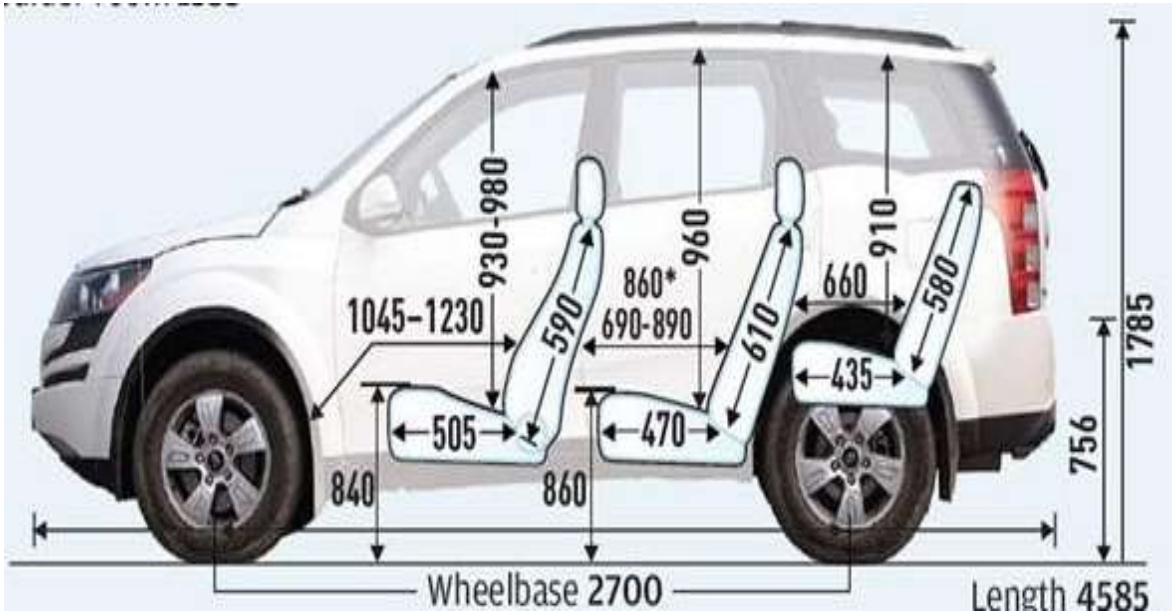
MHRD-GIAN Two Week Workshop on Vehicle Dynamics

January 12th - 23rd , 2016



Source: http://www.carwale.com/skodamahindra-cars/yeti-2010-2014,xuv500-2011-2015/expert-reviews-8905/

Project Title: Tabulation of Important Data for Vehicle

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HW#1

Question:

Identify at least 3 Automotive vehicles of your choice for which you will be able to obtain as much data as possible in searching through various online and other personal resources. Develop your own set of common attributes and their weightages based on which you chose each vehicle. Present the data in the form of table that contains several attributes. Add the weightages of each vehicle and pick one of the vehicles and justify why you picked that vehicle.

Vehicle Attributes Selection

Deepak Raina	Nibodh Boddupalli	Tushar Lohra
Comfort	Body	Safety
Cost	Curb weight	Fuel Economy
Fuel Economy	Distribution	Air Conditioning
Driving	Max. Power	ABS
Safety	**Power-Weight ratio**	Price
Aesthetics	**0-60mph**	Type of Fuel
Passenger Capacity	60-0mph	Mirror
Engine Power	**Cd**	Suspension
Colors	Nur. Lap	Driver Space
Exterior Features	Price	Number of Members
Interior Features		Cruise Control
Environmental Impacts		Style
Warranty		Wet Mode
Vehicles Chosen		
Mahindra XUV 500 W8 AWD	**2011 Nissan GT-R**	**Mahindra Scorpio S4**
Renault Duster 110 PS RxZ AWD	2004 Subaru WRX STi	Tata Safari VX
Toyota Fortuner 3.0 4x4 MT	2008 Caterham R500	Renault Duster

HW#2

Question:

For each vehicle you identified in your group, search on internet

and tabulate the important data using the tables provided to you

in HW#1.

Attributes		Deepak Raina Mahindra XUV 500 W8 AWD	Nibodh Boddupalli 2016 Nissan GT-R	Tushar Lohra Mahindra Scorpio S4
Vehicle Configuration		Sports Utility Vehicle – 7 Seater	Coupe – 4 seater	7 seater off-road vehicle
Curb Weight		1785 kg	2,200 kg	2610 Kg
Distribution	**Front**	1017.45 kg	1188 kg	1383.3 kg
	Rear	767.55 kg **(57:43)**	1012 kg **(54:46)**	1226.7 kg **(55:45)**
Wheelbase		2700 mm	2780 mm	2680 mm
Layout		Front Engine -AWD	Front engine - AWD	4456*1820*1995 mm
Body/Frame		Steel	Aluminium	Steel
Wheels (Diameters)	**Front**	17 inches	20” + 204mm	17 inches
	Rear	17 inches	20” + 119.5mm	17 inches
Brakes	**Front**	Disc Brake with ABS	15.4“ , 6-piston	Disc Brake
	Rear	Disc & Calliper Type	15” , 4-piston	Drum Brake

