BRAKING SYSTEM IN DIFFERENT DRIVING CONDITIONS

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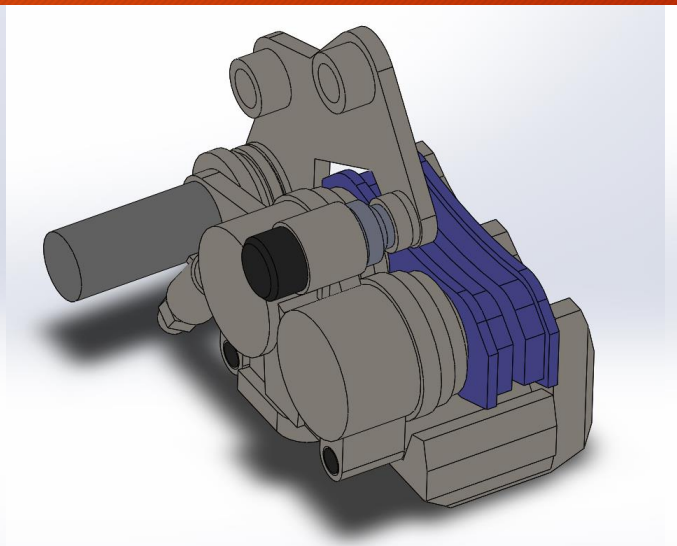
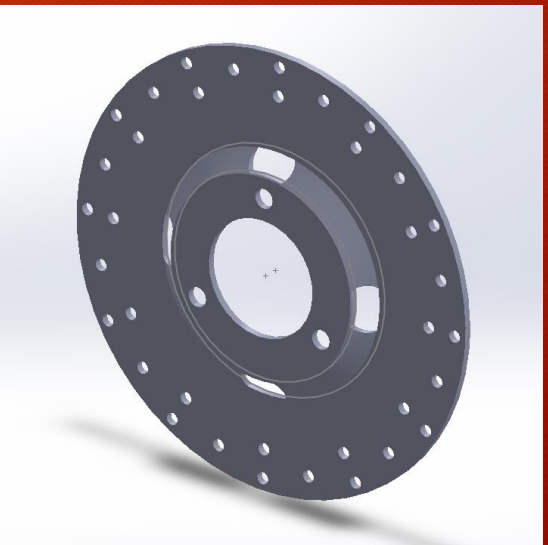
Project outline

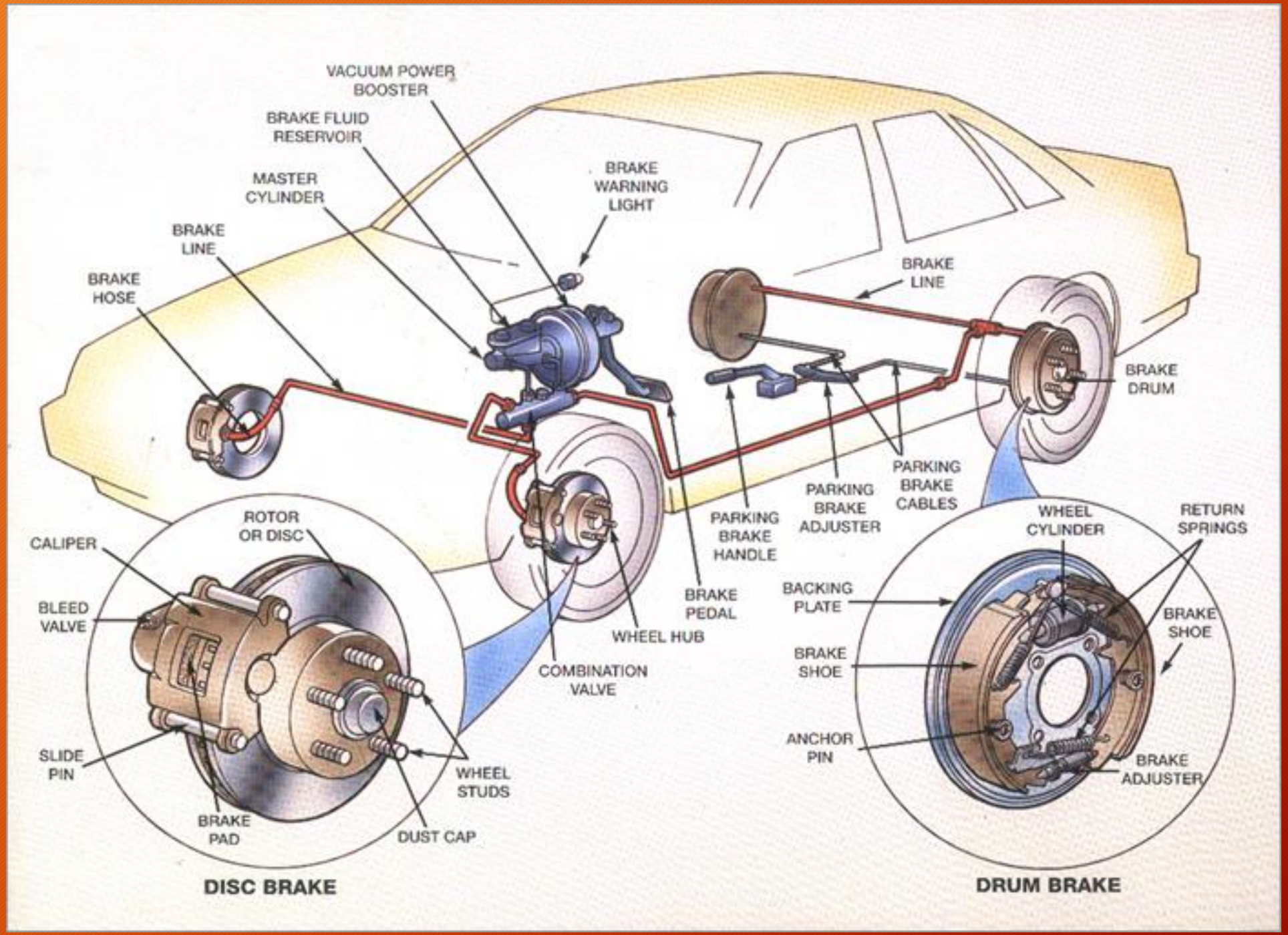
- Solid Model of Vehicle
- Brake System Model
- Introduction of ABS
- Components of ABS
- Objectives of ABS
- Mathematical Model
- CarSim Simulation
- Results

Car Model (Lamborghini Gallardo)

