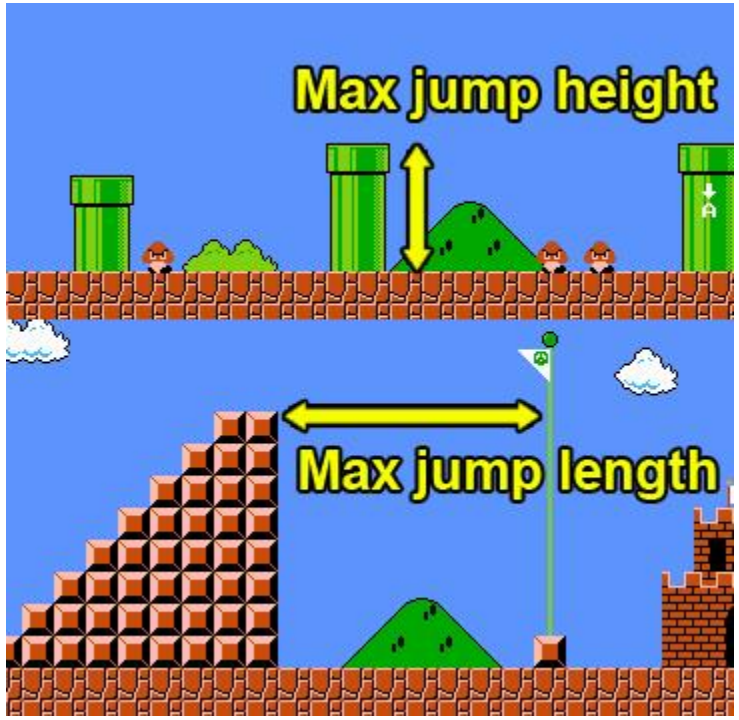
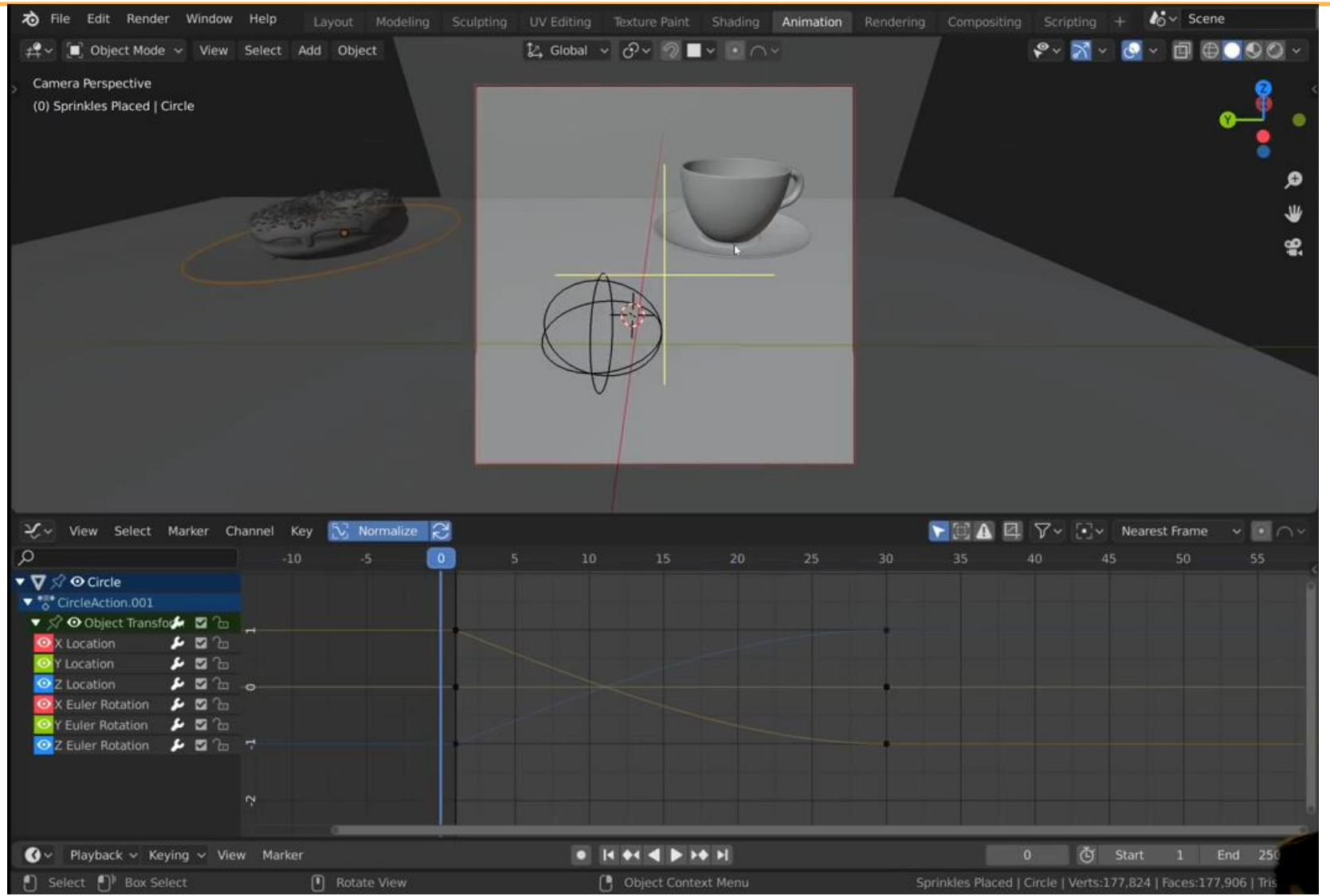
Helge Rhodin