Table for Important Data of Vehicle

Deepak Raina | Nibodh Boddupalli | Tushar Lohra

Attributes		Mahindra XUV 500 W8 AWD	2016 Nissan GT-R	Mahindra Scorpio S4
Steering		Power Assisted (Hydraulic) Rack and Pinion	Vehicle-speed-sensitive power steering	Hydraulic Power Steering
Suspension	**Front**	MacPherson type with anti-roll bar	Double wishbone type	Double wish bone type Independent front coil spring
	Rear	Multi-link type with anti-roll bar	Multi-link type	Multilink Coil Spring Suspension with Anti-Roll Bar
Maximum Installed Power		140 bhp@ 3750 RPM	550 bhp @ 6,400rpm	120 bhp (88 kw)@4000 rpm
Maximum Installed Torque		330 Nm @ 2800 RPM	632 Nm @ 3,200-5,800 rpm	280 N-m@2800 rpm
Redline		$1600 < n_m(rpm) < 3750$	7000 rpm	7000 rpm

	Deepak Raina	Nibodh Boddupalli	Tushar Lohra
Attributes	**Mahindra XUV 500 W8 AWD**	**2016 Nissan GT-R**	**Mahindra Scorpio S4**
Transmission	6 Gear Manual	Dual clutch 6-speed	5 Gear Manual
First Gear Ratio	3.296	4.056	3.357
Second Gear Ratio	1.958	2.301	2.180
Third Gear Ratio	1.348	1.595	1.424
Fourth Gear Ratio	1.000	1.248	1.000
Fifth Gear Ratio	0.725	1.001	0.753
Sixth Gear Ratio	0.582	0.796	-
Final Drive Ratio	3.165	2.937	3.266
0 to 100 kmph	10 sec	2.8 sec	13.2 second
Top Speed	185 kmph	196 mph	180 Kmph

End

Vehicle Chosen for HW #3-#6

Source: http://i.autoportal.com/img/newcars34/normal/mahindra_xuv500-390.JPG

Why MAHINDRA XUV500…..?

- Enriched with exciting new technology, Mahindra XUV 500 has been designed for a whole new experience.

- It is giving a **mileage** of 16 k.m.p.l with a 140 bhp engine.

- It provides a **maximum torque** of 330 N-m which is essential requirement of any SUV.

- It is equipped with lot of **safety features** like Hill Hold Control, 6 air bags etc. which are very essential for Off-Road Driving

- Its **interiors** redefine luxury. But the most striking thing is the view outside from inside.

- It is fitted with a **new electric sunroof** with anti-pinch, which guarantees a thrilling experience from every angle.

The Features that Mahindra XUV 500 only has among three vehicles in Comparison:

1. **Stop/start technology.** It helps customers conserve fuel by automatically shutting off the engine when the car comes to a **stop**, such as at stoplights. The engine automatically restarts when the driver takes his or her foot off the brake.
2. **Cruise control** (sometimes known as speed control or auto cruise) is a system that automatically controls the speed of a motor vehicle. The system is a servomechanism that takes over the throttle of the car to maintain a steady speed as set by the driver.
3. **Hill Hold and descent control.** Any device that prevents a car from rolling backward on a hill when the brake pedal is released can be called a hill holder.
4. It offers **6 air bags** for safety of drivers, co-driver and passengers during front and side impact.
5. It has **GPS Navigation System.**
6. It also provide **driver arm rest**
7. It has **Tire Pressure monitoring system.**
8. It has **6 speakers** and **iPod compatibility.**

HW#3

Question:

Do **ACCELERATION DYNAMICS** for the vehicle you chose, and determine

a) tractive force

b) tractive moment

c) Acceleration

d) time for acceleration and

e) distance travelled

Acceleration Dynamics

Deepak Raina

Gear	Gear Ratio	Differential Ratio	Speed (kph)	Tractive Force (N)	Tractive Moment (N-m)	Road Load (N)
First	3.296	3.165	32.0039426	4023.238922	58336.96438	3681.328683
Second	1.958	3.165	53.8738482	2390.018753	1983.715565	6085.520667
Third	1.348	3.165	78.2529635	1645.426598	23858.68567	3800.873146
Fourth	1	3.165	105.484995	1220.642877	17699.32172	3678.751457
Fifth	0.725	3.165	145.496545	884.9660858	12832.00824	3928.022676
Sixth	0.582	3.165	181.245696	710.4141544	10301.00524	3693.018712

Gear	Acceleration (m/s^2)	Vehicle Drive off Parameter (a)	Vehicle Drive off Parameter (b)	Vehicle Drive off Parameter (c)	Time (sec)	Distance (m)
First	98.17868064	-6.79487E-05	-0.001022738	-0.35965135	19.66783982	6.685601699
Second	47.92707257	-6.79487E-05	-0.000360924	-0.359854831	18.95979227	4.958661088
Third	34.03242414	-6.79487E-05	-0.000171068	-0.359947599	15.0190935	3.937485112
Fourth	22.95563845	-6.79487E-05	-9.41434E-05	-0.360000523	13.60715934	3.301045741
Fifth	13.28036355	-6.79487E-05	-4.94841E-05	-0.360042345	12.82938861	2.805879977
Sixth	9.221553939	-6.79487E-05	-3.18886E-05	-0.360064092	11.70158585	2.569804074

