

**GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)**

**Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)**

Semester –IV

**Course Title: Automotive Mechanics**

(Course Code: 4340202)

Diploma Programme in which this course is offered	Semester in which offered
Automobile Engineering	4 <sup>th</sup> Semester

**1. RATIONALE**

Mechanics is a branch of Physics, which incorporates science concerned with the motion of bodies under the action of forces, including the special case in which a body remains at rest. Study of automotive mechanics includes the underlying study of various forces, motion analysis of mechanisms, braking performance, engine performance, vibration analysis, direction control, etc. This course is mainly concerned with the movements of a vehicle on a road surface. The movements of interest are acceleration, braking, ride and turning. Course is designed to acquaint students with effects of various forces on the vehicle, sources of vibration and its isolation, steering geometry for true rolling and engine performance measurement. Calculation on wheel reaction, braking force impact, traction available at wheel, maximum possible acceleration for given situation, heat balance sheet etc. are also covered in the course with a view to develop problem solving capacity of student in the field of automotive mechanics.

**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 automotive mechanics to improve vehicle performance.**

**3. COURSE OUTCOMES (COs)**

The underpinning knowledge and the relevant skills associated with this competency are to be developed in the student to display the following COs:

- Interpret various terminologies used in Automotive Mechanics.
- Appreciate the importance of true rolling condition for steering to minimize side forces, vehicle vibrations and vibration isolation.
- Evaluate the vehicle performance based on given situation.
- Evaluate various parameters affecting Engine performance.

**4. TEACHING AND EXAMINATION SCHEME**

Teaching Scheme (In Hours)	Total Credits (L+T+P/2)	Examination Scheme		
		Theory Marks	Practical Marks	

L	T	P	C	CA	ESE	CA	ESE	Total Marks
2	2	0	4	30*	70	-	-	100

(\*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

**Legends:** L-Lecture; T – Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, CA - Continuous Assessment; ESE -End Semester Examination.

## 5. SUGGESTED TUTORIAL EXERCISES

The following practical outcomes (PrOs) that are the sub-components of the COs. These PrOs need to be attained to achieve the COs.

Sr. No	Tutorials Outcomes	Unit No.	Approx. Hrs. required
1	a. Interpret and write various terminologies related to mechanics. b. Describe various mechanisms used in automotive mechanics. c. Explain important terms related to Automotive mechanics i) Aerodynamic forces ii) SAE Vehicle axis system iii) Rolling, Pitching and Yawing moments iv) SAE Tire axis system v) Side force	1	4
2	Steering System: a. Derive the equation for Ackerman steering Mechanism. b. Derive the equation for the true rolling conditions (Minimum 2 examples) c. Understand the equation of turning radius. (Minimum 3 examples)	2	4
3	Vibration: a. Recall various terminologies related to Vibration. b. Prepare a list of sources of vibration in vehicle. c. Describe various types of vibration. d. Enlist various factors affecting vehicle vibration and human comfort.	2	4
4	Vehicle Performance: a. Explain various resistances acting on a vehicle. (Along with 2 examples)	3	4

	<p>b. Illustrate the relation between the Engine speed and vehicle speed. (Minimum 4 examples)</p> <p>c. Draw the road performance curve (road speed vs power available at wheel &amp; road speed vs tractive effort) for,</p> <ul style="list-style-type: none"> <li>• Acceleration</li> <li>• Drawbar Pull</li> <li>• Gradability</li> </ul> <p>d. Derive equations for weight distribution (along with 2 examples) in</p> <ul style="list-style-type: none"> <li>• Three wheeled Vehicle</li> <li>• Four wheeled Vehicle</li> </ul>		
5	<p>Vehicle Performance:</p> <p>a. Derive equations for the stability of a vehicle on slope. (Along with 2 examples)</p> <p>b. Calculation of maximum acceleration, maximum tractive effort and relation for different drives (along with 3 examples)</p> <p>c. Calculation of stopping distance. (When brakes are applied to) (Minimum 3 examples)</p> <ul style="list-style-type: none"> <li>• Only front wheel,</li> <li>• Only rear wheels</li> <li>• All four wheels</li> </ul>	3	4
6	<p>Engine Performance:</p> <p>a. Calculation related to basic terminology of engine. (Minimum 4 examples)</p>	4	4
7	<p>Engine Performance:</p> <p>a. Describe Morse test along with its procedure.</p> <p>b. Calculation of Power of multi cylinder along with example (Minimum 3 examples)</p> <p>c. Solve problems related to heat balance sheets (along with 3 examples)</p>	4	4
	<b>Total Hrs.</b>		<b>28</b>

