



The Science Of Offroading

Uncharted 4's 4x4

By Ed Pereira





What Kind Of Simulation?





What Kind Of Simulation?

Realistic

Stylized





What Kind Of Simulation?

Realistic



Stylized



What Kind Of Simulation?

Realistic



Stylized



What Kind Of Simulation?

Realistic



4x4



Stylized





Simulation





Simulation

- Collision Detection And Response





Simulation

- Collision Detection And Response
- Motor





Simulation

- Collision Detection And Response
- Motor
- Tire Friction













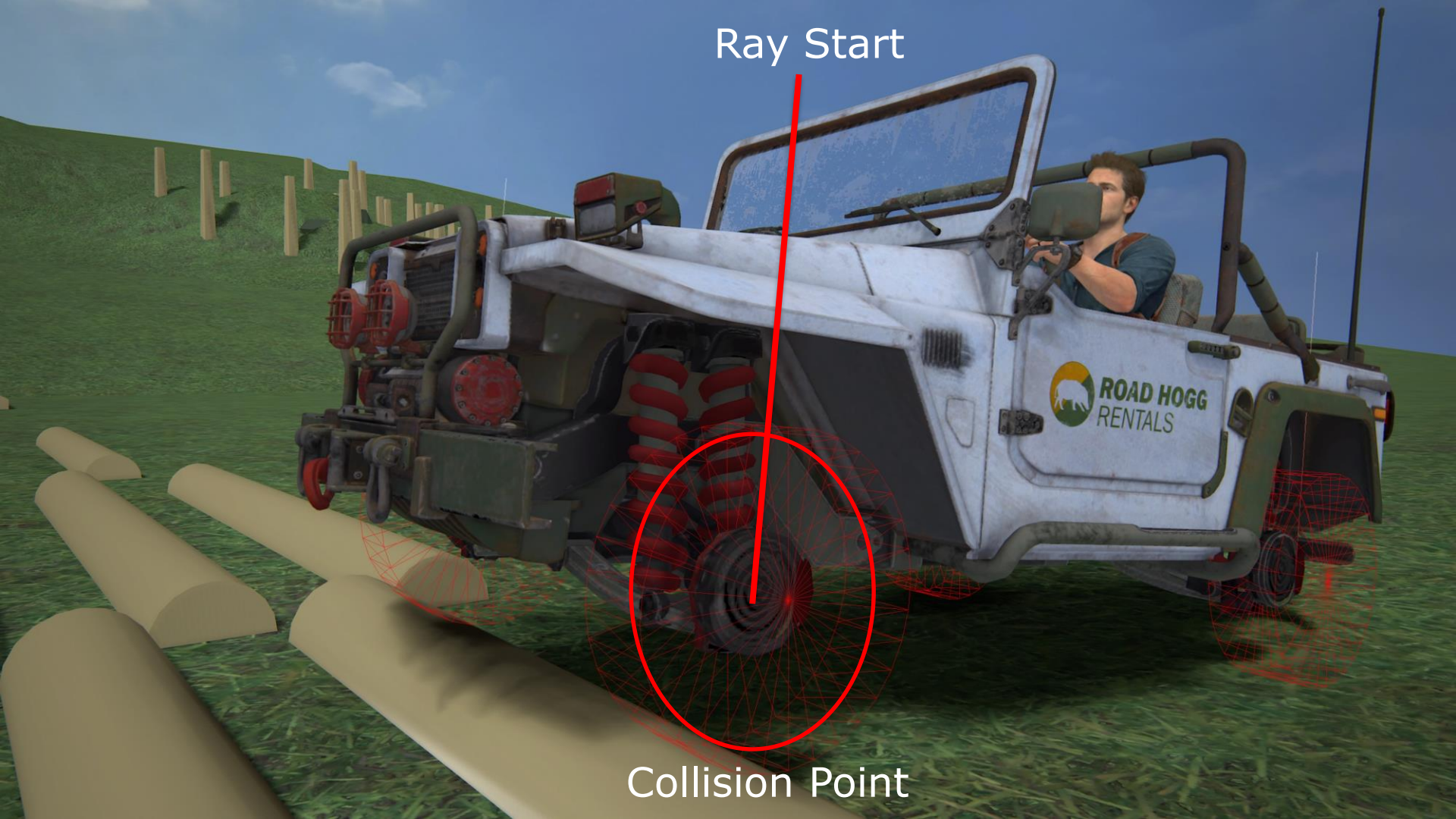








Ray Start



Collision Point











Center

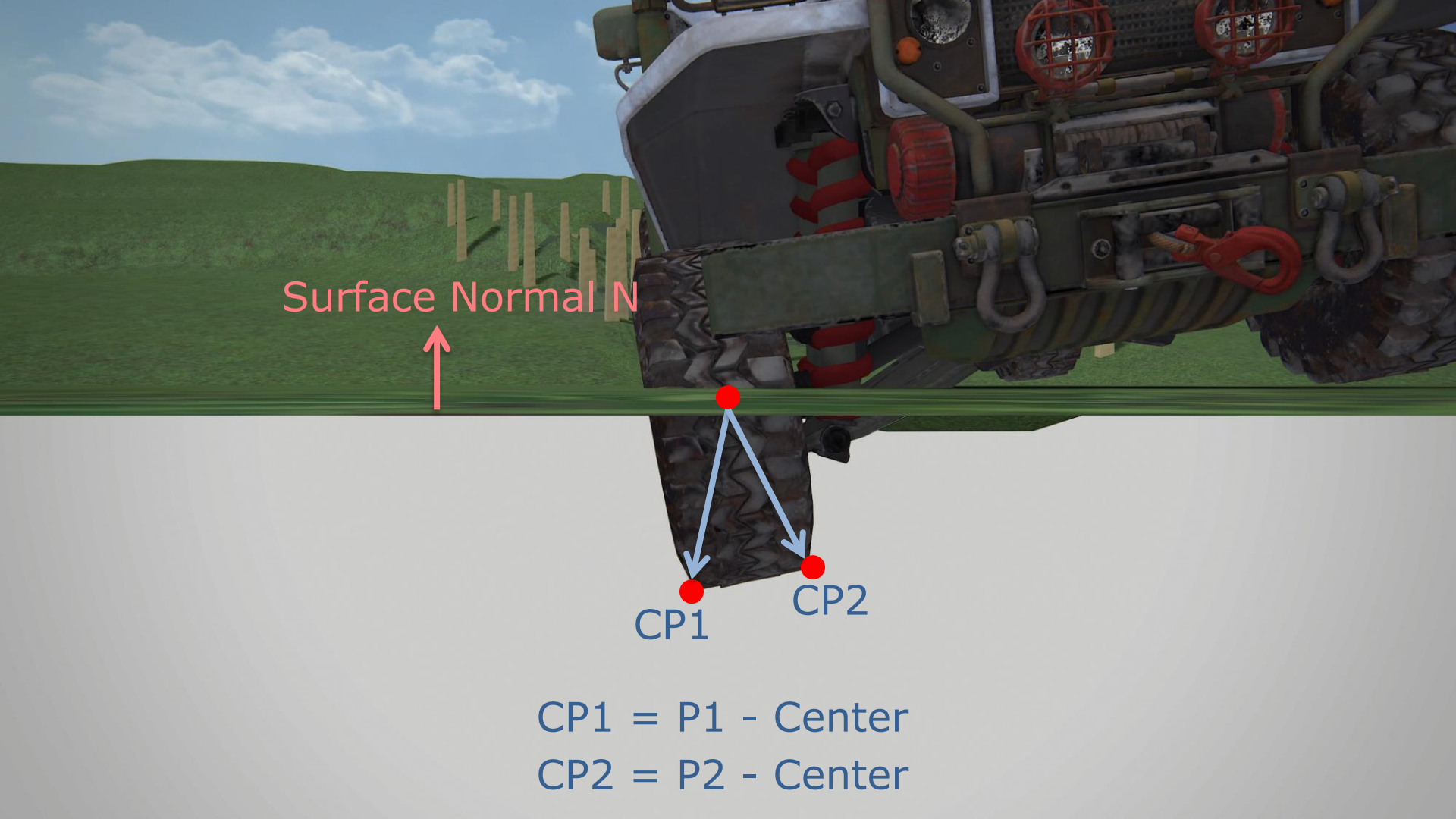
P1

P2



$$P1 = \text{Center} + \text{Right} - \text{Up}$$

$$P2 = \text{Center} - \text{Right} - \text{Up}$$



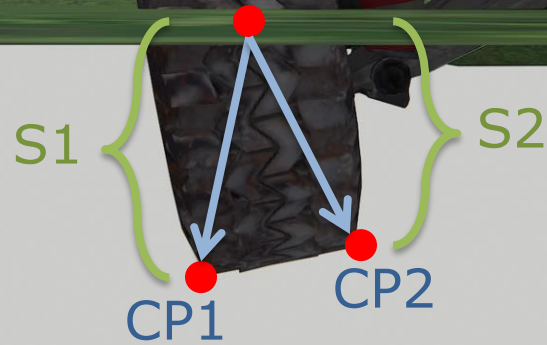
Surface Normal N

CP1

CP2

CP1 = P1 - Center

CP2 = P2 - Center

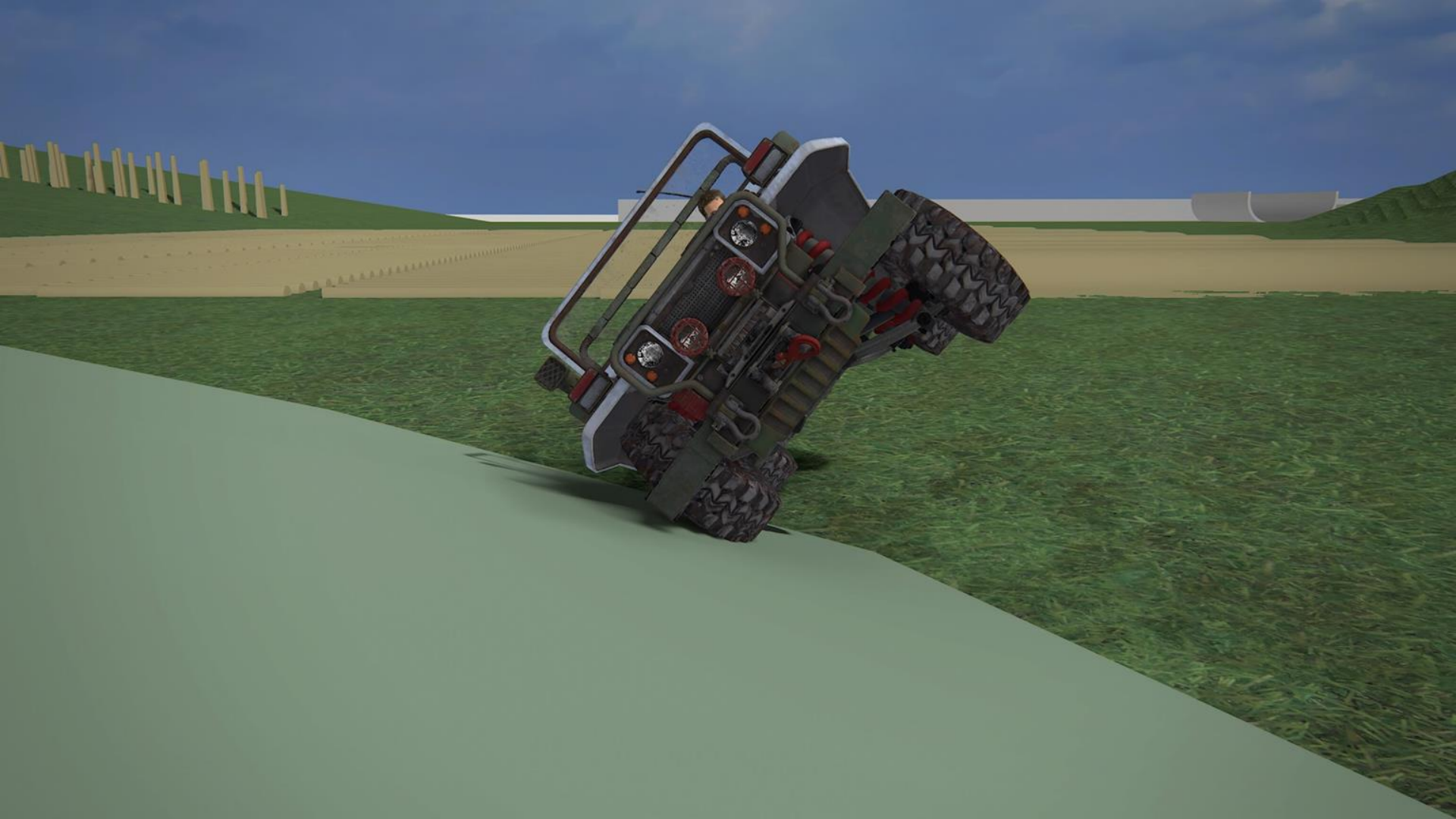


$$S1 = CP1 \cdot N$$