Acceleration Dynamics

Deepak Raina

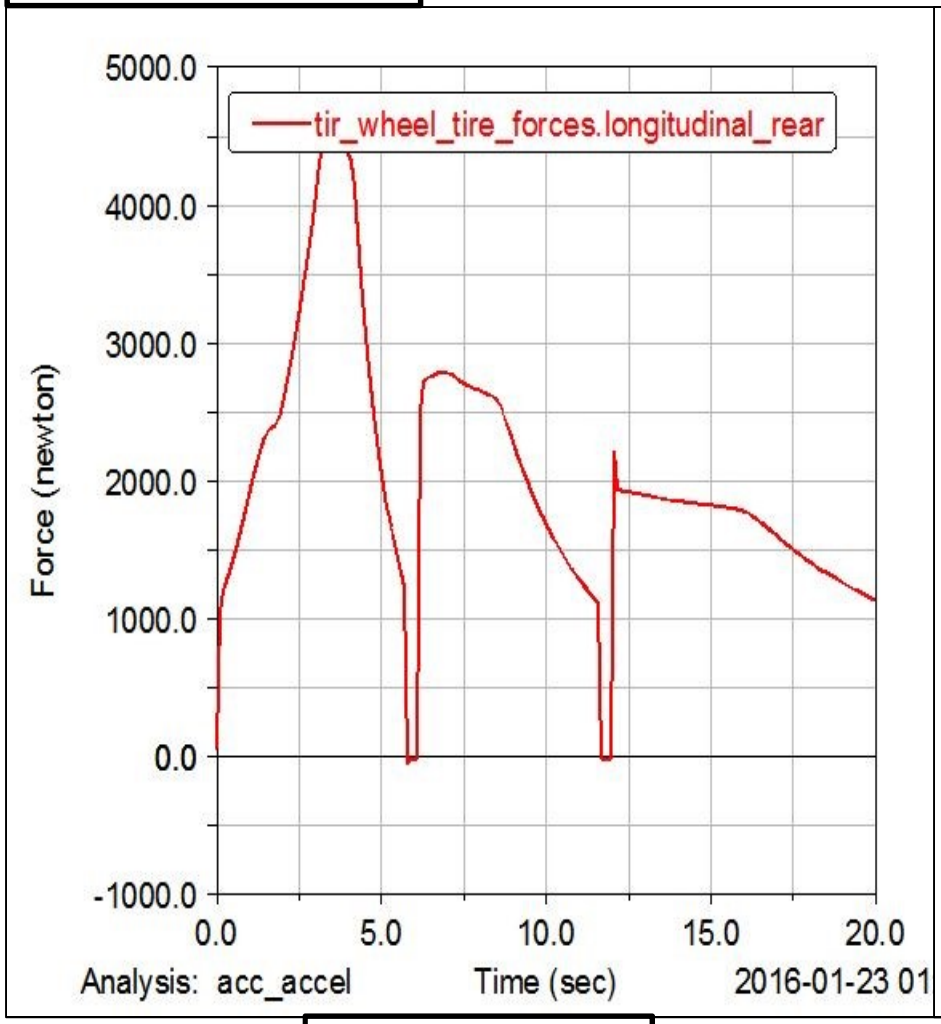
Attributes Used	Value	Units
Head Wind Speed	1	mps
Vehicle Drag Coefficient	1.2	-
Ambient Air Density	1	kg/m^3
Rolling Resistance Coefficient	0.15	-
Frontal Area	140	m^2
Engine output Coefficient Based on Experimental Data (BM)	7.103809524	kW/rpm
Engine output Coefficient Based on Experimental Data (AM)	8.47619E-05	kW/(rpm)^2
Dynamic Tyre Rolling Radius	14.5	inch
Drive Train Efficiency	0.83	-
Rotational Inertia Coefficient	1.3	-
Initial Velocity	2	mps
Final Velocity	100	mps

