SUPERCHARGED!

Vehicle Physics in Skylanders

Patrick Donnelly & Jan-Erik Steel
Senior Software Engineers
Vicarious Visions

SKYLANDERS


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OVERVIEW

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- *Prototypes*

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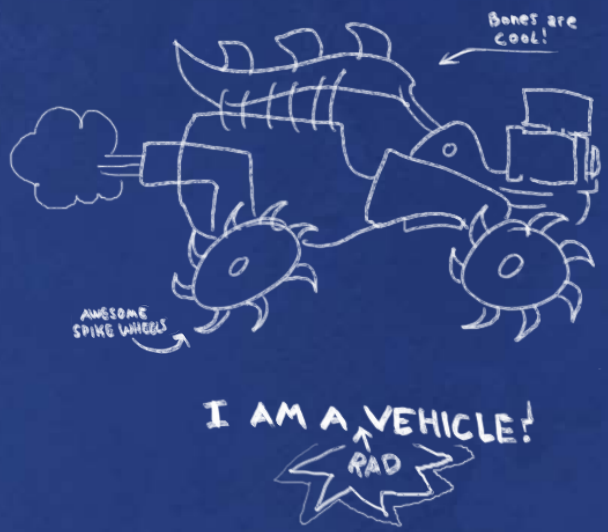
- *Prototypes*
- *Our Pillars*
  - *Examples*

OVERVIEW

- *Prototypes*
- *Our Pillars*
  - *Examples*
- *Technical Deep Dive*

PHYSICS VEHICLES 1.0



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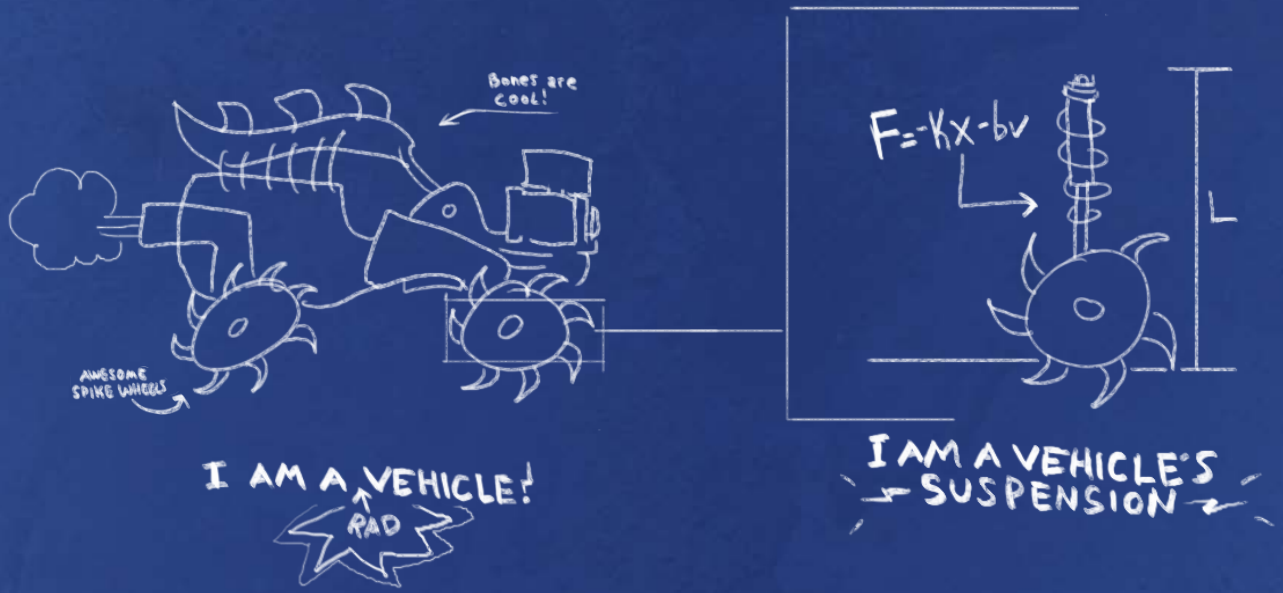

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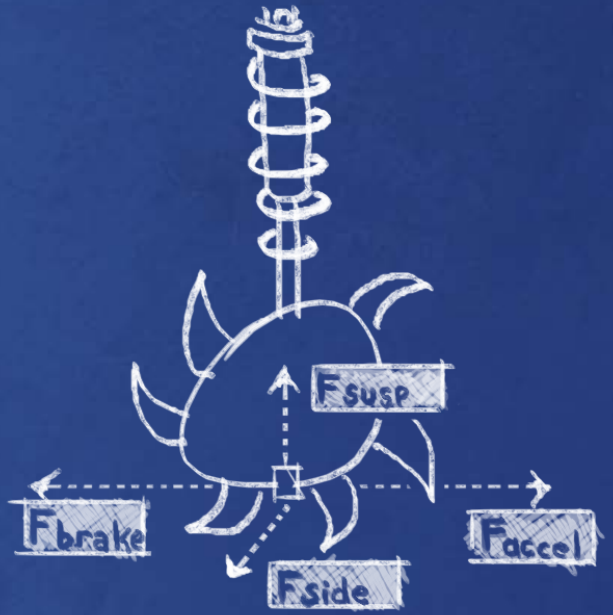

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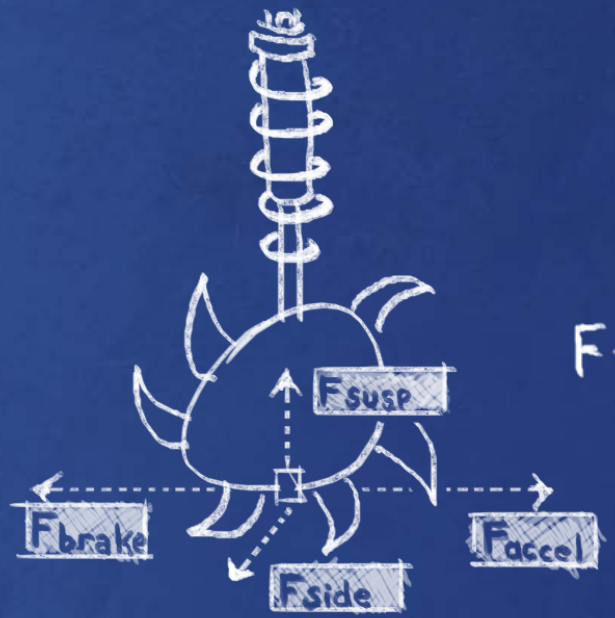
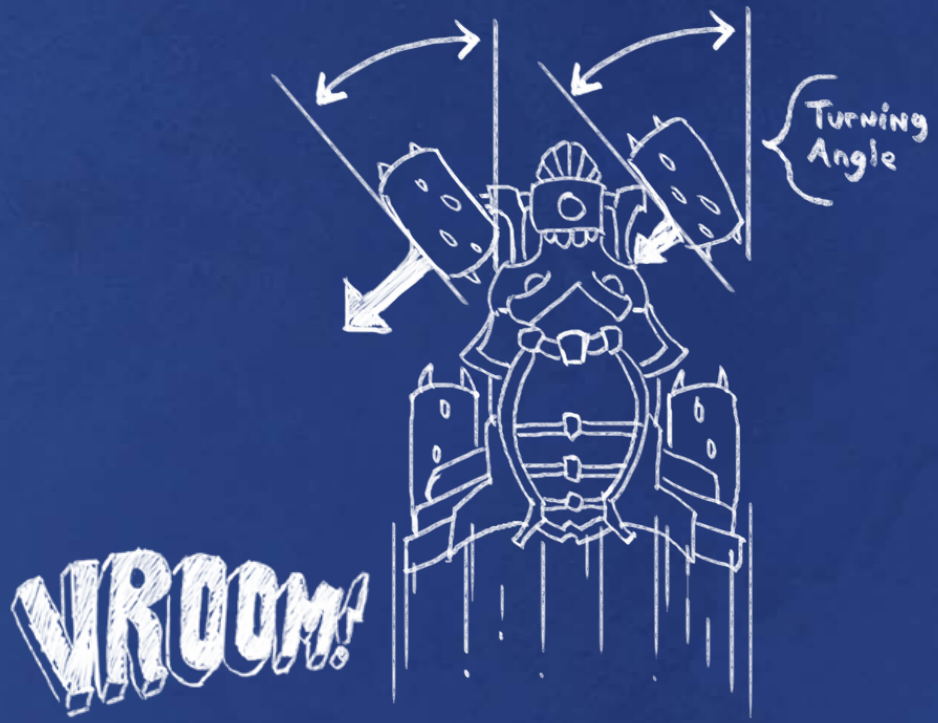


$$|F_{GRIP}| = |F_{SUSP}| \cdot K_{GRIP}$$

$$F_{WHEEL} = F_{ACCEL} + F_{BRAKE} + F_{SIDE}$$

$$F_{TOTAL} = F_{WHEEL} \cdot \frac{\min(|F_{GRIP}|, |F_{WHEEL}|)}{|F_{WHEEL}|} + F_{SUSP}$$

PHYSICS VEHICLES 1.0



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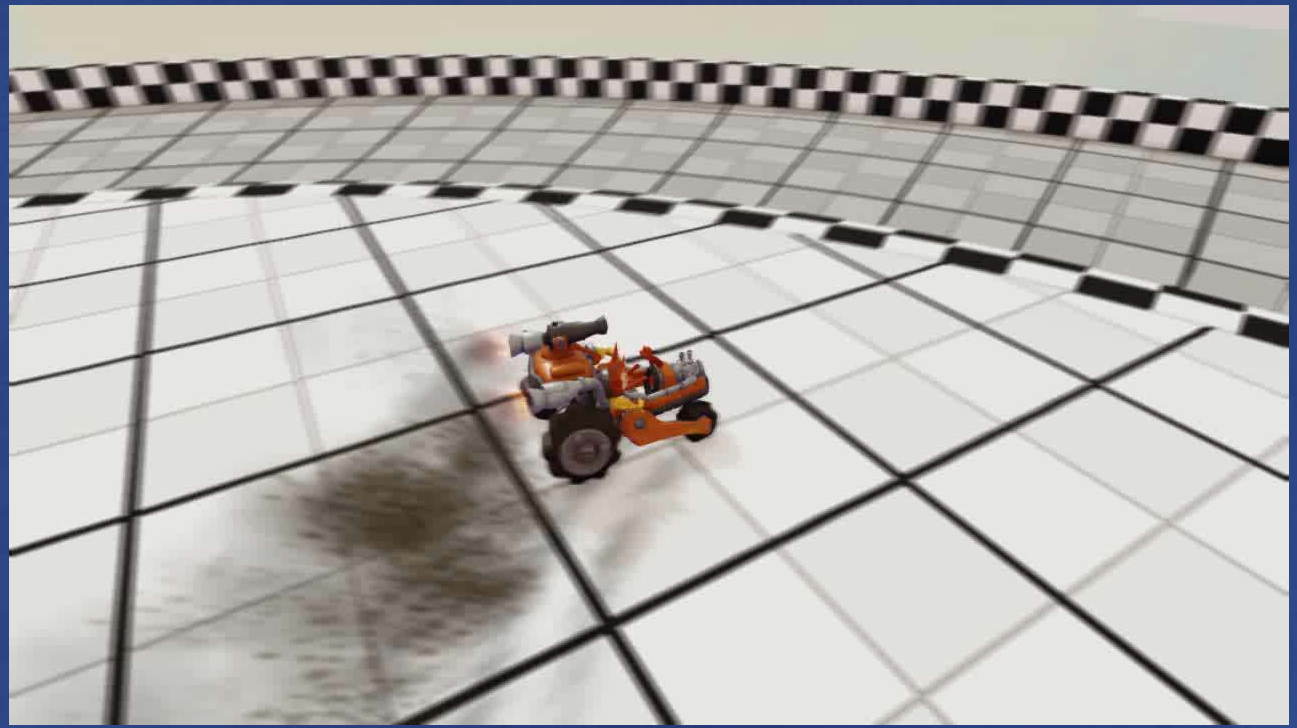

A DESIGN NIGHTMARE

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- *Force/acceleration are essentially magic numbers*

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- *Easy to make vehicles unstable*

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- *Force/acceleration are essentially magic numbers*
- *Easy to make vehicles unstable*
- *Difficult to make vehicle feel unique*

CHARACTER VEHICLES

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- *Leverage our robust character pipeline*

CHARACTER VEHICLES

- *Leverage our robust character pipeline*
- *Move away from physically accurate simulation*
- *State machine driven motion*
- *Animation layering to recapture physical motion*
- *Simpler designer interface*

MISSED THE MARK

WHAT WE LEARNED

Physics Vehicle

inertia + chaos = FUN!