**Note**

- i. More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. **The above table is only a suggestive list.**
- ii. Care must be taken in assigning and assessing study report as it is a study report. Study report, data collection and analysis report must be assigned in a group. Teacher has to discuss about type of data (which and why) before group start their market survey.

iii. The following are some **sample** 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed **Tutorial/ Exercises** of this course required which are embedded in the COs and ultimately the competency.

S. No.	Sample Performance Indicators for the Tutorials	Weightage in %
1	Explain concept/properties/terminology	25
2	Draw appropriate figure/ correct calculation	50
3	Timely submission	25
<b>Total</b>		<b>100</b>

## 6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practical in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications
1	Demonstration models of Four bar chain, Single and Double Slider Crank Mechanisms and Cam and Follower Mechanism.
2	Demonstration model of Steering linkages mechanism.
3	Charts on various mechanisms and SAE Tire axis system.

## 7. AFFECTIVE DOMAIN OUTCOMES

The following **sample** Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs. More could be added to fulfil the development of this course competency.

- a) Work as a leader/a team member.
- b) Follow ethical practices.
- c) Practice environmental friendly methods and processes. (Environment related)

The ADOs are best developed through the field based exercises/project work. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- i. 'Valuing Level' in 1<sup>st</sup> year
- ii. 'Organization Level' in 2<sup>nd</sup> year.
- iii. 'Characterization Level' in 3<sup>rd</sup> year.

## 8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for development of the COs and competency. If required, more such higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs) (4 to 6 UOs at different levels)	Topics and Sub-topics
<b>Unit Introduction to Automotive Mechanics</b>	1.a Explain various terminologies of mechanics. 1.b Differentiate various types of mechanism used in Automobile system. 1.c Describe various forces and moments acting on a vehicle. 1.d Explain SAE Tire axis system.	1.1 Introduction to Mechanics <ul style="list-style-type: none"> <li>● Mechanics</li> <li>● Statics</li> <li>● Dynamics</li> <li>● Kinematics</li> <li>● Kinetics</li> </ul> 1.2 Important terminology in Mechanics <ul style="list-style-type: none"> <li>● Kinematic Link</li> <li>● Kinematic Pair</li> <li>● Kinematic Chain</li> <li>● Mechanisms</li> <li>● Structure</li> <li>● Machine</li> <li>● Degree of freedom for planar mechanism.</li> </ul> 1.3 Basic mechanisms used in Automobile Systems <ul style="list-style-type: none"> <li>● Four bar chain Mechanism.</li> <li>● Single and Double Slider Crank Mechanisms.</li> <li>● Cam and Follower Mechanism (with their types)</li> </ul> 1.4 Introduction to Automotive Mechanics and related Important terms <ul style="list-style-type: none"> <li>● Aerodynamic Forces (Drag &amp; Lift)</li> <li>● Side force</li> <li>● SAE Vehicle Axis System</li> <li>● Rolling, Pitching &amp; Yawing moments</li> </ul> 1.5 SAE Tire axis system