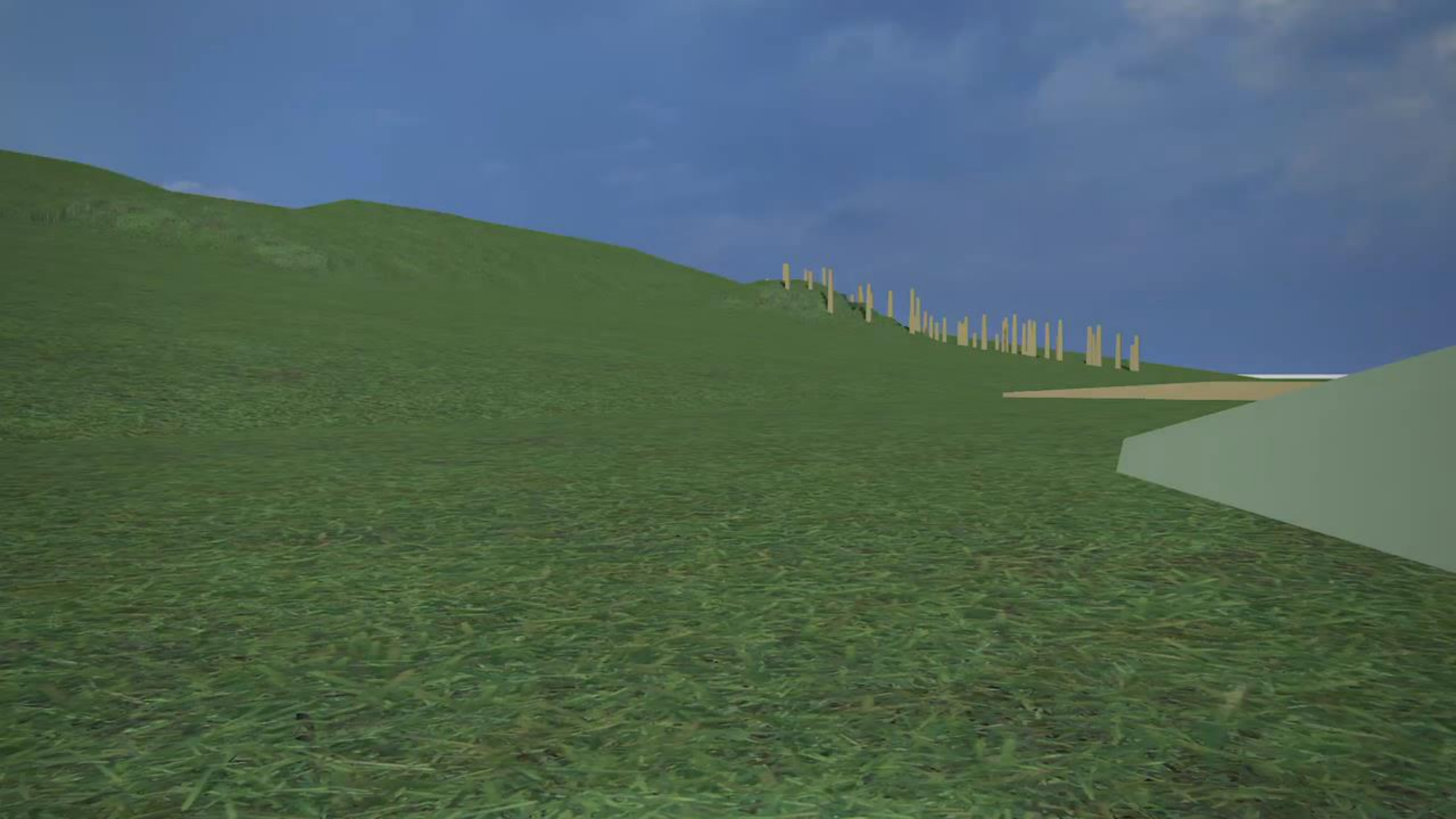
$$S2 = CP2 \cdot N$$



$$S3 = (CP1 - \text{Contact Point}) \cdot N$$









Physics Animation in 'Uncharted 4: A Thief's End'

Speaker:

Michal Mach | Technical Animator, Naughty Dog

Location: Room 130, North Hall

Date: Thursday, March 2

Time: 10:00am - 11:00am

Format: Session

Track:  Visual Arts

Pass Type: GDC All Access, GDC All Access + VRDC, GDC Main Conference, GDC Main Conference + VRDC - **Get your pass now!**