Handles organic terrain well

Complex motion by layering forces

Character Vehicle

More control over simulation

Designer Friendly ☺

Animation layering = POWERFUL!

Physics Vehicles 2.0:

- *Create a system that has best of both worlds!*

OUR PILLARS

“Everything should be made as simple as possible, but not simpler.”
– Albert Einstein

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Simplify physics simulation when appropriate

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Parameters should be translated into designer language

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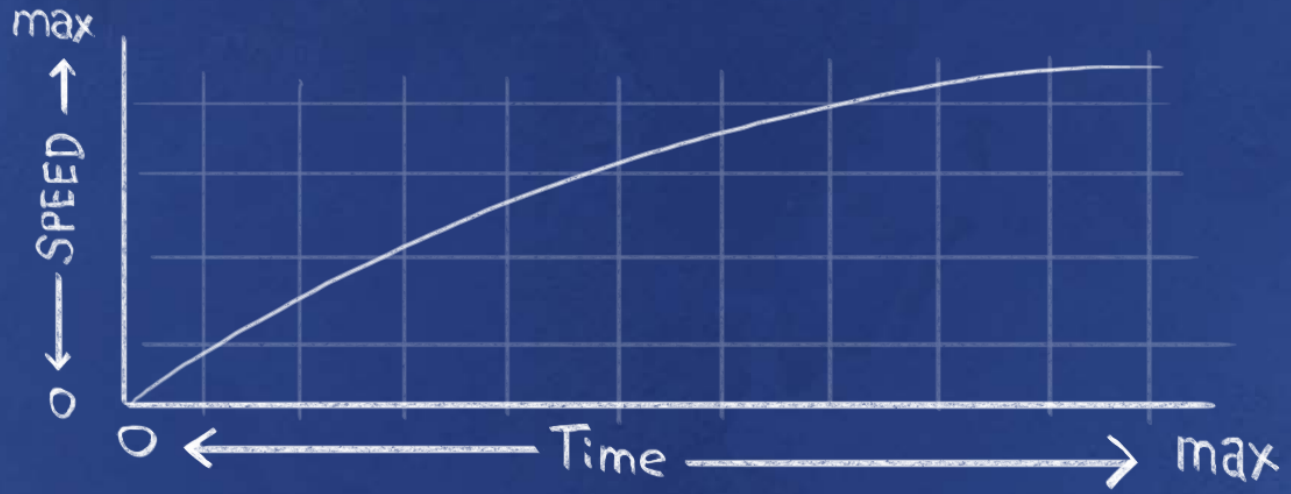
Simplify physics simulation when appropriate

Parameters should be translated into designer language

Complex behavior should come from layering simple systems

Keep parameters independent

ACCELERATING TO TOP SPEED



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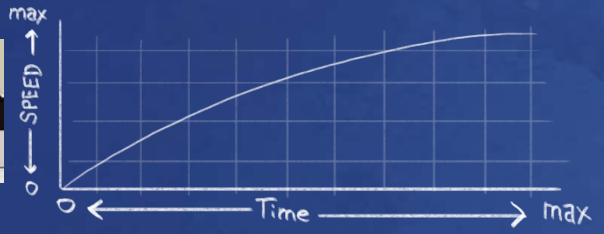
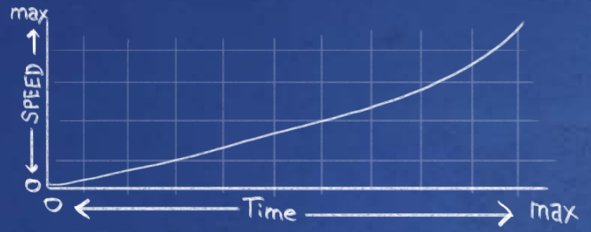
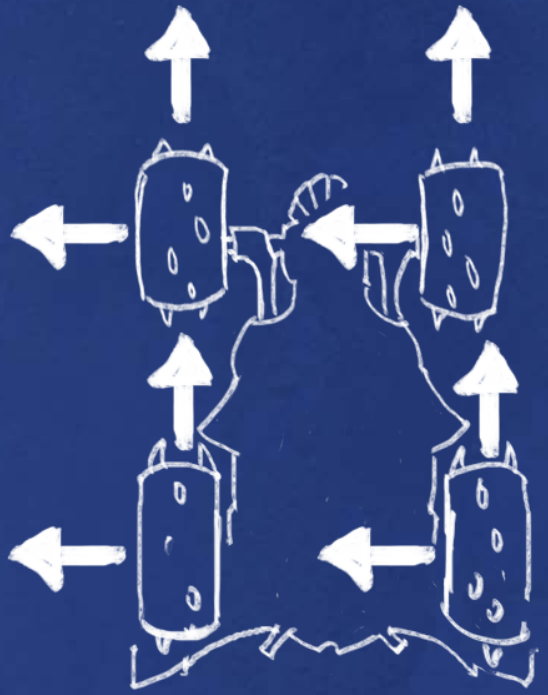


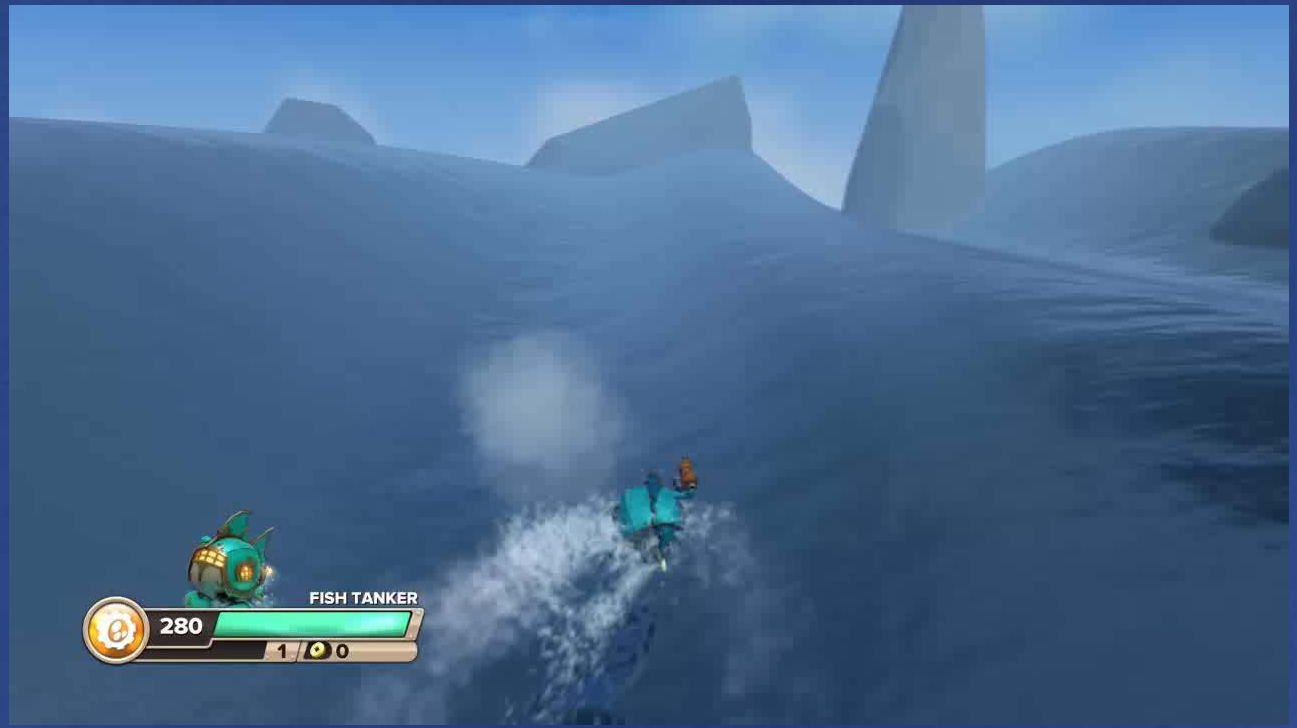


REDUCING COMPLEXITY



REDUCING COMPLEXITY

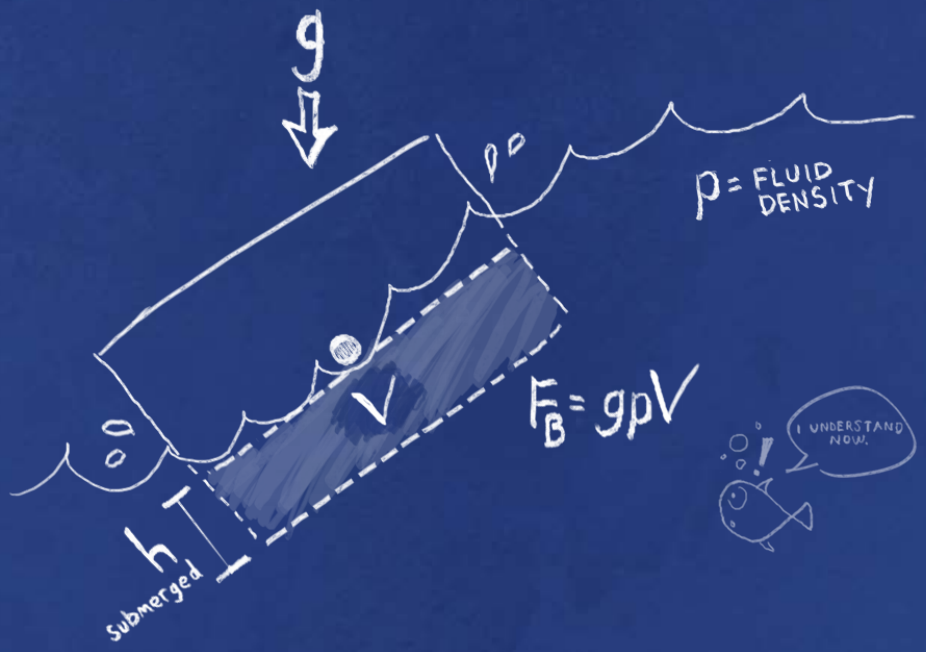
BUOYANCY



MODELING BUOYANCY

Buoyancy: A fluid exerts a 'buoyant' force on an object wholly or partially submerged, and the magnitude of that force is equal to the weight of the fluid that is displaced

