

# Math In Video Games

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# Who Am I?

- Senior Software Engineer at Vicarious Visions
- Graphics specialist
  - Lighting, shadows, animation, etc...
- I wish I paid more attention in Math III

# Scoring

- Maybe we're making a platform game (Like Mario)
- Each level has coins (100 pts) and stars (500 pts)
- Designer builds a level with  $c$  coins and  $s$  stars.
- Kids like to brag to their friends. So we let them post their high score online.
- Q: A user posts a high score of  $h$ . Did they cheat?

# Racing Game Medals

- Racing games typically have target times to get gold, silver, or bronze medals
- The track is 1000m long
- Kart's top speed is 20m/s
- We want to allow people to make *some* mistakes
  - Gold medal time is 110% of perfect
  - Silver is 120%, Bronze is 130%
- **Q:** What are the actual medal times?

# Graphics

- The screen is just a Cartesian plane
- In simple games, objects are drawn as 2D rectangles
- Positioning, rotating, scaling, etc... are all common
- Q: As the vine swings, what path does the player take?
- Q: How do we know if the player runs into the snake?

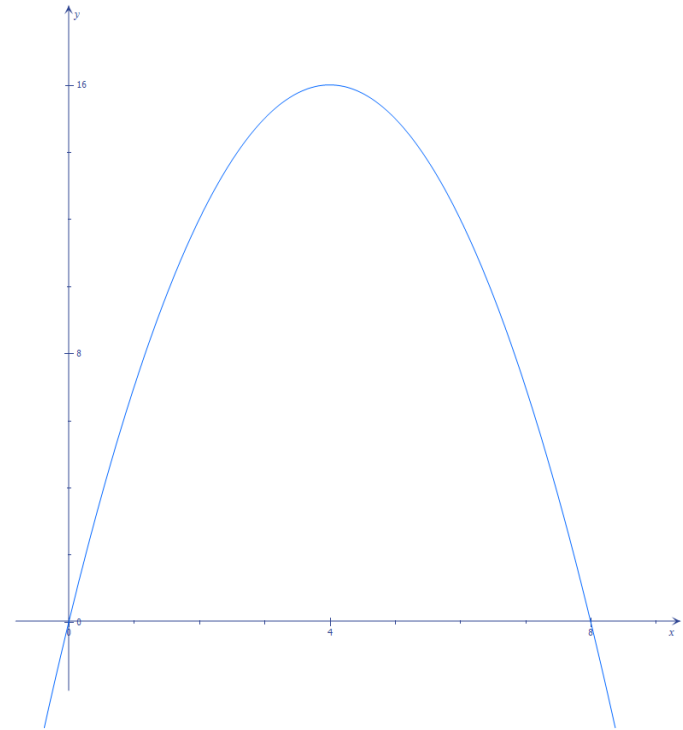


# Physics

- Game physics includes simple motion
- It's easy to describe the path of a projectile:

$$y = 8x - x^2$$

- This might be the path of an Unhappy Avian...
- Q: If the target is  $h$  meters away, how hard must I launch to hit it?



# Physics Continued

- **Time:** Games update via a small time step
  - 30 or 60 Hz (20 or 50 if you want decimals!)
- So every frame, we move something
$$\Delta t \cdot speed = \frac{speed}{30}$$
- If it's a car with the gas pedal down, we adjust speed
$$\Delta t \cdot accel = \frac{accel}{30}$$
- Consider this a stealth introduction to calculus, without any  $\int$ .
- Almost all games include a numerical integrator, many don't even realize it.

# More Advanced

- Discrete Math
  - Computer science is built on this foundation
- Linear Algebra
  - Matrices for coordinate space transforms
  - Quaternions for animated rotation in 3D
- Calculus
  - “The rendering equation”
- Signal Processing
  - Filtering of audio (and visual) signals