CPSC 427
Video Game Programming

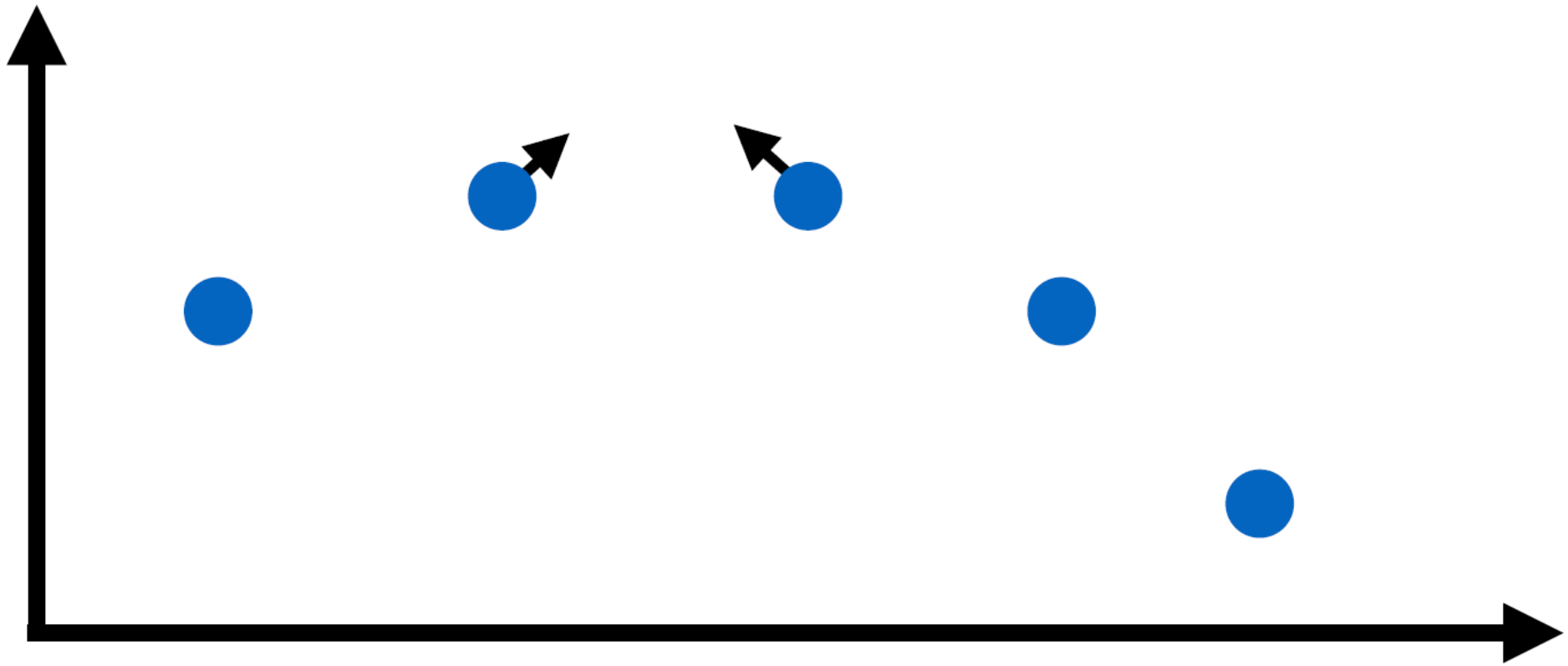
Game Balancing



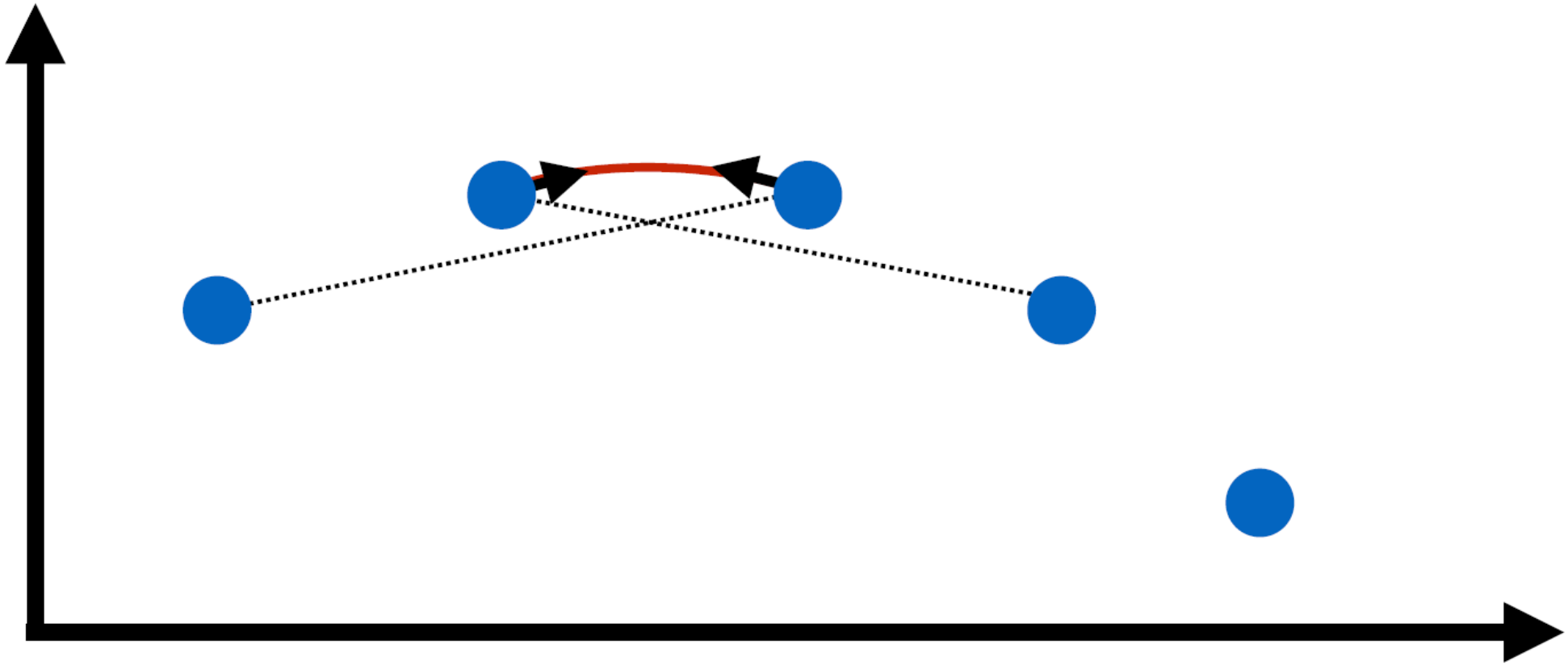
Recap:
Keyframe animation & mesh creation