<p><b>Unit II</b></p> <p><b>Vehicle Steering and Vibrations</b></p>	<p>2.a Explain Ackerman steering Mechanism.</p> <p>2.b Derive equation of true rolling condition for solving numerical.</p> <p>2.c Derive an equation for Turning circle radius.</p> <p>2.d Define various terminologies related to Vibrations.</p> <p>2.e Classify different types of vibration.</p> <p>2.f Explain sources of vibration and their isolation in vehicle for human comfort.</p>	<p>2.1. Ackerman steering Mechanism</p> <p>2.2. Condition for true rolling</p> <p>2.3. Turning circle radius (along with calculations)</p> <p>2.4. Definitions and Terminologies related to Vibration</p> <p>2.5. Types of Vibrations</p> <p>2.6. Sources of vibrations in a vehicle.</p> <p>2.7. Vibration isolation in a vehicle.</p>
<p><b>Unit III</b></p> <p><b>Vehicle Performance</b></p>	<p>3.a Explain various resistances acting on moving vehicle and tractive effort available at wheel.</p> <p>3.b Derive equation of relation between engine speed and vehicle speed for solving numerical.</p> <p>3.c Explain road performance on the basis of available power.</p> <p>3.d Derive formula for reactions at wheel on weight distribution in three and four wheeler.</p> <p>3.e Explain wheel reaction for stability of vehicle on slope.</p> <p>3.f Determine various performance parameters for given operating conditions and braking of vehicle.</p>	<p>3.1. Power for propulsion</p> <ul style="list-style-type: none"> <li>● Various resistances to vehicle</li> <li>● Traction and tractive effort</li> </ul> <p>3.2. Relation between engine speed and vehicle speed (along with numerical)</p> <p>3.3. Road Performance Curves on the basis of available power</p> <ul style="list-style-type: none"> <li>● Acceleration</li> <li>● Drawbar Pull</li> <li>● Gradeability</li> </ul> <p>3.4. Weight Distribution and reaction at wheel in</p> <ul style="list-style-type: none"> <li>● Three wheeled vehicles</li> <li>● Four wheeled vehicles</li> </ul> <p>3.5. Stability of a vehicle on slope</p> <p>3.6. Calculation of maximum acceleration, maximum tractive effort and relation for different drives</p> <p>3.7. Factors affecting braking efficiency</p> <p>3.8. Calculation of stopping distance. (When brakes are applied to...)</p> <ul style="list-style-type: none"> <li>● Only front wheel,</li> <li>● Only rear wheels</li> </ul>

		<ul style="list-style-type: none"> <li>● All four wheels</li> </ul>
<b>Unit IV</b> <b>Engine Performance</b>	<p>4.a Describe various terminologies related to performance of engine.</p> <p>4.b Describe working of common dynamometer used for measuring power.</p> <p>4.c Analyze results of Morse test</p> <p>4.d Prepare heat balance sheet from given data.</p>	<p>4.1. Performance Indicators of I.C engine</p> <ul style="list-style-type: none"> <li>● Indicated power</li> <li>● Brake power</li> <li>● Friction power</li> <li>● Indicated thermal efficiency</li> <li>● Brake thermal efficiency</li> <li>● Mechanical efficiency</li> <li>● Volumetric efficiency</li> <li>● Relative efficiencies</li> </ul> <p>4.2. Dynamometers used for measuring power of engine</p> <ul style="list-style-type: none"> <li>● Rope brake dynamometer</li> <li>● Prony brake dynamometer</li> <li>● Hydraulic dynamometer</li> </ul> <p>4.3. Morse test – procedure – problems</p> <p>4.4. Heat balance sheet - problems.</p> <p>4.5. Variables affecting performance and methods to improve engine performance.</p>

**Note:** The UOs need to be formulated at the 'Application Level' and above of Revised Bloom's Taxonomy' to accelerate the attainment of the COs and the competency.