SIMPLIFIED BUOYANCY MODEL



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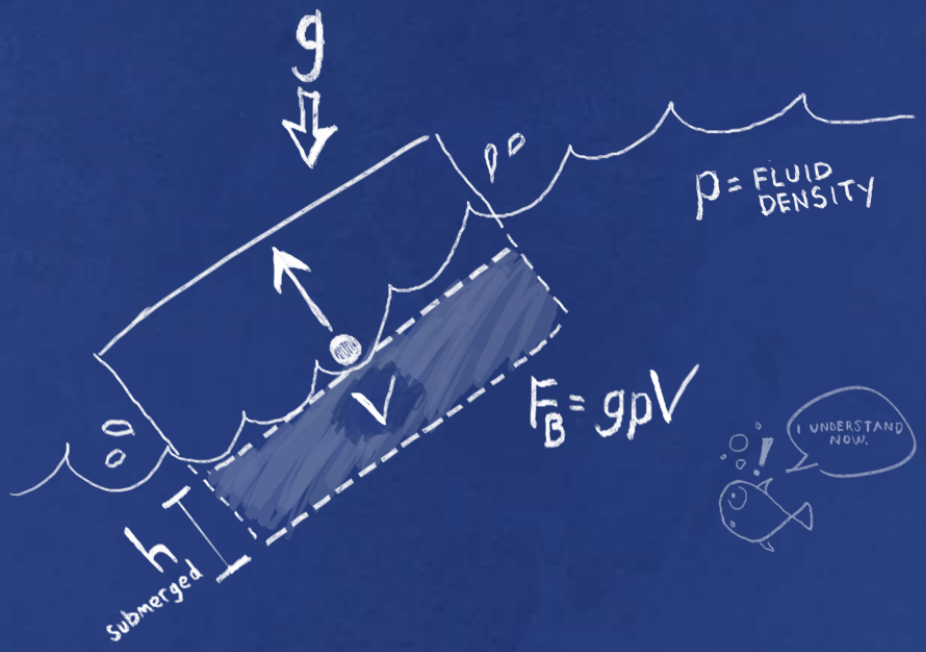
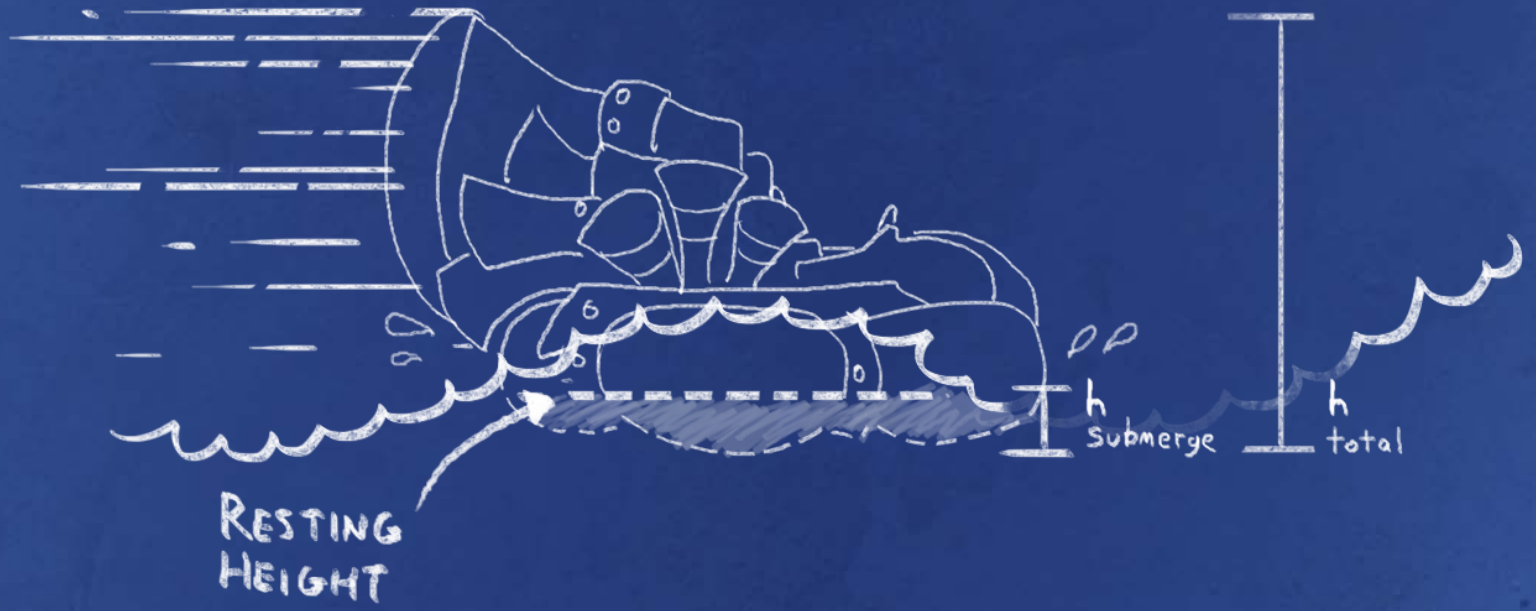


BUOYANCY

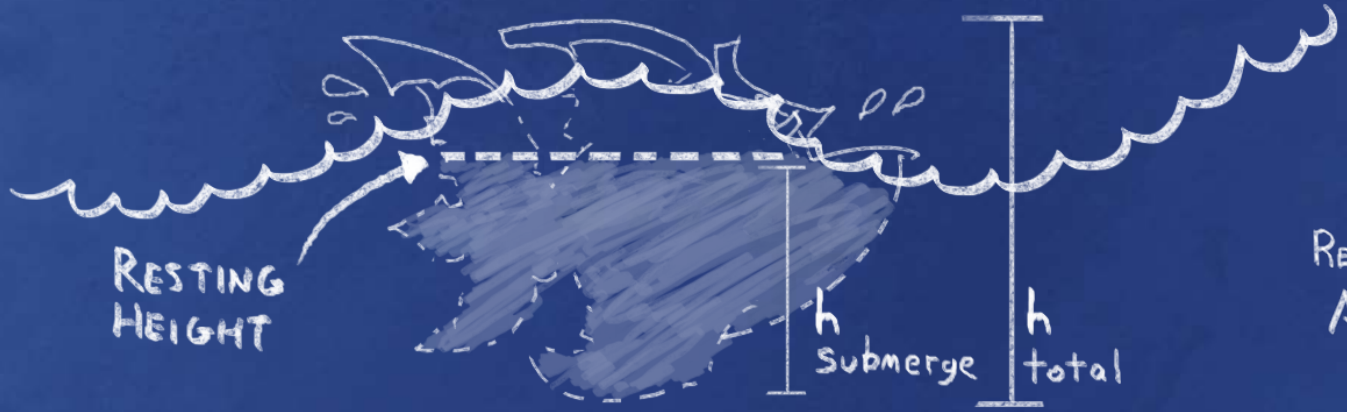
BUOYANCY RESTING HEIGHT



BUOYANCY RESTING HEIGHT

TRANSLATE

INDEPENDENT



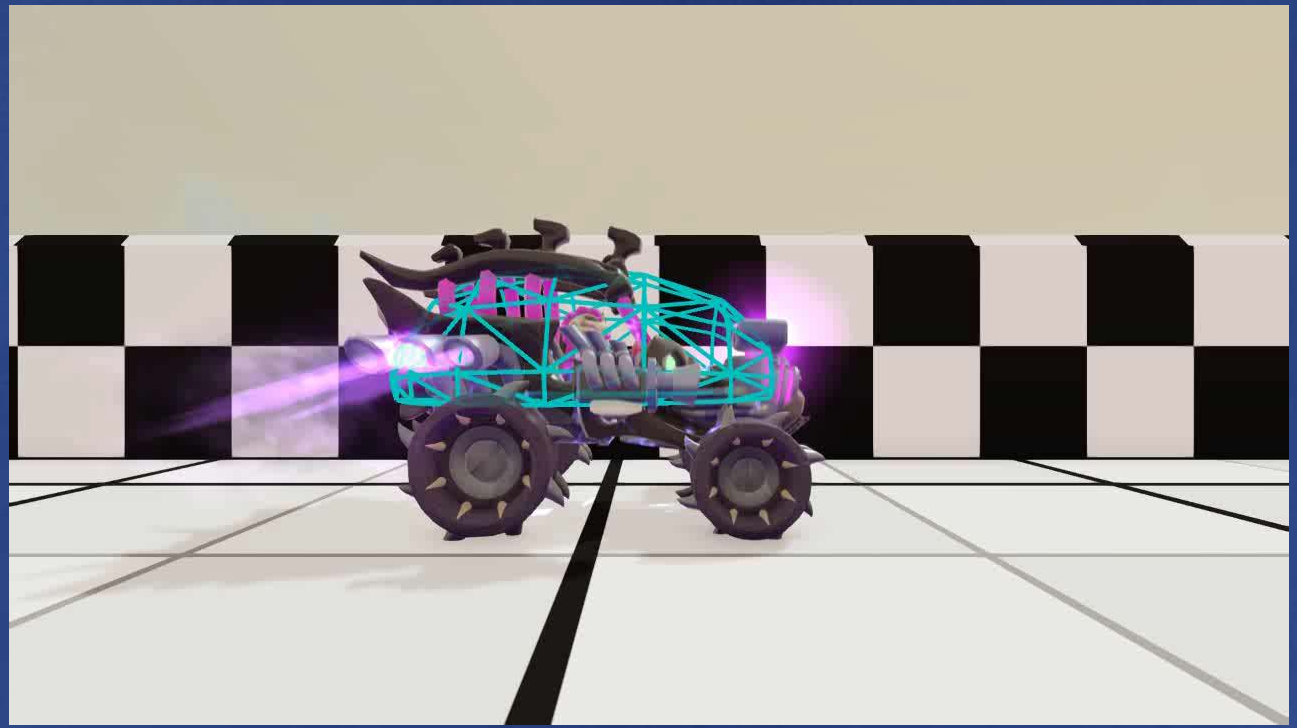
Resting ratio $R = \frac{h_{submerge}}{h_{total}}$

At rest: $F_G = F_B$

$\therefore V = \frac{mass}{R \cdot P}$

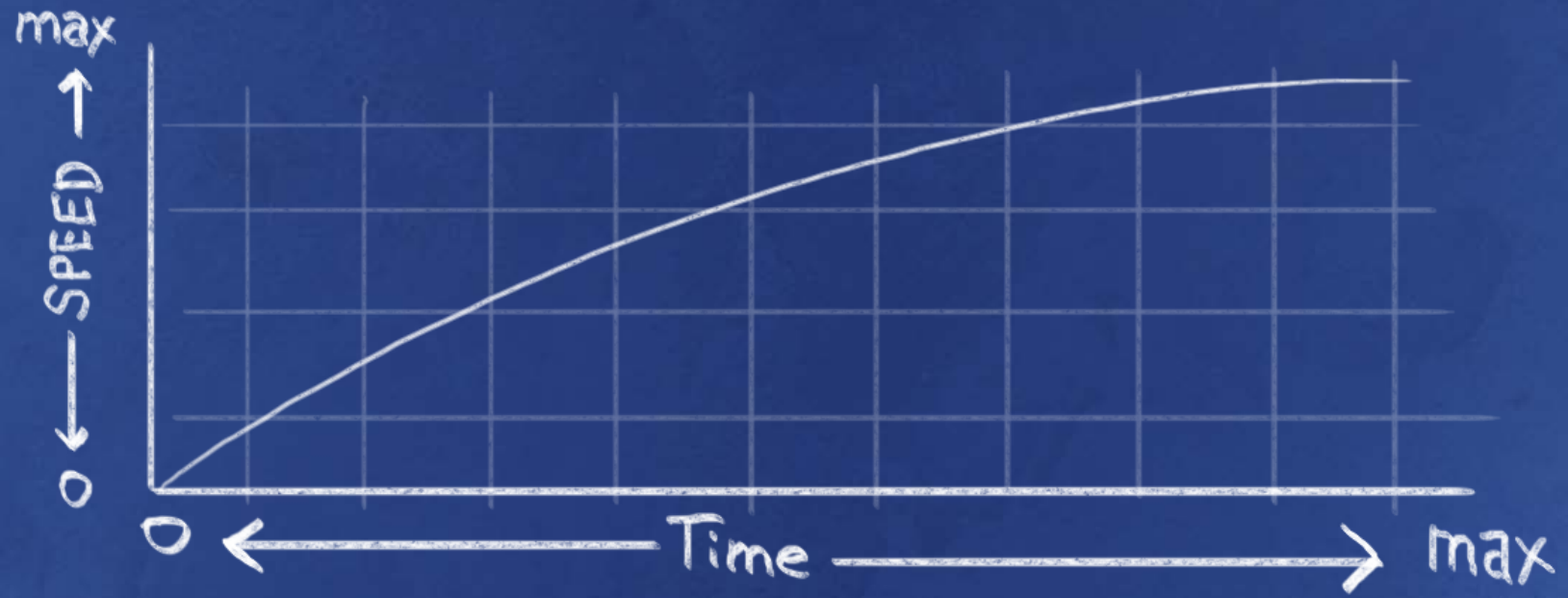
(This means "Therefore")