Braking system



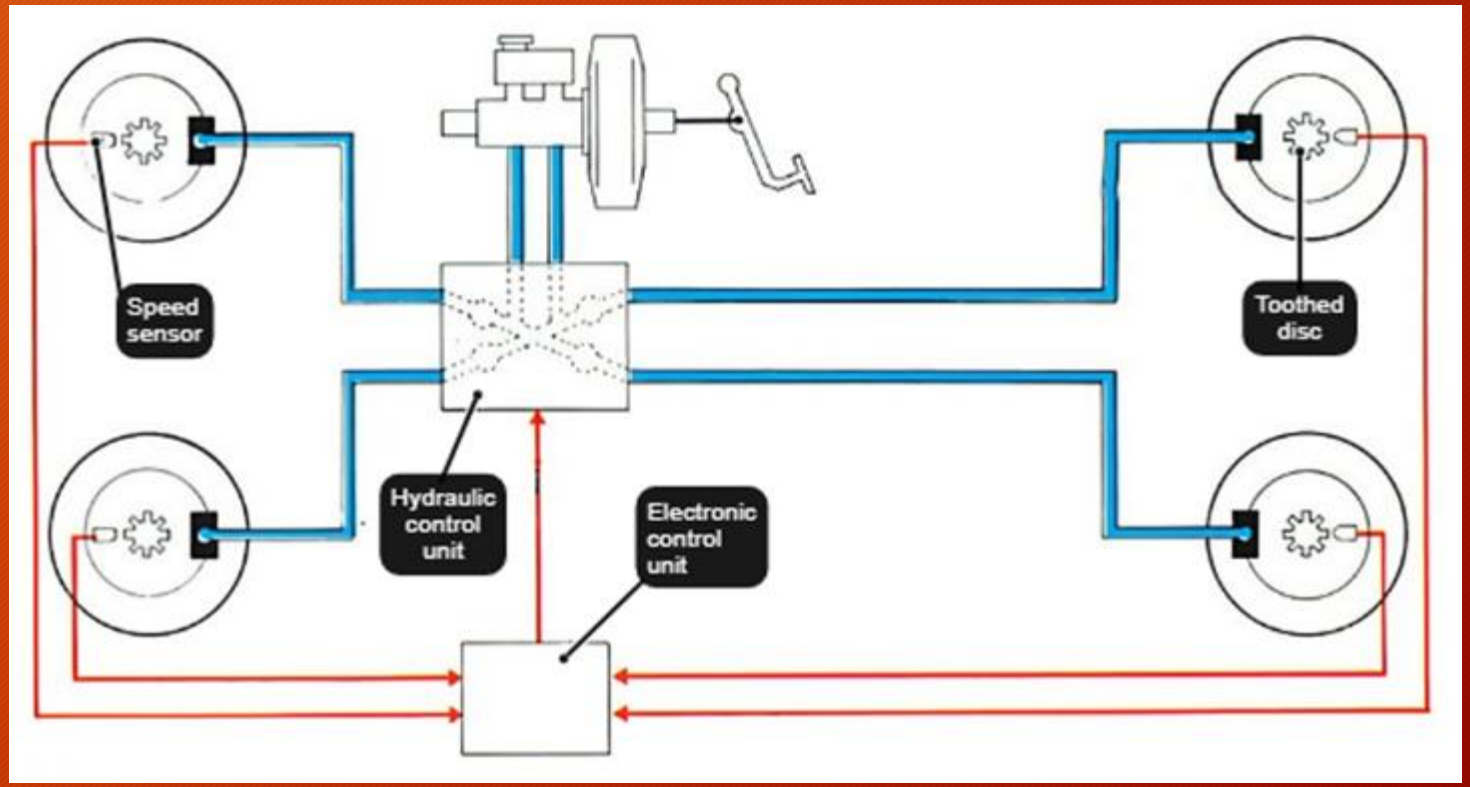

VACUUM POWER BOOSTER
BRAKE FLUID RESERVOIR
MASTER CYLINDER
BRAKE LINE
BRAKE HOSE
BRAKE WARNING LIGHT
BRAKE LINE
BRAKE DRUM
PARKING BRAKE HANDLE
PARKING BRAKE ADJUSTER
PARKING BRAKE CABLES
BRAKE PEDAL
WHEEL HUB
COMBINATION VALVE
CALIPER
ROTOR OR DISC
BLEED VALVE
SLIDE PIN
BRAKE PAD
DUST CAP
WHEEL STUDS
DISC BRAKE
WHEEL CYLINDER
RETURN SPRINGS
BACKING PLATE
BRAKE SHOE
BRAKE SHOE
ANCHOR PIN
BRAKE ADJUSTER
DRUM BRAKE

Antilock Braking System

- ABS Braking prevents locking of wheels during braking and allows the vehicle to have tractive contact with the road surface thus preventing skidding.
- It is very useful during severe braking or on slippery surfaces
- ABS essentially modulates the brake line pressure independent of the pedal force, to bring the wheel speed back to the slip level range that is necessary for optimal braking performance.

Components Of ABS

- Wheel speed sensors
- Controller unit
- Hydraulic modulator Unit
- Braking device



Objectives of ABS

- Steerability:
  - Steerability while braking is important not only for minor course corrections but also for the possibility of steering around an obstacle
  - All braking and steering forces must be generated within the small tire contact patch between the vehicle and the road
- Stability:
  - Driving on p-split surface(yaw in conventional but managed in ABS)
  - Antilock system manages this by maintaining the slip both rear wheels at level where lower of the two coefficients peak
- Reducing stopping distance:
  - Distance = f(mass , initial velocity , brake torque)
  - There is peak in friction for a surface where antilock system can attain maximum fictional force and, therefore, minimum stopping distance.

Mathematical Model

Quarter vehicle/Single wheel model

- Brake torque and friction force
- Two DOF model : V_x and ω
- Equations of Motion
- $ma_x = -\mu F_N$
- $J_w\dot{\omega} = \mu R F_N - T_b$
- Slip Ratio = $\lambda = \frac{V_x - \omega R}{V_x}$
- Slip rate = $\dot{\lambda} = \frac{\dot{V_x}(1-\lambda) - R\dot{w}}{V_x}$