ADAMS Car Simulation

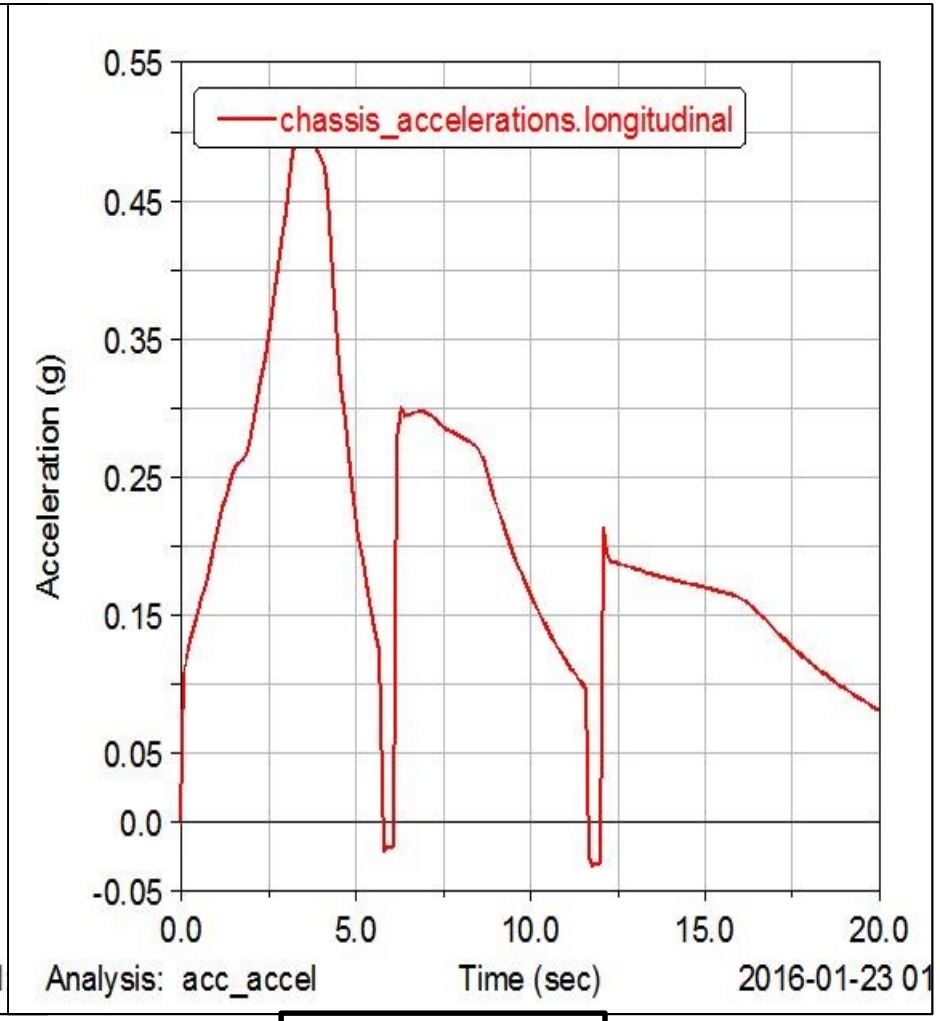
Nibodh Boddupalli

ADAMS Car Results

Nibodh Boddupalli



Tractive Force



Deceleration

HW#4

Question:

Do **BRAKING DYNAMICS** for the vehicle you chose, and determine

a) Braking force

b) Braking torque

c) Deceleration

d) time to stop and

e) distance to stop

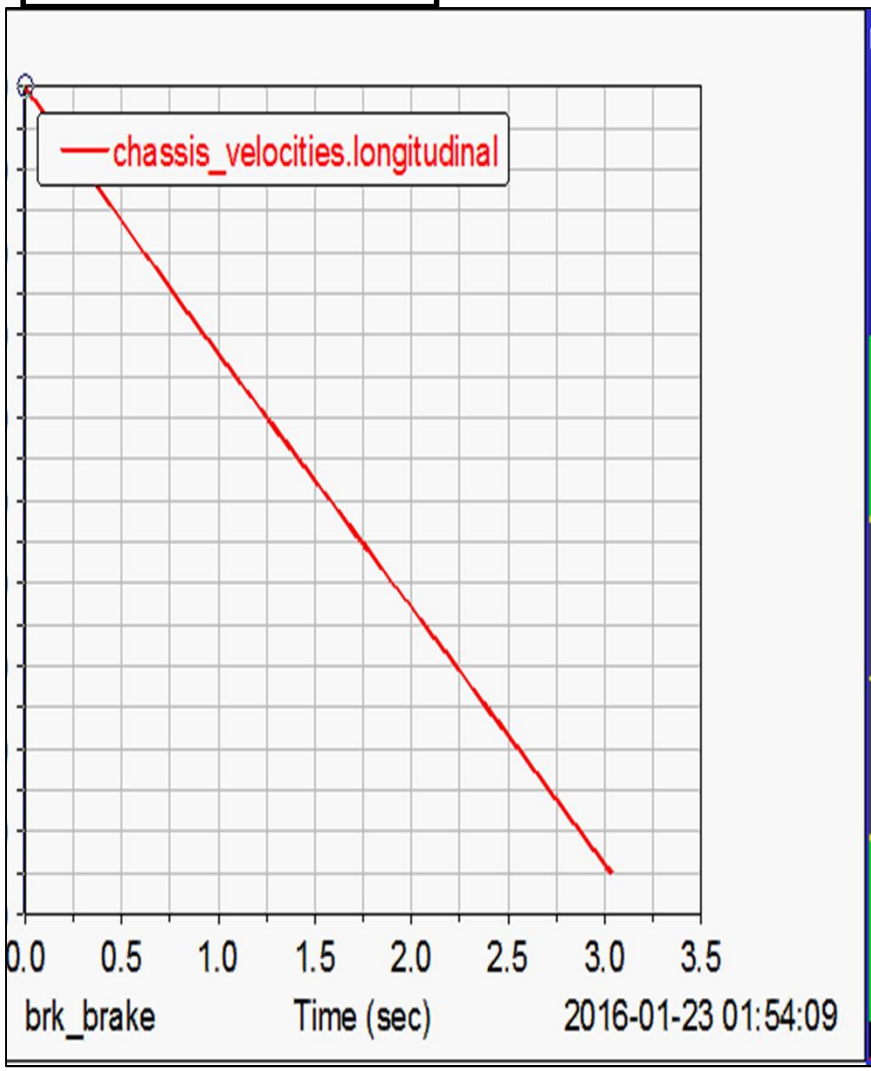
Braking Dynamics

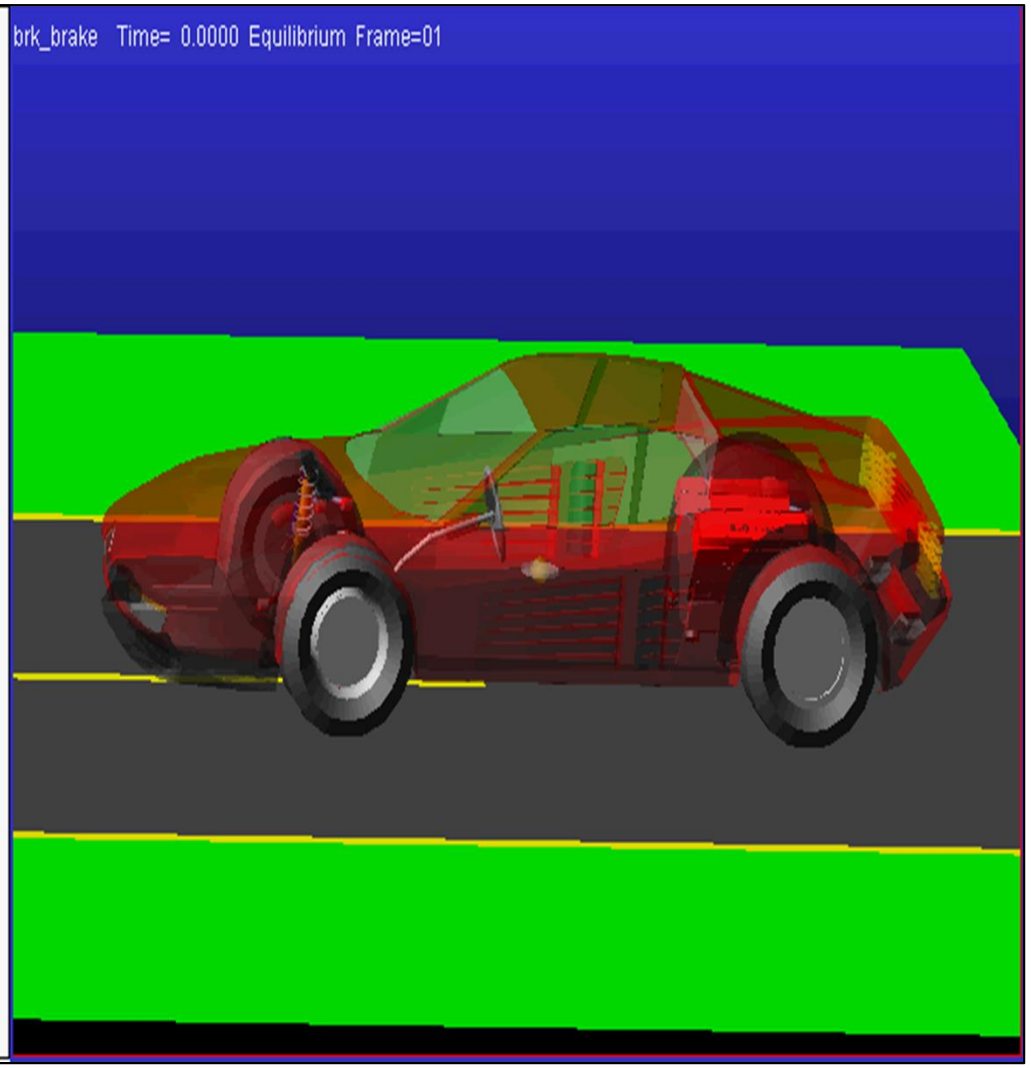
Deepak Raina

Attribute	Value	Units
Vehicle Speed	60	kph
Dynamic Tire Rolling Radius	0.3683	m
Distance between CG behind the front axle	1.269	m
Distance between CG infront the rear axle	1.431	m
The vertical raise of the front axle	0.4	m
Angle of Inclination of Vehicle With ground	8.519624	-
Vehicle System CG Height	0.3683	m
Weight Transfer due to Braking Inertia Force	2947.628	N
Front Tire Patch Ideal Braking Force	6480.179	N
Rear Tire Patch Ideal Braking Force	3827.314	N
Total Braking Force	10307.49	N
Braking Torque	3796.25	N-m
Deceleration	0.9	-
Time to Stop	3.437676	sec
Distance to Stop	33.23099	m