LAYERED COMPLEXITY THROUGH ANIMATION



TECHNICAL DEEP DIVE

EVALUATING VELOCITY CURVES



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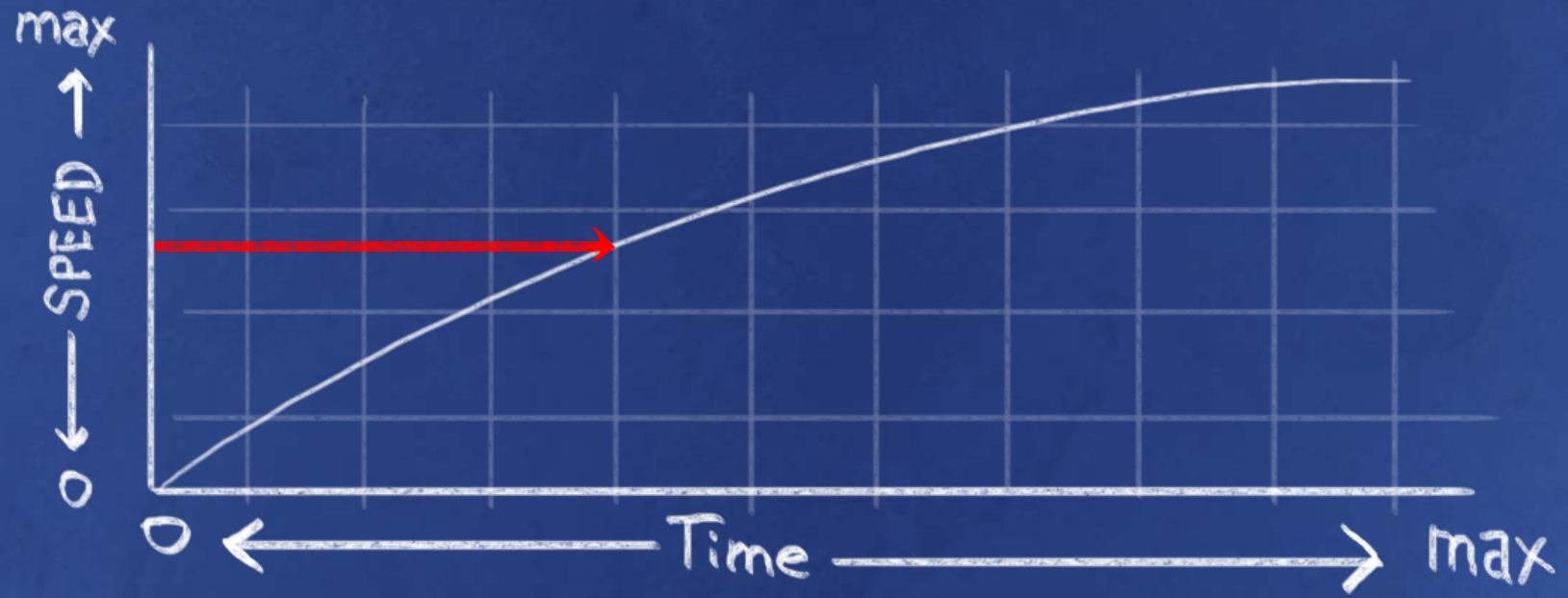

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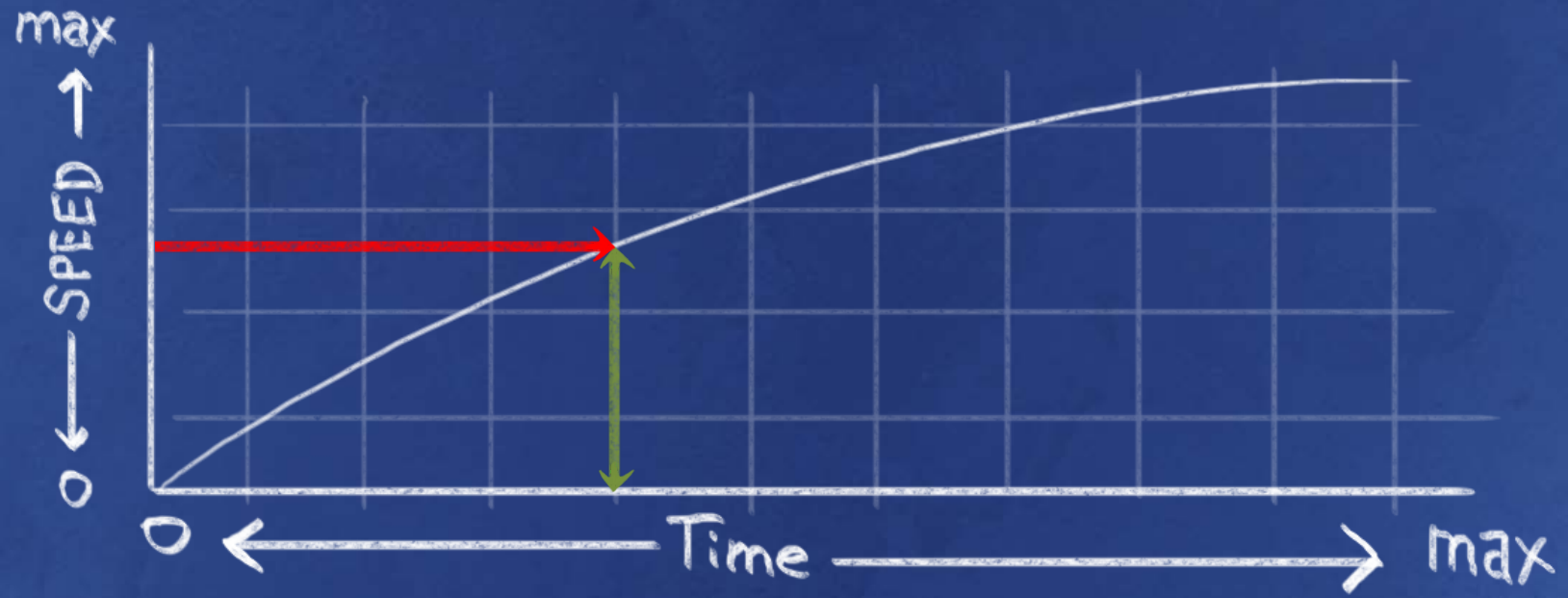

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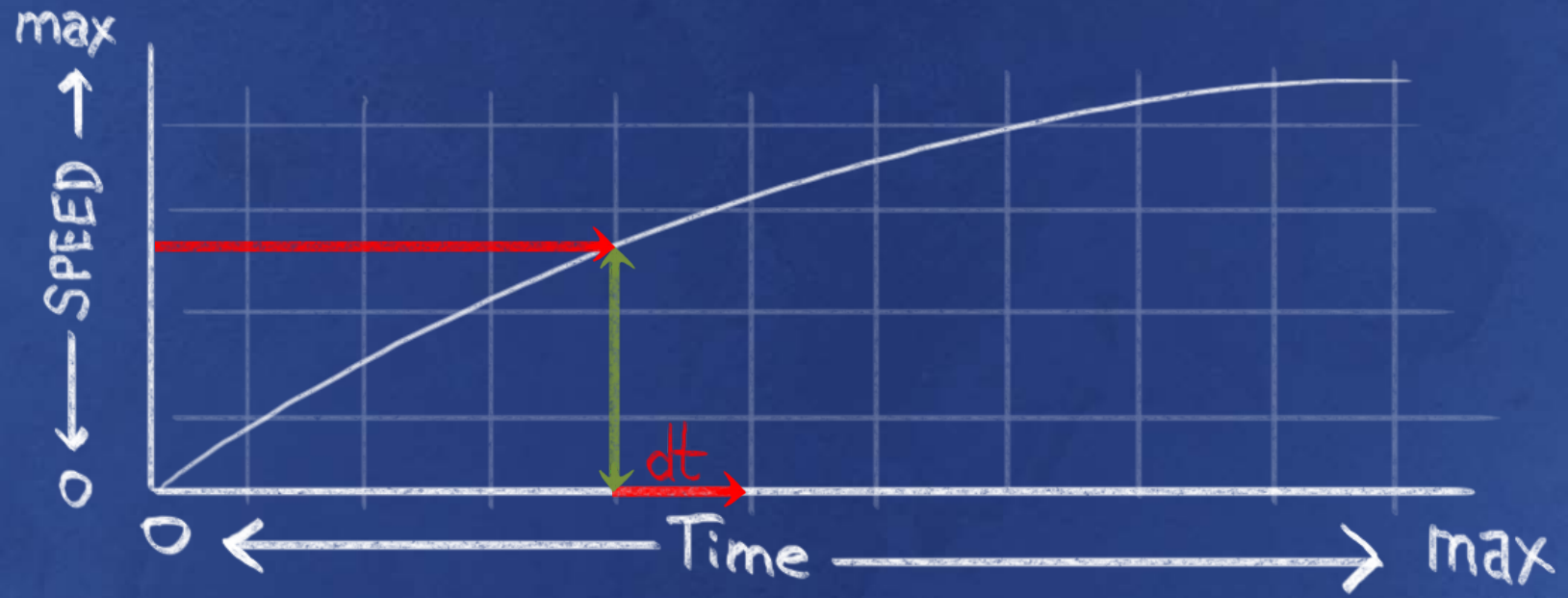

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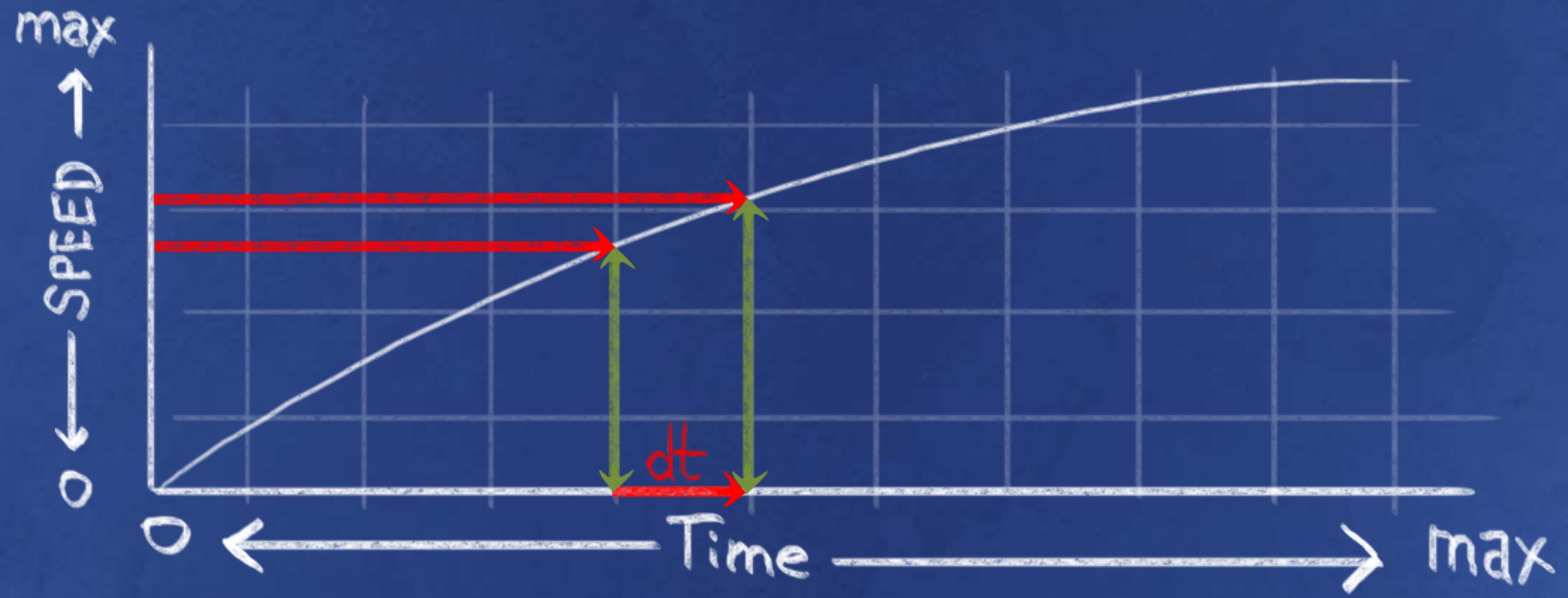

