

Name of Institute: Indus Institute of Technology and Engineering

Name of Faculty: Prof. Krupal Shah

Course code: AU0702

Course name: Vehicle Dynamics

Pre-requisites: N.A.

Credit points: 4

Offered Semester: 7

Course Coordinator (weeks 01 - 12)

Full Name: Prof. Krupal Shah

Department with sitting location: Automobile Department (Auto Lab-2)

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Email: krupalshah.am@indusuni.ac.in

Consultation times: 03.50 PM – 04:15 PM (Tuesday and Friday)

09.00 AM – 10.00 AM (Working Saturdays)

Course Lecturer (weeks 01 - 12)

Full name: Prof. Krupal Shah

Department with sitting location: Automobile Department (Auto Lab-2)

Telephone: +919712745067

Email: krupalshah.am@indusuni.ac.in

Consultation times: 03.50 PM – 04:15 PM (Tuesday and Friday)

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Students will be contacted throughout the Session via Mail with important information relating to this Course.

Course Objectives

By participating in and understanding all facets of this Course a student will be able:

1. To understand the principle and performance of vehicle in various modes such as longitudinal, vertical and lateral directions.
2. To identify the various forces and loads and performance under acceleration, ride and braking.

Course Outcomes (CO)

The students should be able to:

1. Explain the dynamics of vehicle ride. [BT-2]
2. Analyze the behavior of the vehicles under acceleration and braking [BT-4]
3. Compare active and passive suspensions system for dynamic performance of the vehicle [BT-5]
4. Integrate and evaluate the loads and forces associated to the vehicles [BT-6]
5. Analyze the behavior of the vehicles with different steering angles and geometry. [BT-4]
6. Integrate and evaluate the loads and forces associated to the steering and tyres. [BT-6]

Course Outline

UNIT 1

[12 hours]

PERFORMANCE CHARACTERISTICS OF VEHICLE

SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system, Dynamic axle loads, Equations of motion, transmission characteristics, vehicle performance, power limited and traction limited acceleration, braking performance, Brake proportioning, braking efficiency.

AERODYNAMICS

Mechanics of Air Flow Around a Vehicle, Pressure Distribution on a Vehicle, Aerodynamic Forces, Drag Components, Aerodynamics Aids.

UNIT 2

[12 hours]

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

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

UNIT 3

[12 hours]

THE STEERING SYSTEM

The Steering Linkages, Steering System Forces and Moments, Steering System Models, Steering Geometry, Steady Handling (2 DOF steady-state model), Understeer and Oversteer, 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.

ROLLOVER

Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover

UNIT 4

[12 hours]

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.

Method of delivery

1. Chalk and talk
2. PowerPoint Presentations
3. Self-study material

Study time

3 hours per week Lectures and 2 Hours practical per week

CO-PO Mapping (PO: Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3	2	1	-	-	-	-	-	1	-	2
CO2	1	2	3	3	1	2	-	-	-	-	-	-
CO3	1	3	-	-	2	2	-	-	-	-	-	-
CO4	2	3	3	3	2	-	-	-	-	-	-	-
CO5	1	2	3	3	1	2	-	-	-	-	-	-
CO6	2	3	3	3	2	-	-	-	-	-	-	-

1-Lightly Mapped 2- Moderately Mapped 3- Highly Mapped

Blooms Taxonomy and Knowledge retention(For reference)

(Blooms taxonomy has been given for reference)