Vault Recording: Video















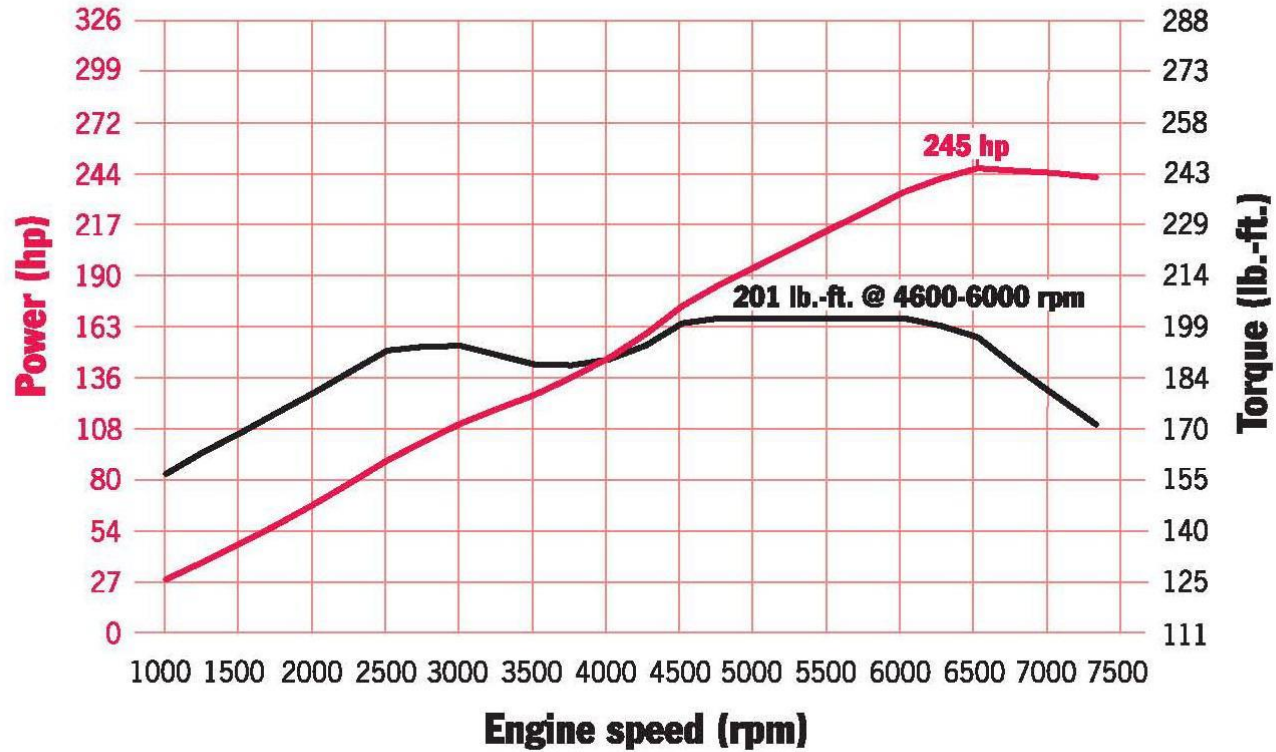
Simulation

- Collision Detection And Response
- Motor





Porsche Cayman Torque Curve



Gas Pedal %



Motor Torque

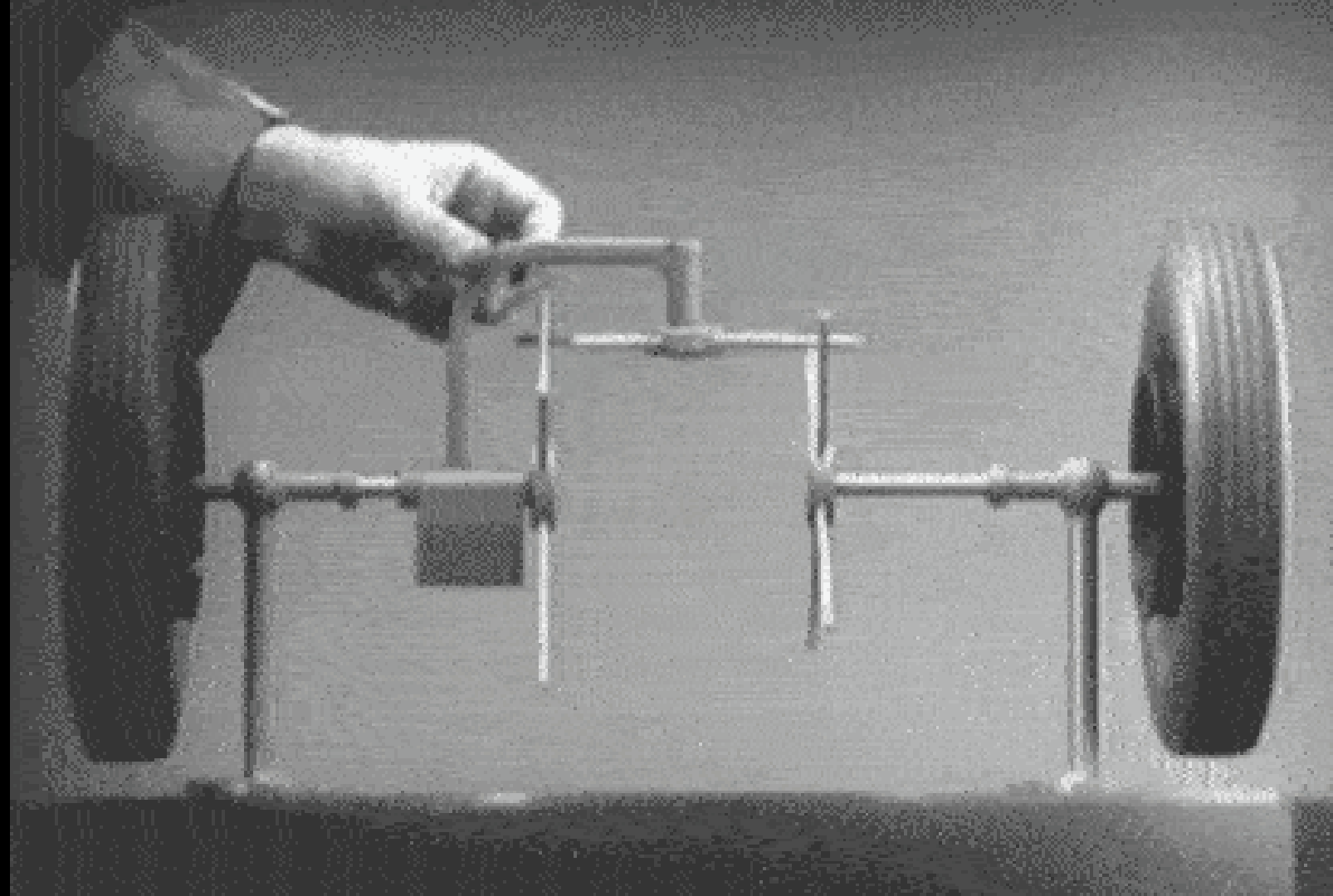
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=