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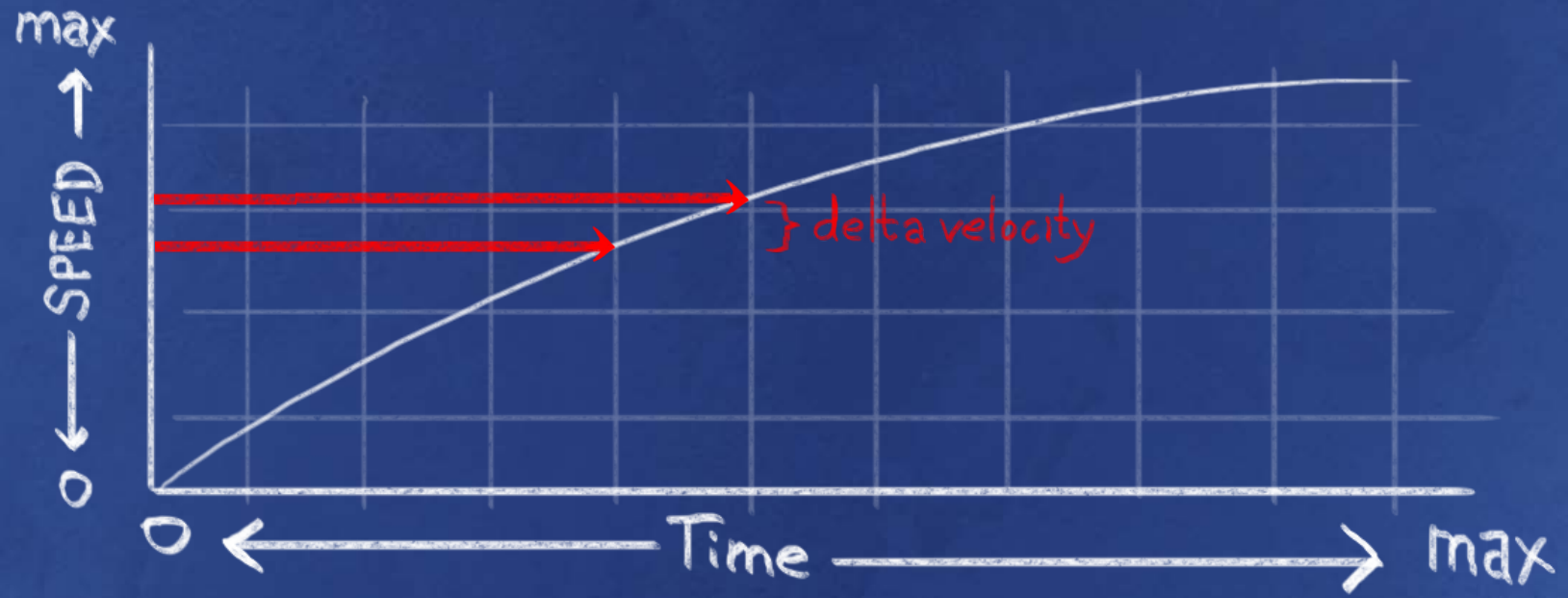

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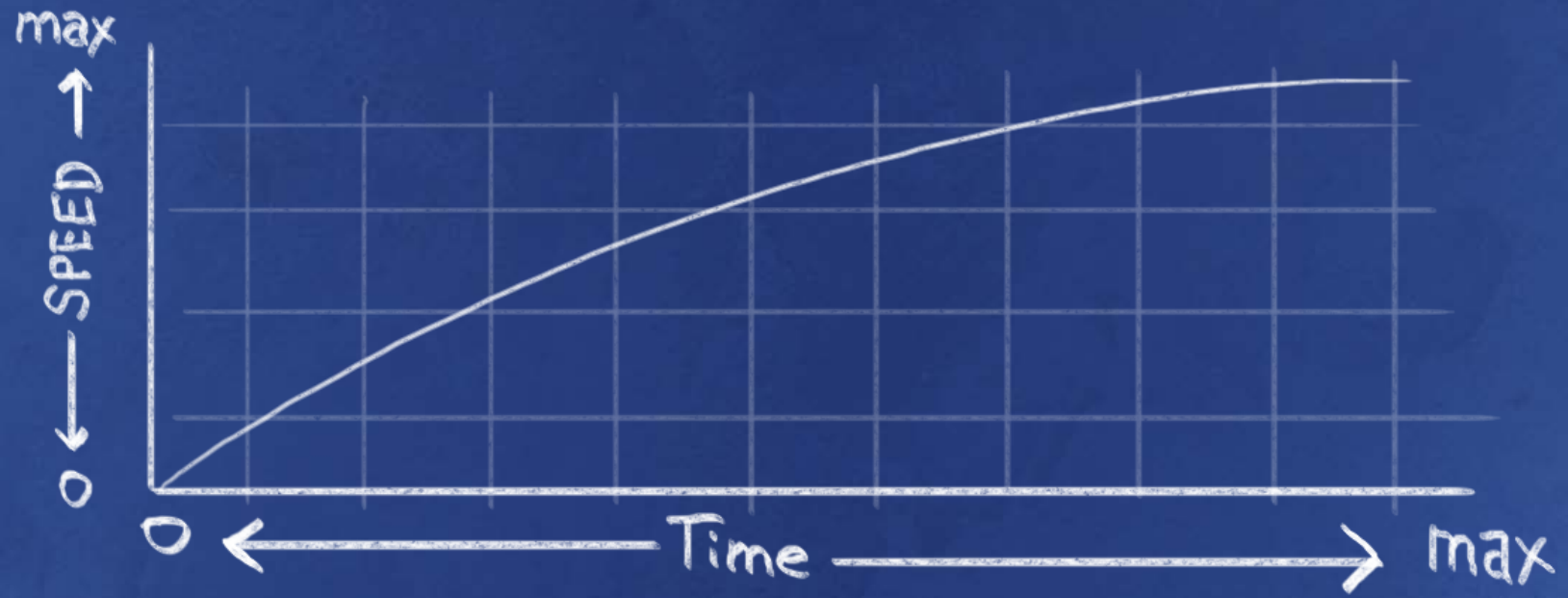

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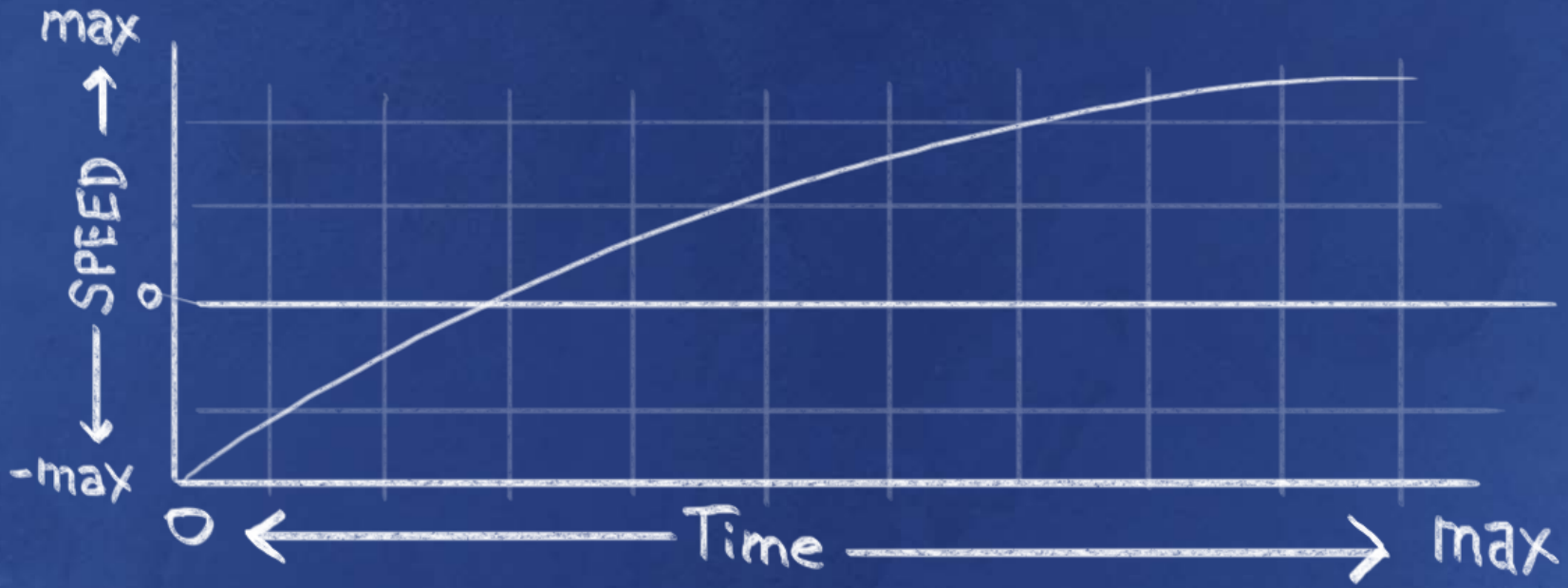

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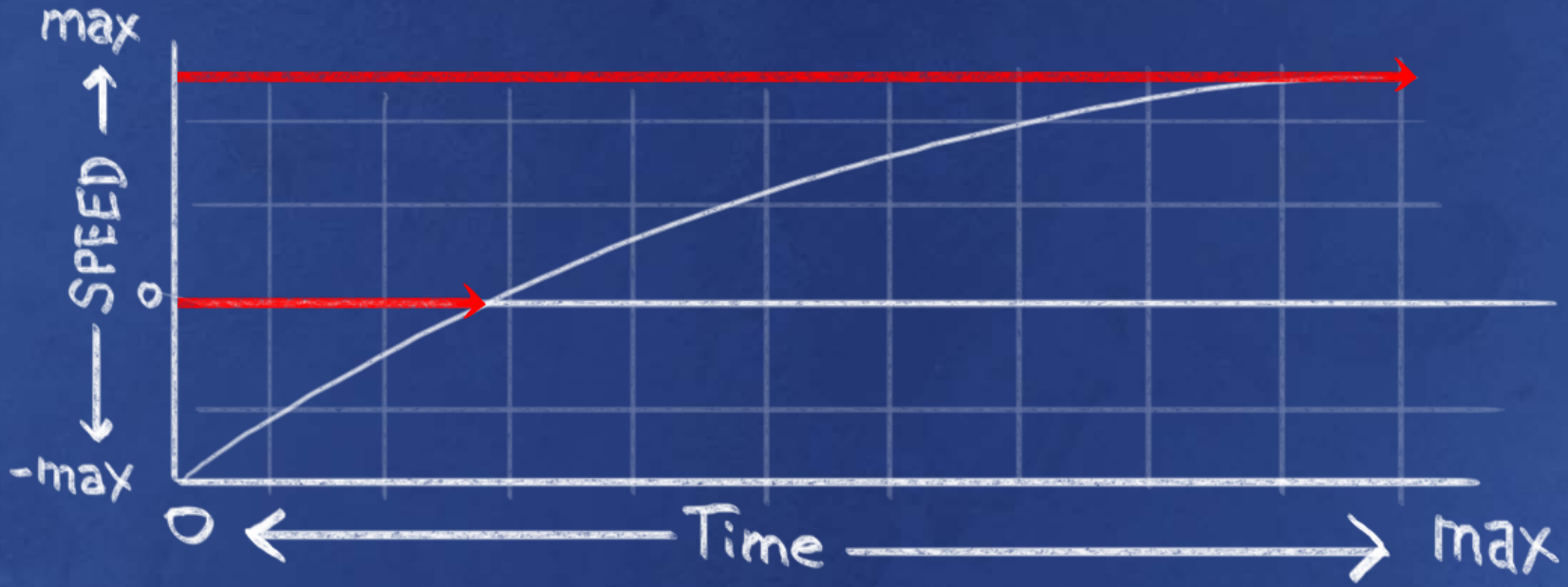

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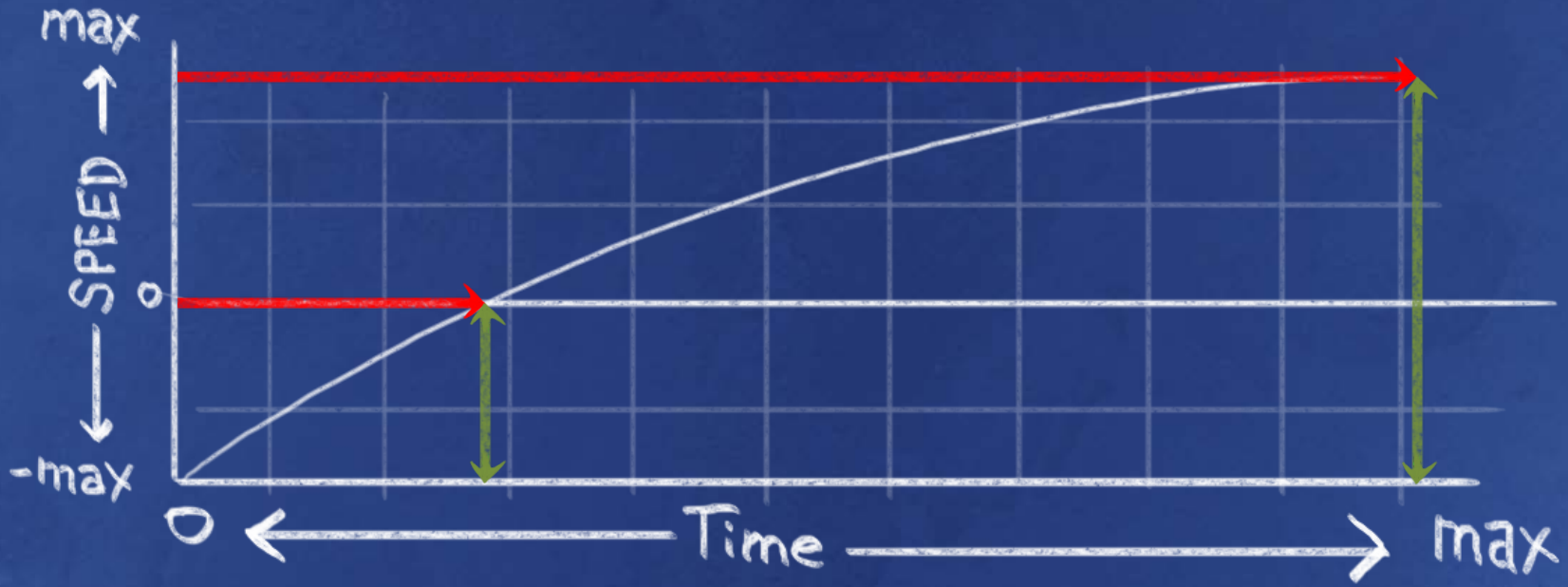