Smooth curve



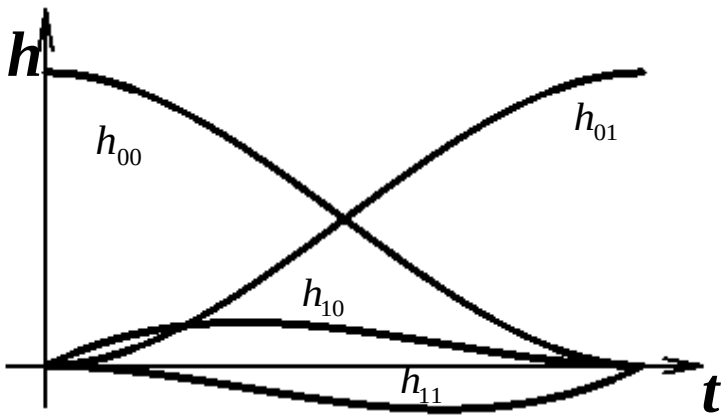
Smooth curve



Hermite Cubic Basis

Four cubic polynomials that satisfy the conditions

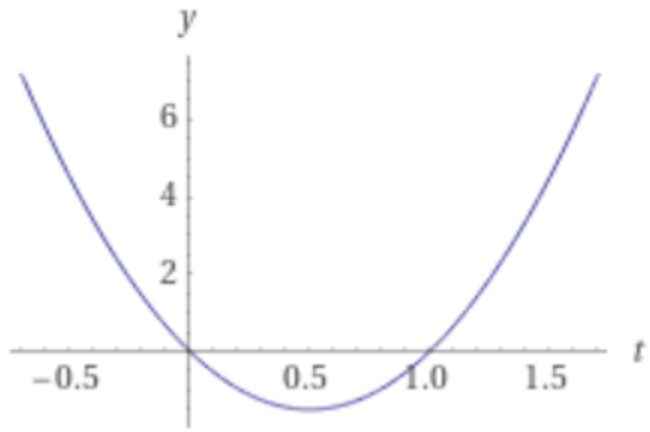
$$h_{00}(t) = t^2(2t-3)+1 \qquad h_{01}(t) = -t^2(2t-3)$$