Wheel Torque







Torque Divided Evenly



Motor Torque: 200lb-ft

Wheel 1 Torque: 50lb-ft

Wheel 2 Torque: 50lb-ft

Wheel 3 Torque: 50lb-ft

Wheel 4 Torque: 50lb-ft

Motor RPM Calculation



Wheel 1 RPM: 3500

Wheel 2 RPM: 4000

Wheel 3 RPM: 2500

Wheel 4 RPM: 3800

Motor RPM: 4000



Simulation

- Collision Detection And Response
- Motor
- Tire Friction















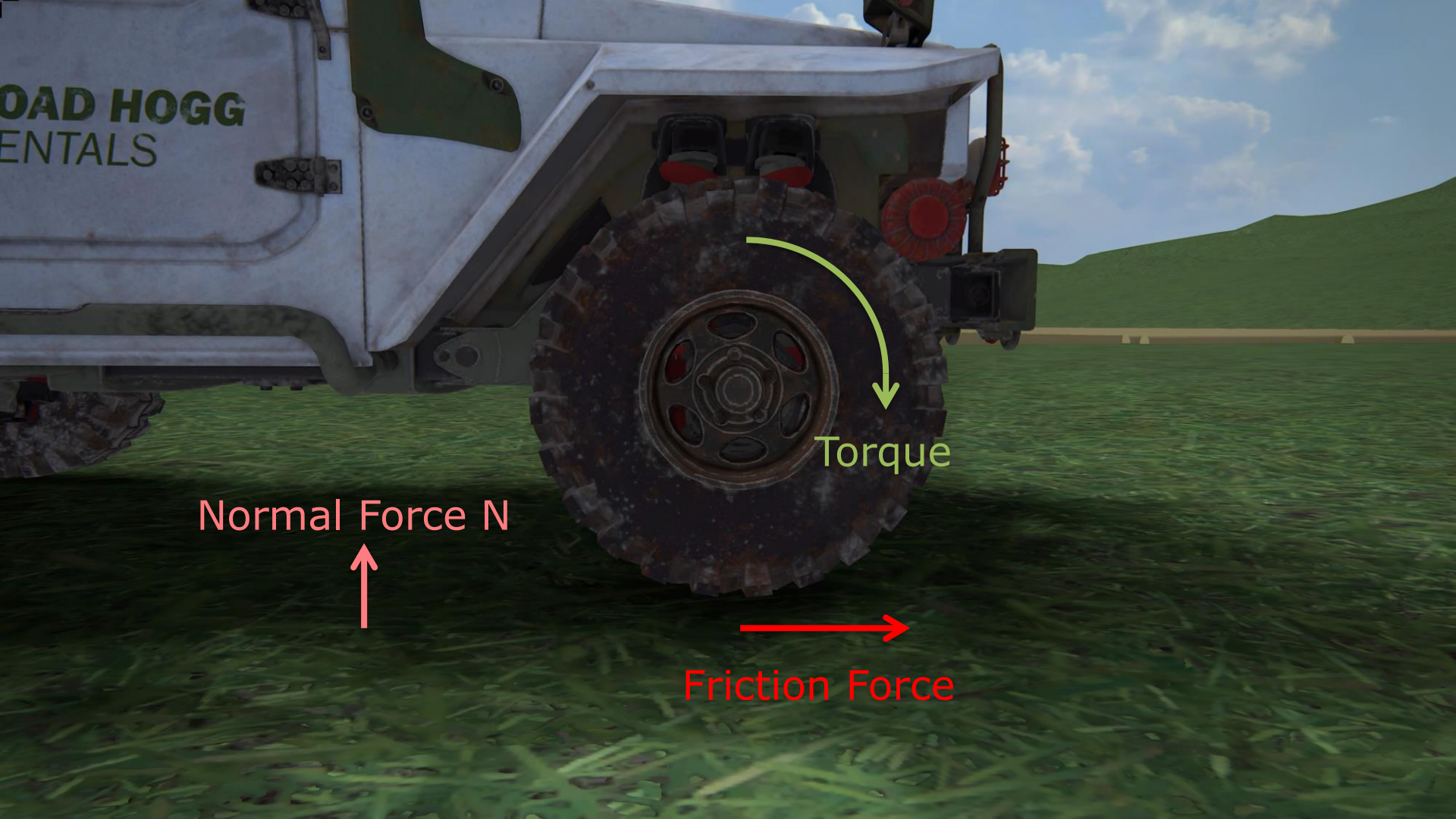


