Mechanics Simulations With JavaScript

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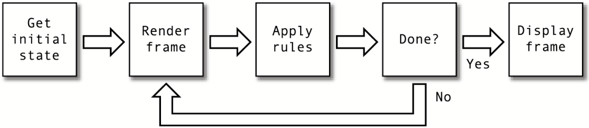
Overview - Why Did I Choose This Topic?

- I hope to use programming as a lens to view physics
- Examine mechanics in more detail
- Solve physics problems through simulations
- JavaScript high level language - viewable easily in web browser

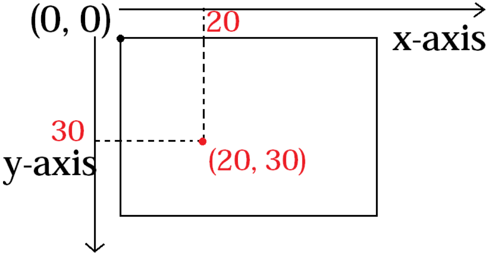
What is a simulation?

- Animation vs. Simulation
- Frames per second
- File size



Method of Basic Simulation

- HTML5 canvas application programming interface (API)
- Timer for each frame



Chapter 1: Basic kinematics and aerodynamic drag

- Three simulations
- Simulation #1: Basic bouncing ball
- Simulation #2: Bouncing ball with aerodynamic drag
- Simulation #3: Multiple bouncing balls

Simulation #1: Basic Bouncing Ball

- Realistic g value
- $9.81\ \frac{px}{s^2} = .1635\ \frac{\frac{px}{s}}{frame} \times \frac{60frame}{s}$

- Coefficient of restitution (C_r)
- $C_r = \sqrt{\frac{KE_f}{KE_i}} = \sqrt{\frac{\frac{1}{2}mv_f^2}{\frac{1}{2}mv_i^2}} = \frac{v_f}{v_i}$
- $v_f = v_i * C_r$

Simulation #2: Bouncing Ball With Aerodynamic Drag

- $f_{drag} = -\frac{1}{2} C_d \rho A v^2$

- $F_D =$ force of drag
- $\rho =$ density of fluid
- $v =$ speed of object relative to fluid
- $C_d =$ drag coefficient (affected by texture, shape, viscosity, lift, etc)
- $A =$ cross-sectional area of object

Simulation #3: Multiple Balls Bouncing

- Same physics as simulation #1
- Array of ball objects
- Each object has properties
- Each frame cycles through array, updating properties of each object

Chapter 2: Planetary Motion

- 3 Simulations
- Simulation #4: Orbits
- Simulation #5: Escape velocity
- Simulation #6: Kepler's 2nd law

Simulation #4: Orbits

- Newton's Law of universal gravitation
- $F_g = G\frac{m_1 m_2}{r^2}$

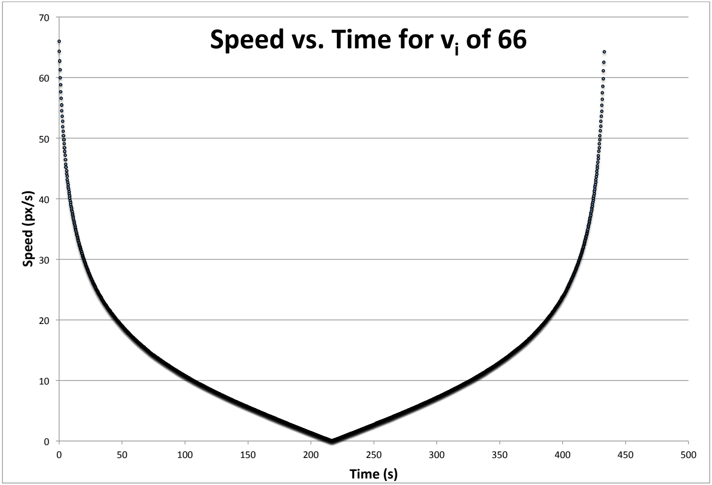
- Euler's Method to update velocity
- $x(t + dt) = x(t) + \frac{dx}{dt}(t)\, dt$

Simulation #5: Escape Velocity

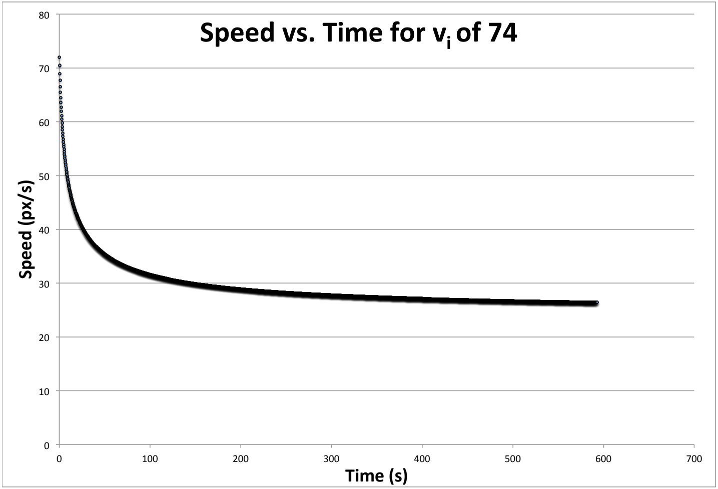
- $K_i + U_{g_i} = K_f + U_{g_f}$
- $\frac{1}{2} m v_{esc}^2 - \frac{GMm}{r} = 0 + 0$
- $v_{esc} = \sqrt{\frac{2GM}{r}}$
- $v_{esc} = \sqrt{\frac{2 * 1 \frac{px^3}{s^2} * 1000000}{410 px}} \approx 69.843 \frac{px}{s}$

- Used bigger canvas, and plotted velocities during planet's travel

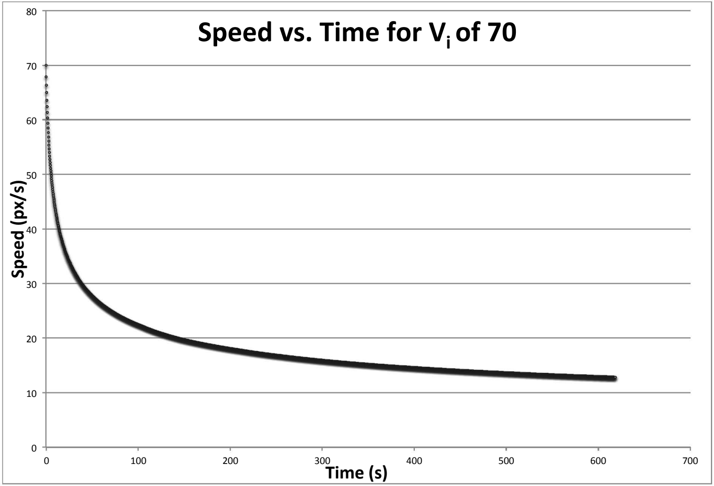
Simulation #5: Escape Velocity



Simulation #5: Escape Velocity



Simulation #5: Escape Velocity



Thank You