$$h_{10}(t) = t(t-1)^2 \qquad h_{11}(t) = t^2(t-1)$$



Derivative of h00

$6(-1+t)t$

Plots:



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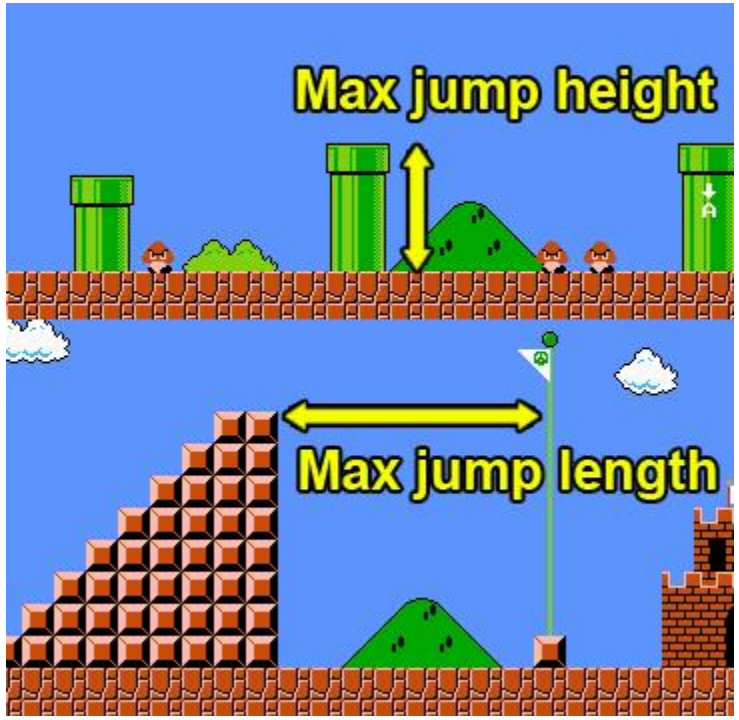
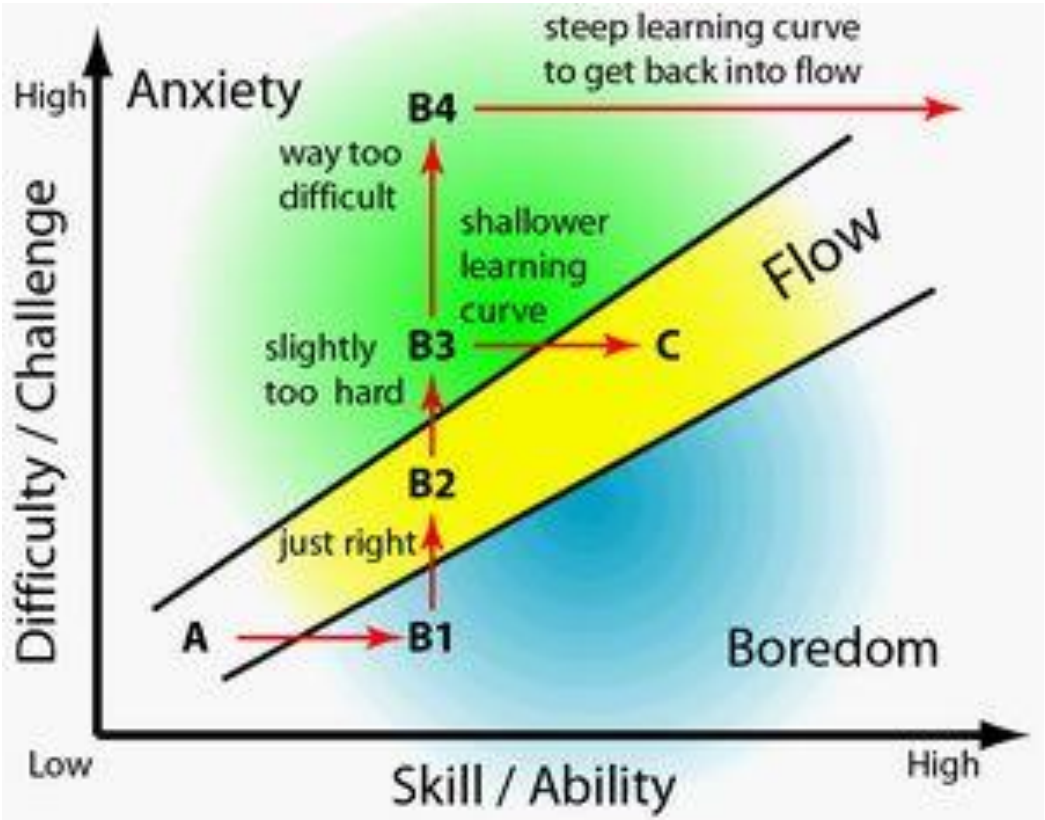