Normal Force N



Tire Friction

Surface Friction



ROAD HOGG
RENTALS

Torque

Normal Force N

Friction Force

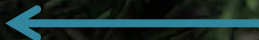
Forward Force = Torque / Radius



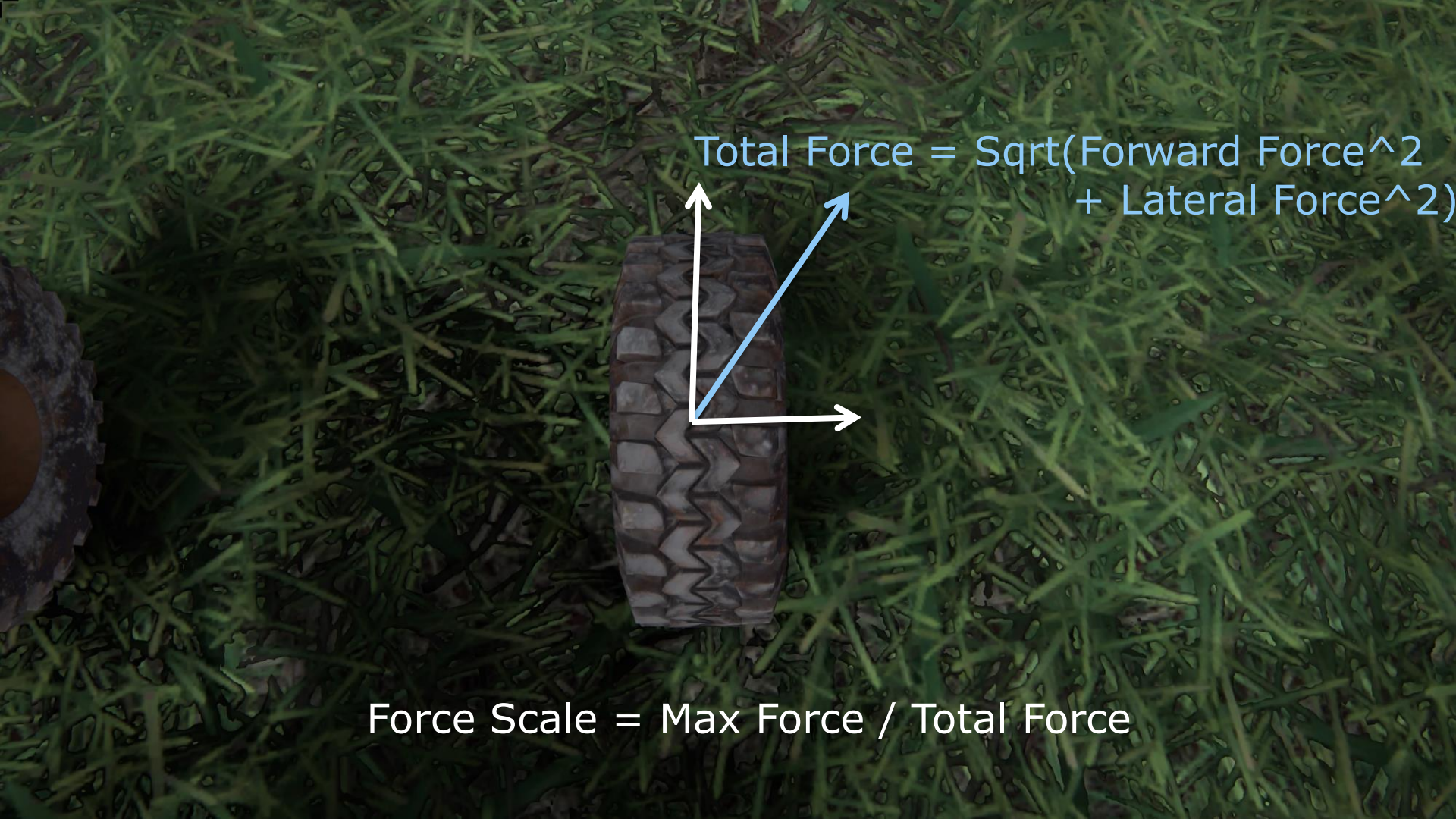
Lateral Force



= (Lateral Velocity
/ Forward Velocity)
* Normal Force



Lateral Velocity



$$\text{Total Force} = \text{Sqrt}(\text{Forward Force}^2 + \text{Lateral Force}^2)$$