State Space representation

State Variables are -

$x_1 = S_x$, $x_2 = V_x$, $x_3 = \lambda$

State Space Equations are –

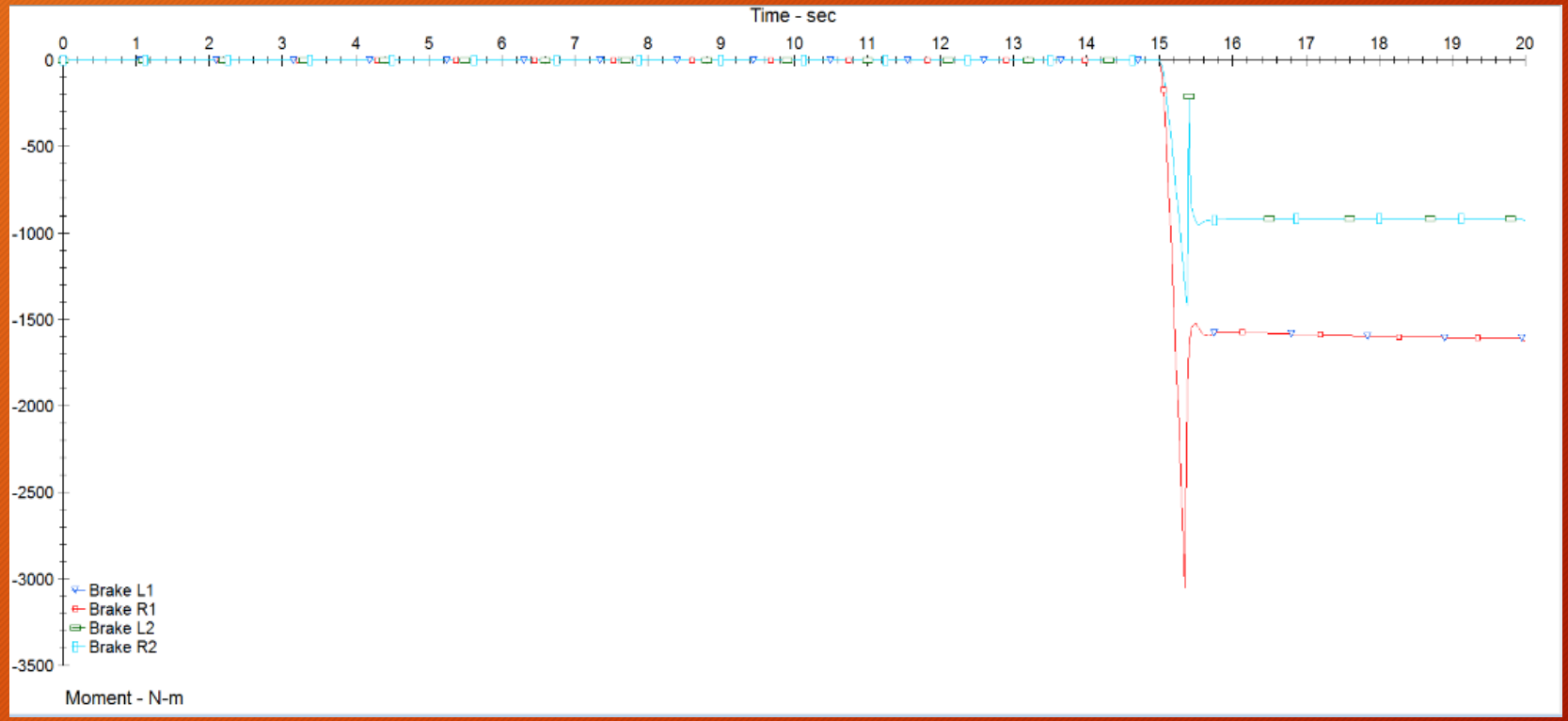
- $\dot{x_1} = x_2$
- $\dot{x_2} = \frac{-\mu FN}{m}$
- $\dot{x_3} = \frac{-\mu FN}{x_2}\left(\frac{1-x_3}{m} + \frac{R^2}{J_w}\right) + \frac{R}{J_w \times x_2} T_b$

CarSim Simulations

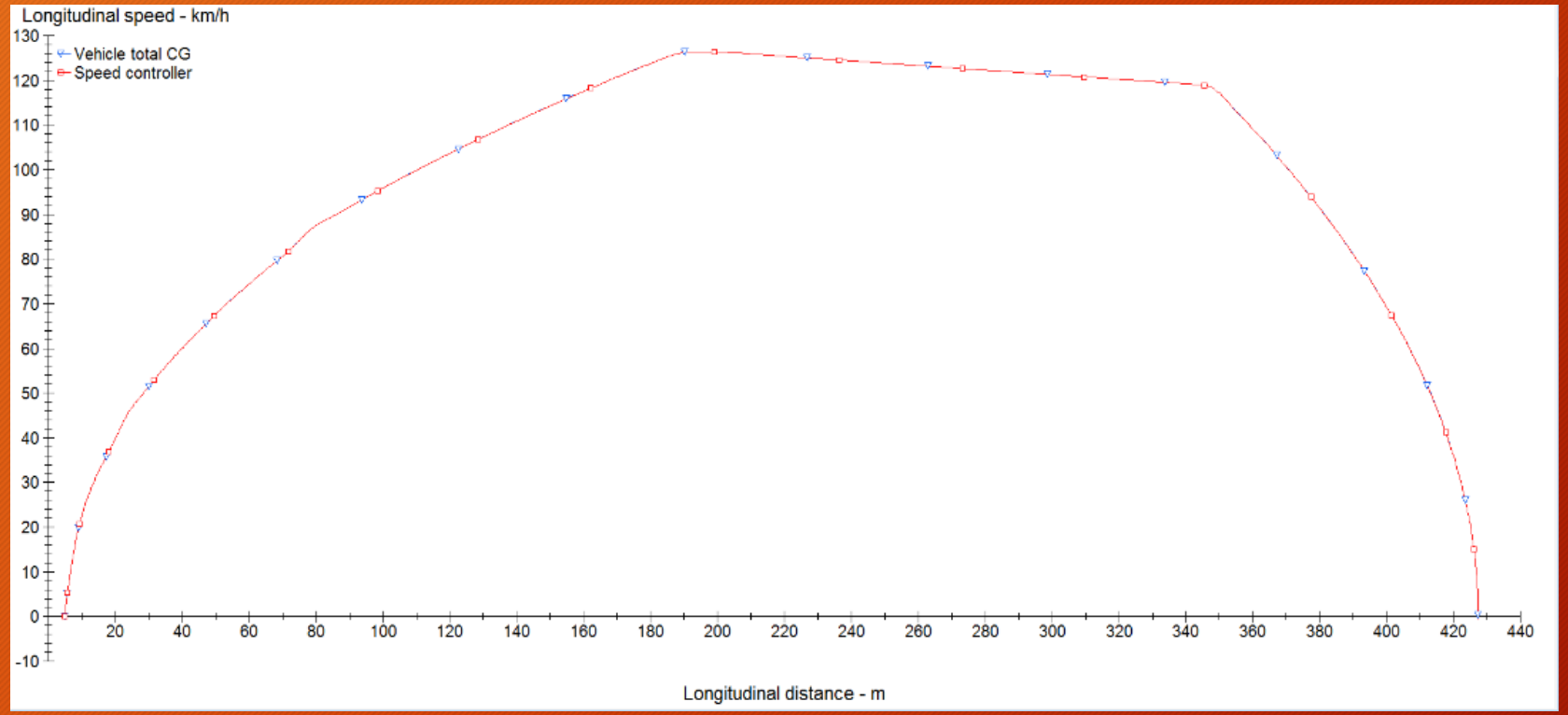
- Model- E-Class ,Sedan w/5 Driver sensors
  - Sprung mass -1650 kg
- Procedure – Accelerate then brake
- ABS Control settings: Two channel front and rear ABS:
  - Slip on – 0.1
  - Slip off – 0.15
  - Brake torque vs pressure
  - Left and right Front Brake torque – 350 Nm/MPa
  - Left and right Rear Brake torque – 150 Nm/MPa