Resources on Balancing

https://gamebalanceconcepts.wordpress.com/2010/07/07/level-1-intro-to-game-balance/

by Ian Schreiber

Fun to play?



https://www.androidauthority.com/level-design-mobile-games-developers-make-games-fun-661877/

What does balanced mean?

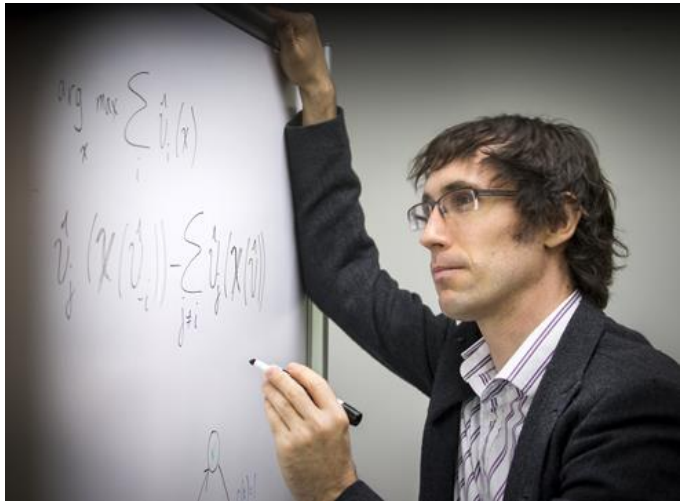
- *Is chess balanced*
- *Settlers of Catan?*
- *Is Tetris balanced?*
- *Is your game balanced?*

Game Theory

A mathematical concept

- ***Used for trading, road design, …***

Interested?



Kevin Leyton-Brown

Terminology

- **Dominant strategy**: one path that is stronger than all others
- **Fairness**: equal chances to win
- **Nash equilibrium:** each player's strategy is optimal when considering the decisions of other players

Important Considerations

- ***Determinism vs. randomness***
- ***Solvability***
  - *Has a best/dominant strategy*
    - Is this desirable?
  - *Can you solve a non-deterministic game?*

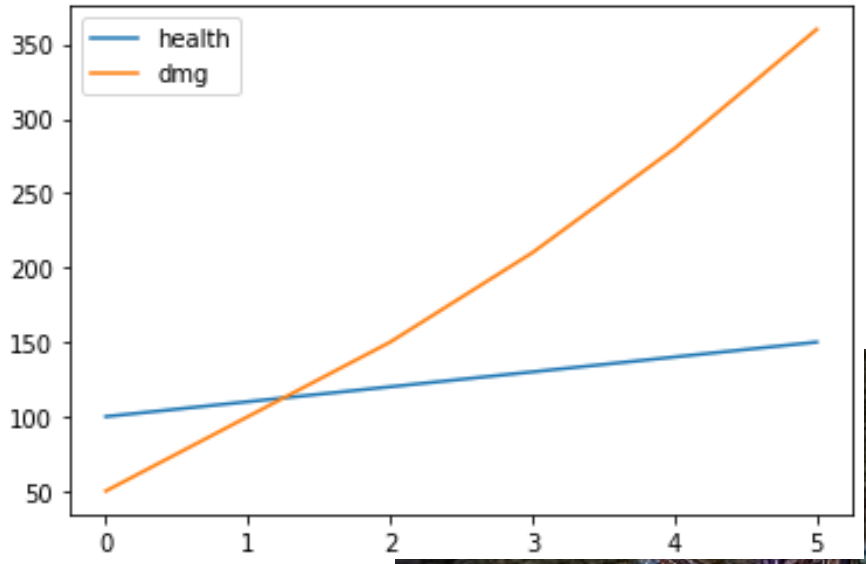
- ***Intransitive games***
  - simultaneous choice between opponents, e.g. *Rock-Paper-Scissors*
- ***Symmetric***
  - *same chances*
- ***Game and meta game***