ADAMS Car Simulation

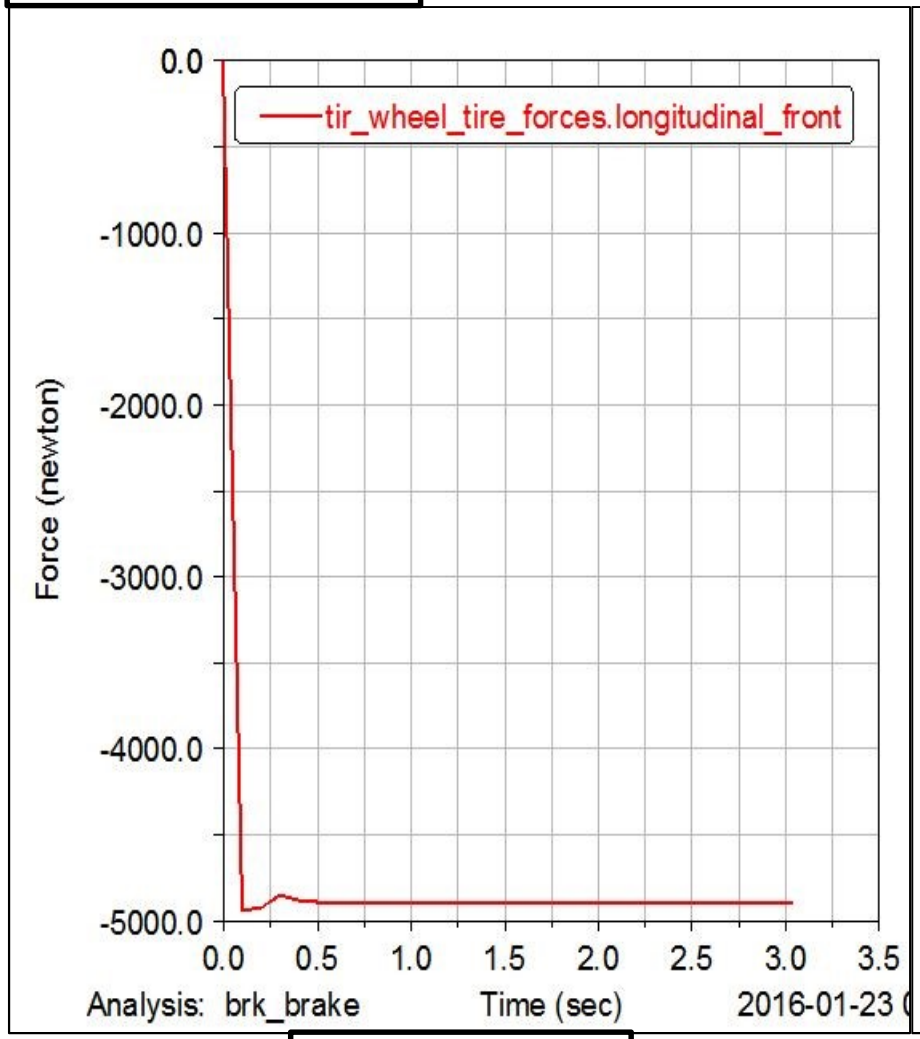
Nibodh Boddupalli



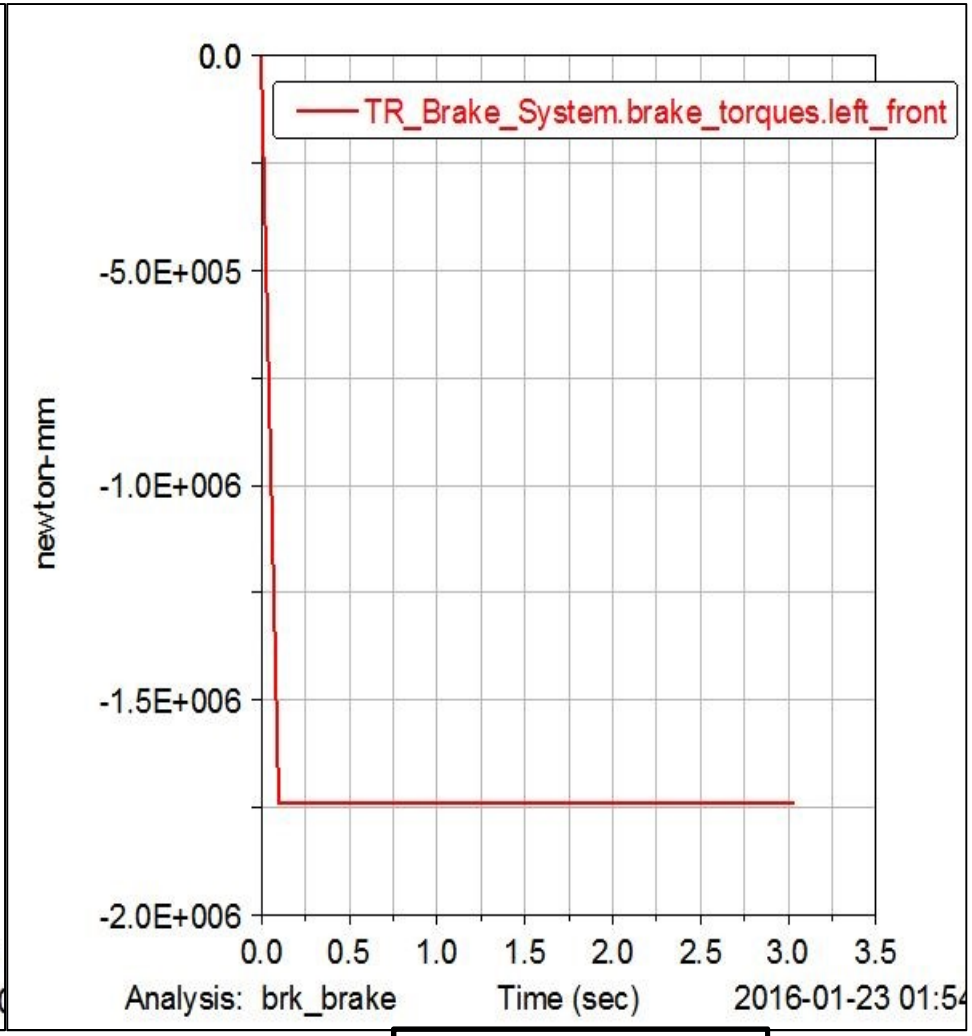


ADAMS Car Results

Nibodh Boddupalli



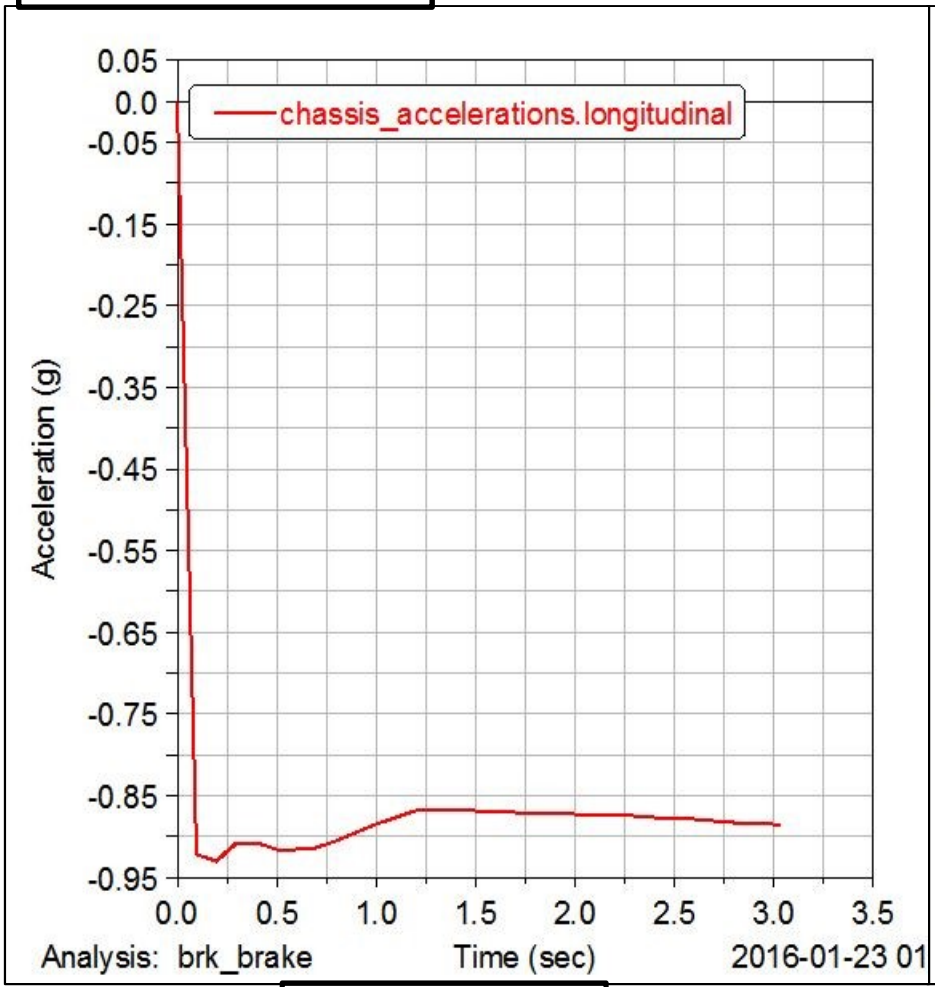
Braking Force



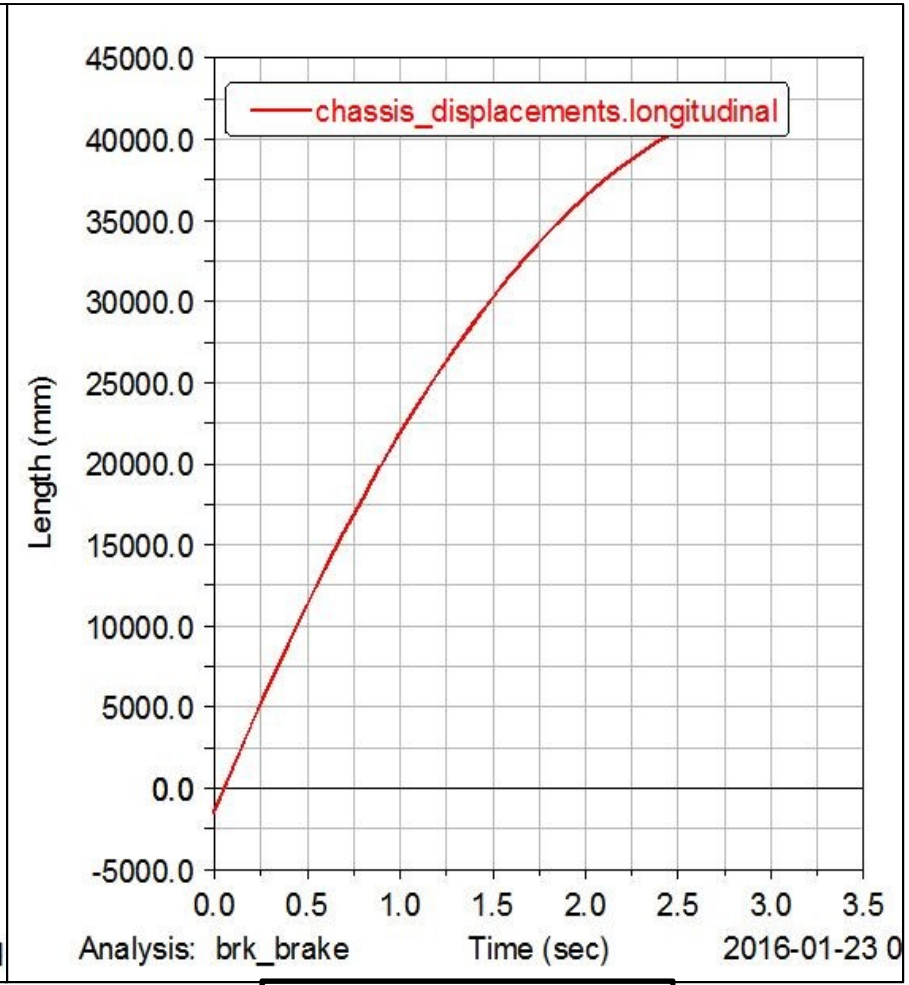
Braking Torque

ADAMS Car Results

Nibodh Boddupalli



Deceleration



Braking Distance

Discussion:

- Low speed steering is concerned with vehicle system turning at low speeds.
- It is used for parking maneuvers and other maneuvers with negligible acceleration .
- It also allows easy turning of vehicle with trailer attached.

Learning Outcomes

- ✓ Ackermann Steering Geometry
- ✓ Effect of Vehicle Wheel base on Turning Circle diameter
- ✓ Dependence of Steering Behavior on Scrub Radius

HW#5

Question:

Determine the **natural frequencies for primary and secondary rides** (of sprung and unsprung masses) using three math models. The first two models are the simplified single degree of freedom mass and spring models for sprung and unsprung masses while the third one is based on two degrees of freedom (quarter-car) model. **Use MATLAB or SIMULINK for the quarter car model** to determine the two frequencies (Eigen values) and the corresponding mode shapes (Eigen vectors).

