GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: VEHICLE KINEMATICS & DYNAMICS
(Code: 3340202)

Diploma Programme in which this course is offered	Semester in which offered
Automobile Engineering	4th Semester

1. RATIONALE

This subject is concerned with the movements of vehicle on a road surface. The movements of interest are acceleration, braking, ride and turning. Dynamic behavior is determined by the forces imposed on the vehicles from the tires, gravity and aerodynamics. Dynamics is the branch of Theory of Machine which deals with the forces and their effects acting on the components of machine so first chapter is related to introduction to theory of machine. The rest course is designed to provide understanding about effects of various unbalanced forces, its effects on the various components of vehicle and method to balance that unbalanced forces for getting smooth operation and long life of the vehicle. This course also aims to build higher level cognitive skill of future technicians for analyzing vehicle performance against various resistances acting on it during operation, vibrations and its effects with respect to ergonomics of the vehicle. The knowledge of this subject is essential to design aerodynamics shapes of car body, to calculate equivalent weight and maximum acceleration, desired power to propel the vehicle.

2.   COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop different types of skills leading to the achievement of the following competency

- **Use knowledge of Kinematics and Dynamics in manufacturing and maintenance of automobile systems for vehicle operation and performance.**

3.   COURSE OUTCOMES (CO's)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning out comes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

   i.   Explain basic terminology related theory of machine and vehicle dynamics with their appropriate examples
  ii.   Solve numerical problems of Rotating mass or Reciprocating mass balancing in the same or different planes applying graphical and/or analytical method.
 iii.   Identify causes of vibration and factors affecting human comfort in a vehicle
  iv.   Derive and apply equation of true rolling condition for solving numerical

v. Determine various performance parameters for given operating conditions and braking of vehicle
vi. Explain various types of suspension system used in vehicles
vii. Describe various factors affecting tyre life and which are responsible for vehicle performance

4.   TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE	PA	ESE	PA	
4	2	0	6	70	30	00	00	100

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** – Credit;; **ESE** - End Semester Examination; **PA** - Progressive Assessment.

5.   DETAILED COURSE CONTENTS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit– I Introduction to Theory of Machine and Vehicle Dynamics	1a. Explain the division of theory of machine 1b. Differentiate Mechanism, Structure and Machine 1c. Classify different types of kinematic pair with their examples 1d. Describe inversions of mechanism with neat sketch 1e. Describe various forces and moments acting on a vehicle.	1.1 Introduction to theory of machine 1.2 Basic terminology related to theory of machines like kinematic link, kinematic pair, kinematic chain, mechanism, structure, machine, degree of freedom for plane mechanism. 1.3 Different types of basic mechanisms used in Automobile System like - Four bar Mechanism. - Single and Double Slider Crank Mechanisms. - Cam and Follower Mechanism with their types 1.4 Introduction to vehicle dynamics - Drag, Lift, Side force, rolling moment, pitching moment, yawing moment, - Dynamic load on axle

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – II **Balancing**	2a. Define Static and dynamic Balancing, Primary and Secondary Balancing 2b. Derive an expression for determining value of balancing mass at given radius for given unbalanced Rotating or Reciprocating Masses in the same or different planes 2c. Explain Effects of unbalance primary force in reciprocating engines 2d. Solve numerical of Rotating mass or Reciprocating mass balancing in the same or different planes applying graphical and/or analytical method	2.1 Need of Balancing, Static and Dynamic Balancing 2.2 Balancing of rotating mass. 2.3 Balancing of single rotating mass. 2.4 Balancing of several rotating masses. 2.5 Primary and secondary unbalanced forces of reciprocating masses. 2.6 Partial balancing of unbalanced primary force in reciprocating engines. 2.7 Variation of tractive force, Swaying couple and Hammer blow with respect to locomotive engine. 2.10 Balancing of primary forces of multi cylinder in-line engine. 2.11 Balancing of secondary forces of multicylinder in-line engine.
Unit – III **Vehicle** **Vibrations** **&** **Ergonomics**	3a. Define various terminologies related to Vibrations 3b. Explain causes of vibration 3c. Explain the concept of ergonomic with reference to vehicle	3.1 Definitions of Terminologies related to Vibrations 3.2 Sources of vibration in a vehicle, isolation 3.3 Vibration isolation in a vehicle 3.3 Vehicle Vibration and human comfort 3.4 Factors affecting human comfort in a vehicle
Unit– IV **Steering** **Mechanism**	4a. Differentiate types of Steering Mechanisms 4b. Derive and Apply equation of true rolling condition for solving numerical 4c. Derive an equation for Turning circle radius	4.1 Ackerman steering Mechanism 4.2 Condition for true rolling 4.3 Turning circle radius
Unit–V **Vehicle** **Performance**	5a. Explain effects of various resistances on vehicle performance. 5b. Derive relations between various terms responsible for vehicle performance 5c. Determine various performance parameters for given operating conditions and braking of vehicle	5.1 Various resistances to vehicle. 5.2 Power for propulsion 5.3 Traction and tractive effort 5.4 Relation between engine speed and vehicle speed 5.5 Acceleration, drawbar pull and grade ability 5.6 Distribution of weight in three wheeled and four wheeled vehicle 5.7 Stability of vehicle on slope 5.8 Calculation of maximum acceleration, maximum tractive effort and relation for different drives 5.9 Factors affecting braking efficiency. 5.10 Calculation of stopping distance.(when

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
		brakes are applied to front wheel, rear wheels and four wheels) 5.11 Braking of vehicle on curved path
Unit VI Suspension and Tyres	6a. Explain the function of suspension with respect to force generation 6b. Explain various types of suspension system 6c. Describe various terminologies related to tyre which is responsible for vehicle performance	6.1 Function of suspension system(Ride control, height control, roll control, dive and squat control, road holding) 6.2 Types of front and rear suspension (Solid axles (Hotchkiss, Four Link, DeDion), Independent suspensions (SLA Front Suspension, Macpherson Strut, Trailing-Arm Rear Suspension, Semi-Trailing Arm, Swing Axle, Multi link rear suspension) 6.3 Roll axis and effect of side forces. 6.4 Tyre construction, size and load rating, various terminologies related to tyre, concept of mechanism of force generation in tyre.