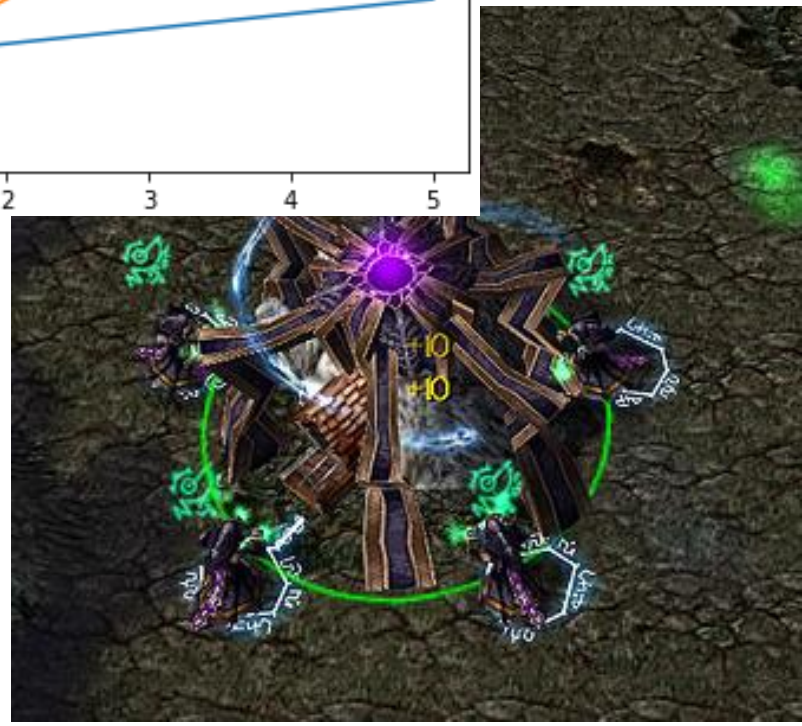
Numeric quantities

- ***Values?***

Relationships

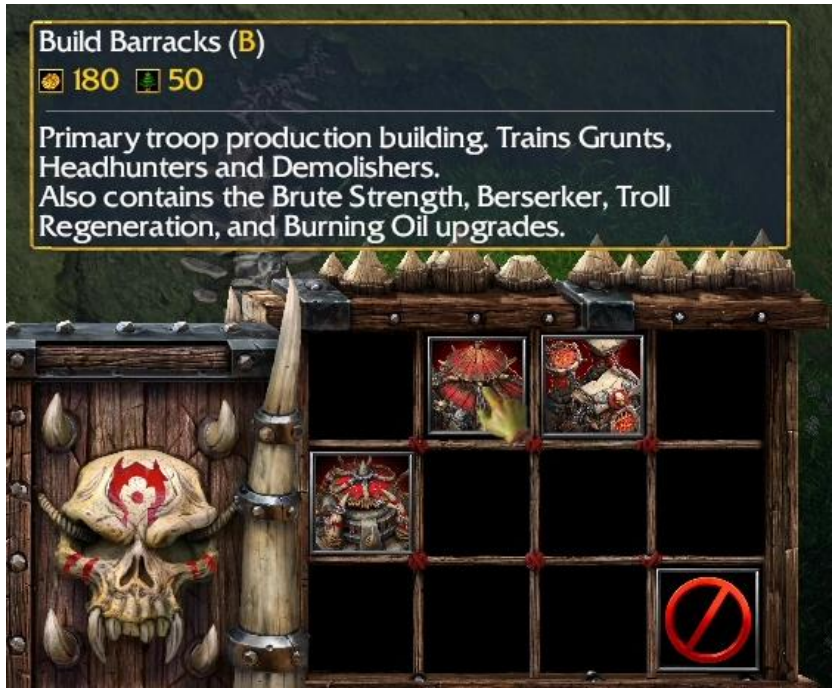
- ***Linear relations***
- ***Exponential relations***
- ***Triangular relationship***
  - 1, 3, 6, 10, 15, 21, 28, …
  - The difference increases linearly
- ***Periodic relations***