Non ABS on Dry Roads

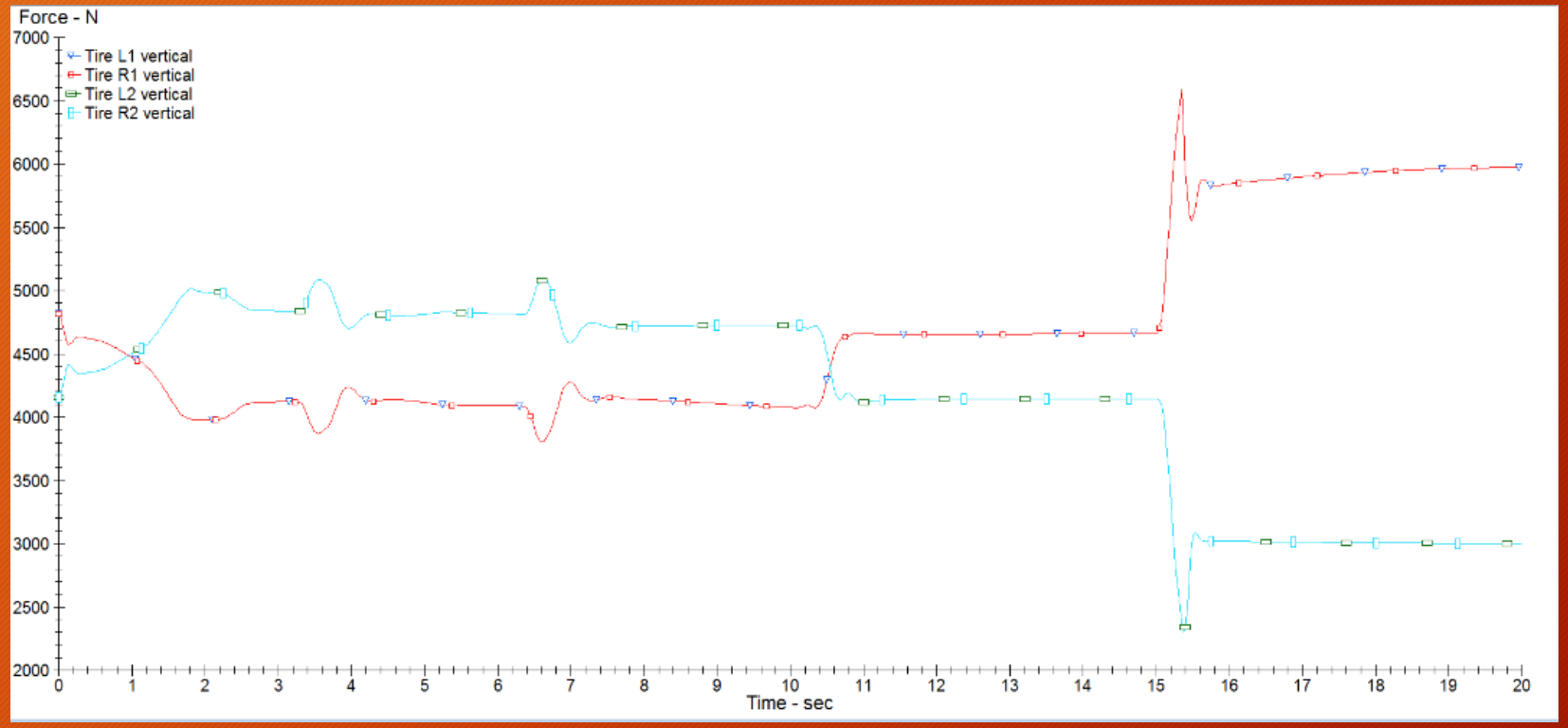
Brake Torque vs Event Elapsed Time



Longitudinal Speed vs Station



Vertical Forces



ABS on Dry Roads

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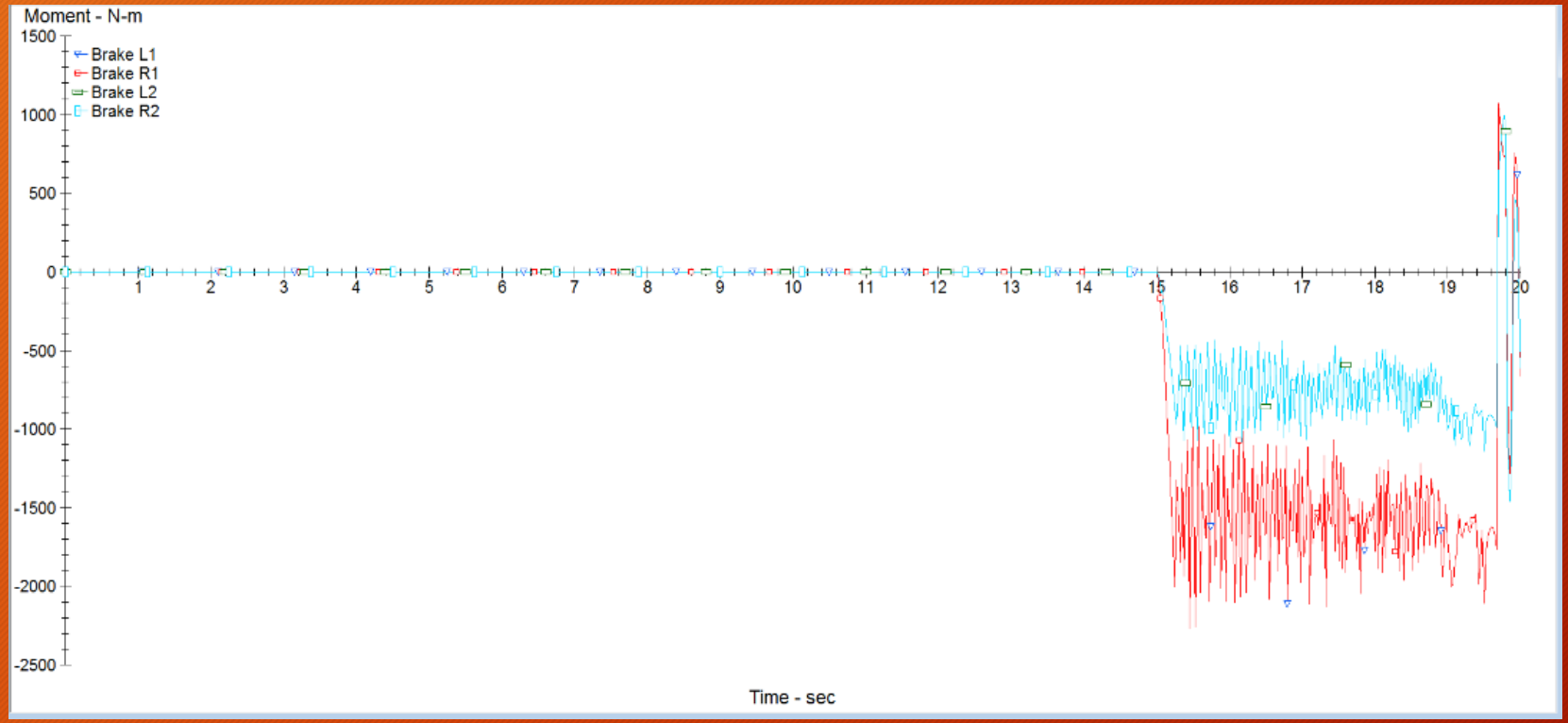

