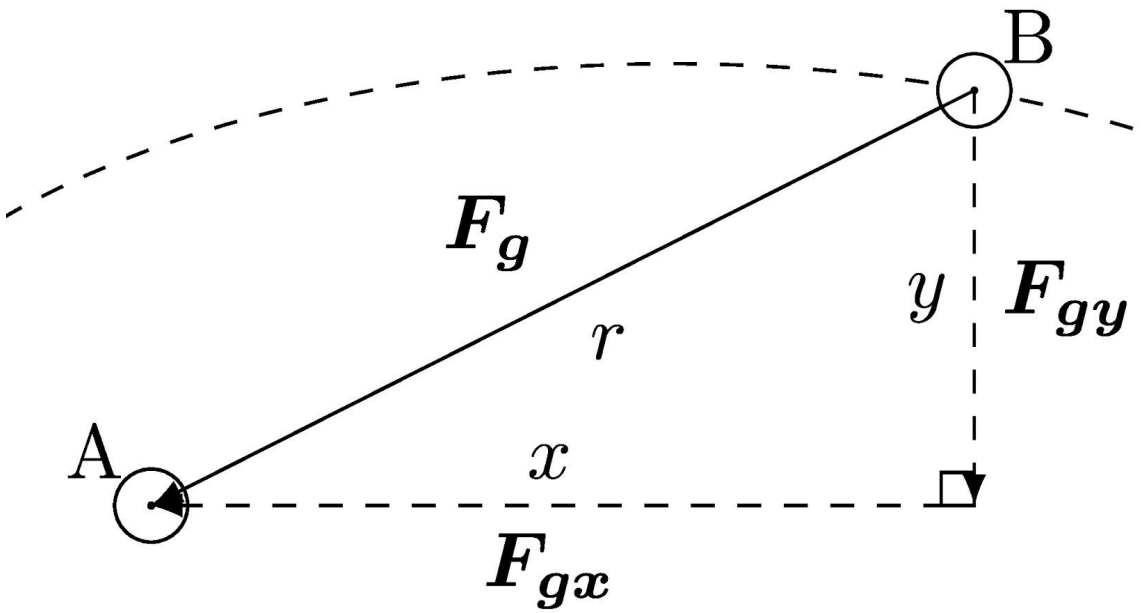
- Euler's option available in defining x/y-path in solid
- Enables motion to be defined in terms of acceleration

North Carolina School of Science and Mathematics

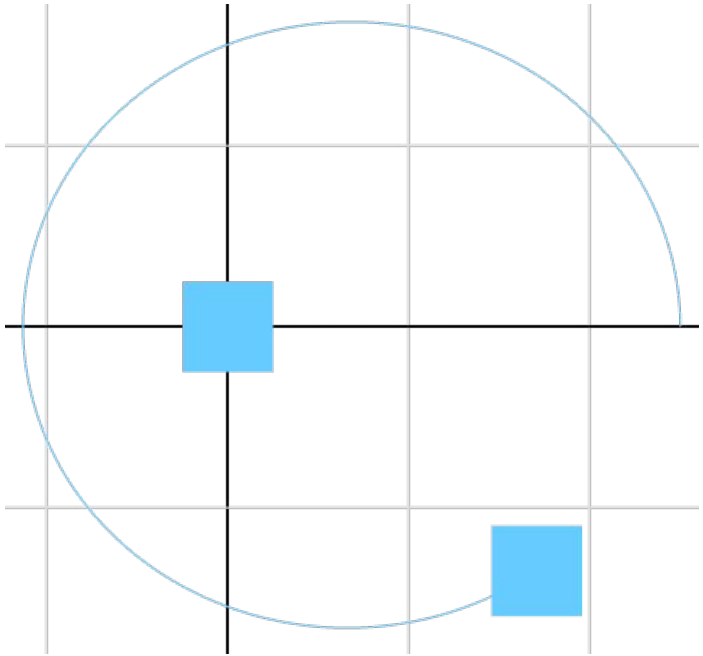
Gravity Parameterization (B orbits A)