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction to Automotive Mechanics	06	4	7	3	14
II	Vehicle Steering and Vibrations	06	3	7	4	14
III	Vehicle Performance	10	4	14	10	28
IV	Engine Performance	06	4	4	6	14
	<b>Total</b>	<b>28</b>	<b>15</b>	<b>32</b>	<b>23</b>	<b>70</b>

**Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

**Note:** This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at

*different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.*

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related **co-curricular** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should conduct following activities in group and prepare reports of each activity. They should also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

- a) Charts can be prepared.
- b) Small report on any topic given by concern faculty.
- c) Small groups of students can be formed for assigned work. Assigned work should be such that it covers market survey, team work, presentation, time management, quality development.

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
- b) Guide student(s) in undertaking micro-projects.
- c) **'L' in section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- d) About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for **self-learning**, but to be assessed using different assessment methods.
- e) With respect to **section No.10**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.
- f) Guide students on how to address issues on environment and sustainability

## 12. SUGGESTED MICRO-PROJECTS

**Only one micro-project** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project are group-based. However, in the fifth and sixth semesters, it should be preferably being **individually** undertaken to build up the skill and confidence in every student to become problem solver so that she/he contributes to the projects of the industry. In special situations where groups have to be formed for micro-projects, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to



maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should be about **14 - 16 (fourteen to sixteen) student engagement hours** during the course. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

Prepare chart representing various kinematics links, pair and chain.
Prepare charts indicating various Aerodynamic Forces (Drag & Lift), Side force, SAE Vehicle Axis System, Rolling, Pitching & Yawing moments.
Prepare PPT or Poster presentation on different types of Vibrations with explanation.
Prepare booklet which covers all the formulae that requires to be recalled for calculation of vehicle and engine performance problems.
Make a model of basic mechanisms used in Automobile Systems using suitable material like thermocol /wood/plastic.
Prepare report on sources of vibrations and their isolation in a vehicle.
Draw on sheet various Road Performance Curves of Acceleration, Drawbar Pull, Gradeability

### 13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Fundamentals of Vehicle Dynamics	Thomas D. Gillespie	SAE International (2021) ISBN: 978-1468601770
2	Automobile Mechanics	Dr. N K Giri	Khanna Publishers, Delhi (2008); ISBN: 9788174092168
3	Theory of Machines	R S Khurmi, J K Gupta	S. Chand & Co. Ltd, New Delhi (2022); ISBN: 9789355010780
4	Theory of Machines	S S Rattan	McGraw Hill Education

			India Pvt. Ltd., Noida (2017) ISBN:978-9351343479
5	Theory Of Machines	V. P. Singh	Dhanpat Rai & Co. (P) Limited New Delhi (2017) ISBN:978-8177000665
6	Vehicle Dynamics	Martin Meywerk	Wiley Publishing company, New York, United States. (2015) ISBN: 9781118971352
7	Vehicle Dynamics	Basilio Lenzo	Springer, Cham (Publisher) Denmark. (2022) ISBN: 0254-1971

#### 14. SOFTWARE/LEARNING WEBSITES

- <https://www.howacarworks.com>
- <https://swayam.gov.in>
- <https://auto.howstuffworks.com>
- <https://nptel.ac.in/courses/112106270>
- <https://tinyurl.com/2ms7ydz4> for video link
- <https://tinyurl.com/3zrfjwn8> for web link

#### 15. PO-COMPETENCY-CO MAPPING

Semester IV	Automotive Mechanics (4340202)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning

<b>Use knowledge of automotive mechanics to improve vehicle performance.</b>	3	2	1	2	2		2
Interpret various terminologies used in Automotive Mechanics.	3						1
Appreciate the importance of true rolling condition for steering to minimize side forces, vehicle vibrations and vibration isolation.	3	2	1		2		2
Evaluate the vehicle performance based on given situation.	3	1	1	2			1
Evaluate various parameters affecting Engine performance	3	1	1	3	2		2

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

**16. COURSE CURRICULUM DEVELOPMENT COMMITTEE****GTU Resource Persons**

<b>S. No</b>	<b>Name and Designation</b>	<b>Institute</b>	<b>Contact No.</b>	<b>Email</b>
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