Interactions between relationships

- *2x item A + 1x item B = 5x item C*
- *attack speed * damage = damage / second*
- *Buff: 2x health or +100 health*
  - *what is better?*
- *Progression:*
  - *XP -> level up -> new skill -> ?*

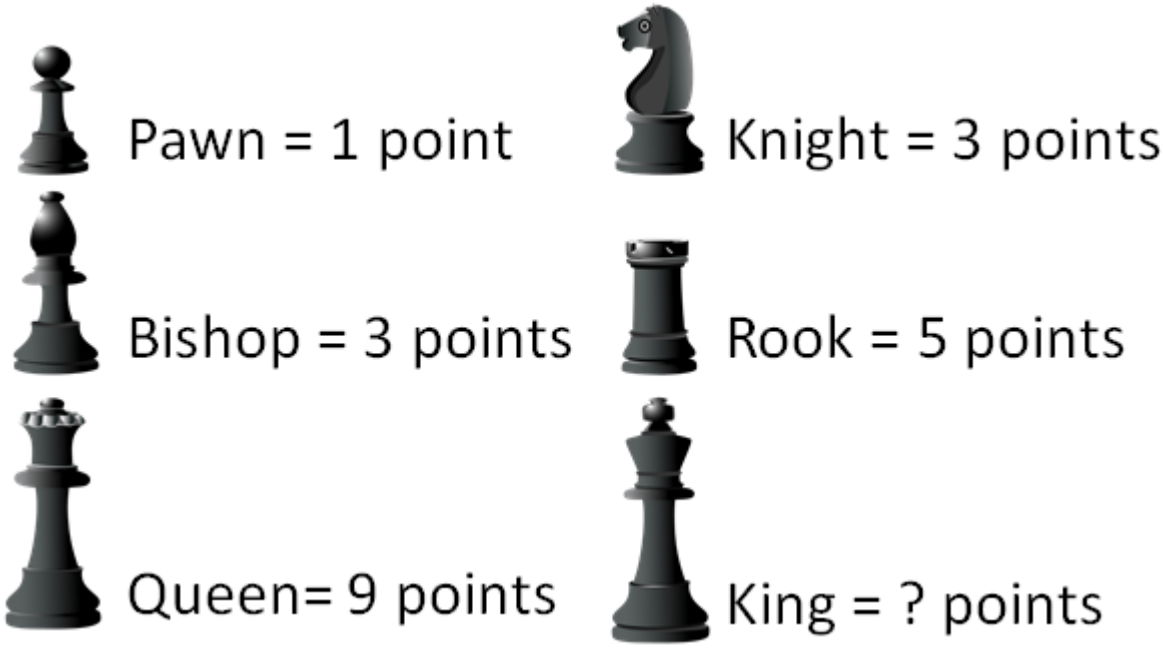


Indirect relationships

Value of a piece

- *It is not possible to get a knight for 3 pawns*
- *But one can 'trade' pieces*
- *A currency*

How to determine?



Breakout

- ***List all relevant quantities in your game***
- ***List their relations:***
  - Type: e.g., linear
  - Quantitatively: e.g., +5 gold per round,
    1 gold = 100 silver
- *Investigate interactions between relations*
- ***What is your game's currency?***
  - *Gold, life, …?*

6 min
select representative to report

How to quantify difficulty?

- ***Player vs. enemy strength***
- ***Likelihood of winning***
- ***Required skill***
  - *Knowledge of the game*
  - *Reaction*
  - *Precision*
  - *Tactics*

-> Estimate player strength in relation skill level: beginner, intermediate, pro?
-> requires user studies!

Randomness

- ***How to compute with probabilities?***
- ***Distributions instead of single values***
- ***Expectation instead of a certain value***

- ***How to quantify uncertainty?***
  - *Probability over discrete events, e.g., Bernoulli distribution*
  - *Variance for continuous variables*