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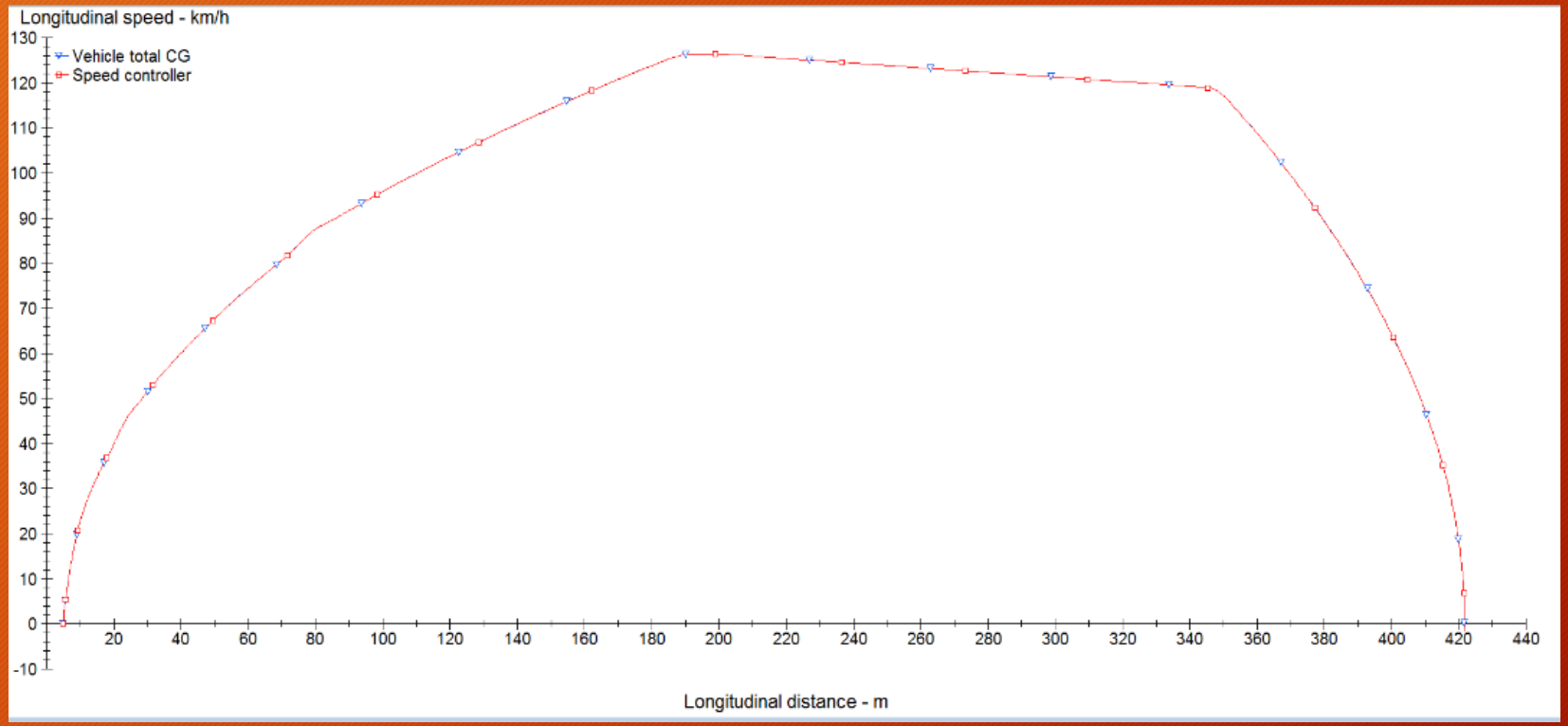
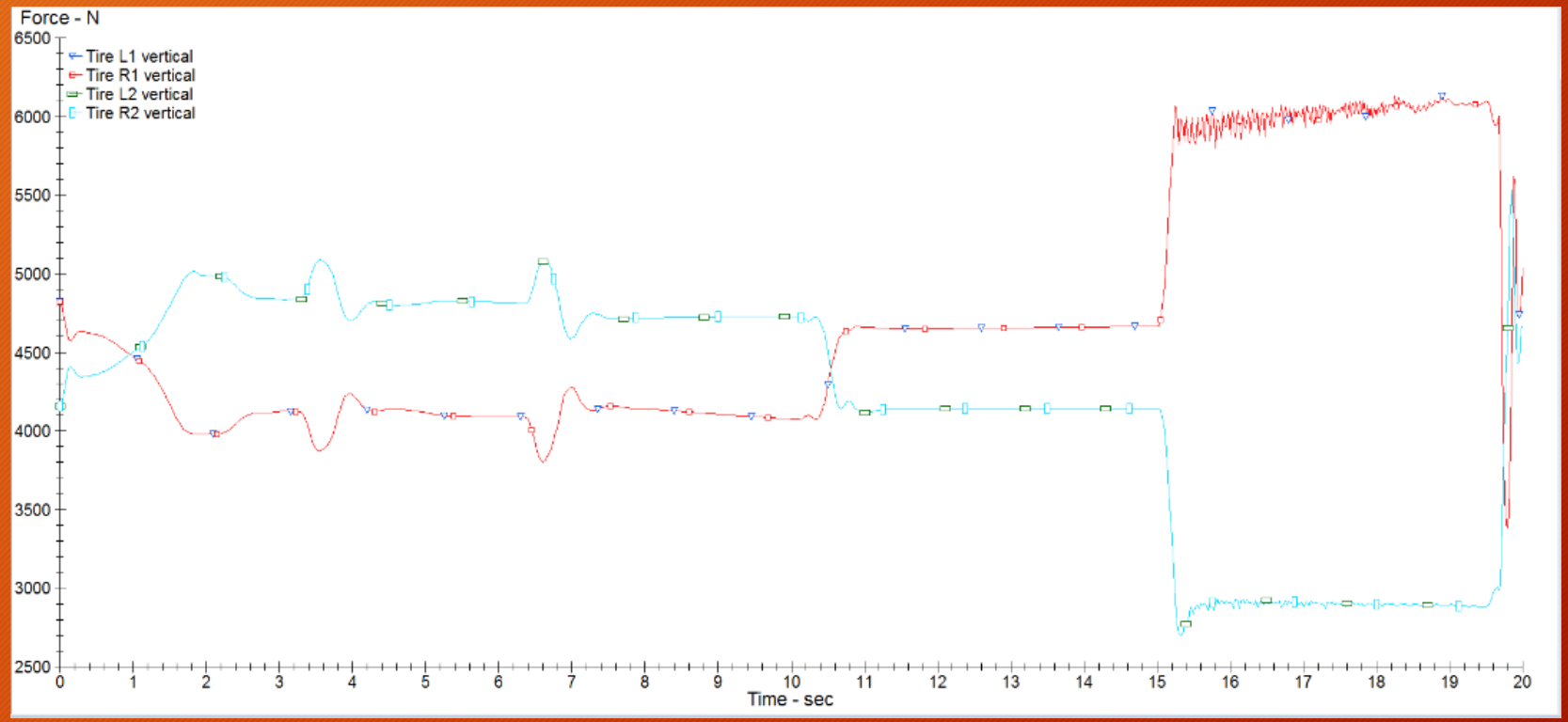
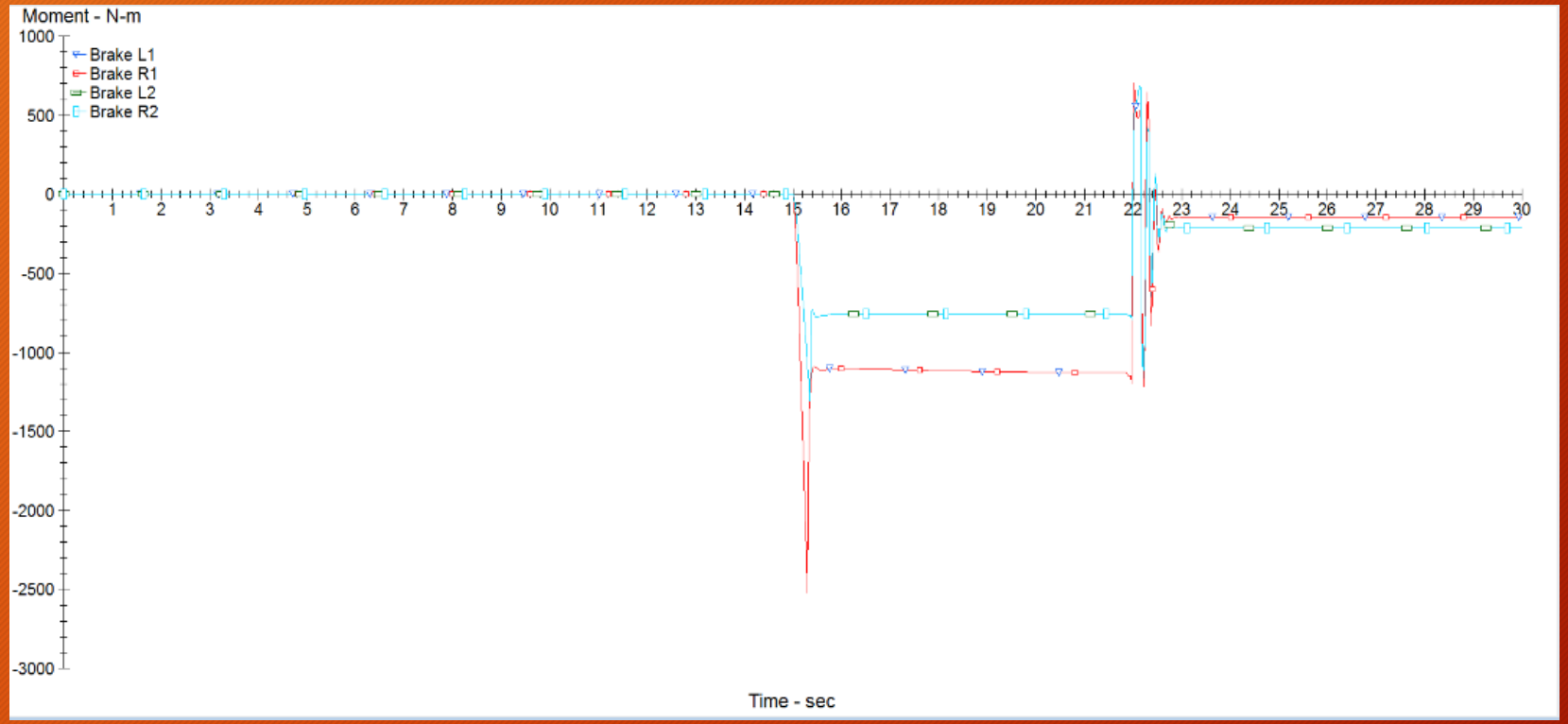