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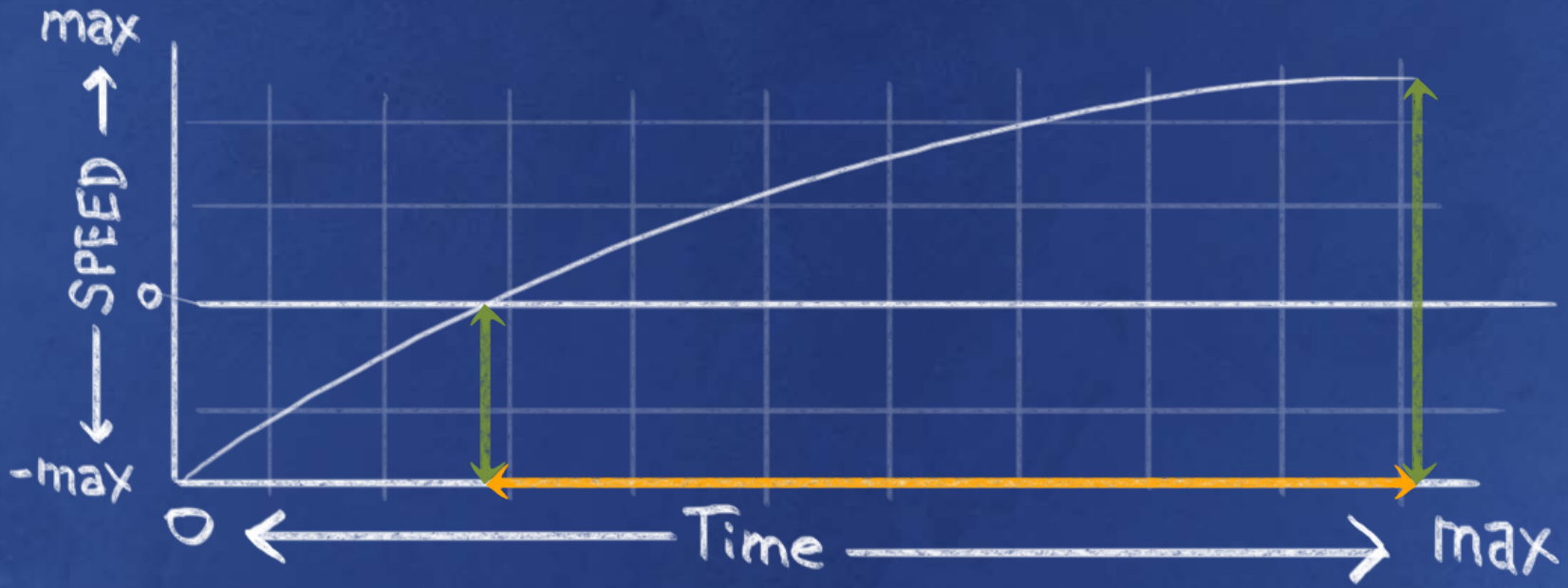

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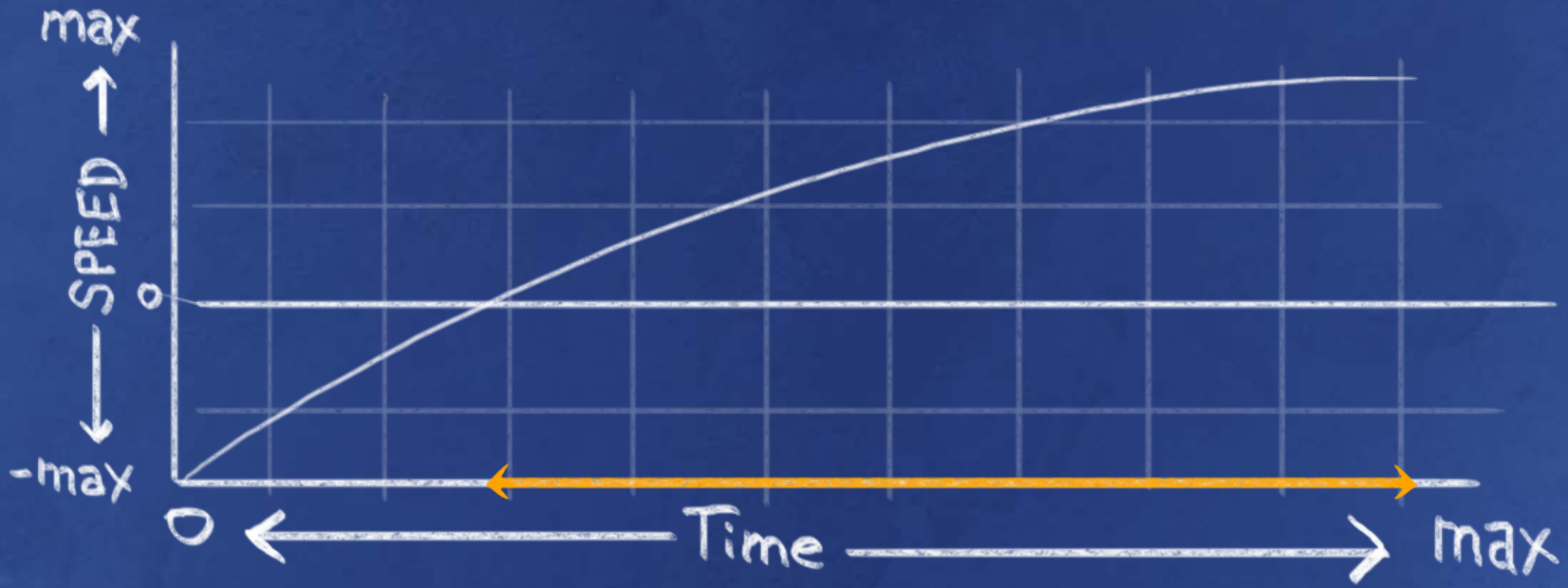

SUSPENSION

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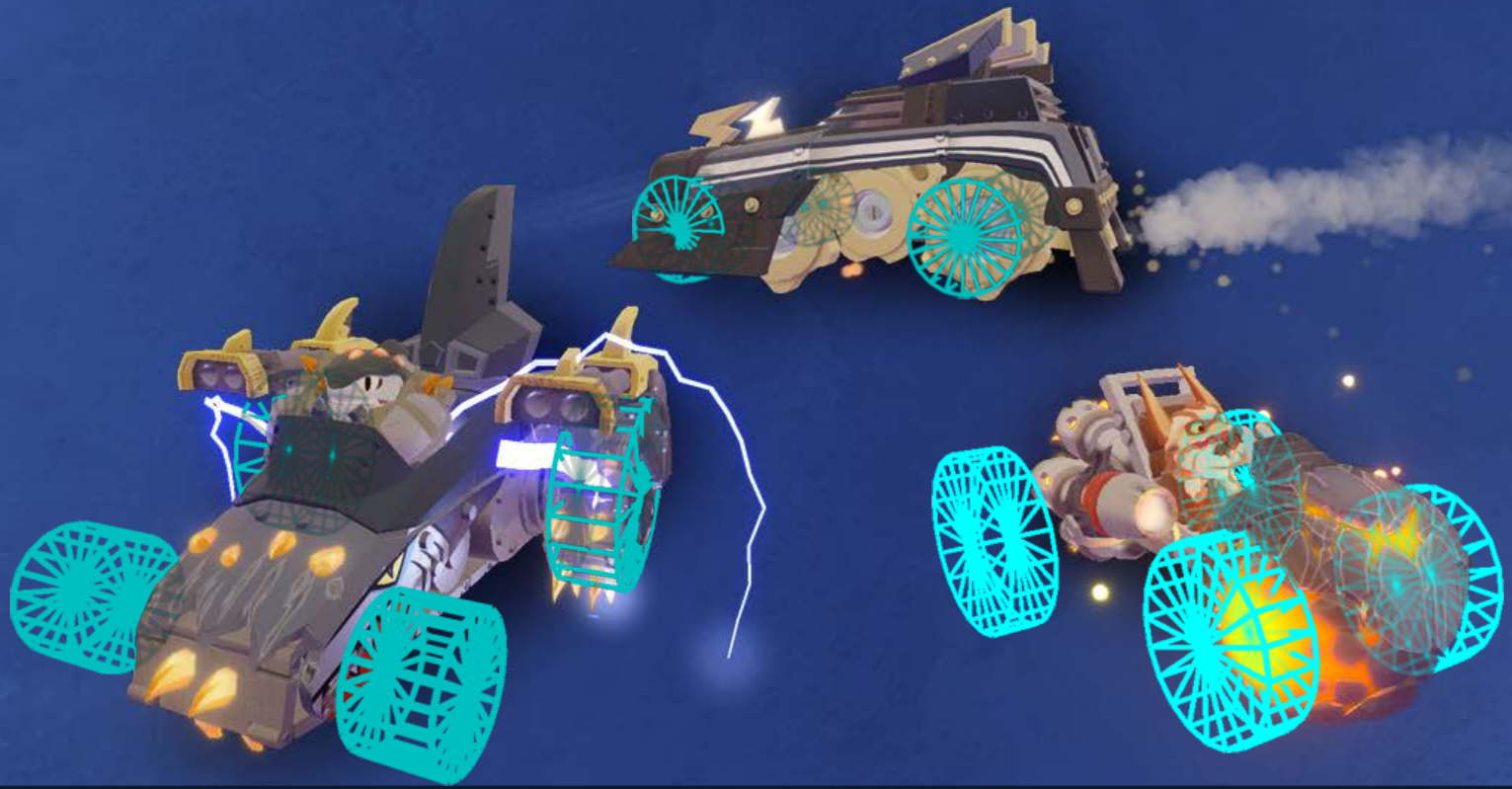
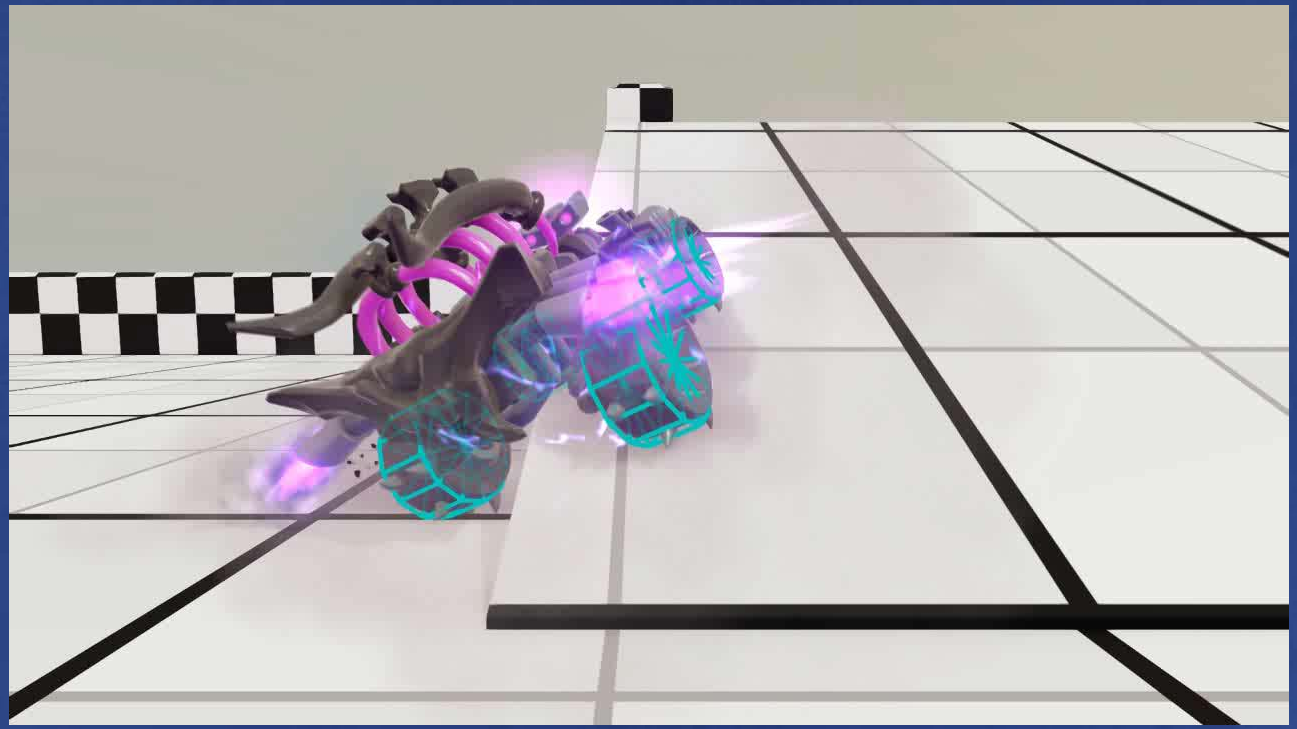