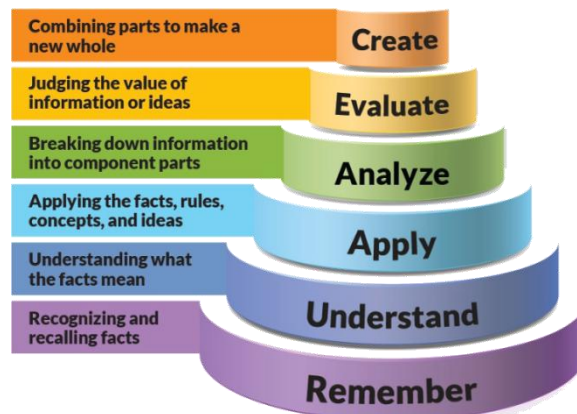


Figure 1: Blooms Taxonomy

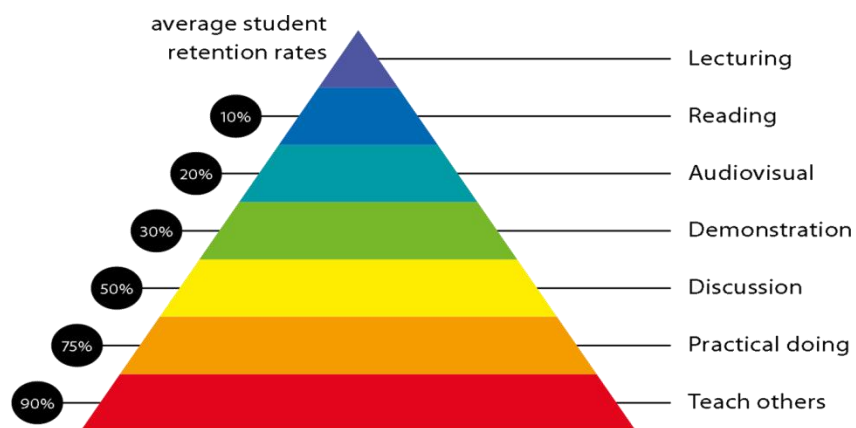


Figure 2: Knowledge retention

Graduate Qualities and Capabilities covered

General Graduate Qualities	Specific Department of Automobile Graduate Capabilities
Informed Have a sound knowledge of an area of study or profession and understand its current issues, locally and internationally. Know how to apply this knowledge. Understand how an area of study has developed and how it relates to other areas.	1 Professional knowledge, grounding & awareness
Independent learners Engage with new ideas and ways of thinking and critically analyze issues. Seek to extend knowledge through ongoing research, enquiry and reflection. Find and evaluate information, using a variety of sources and technologies. Acknowledge the work and ideas of others.	2 Information literacy, gathering & processing
Problem solvers Take on challenges and opportunities. Apply creative, logical and critical thinking skills to respond effectively. Make and implement decisions. Be flexible, thorough, innovative and aim for high standards.	4 Problem solving skills
Effective communicators Articulate ideas and convey them effectively using a range of media. Work collaboratively and engage with people in different settings. Recognize how culture can shape communication.	5 Written communication
	6 Oral communication
	7 Teamwork
Responsible Understand how decisions can affect others and make ethically informed choices. Appreciate and respect diversity. Act with integrity as part of local, national, global and professional communities.	10 Sustainability, societal & environmental impact

Lecture/tutorial times

Lecture/Practical	Timings	Room No.
Lecture		
Lecture		
Lecture		
Practical Batch-1		
Practical Batch-2		

Attendance Requirements

The University norms states that it is the responsibility of students to attend all lectures, tutorials, seminars and practical work as stipulated in the Course outline. Minimum attendance requirement as per university norms is compulsory for being eligible for mid and end semester examinations.

Details of referencing system to be used in written work

1. Text Books and Reference Books
2. Online Resources

Text books

1. Hans Pacejka, "Tire and Vehicle Dynamics" , Elsevier, 2012.
2. Thomas D Gillespie, "Fundamentals of Vehicle dynamics", SAE USA 1992.

Additional Materials

1. Rajesh Rajamani, "Vehicle Dynamics & control", Springer-2016
2. R.V. Dukkipati, "Vehicle dynamics", Narsova Publications-2010
3. Wong J Y, "Theory of Ground Vehicles", John Wiley & Sons, New York, 1978.
4. Milliken W F and Milliken D L, "Race car Vehicle Dynamics", SAE,2012
5. <http://nptel.ac.in/courses/107106080/> - Whole Syllabus

LIST OF EXPERIMENTS

No	Title	Learning Outcomes
1.	Experimental study of mechanism for air flow over different geometry of vehicles.	Develops Basic understanding 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.	Develops Understanding of methods of Experimental studies of measurements of drag and lift coefficients for different geometry vehicles
3.	To study Anti-lock Brake System (ABS) used in automobile vehicles.	Develops Understanding of Anti-lock Brake System (ABS) used in automobile vehicles
4.	To study Cruise Control and Adaptive Cruise Control (ACC) used in automobile vehicles.	Develops Understanding of Cruise Control and Adaptive Cruise Control (ACC) used in automobile vehicles
5.	To study advanced cornering and parking system used in automobile vehicles.	Develops Understanding of advanced cornering and parking system used in automobile vehicles.
6.	To study automatic wheel alignment and balancing system	Develops Basic understanding of mechanism for air flow over different geometry of vehicles