Vertical Forces

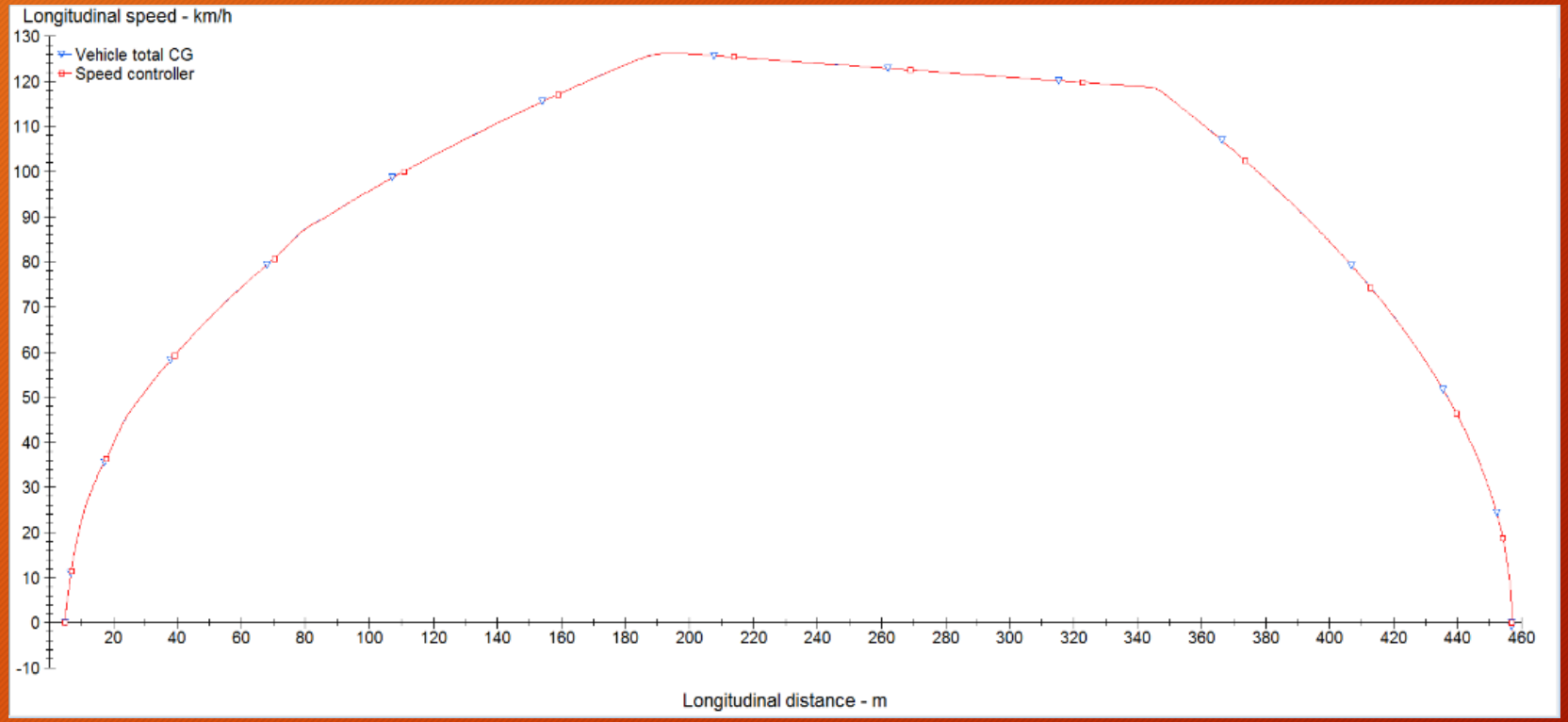


Non ABS on Wet Roads

Brake Torque vs Event Elapsed Time



Longitudinal Speed vs Station



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