$$\text{Force Scale} = \text{Max Force} / \text{Total Force}$$



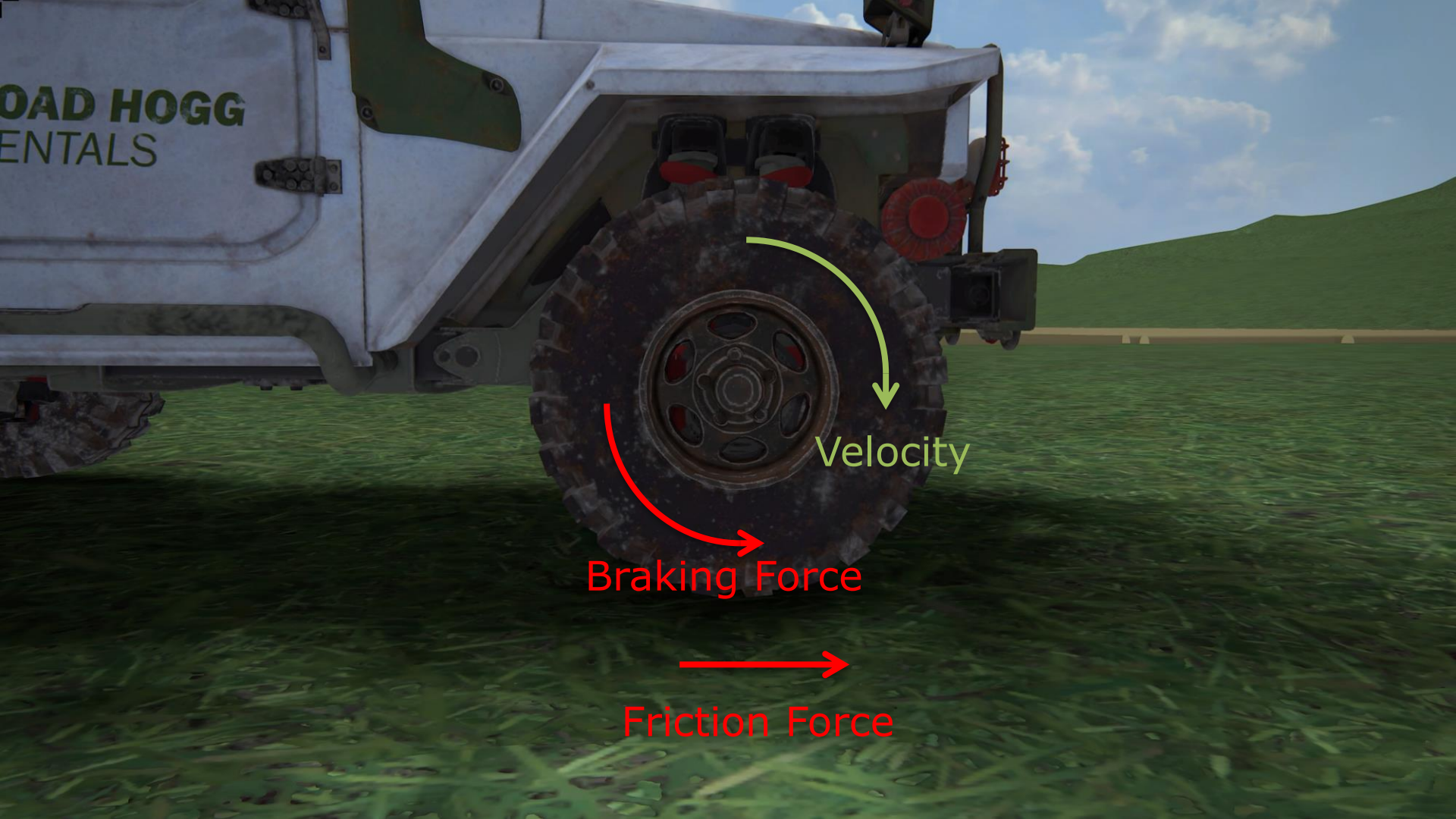
Max Force

ROAD HOGG
RENTALS

Rotational Force

Velocity





ROAD HOGG
RENTALS

Velocity

Braking Force

Friction Force







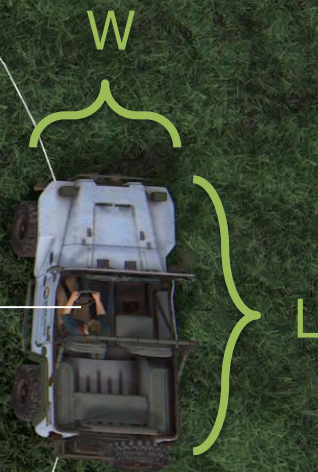




Ackermann Steering Geometry

R

$$R = W/2 + L/\sin(\text{Theta})$$

















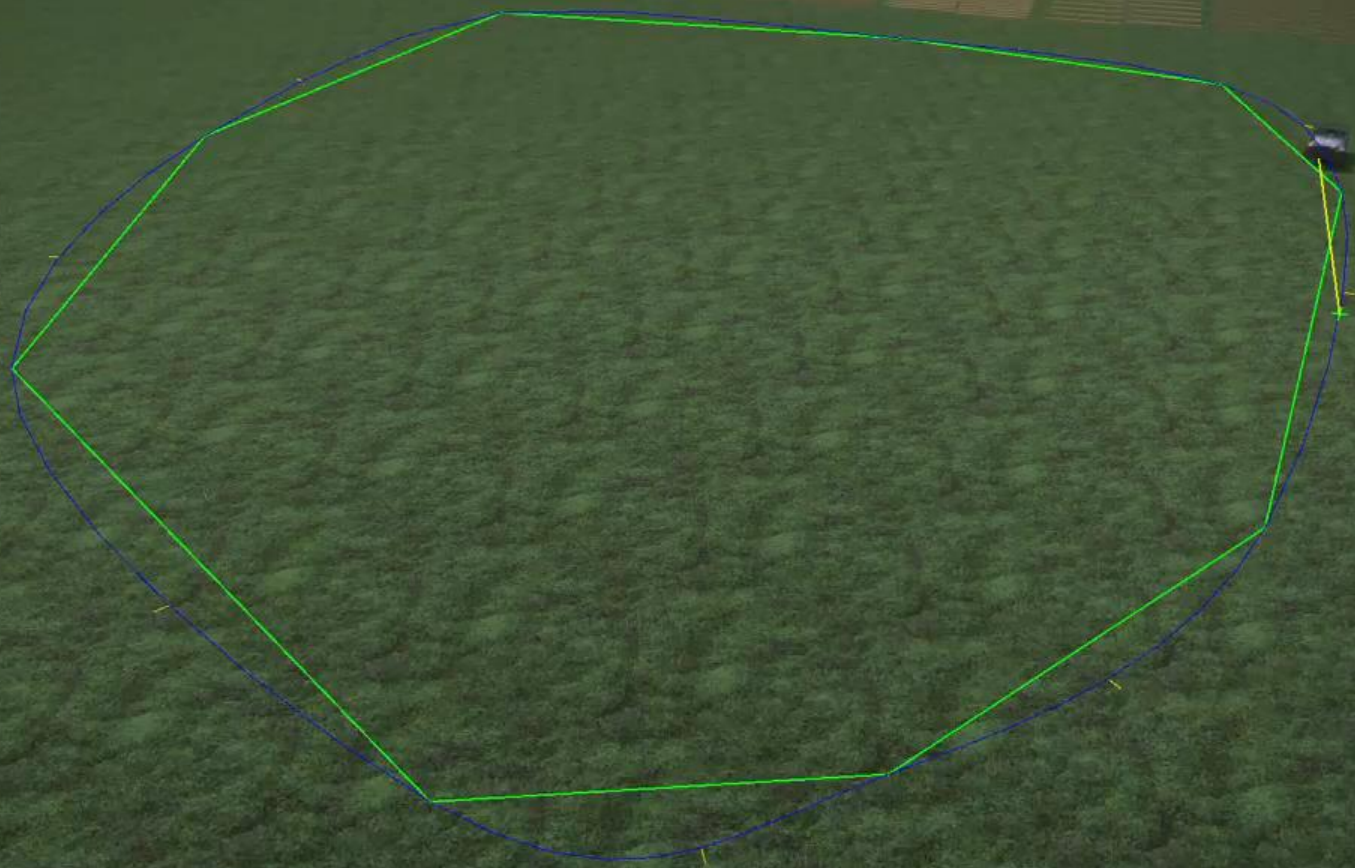
DIAMOND
CARPOOLS ONLY
2 OR MORE PERSONS
PER VEHICLE
↓

CLICK IT
OR TICKET

Culver City
West & 49th

EXIT 49A
29

EXIT 49A
29





4x4 Wrap Up

- Collision Detection And Response





4x4 Wrap Up

- Collision Detection And Response
- Motor





4x4 Wrap Up

- Collision Detection And Response
- Motor
- Tire Friction





4x4 Wrap Up

- Collision Detection And Response
- Motor
- Tire Friction
- Navigation





4x4 Wrap Up

- Collision Detection And Response
- Motor
- Tire Friction
- Navigation
- Steering

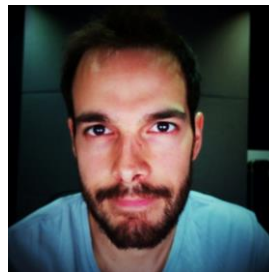




Special Thanks



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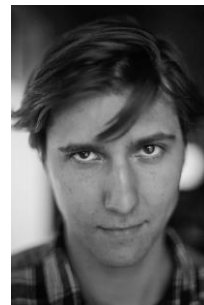




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Kurt Margenau



Travis McIntosh



James Cooper





The Science Of Offloading

Questions?