ASSESSMENT GUIDELINES

Your final course mark will be calculated from the following:

1. Theory CIE 60 marks:
 - a. Attendance: 05 Marks
 - b. Mid-Semester Exam: 40 Marks
 - c. Presentation: 05 Marks
 - d. Assignments: 10 Marks

2. Practical CIE 60 marks:
 - a. Attendance 10 Marks
 - b. Experiment Performance 20 Marks
 - c. File work + Skill Test 20 Marks
 - d. Presentation 10 Marks

SUPPLEMENTARY ASSESSMENT

Students who receive an overall mark less than 40% in mid semester or end semester will be considered for supplementary assessment in the respective components (i.e mid semester or end semester) of semester concerned. Students must make themselves available during the supplementary examination period to take up the respective components (mid semester or end semester) and need to obtain the required minimum 40% marks to clear the concerned components.

Late Work

Late assignments will not be accepted without supporting documentation. Late submission of the reports will result in a deduction of 10% of the maximum mark per calendar day

Format

All assignments must be presented in a neat, legible format with all information sources correctly referenced. **Assignment material handed in throughout the session that is not neat and legible will not be marked and will be returned to the student.**

Retention of Written Work

Written assessment work will be retained by the Course coordinator/lecturer for two weeks after marking to be collected by the students.

University and Faculty Policies

Students should make themselves aware of the University and/or Faculty Policies regarding plagiarism, special consideration, supplementary examinations and other educational issues and student matters.

Plagiarism - Plagiarism is not acceptable and may result in the imposition of severe penalties. Plagiarism is the use of another person's work, or idea, as if it is his or her own - if you have any doubts at all on what constitutes plagiarism, please consult your Course coordinator or lecturer. Plagiarism will be penalized severely.

Do not copy the work of other students.

Do not share your work with other students (except where required for a group activity or assessment)

Course schedule (subject to change)

Week #	Topic & contents	CO Addressed	Teaching Learning Activity (TLA)
Weeks 1	SAE Vehicle axis system, Forces & moments affecting vehicle, Earth Fixed coordinate system	CO1,CO2	1. Chalk and talk 2. PowerPoint Presentations
Weeks 2	Mechanics of Air Flow Around a Vehicle, Pressure Distribution on a Vehicle, Aerodynamic Forces, Drag Components, Aerodynamics Aids.	CO4	1. Chalk and talk 2. Powerpoint presentation
Week 3	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	CO6	1. Chalk and talk 2. PowerPoint Presentations
Week 4	Slip, Skid, Rolling Resistance, Elastic Band Model for longitudinal slip, Simple model for lateral slip,	CO3, CO4	1. Chalk and talk 2. PowerPoint Presentations
Week 5	Independent Suspensions, Anti-Squat and Anti-Pitch Suspension Geometry, Quiz	CO5	1. Chalk and talk
Week 6	Anti-Dive Suspension Geometry, Roll Center Analysis, Suspension Dynamics, Multi-body vibration, Body and Wheel hop modes, Invariant points	CO5	1. Chalk and talk
Week 7	The Steering Linkages, Steering System Forces and Moments, Steering System Models, Steering Geometry, Steady Handling (2 DOF steady-state model), Understeer and Oversteer	CO5	1. Chalk and talk
Week 8	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.	CO4	1. Chalk and talk 2. PowerPoint Presentations
Week 9	Quasi-Static Rollover of a Rigid Vehicle, Quasi-Static Rollover of a Suspended Vehicle, Transient Rollover	CO3	1. Chalk and talk 2. PowerPoint Presentations

Week 10	Kinematic structure of motorcycle, geometry of motorcycles, importance of trail, Resistance forces acting on motorcycle, Quiz	CO3	1. Chalk and talk 2. PowerPoint Presentations
Week 11	Location & height of motor cycle's centre of gravity (C.G), Moments of inertia on Motorcycle	CO6	1. Chalk and talk 2. PowerPoint Presentations
Week 12	Introduction to Front & Rear suspensions of Motorcycle	CO6	1. Chalk and talk 2. PowerPoint Presentations
Week 13	Suspension Kinematics, Suspension types, Solid Axles,	CO5, CO6	1. Chalk and Talk 2. PowerPoint presentations
Week 14	Combined longitudinal/lateral slip (friction ellipse), Taut string model for lateral slip, Magic Tire Formula	CO6	1. Chalk and Talk 2. PowerPoint presentations
Week 15	Revision, Quiz		