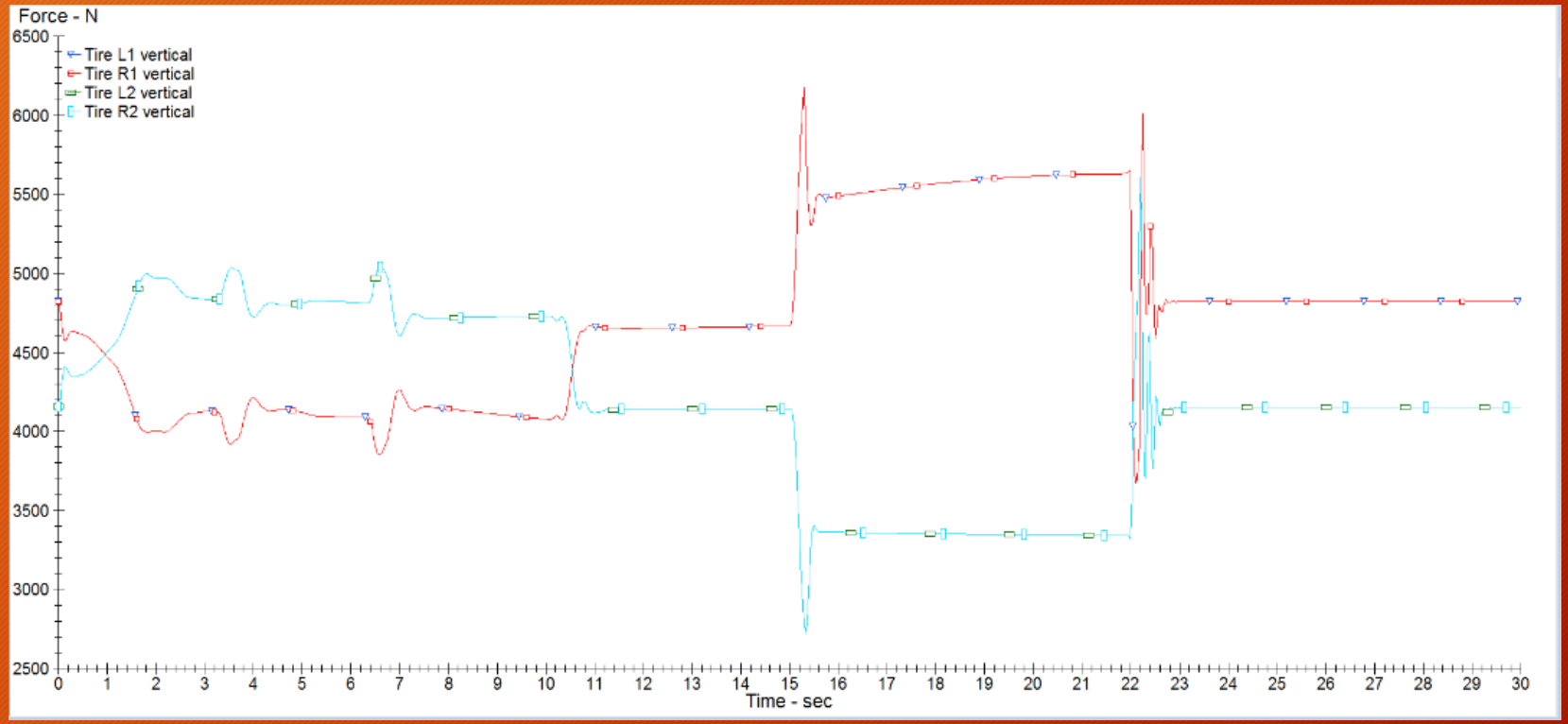

ABS on Wet Roads

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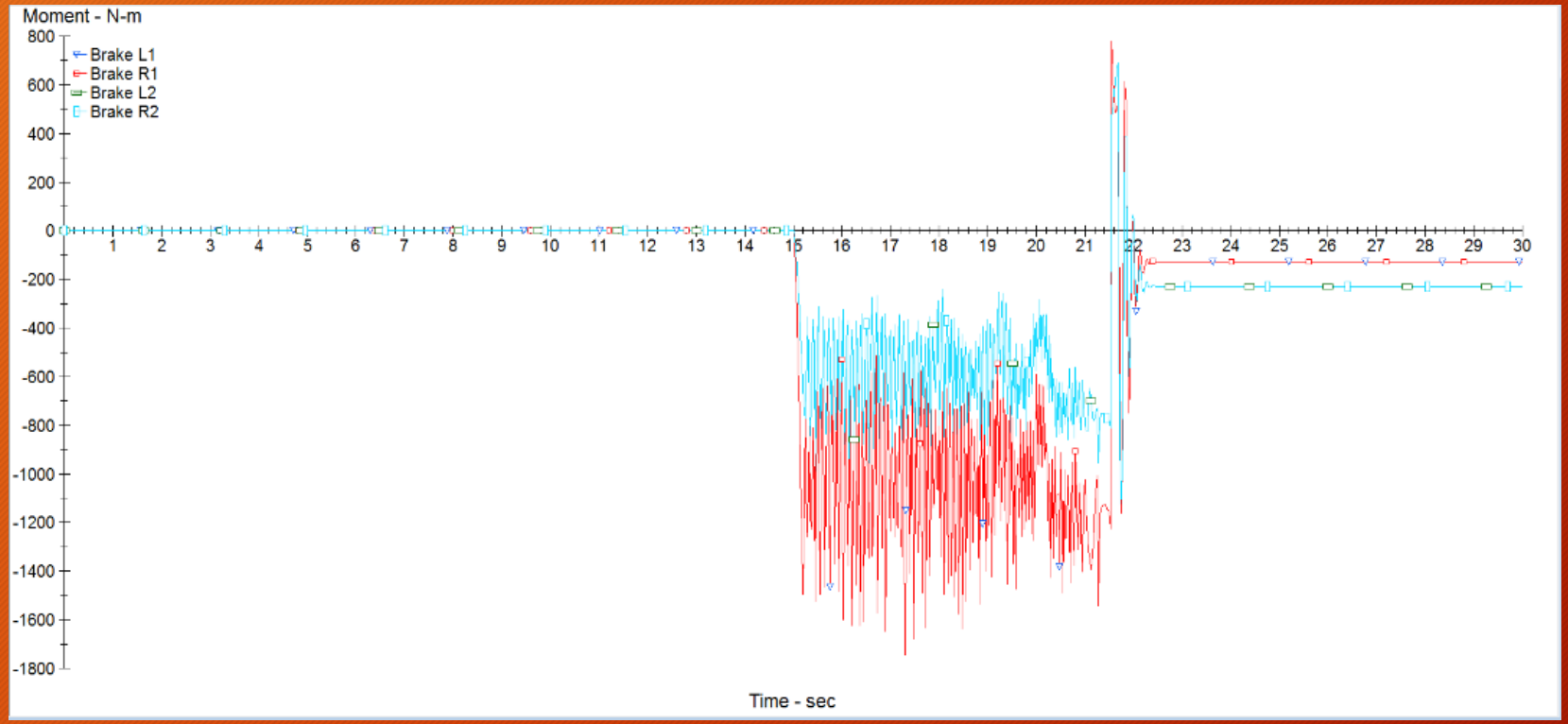