SHAPE CAST



SHAPE CAST

SPRING SIMULATION

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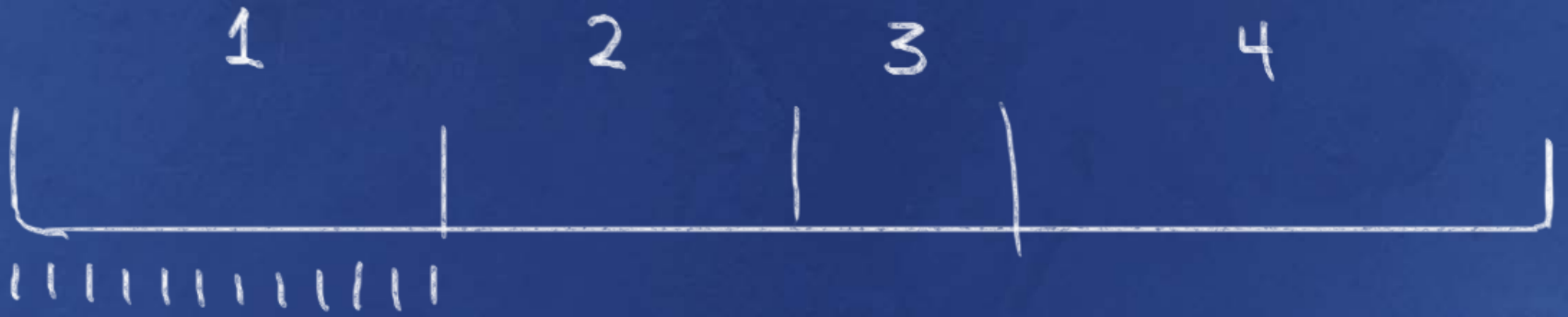

SPRING SIMULATION

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HIGH-FREQUENCY SUBSTEPPING

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mTimeToProcess += deltaFrameTime
totalSubStepTime = 0.0f
travelDistance = 0.0f
while (mTimeToProcess >= subStepFixedDeltaTime)
{
    suspVel = rigidBody.getPointVelocity(suspPoint) + gravity * totalSubStepTime
    suspVelProjected = suspDir * suspDir.dot(suspVel)
    springLen = origSpringLen - travelDistance
    // Calculate force based on springLen and suspVelProjected (spring damper)
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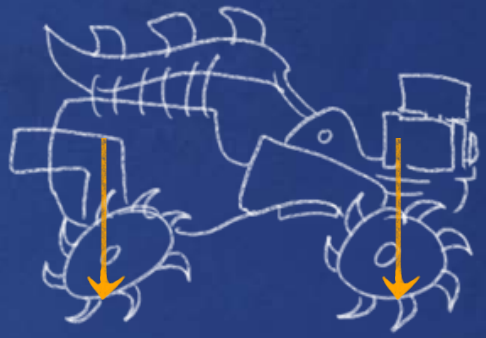

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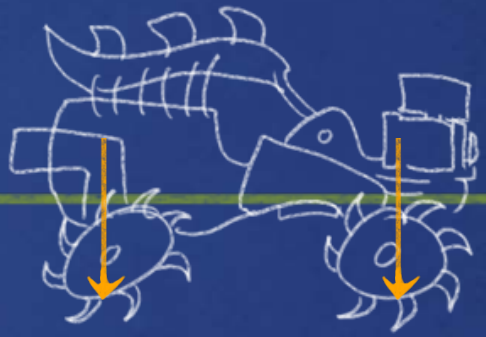

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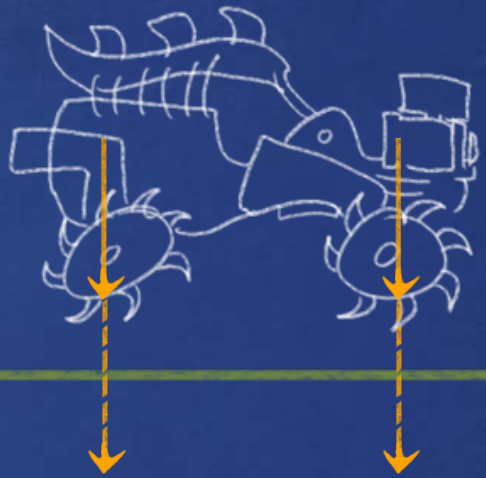

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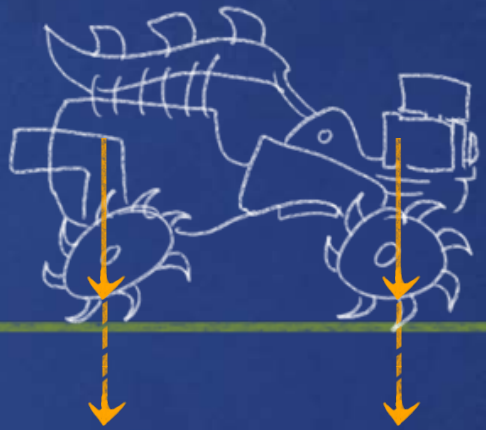

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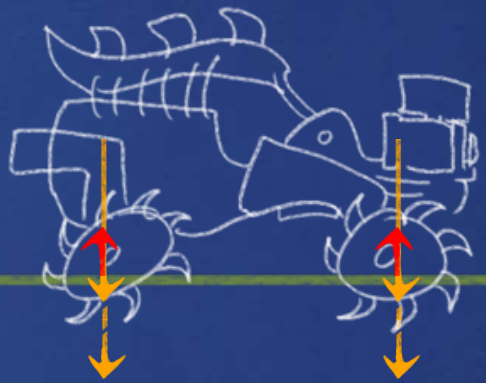

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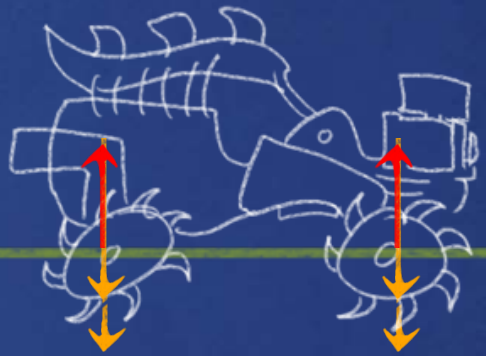

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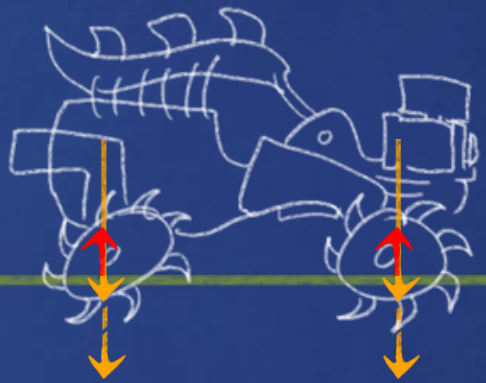

HIGH-FREQUENCY SUBSTEPPING

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COLLISION RESPONSE SYSTEM

*Goal: **Fun** vehicle physics for a young, novice demographic*

Game for kids: expect them to crash into things

Flexible one-stop shop for all collision responses involving vehicles

- *Had to work for all vehicle types*

Data driven

COLLISION RESPONSE SYSTEM

COLLISION RESPONSE SYSTEM

Rule based

COLLISION RESPONSE SYSTEM

Rule based

- *Set of criteria*

COLLISION RESPONSE SYSTEM

Rule based

- *Set of criteria*
- *Priority*

COLLISION RESPONSE SYSTEM

Rule based

- *Set of criteria*
- *Priority*
- *Must involve a vehicle*

COLLISION RESPONSE SYSTEM

Rule based

- *Set of criteria*
- *Priority*
- *Must involve a vehicle*
- *Scoped*

COLLISION RESPONSE SYSTEM

Rule based

- *Set of criteria*
- *Priority*
- *Must involve a vehicle*
- *Scoped*
- *Bi-directional*

COLLISION RESPONSE SYSTEM

Rule based

- *Set of criteria*
- *Priority*
- *Must involve a vehicle*
- *Scoped*
- *Bi-directional*
- *Response*

COLLISION RESPONSE SYSTEM

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Phase 1: Mid-simulation

- *Limited*
- *Predictive*

COLLISION RESPONSE SYSTEM

Phase 1: Mid-simulation

- *Limited*
- *Predictive*

Phase 2: Post-solve

- *Unlimited*
- *Reactive*

COLLISION RESPONSE SYSTEM

Phase 1: Mid-simulation

- *Limited*
- *Predictive*
- *Best match per contact*

Phase 2: Post-solve

- *Unlimited*
- *Reactive*

COLLISION RESPONSE SYSTEM

Phase 1: Mid-simulation

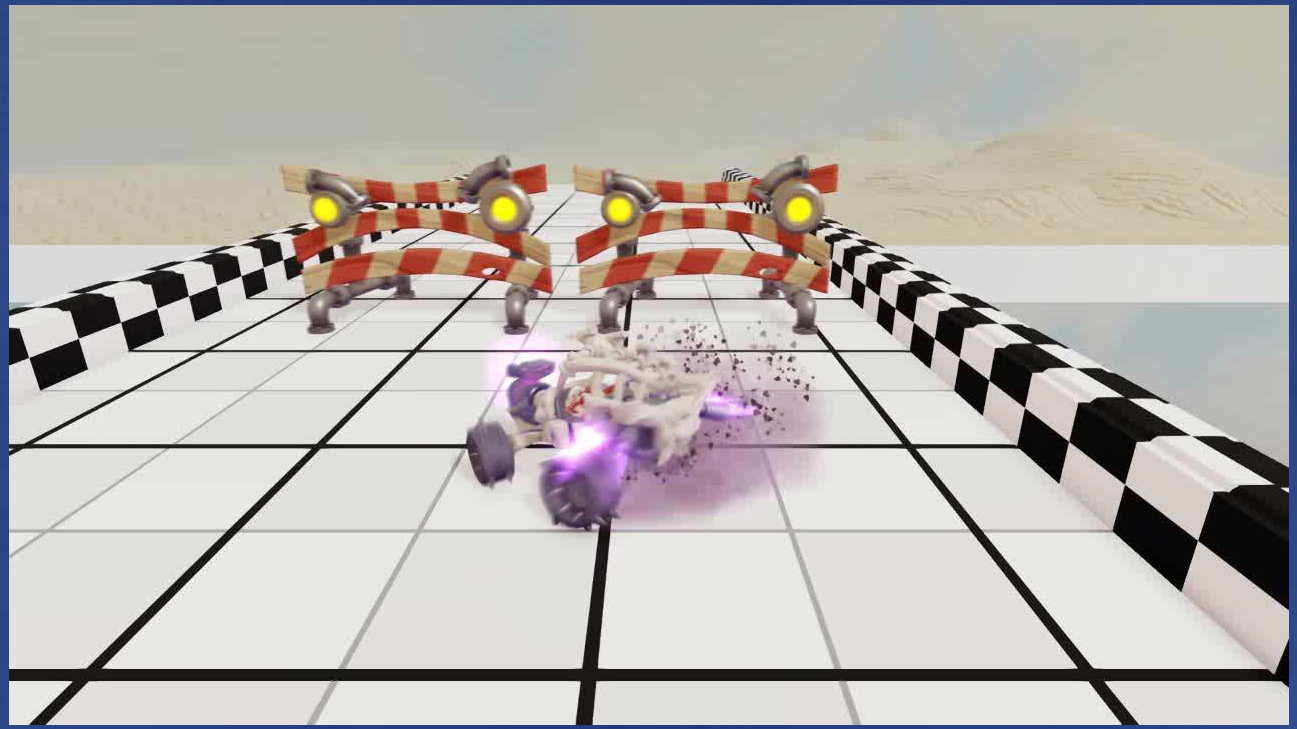
- *Limited*
- *Predictive*
- *Best match per contact*