$$F_x = -\frac{Gm_Am_B}{r^2}\frac{x}{r} = -\frac{Gm_Am_Bx}{(x^2+y^2)^{1.5}}$$

$$F_y = -\frac{Gm_Am_B}{r^2}\frac{y}{r} = -\frac{Gm_Am_By}{(x^2+y^2)^{1.5}}$$



North Carolina
School of Science
and Mathematics



$F_g \propto r^{-2}$

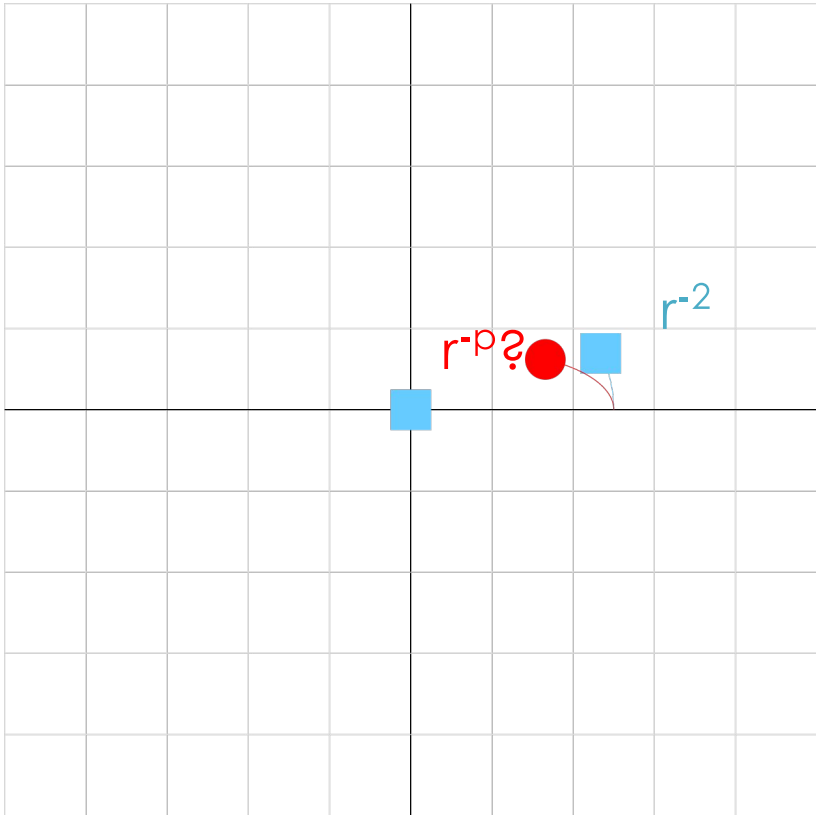
Template Results

North Carolina School of Science and Mathematics

CHALLENGE

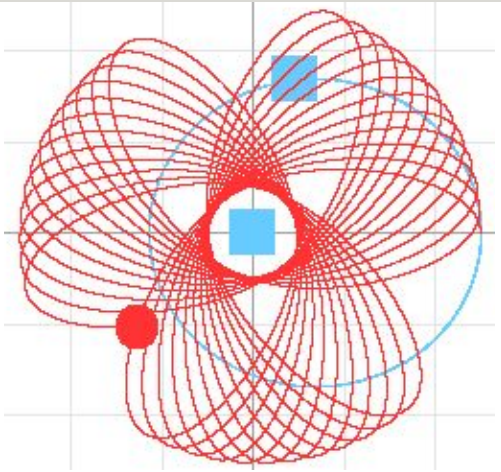
Compare:

$F_g \propto r^{-p}$ VS $F_g \propto r^{-2}$

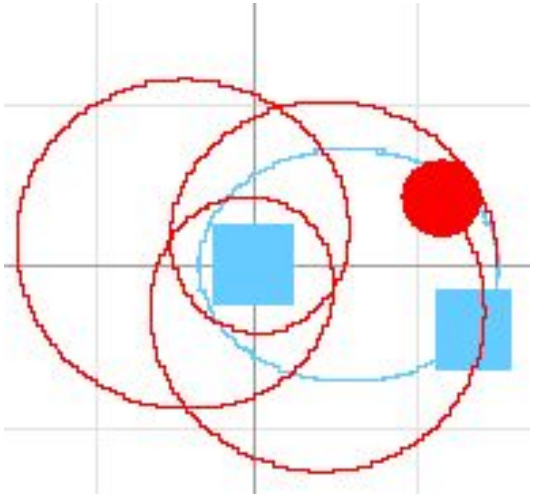


North Carolina
School of Science
and Mathematics

RESULT

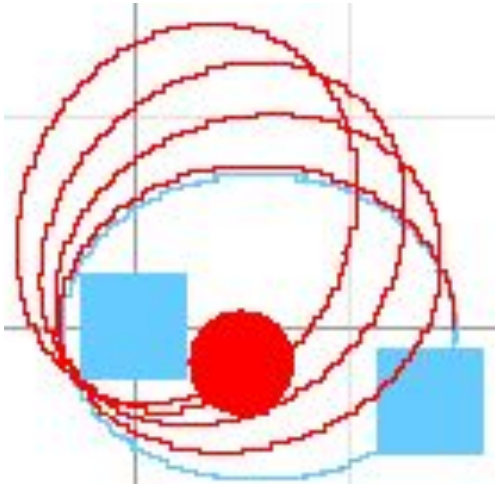


$F \propto r^{-1}$



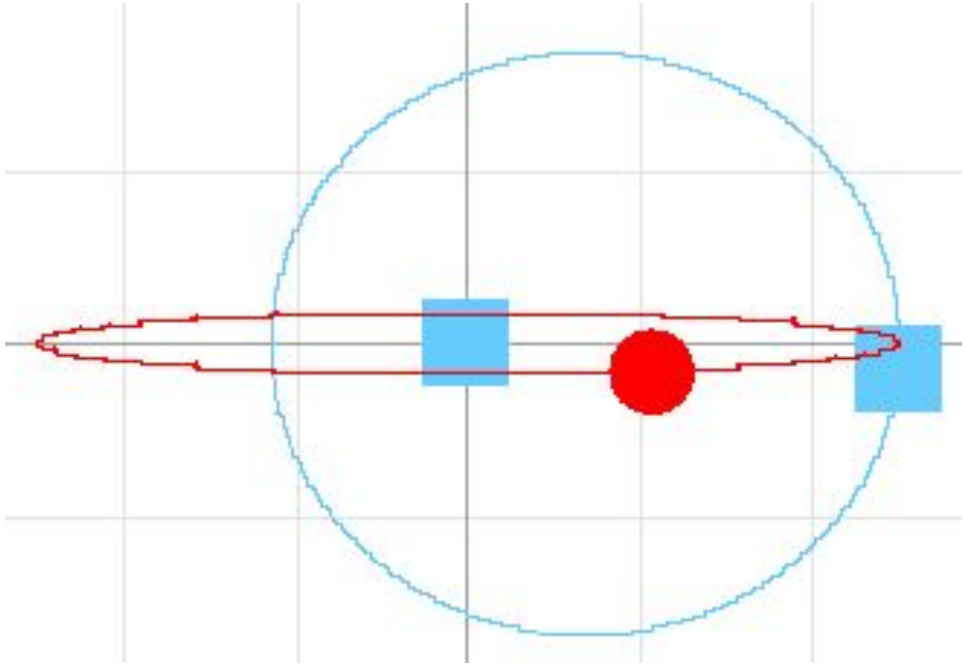
$F \propto r^{-2.5}$

$F \propto r^{-2.1}$



North Carolina
School of Science
and Mathematics

RESULT



Only closed cycles:

Blue: $F \propto r^{1}$
Red: $F \propto r^{-2}$

North Carolina School of Science and Mathematics

Workshop Agenda 5

1. Origin story, connectivity, and tour of IWP6 - **Taylor**, 10m

2. Creating a simple animation with projectile motion - **Jon**, 10m

3. Using the IWP6 library of built-in functions to create more complex animations, specifically elastic collision - **Ben** 10m

4. Simulation with Euler's method with IWP + orbital motion challenge - **Andy** 20m

5. Q&A and Discussion about ways to use IWP - **Everybody** 10m

North Carolina School of Science and Mathematics

Discussion

Question 1 / 3

How is IWP similar or different from other physics software?

North Carolina School of Science and Mathematics

Discussion

Question 2 / 3

How could students benefit from using IWP?

North Carolina School of Science and Mathematics

Discussion

Question 3 / 3

What content should we develop to enhance your curriculum?

North Carolina
School of Science
and Mathematics

Interactive Web Physics

Physics Animations that Run in a Web Browser

THANK YOU !!

www.iwphys.org

bennett@ncssm.edu

taylor.brockman@gmail.com