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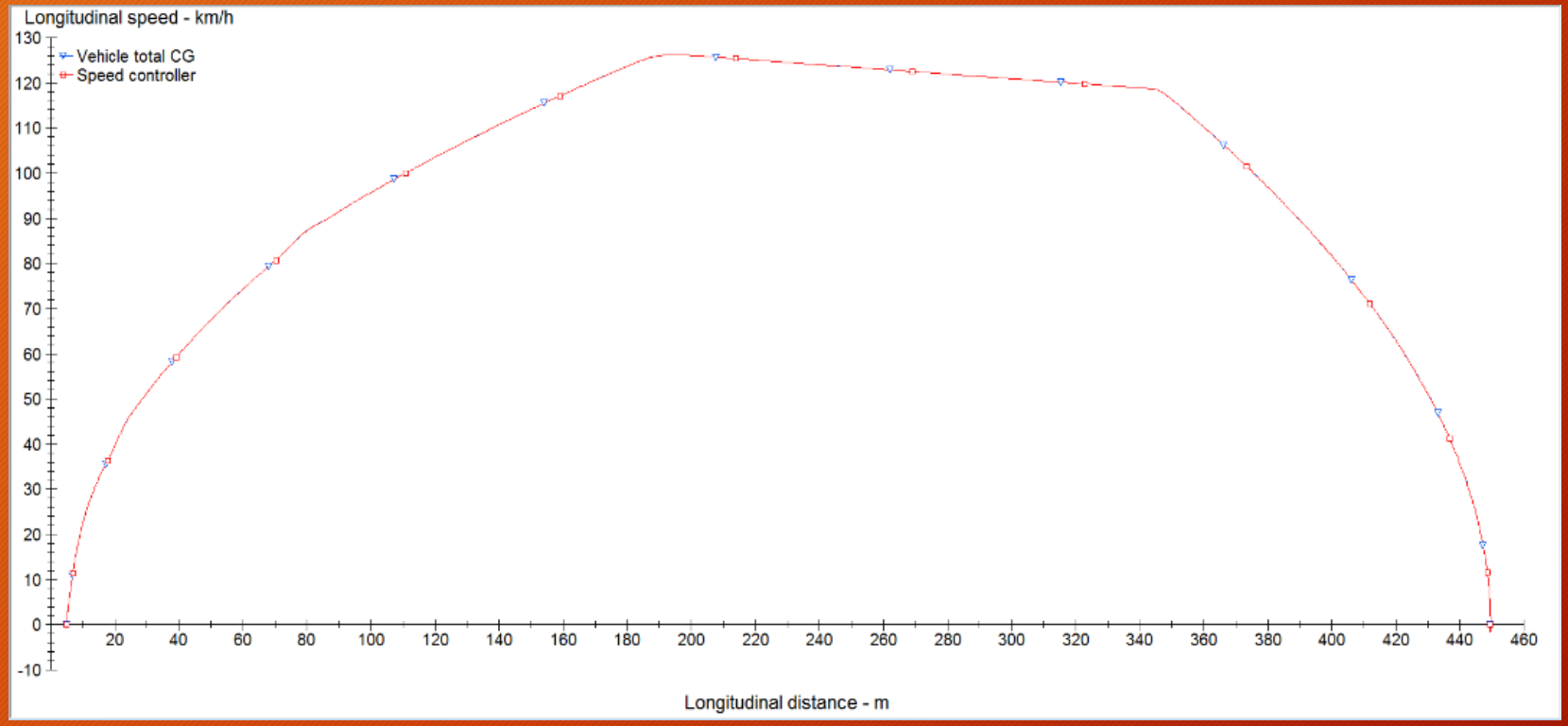
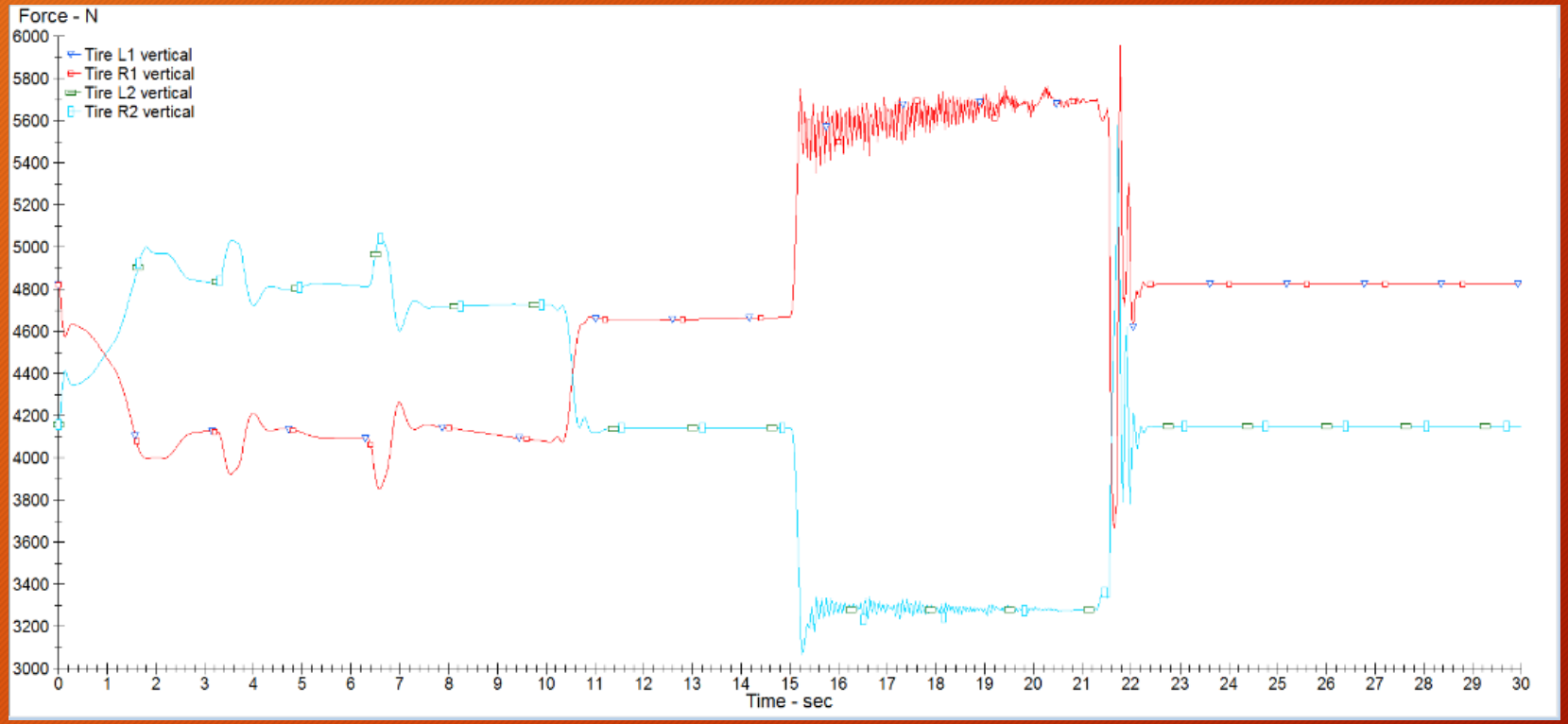


Vertical Forces vs time



Comparing ABS with Non ABS Braking system

Limitations

- On gravel or snow the conventional breaking system causes the tires to lock and thus they tend to dig in so stopping distance decreases whereas in ABS it increases due to anti locking.
- Some experienced drivers can even stop the car at a shorter distance than ABS
- Sometimes ABS also activates on a bumpy surface

Conclusions:

- From the Analysis done we conclude that ABS is clearly a better braking system compared to ordinary one.
- With ABS we get enhanced steering, stability and safety
- ABS improves stopping distances considerably as shown in the simulations
- It is a safe system for a beginner to learn driving
- Although ABS has its merits some still prefer than old braking system
- Solution to some of the problems may be the technologies which enable us to switch between ABS and Non ABS Braking