HW#6

Question:

For **low speed Steering**, estimate the

a) Percent Ackerman

b) Turning Circle Diameter and

c) Curb to Curb turning circle

For **high speed Steering**, estimate the

a) Inside and outside vehicle normal forces

b) Inside and outside vehicle cornering forces

c) Impending lift off condition and

d) Front lateral load transfer with body roll angle

Low Speed Steering

Deepak Raina

Attribute	Value	Units
Scrub Radius	5	mm
Inside Front Wheel Steering Angle	45	degrees
Outside Front Wheel Steering Angle	36.43958989	degrees
Actual Outside Front Wheel Steering Angle	40.5	degrees
Steering Deviation	4.060410115	degrees
Percent Ackermann	52.56757491	%
Turning Circle	2.072302786	m
Tire Maximum Running Width	235	mm

Discussion:

- Low speed steering is concerned with vehicle system turning at low speeds.
- It is used for parking maneuvers and other maneuvers with negligible acceleration .
- It also allows easy turning of vehicle with trailer attached.

Learning Outcomes

- ✓ Ackermann Steering Geometry
- ✓ Effect of Vehicle Wheel base on Turning Circle diameter
- ✓ Dependence of Steering Behavior on Scrub Radius

High Speed Steering

Deepak Raina

Attribute	Value	Units
Cornering Acceleration in g's	0.85	-
Vehicle's Height of Center of Gravity	0.3683	m
Weight Transfer due to cornering Inertia force	2794.016	N
Inside Vehicle Normal Force	6808.912	N
Outside Vehicle Normal Force	11558.74	N
Impending Lift-off Condition	3.66549	-

Discussion:

- High speed steering is concerned with vehicle system turning at high speeds.
- It is used for steering vehicle with some acceleration .
- It is concerned with roll-over and handling stability during high speed maneuvers of vehicle.

Learning Outcomes

- ✓ Distribution of force on inside and outside wheel during cornering.
- ✓ Effect of Vehicle system Centre of gravity height on stability of vehicle.
- ✓ Condition for Roll-over prevention of Vehicle (Lift-off Condition)

References

Books:

1. Fundamental of Vehicle Dynamics by Thomas Gillespie
2. Vehicle Dynamics by Reza Jazar
3. Vehicle dynamics Class notes by Richard Lundstorm

Websites:

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2. *http://www.mahindraxuv500.com/pdf/owners_manual.pdf*
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