GUJARAT TECHNOLOGICAL UNIVERSITY
Bachelor of Engineering
Subject Code: 3170203
Vehicle Dynamics
7thSEMESTER

Type of course: Professional Elective

Prerequisite: Dynamics of machine, Automobile systems

Rationale: To understand the principle and performance of vehicle in various modes such as longitudinal, vertical and lateral directions. At the end of the course the student will be able to identify the various forces and loads and performance under acceleration, ride and braking.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Understanding Vehicle dynamics: History, Fundamental Approach to Modeling (Lumped mass, Vehicle Fixed Coordinate system, Earth Fixed Coordinate System, Euler Angles). Acceleration performance of Vehicle Power-limited Acceleration (based on Engines, Power Train – transmission & final drive ratio, Automatic Transmissions). Traction-limited Acceleration (Transverse weight shift due to drive torque, traction limits). Braking Performance Basic Equations (Constant Deceleration, deceleration with wind resistance), Energy / Power absorbed during braking, Braking Forces, Brakes factor, Tire road Friction, Federal Requirements for Braking Performance, Braking Proportioning, Anti-Lock brake system, Braking Efficiency, Rear wheel Lockup, Pedal Force Gain.	**06**
2	Aerodynamics: Mechanics of Air Flow Around a Vehicle, Pressure Distribution on a Vehicle, Aerodynamic Forces, Drag Components, Aerodynamics Aids. Rolling Resistance (Factors affecting rolling resistance, Typical coefficient), Total road Loads and effect of Road loads on Fuel economy.	**04**
3	Tire Mechanics: Tire Construction, Size and Load Rating, Terminology and Axis System, Tractive Properties, Cornering Properties, Camber Thrust, Aligning Moment, Combined Braking and Cornering, Conicity and Ply Steer, Slip, Skid, Rolling Resistance, Elastic Band Model for longitudinal slip, Simple model for lateral slip, Combined longitudinal/lateral slip (friction ellipse), Taut string model for lateral slip, Magic Tire Formula.	**07**
4	Suspensions: Suspension Kinematics, Suspension types, Solid Axles, Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points, Controllable Suspension Elements: Active, Semi-Active. Choice of suspension spring rate, Calculation of effective spring rate, Vehicle suspension in fore and apt directions.	**08**
5	The Steering System: The Steering Linkages, Steering System Forces and Moments, Steering System Models, Steering Geometry, Steady Handling (2 DOF steady state model),	**08**

	Under steer and Over steer, Effect of Tire Camber and Vehicle Roll (3 DOF steady-state model), Transient Handling and Directional Stability (2 DOF unsteady model), Effect of Vehicle Roll on Transient Handling (3 DOF unsteady model), Steady-State and Transient Handling of Articulated Vehicles.	
6	Rollover: Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover, Steady-state Cornering Basics, Low-speed Turning, High-speed cornering (Tire Cornering forces, Cornering Equations).	**04**
7	Motorcycle Dynamics:Kinematic structure of motorcycle, geometry of motorcycles, importance of trail, Resistance forces acting on motorcycle (tyre rolling resistance, aerodynamic resistance forces, resistant force caused by slope), Location & height of motor cycle's centre of gravity (C.G), Moments of inertia on Motorcycle. Introduction to Front & Rear suspensions of Motorcycle.	**05**

Suggested Specification table with Marks (Theory):

R Level	U Level	A Level	N Level	E Level	C Level
9	11	17	13	15	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Hans Pacejka, Tire and Vehicle Dynamics, Elsevier, 2012.
2. Thomas D Gillespie, "Fundamentals of Vehicle dynamics", SAE USA 1992.
3. Rajesh Rajamani, Vehicle Dynamics & control, Springer.
4. R.V. Dukkipati, Vehicle dynamics, Narsova Publications.
5. Wong J Y, "Theory of Ground Vehicles", John Wiley & Sons, New York, 1978.
6. Milliken W F and Milliken D L, Race car Vehicle Dynamics, SAE.
7. Garrett T K, Newton K and Steeds W, "Motor Vehicle", Butter Worths& Co., Publishers Ltd., New Delhi, 2001.
8. Heinz Heister, "Vehicle and Engine Technology", SAE Second Edition, 1999.
9. VittoreCossalter, Motorcycle Dynamics, 2nd Edition, Publisher: LULU.com
10. R N Jazar, Vehicle Dynamics: Theory and Application, Springer.

Course Outcome:After learning the course the students will able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Demonstrate a skill to apply basic theories to establish useful models for either the entire vehicle or components of the vehicle.	20
CO-2	Interpret the properties of critical factors in vehicle motion control and apply the models established from basic theories for vehicle design and improvement	25
CO-3	Identify key components and their working principles of modern vehicles	34

	alsoidentify the technology improvements in vehicles in the last several decades.	
CO-4	Relate the course materials to daily driving experience of a vehicle, in particular those related to driving safety	21

List of Experiments

1. Experimental study of mechanism for air flow over different geometry of vehicles.
2. Experimental studies of measurements of drag and lift coefficient for different geometry vehicle using wind tunnel apparatus.
3. To study the effect of tire pressure and temperature on the performance of the tyre.
4. To simulate and study a quarter car models using MBD (Multi Body Dynamics) software.
5. To simulate and understand behavior of sprung / un-sprung mass & lumped mass system MBD software.
6. Finding the stiffness of tire with variation of air pressure.
7. To simulate and study the effect of different conditions on vehicle loading.
8. Study of latest technologies available nowadays in vehicles helping to maintain stability of the vehicle on the road.
9. Study geometry of motorcycles as well as various types of forces faced by the motorcycle & its rider
10. Study the location & height of Centre of gravity (C.G) of a motorcycle

Major Equipment:

1. Wind tunnel apparatus
2. Multibody (MBD) simulation software

Design based Problems (DP)/Open Ended Problem:

1. As the chief engineer of a drag racing team find the best vehicle configuration ,try to configure as either front wheel drive or rear wheel drive ,investigate the influence of road friction
2. To design/check aerodynamics shapes of various car bodies, to calculate equivalent weight and maximum acceleration, desired power to propel the vehicle by CFD analysis.
3. Simulation of longitudinal dynamics using any Multibody (MBD) simulation software

List of Open Source Software/learning website:

1.http://nptel.ac.in/courses/107106080/