6.   SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks (Duration – …..Hours)			
			R Level	U Level	A Level	Total
1.	Introduction to theory of machine and vehicle dynamics.	10	04	07	03	14
2.	Balancing.	14	00	07	07	14
3.	Vehicle vibration & Ergonomics.	05	03	04	00	07
4.	Steering mechanism.	05	00	03	04	07
5.	Vehicle.Performance	14	00	11	07	18
6.	Suspension and tyre.	08	07	03	00	10
	Total	**56**	**14**	**35**	**21**	**70**

Legends: R = Remember, U = Understand, A= Apply and above Level (Bloom's revised 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

7.   SUGGESTED LIST OF TUTORIAL

S. No.	Unit No.	Tutorial/Exercises	Approx. Hrs. Required
1	I	Exercise on theory of machine	02
2	II	Exercise on balancing of rotating mass.	04
3	II	Exercise on balancing of reciprocating mass.	04
4	III	Exercise on vibration and ergonomics	04
5	IV	Exercise on steering mechanism.	04
6	VI	Exercise on suspension system and tyre	04
7	V	Exercise on vehicle performance.	06
		Total	28

8. SUGGESTED LIST OF PROPOSED STUDENT ACTIVITIES

Following is the list of proposed student activities such as:

i. Seminars using power point presentations including video/animation to get better understanding of various components of mechanisms, pairs, joints, inversions etc and their working.

ii. Group discussion on various parameters to be considered for aerodynamic design, vehicle performance etc., mini-projects to develop model of various mechanisms for   specific task, internet based assignments, teacher guided self learning activities, course/library/internet/lab based mini-projects etc. These could be individual or group-based.

iii.   Case studies from real life problems of balancing, vibration etc.

9. SPECIAL INSTRUCTIONAL STRATEGIES (If any)

i. Presentation through video/animation to explain working of various mechanisms and their inversions.
ii. Power point presentation showing wheel balancing, balancing of reciprocating masses, various types of vibrations, its effect and remedies to reduce it, vehicle performance testing etc.
iii. Chart and models showing models of various mechanisms and their inversions.
iv. Assignments to solve problems related to balancing, steering mechanism, vehicle performance etc.

10.   SUGGESTED LEARNING RESOURCES

A.   List of Books

S.No.	Author	Title of Books	Publication
1	Thomas D. Gallespie	Fundamentals of vehicle dynamics	SAE.
2	Oleg Vinogradov	Fundamentals of kinematics and dynamics of machine and machanisms.	CRC Press

S.No.	Author	Title of Books	Publication
3	N.K. Giri	Automobile Mechanics	Khanna Publishers, Delhi
4	R.S. Khurmi	Theory of Machines	Eurasia Publishing house (P) Ltd. New Delhi
5	R.S. Khurmi; J.K. Gupta	Theory of Machines	S. Chand and Compny., New Delhi
6	S.S. Rattan	Theory of Machines	Tata Mc Graw-Hill Pub., New Delhi
7	V. P. singh	Theory of Machines in SI Units	Dhanpat Rai and Co (P) Ltd. New Delhi
8	J. Shigley	Theory of Machines and Mechanisms	McGraw Hill International. New Delhi
9	J. R. Ellis	Vehicle dynamics	Business Books, 1969
10	W. steeds	Mechanics of road vehicle	Iliffe, 1960

B. List of Major Equipment/ Instrument

    i. Charts for various mechanisms and their inversions.
    ii. Models for various mechanisms and their inversions.
    iii. Rotating mass balancing equipment.
    iv. Universal Vibration Apparatus.

C. List of Software/Learning Websites

  i.http://www.youtube.com/watch?v=GBnk0iRxEqY (Ackerman Steering Mechanism)

  ii.http://www.youtube.com/watch?v=YzGM8Uc2HB0 (Davis Steering Mechanism)

  iii.http://www.youtube.com/watch?v=hvpFcSPtDV0 (Balancing)

  iv.http://www.youtube.com/watch?v=y60dTiuJv24 (Balancing)

  v.http://www.youtube.com/watch?v=OfTpw4L9y4Y

  vi.http://www.bandgmachine.com/news-media/videos/video-balancing/

  vii.http://www.youtube.com/watch?v=XAgRNI6tY58

  viii. http://www.youtube.com/watch?v=lLqF7A3SAXE (Vibration of a Steering Wheel)
  ix.http://www.youtube.com/watch?v=qhF3I5ylIHM (Wheel Alignment)

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. M. J. Pathak, H.O.,** Automobile Engineering Department., Sir Bhavsinhji Polytechnic Inst., Bhavnagar.
- **Prof. M. N. Vibhakar, Lecturer,** Automobile Engineering Department. Dr.S&SS Gandhi Polytechnic, Surat
- **Prof. S.V. Trivedi**, H.O.D., Automobile Engineering Department, Parul Institute of Technology, Vadodara.
- **Prof. A. C. Suthar** Lecturer, Automobile Engineering Department, M. L. Institute of Diploma Studies, Bhandu

Coordinator and Faculty Members from NITTTR,Bhopal

- **Dr. C. K. Chugh,** Professor, Department of Mechanical Engineering
- **Dr. K. K. Jain,** Professor, Department of Mechanical Engineering