SEMESTER S6

VEHICLE DYNAMICS

Course Code	PBMUT604	CIE Marks	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	ESE Marks	40
Credits	4	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMUT303 PCMUT402 PBMUT504	Course Type	Theory

Course Objectives:

1. Examine the dynamics of automotive systems and assessing their performance parameters.
2. Provide students with hands-on experience in simulating the dynamics of ground vehicles.
3. Determine the longitudinal, lateral, and vertical stability of the vehicle and their influence on vehicle dynamics.

SYLLABUS

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Module No.	Syllabus Description	Contact Hours
1	**Introduction to vehicle dynamics:** History of road and off-road vehicle system dynamics. Vehicle coordinate systems- vehicle fixed coordinates system, earth fixed coordinate system, SAE coordinate system. Fundamental approaches to vehicle dynamics modelling lumped mass, vehicle fixed coordinate system, motion variables, Euler angles, forces, Newton's second law. Modelling and simulation of dynamic behaviour of vehicle, motion analysis, force analysis, and energy analysis using software (simple models). **Performance of road vehicles**: Forces and moments on vehicle, equation of motion, tire forces, rolling resistance, weight distribution, tractive effort/tractive resistance and power available from the engine/ power required for propulsion, road performance curves- acceleration, grade ability, drawbar pull and the problems related to these terms.	11
2	**Longitudinal dynamics:** Calculation of maximum acceleration braking torque, braking force, brake proportioning, braking efficiency, stopping distance, load distribution (three wheeled and four wheeled vehicles), calculation of acceleration, tractive effort and reactions for different drives,	11

	Stability of a vehicle on slope, (Problems related to these). Weight transfer during acceleration, cornering and braking MATLAB simulation for longitudinal dynamic response during acceleration and braking of automotive system. Vehicle dynamic Control, modelling of actuators, sensors for automobile control, sensors for detecting vehicle environment, central tyre inflation system. Prediction of vehicle performance. ABS, stability control, traction control.	
3	**Introduction to lateral dynamics** - Development of lateral forces. slip angle, cornering force, cornering stiffness, pneumatic trail, self-aligning torque, power consumed by tire, tire stiffness, hysteresis effect in tires, steady state handling characteristics. yaw velocity, lateral acceleration, curvature response & directional stability. Stability of a rigid vehicle and equations of motion of a rigid vehicle, cross wind handling, the problems related to these terms. **MATLAB simulation for lateral dynamic** response during cornering of automotive system. Stability of a vehicle on a curved track and a banked road. gyroscopic effects.,	**11**
4	**Introduction to vertical dynamics** - Human response to vibrations, classification of vibration, specification and vibration, sources of vibration, suspension systems, Modal Analysis, One DOF, two DOF, free and forced vibration, damped vibration, magnification and transmissibility, body vibrations: bouncing and pitching. doubly conjugate points (only basic idea). body rolling. roll centre and roll axis, roll axis and the vehicle under the action of side forces, stability against body rolling. **Vehicle dynamics and suspension design for stability**. Design and analysis of passive, semi-active and active suspension using quarter car, half car and full car model. Matlab simulation for vertical dynamic response to analyze ride, pitch and roll of automotive system, Matlab simulation for Half Car Model, Matlab simulation for Quarter Car Model	**11**

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Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microprojects	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**30**	**12.5**	**12.5**	**60**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 1 Questions from each module. • Total of 4 Questions, each carrying 2 marks **(4x2 =8 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 2 sub divisions. • Each question carries 8 marks. **(4x8 = 32 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	To understand the vehicle system dynamics and performance of road vehicles	**K5**
CO2	To develop an analytical model in MATLAB to assess the stability of a ground vehicle during braking and acceleration.	**K5**
CO3	To asses the lateral dynamics of ground vehicle using MATLAB package.	**K5**
CO4	To Simulate the vertical dynamic response to analyze ride, pitch, and roll of an automotive system, including MATLAB simulations for both the Half Car Model and the Quarter Car Model.	**K5**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	1	-	-	-	1	1	1
CO2	3	3	3	-	3	2	-	-	2	3	2	2
CO3	3	3	3	-	3	2	-	-	2	3	2	2
CO4	2	3	2	-	3	2	-	-	2	3	2	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

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Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Vehicle Dynamics	Thomas D. Gillespie	Society of Automotive Engineers Inc	1992
2	Automotive Mechanics	N.K.Giri	Khanna Publishers	2013
3	Road Vehicle Dynamics: Fundamentals and Modeling with MATLAB	Georg Rill, Abel Arrieta Castro	CRC	2020
4	Vehicle Dynamics and Control	Rajesh Rajamani	Springer	1st, 2005

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Vehicle Dynamics: Theory and Application	Reza N Jazar	Springer	2008
2	Theory of Ground Vehicles	J. Y. Woung	John Willey & Sons	2008
3	Mechanics of Road Vehicles	W. Steed	Iliffe & Sons	1962
4	Fundamentals of Vehicle Dynamics and Modelling: A Textbook for Engineers with Illustrations and Examples	Bruce P. Minaker	Wiley	2019
5	Vehicle Handling Dynamics Theory and Application	Masato Abe	Science direct	2015
6	The Multibody Systems Approach to Vehicle Dynamics	Blundell	Butterworth-Heinemann	2014

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/107106080
2	https://nptel.ac.in/courses/107106080
3	https://nptel.ac.in/courses/107106080
4	https://nptel.ac.in/courses/107106080

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