Self study: *Gambler's Fallacy*
Hot-Hand fallacy

Do you have randomness in your game

- ***Where?***
  - *Level, damage, AI, ???*

- What kind?
  - *Independent, correlated, uniform, normal distribution?*

- Random or pseudo-random?
  - *Save a player from being unlucky!*

Balancing example

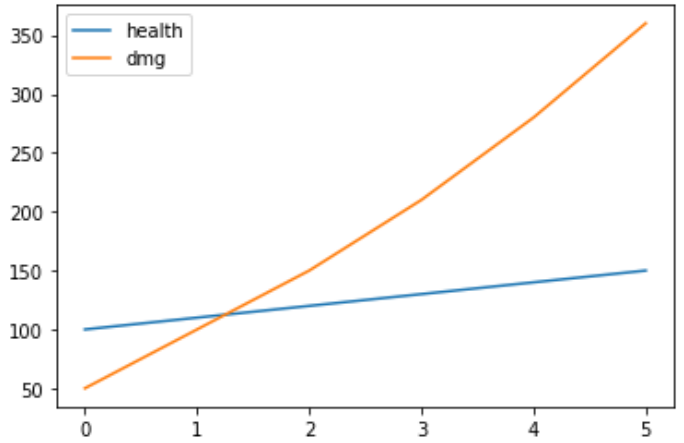
- *10 enemies per level*
- *One tower does 1 damage / sec*
- *One tower costs 2 gold*
- *It takes enemies 10 seconds to pass*

- ***How much gold should the player start with?***

- ***Enemy health increases:*** *11,12,14,17,21,…*
- ***How much gold should the player get in round 2?***
- ***How much gold should each eliminated enemy give?***

Asymptotic analysis?

- *Linear * linear?*
- *Linear + linear?*
- *Linear + exponential?*
- *Linear * exponential?*



Formally, given functions $f(x)$ and $g(x)$, we define a binary relation

$$f(x) \sim g(x) \quad (\text{as } x \to \infty)$$

if and only if (de Bruijn 1981, §1.4)

$$\lim_{x \to \infty} \frac{f(x)}{g(x)} = 1.$$

Demo

Numerical Methods - Optimization

- ***Iterative optimizers***
  - Single variable?
  - Multiple variables?
  - Gradient descent?

Difficulties:

- ***Placement of towers changes the time damage is dealt***
- ***Path of enemies can be hindered to increase time***
- ***Measure during playtest***
  - *cross-play*
- ***Some enemies are resistant to fire/magic/…?***
  - *kind of a periodic feature*

M4 updated requirement

~~*User study*~~

Carefully balance one aspect of your game (e.g., movement-speed, health points, strength, bonus,…).

- *Report on the theoretical analysis*
- *Change log with testing*

Breakout II

- ***Sketch progression***
  - *Quantities over time*
  - *Interactions between quantities*
- ***Use pen & paper, plotting tool, or python***
- ***Start balancing your game***

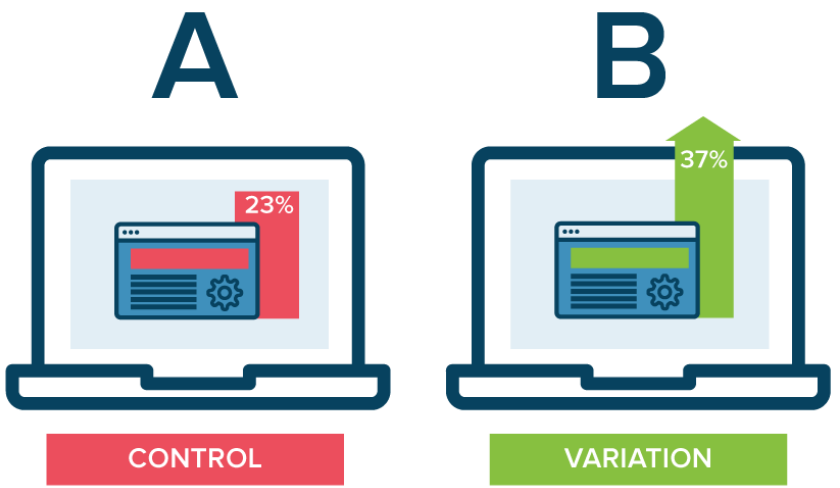
Counter Measures

- **Transitive Mechanics**
  - *Repair costs*
  - *Consumables (food, potions, …)*
  - *Tax*

A/B Testing

Testing two variants of your game (with and w/o a feature)

- *randomized participants (same pool)*
- *with respect to a measurable objective (e.g., clicks on website)*



Related to

- two-sample hypothesis testing
- Clinical tests, e.g., testing of a COVID-19 vaccine
- Placebo effect

https://www.optimizely.com/optimization-glossary/ab-testing/

Next week:

Tuesday:

Guest lecture

- *By Skybox*
- *On multithreading and optimization*

Thursday:

Team presentation

- *30 min*

Cross-play

- *50 min* *be there!*

Next next week ():

Tuesday:

Guest lecture

- *By Dinos (Charm Games)*
- *Virtual Reality*

Thursday:

- ***Lecture***
  - *Articulated motion and inverse kinematics*