Phase 2: Post-solve

- *Unlimited*
- *Reactive*
- *Best match between body pairs*

COLLISION RESPONSE SYSTEM

COLLISION RESPONSE SYSTEM



COLLISION RESPONSE SYSTEM

	SOURCE	TARGET
Criteria		
Reaction		

COLLISION RESPONSE SYSTEM

	SOURCE	TARGET
Criteria	Is Vehicle = True	
Reaction		

COLLISION RESPONSE SYSTEM

	SOURCE	TARGET
Criteria	Is Vehicle = True Min Speed = 20%	
Reaction		

COLLISION RESPONSE SYSTEM

	SOURCE	TARGET
Criteria	Is Vehicle = True Min Speed = 20%	
Reaction	Ignore Collision	

COLLISION RESPONSE SYSTEM

	SOURCE	TARGET
Criteria	Is Vehicle = True Min Speed = 20%	
Reaction	Ignore Collision	Apply Damage

COLLISION RESPONSE SYSTEM

COLLISION RESPONSE SYSTEM

Be prepared for complexity

- *Layering rules is hard*

COLLISION RESPONSE SYSTEM

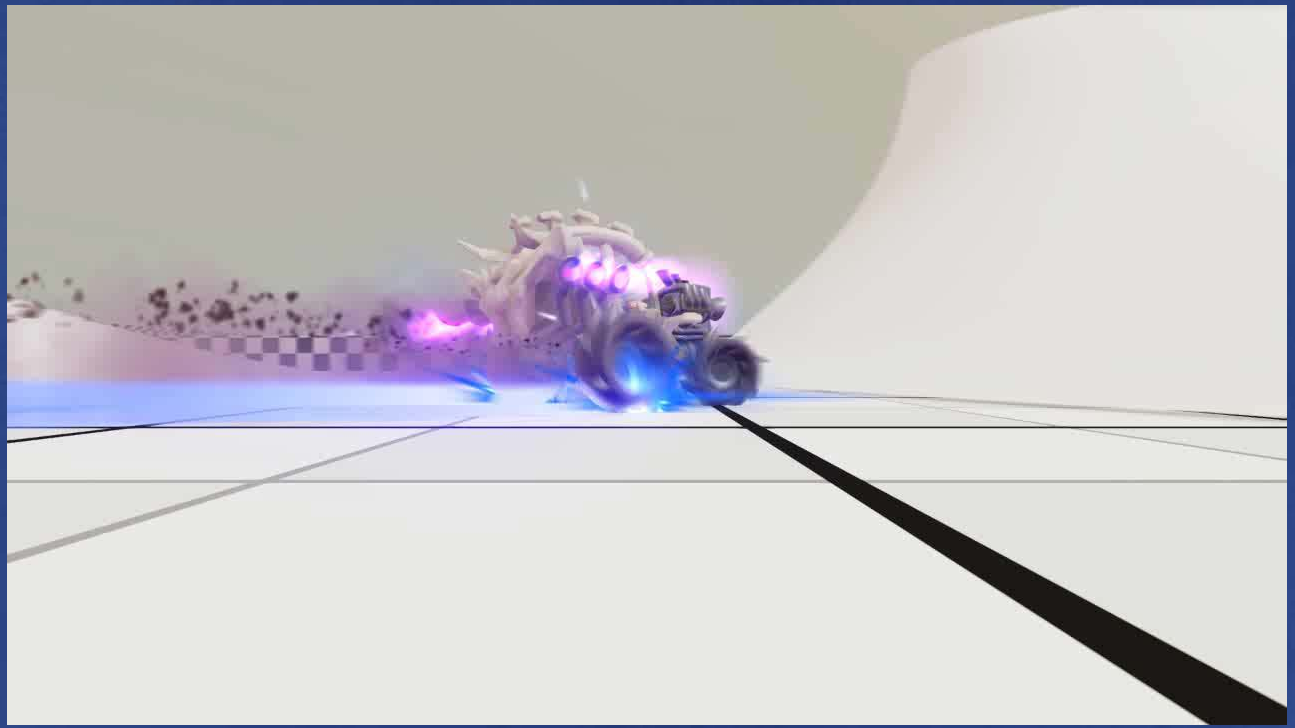
Be prepared for complexity

- *Layering rules is hard*

Flexibility is key

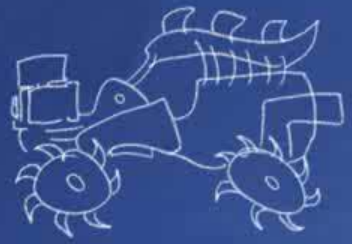
- *Scope of rules*
- *Criteria and response capabilities*

PREDICTIVE LANDING



PREDICTIVE LANDING

PREDICTIVE LANDING



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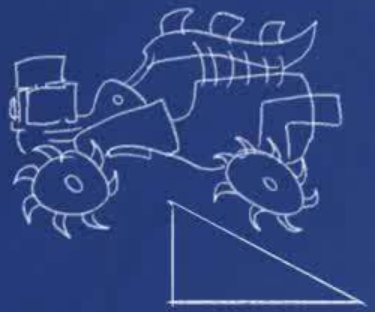
PREDICTIVE LANDING



PREDICTIVE LANDING

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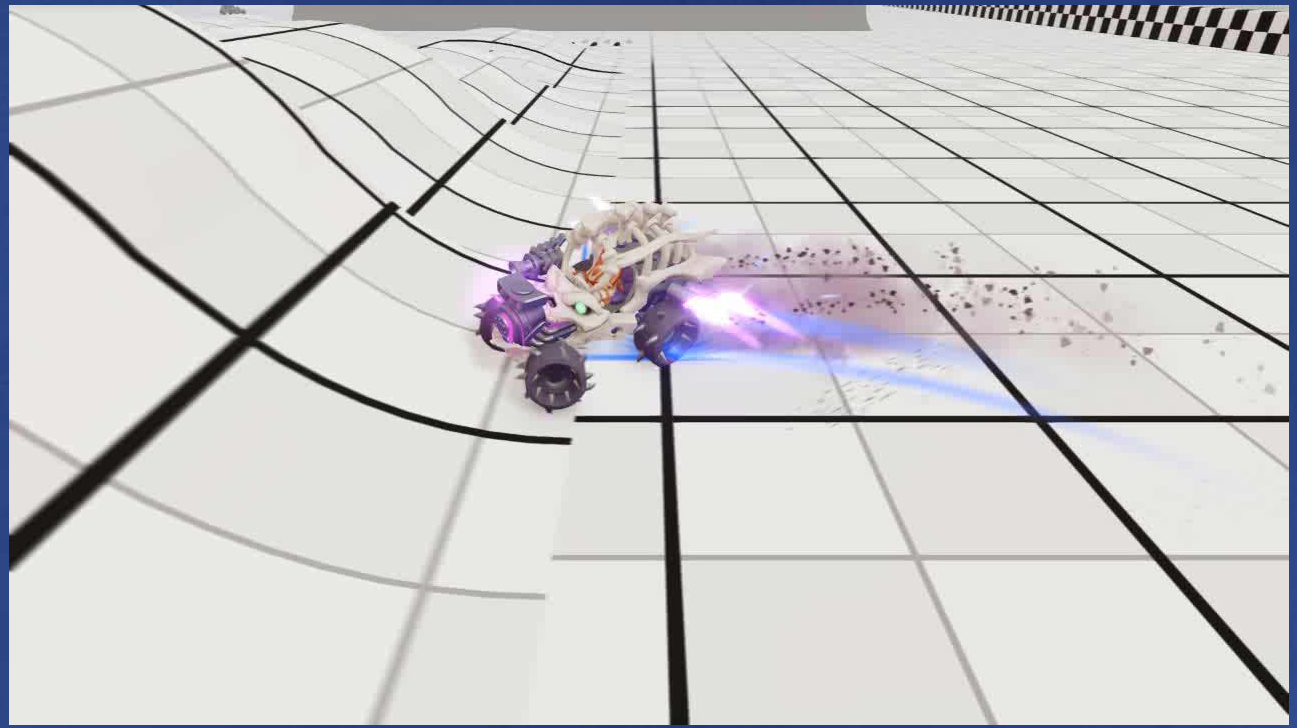

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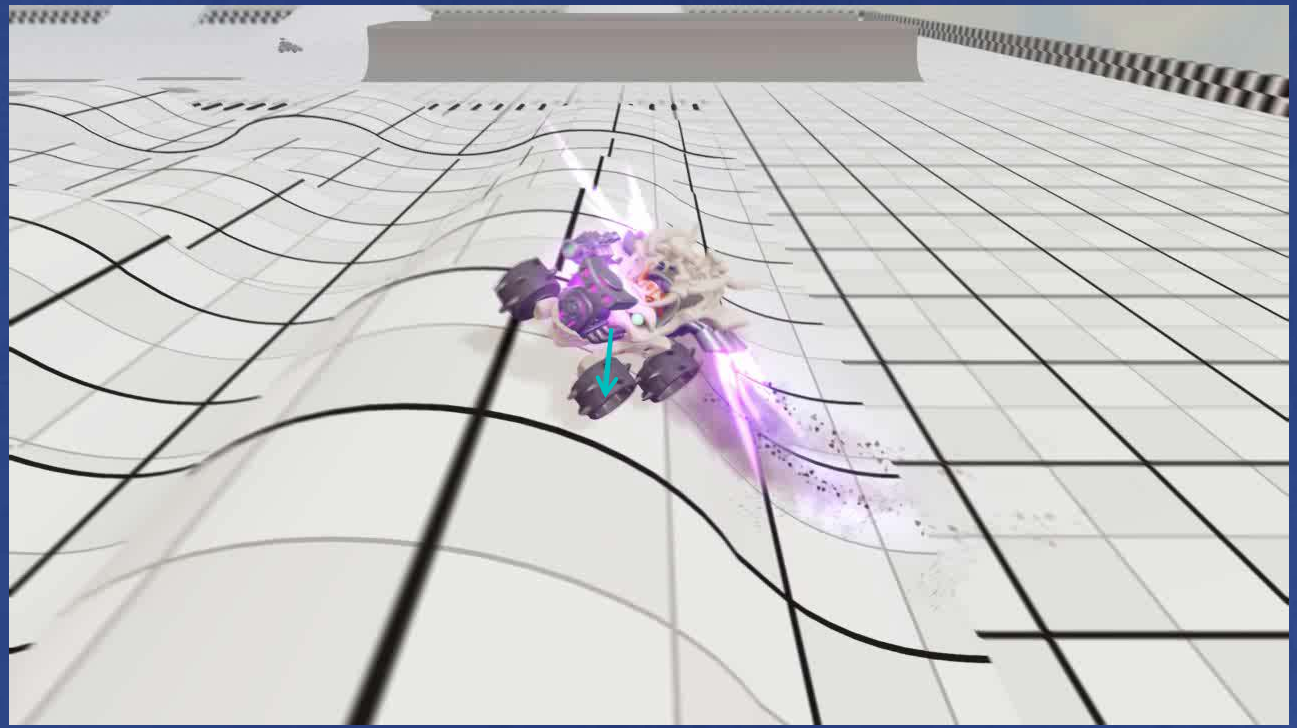

CONCLUSION

QUESTIONS?

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