

Module Information	
Module Title	Vehicle Dynamics, Handling and Simulation
Module Code	AME 508

1. MODULE SUMMARY

Aims and Summary

It is intended to prepare students for road vehicle dynamics modelling and simulation. In this module, to begin with students will be introduced to vehicle dynamics terminology, they will be taught underlying theoretical concepts, mathematical modelling and simulation of motor vehicle performance, ride and handling. In addition, suspension system design, steering mechanisms, modelling of road loads and tyres will be taught. Students will be trained on the use of ADAMS (Automatic Dynamic Analysis of Mechanical Systems), MATLAB/ Simulink software tools for vehicle dynamic simulation.

Module Size and Credits

Module size	Single
CATS points	12
ECTS credits	N/A
Open / restricted	Restricted
Availability on/off campus	On Campus/Off campus
Total student study hours	120
Number of weeks	4 weeks Full-time or 8 weeks Part-time.
Centre responsible	Centre for Automotive Engineering / Department of Mechanical and Automotive Engineering
Academic Year	2009

Entry Requirements (pre-requisites and co-requisites)

Normally to be qualified for entry to the Postgraduate Engineering Programme

Excluded Combinations

None

Composition of Module Mark (including weighting of components)

Full-time / Part-time : 50% Written Examination and 50 % Assignment

Pass Requirements

A minimum of 40 % marks in the written examination and a minimum of 40% marks in the assignment and overall 40% marks are required for a pass

Special Features

80% attendance in theory and 80% attendance in laboratory are required.
It is likely that considerable time will be spent in School facilities outside of normal timetabled class time.

Courses for which this module is mandatory

M.Sc. [Engg] in Automotive Engineering

M.Sc. [Engg] in Automotive Electronics

Courses for which this module is a core option

none

2. TEACHING, LEARNING AND ASSESSMENT

Intended Module Learning Outcomes

After undergoing this module, students will be able to:

1. Explain and analyze tire forces influencing vehicle acceleration and braking
2. Model and simulate suspension characteristics
3. Explain and analyse the models used in vehicle handling simulation
4. Operate an industry standard dynamic analysis program (ADAMS) and perform suspension analysis, tyre modelling and vehicle handling / braking simulations

Indicative Content

Class Room Lectures

1. Vehicle Dynamics Terminology
Vehicle Dynamics System and Simulation, Axis/coordinate System, Wheel Base, Wheel Track or tread width, Sprung/Unsprung weight, Curb weight, Center of gravity height, weight distribution, Projected Steering Axis, Caster/Caster trail, Camber, Steering Axis Inclination, Scrub Radius, Toe, Ackermann Steer, Under steer, Neutral steer, Over steer, Neutral steer point, Static margin, Characteristic speed, Critical speed, Instant centers, Roll centers/Roll Axis, Anti-Squat/Anti-Dive, Road Loads/Tractive forces, Spring centers, Bounce centers/nodes, Pitch centers/node, Ride Frequencies, Wheel/Tire/Unsprung Frequencies, Roll Frequencies, Damping/Damping Coefficients
2. Tire Fundamentals and Dynamic Characteristics
Traction Limits, Friction Circle, Slip Angle, Cornering Stiffness, Carpet Plot, Self-Aligning Torque, Camber Thrust, g-g diagram
3. Acceleration Performance
Engine power limited Acceleration: Effect of Transmission, Engine power, Power Train component inertia on acceleration, Traction Limited Acceleration
Effect of weight transfer on traction limits for rear wheel and front wheel drive vehicles which in turn affect the acceleration performance, Driving Cycle and Fuel Consumption
4. Braking Performance
General Equation for Braking, Braking Forces, Brakes & Brake System, Brake Factor, Tire Load Friction, Braking Coefficient and Slip, Federal requirements for Braking Performance, Brake proportioning, Anti lock Brake Systems, Braking Efficiency
5. Ride
Meaning of Ride, Subjective and Objective Engineering, Road Surface Irregularities, Power Spectral Density, Spectral Densities of Road Elevation Profiles, Tire and wheel Excitations, Drive Line Excitation, Engine Excitations, Vehicle Response to Excitations, Active Vibration Control, Wheel hop resonance, Suspension Non-Linearities, Bounce and Pitch Motions, Human perception and tolerance of vibrations.
6. Vehicle Handling (Steady and Transient)
Low Speed Turning, High Speed Cornering, Suspension Effects on Cornering, Roll Moment Distribution, Camber Change, Roll Steer, Lateral Force Compliance Steer, Aligning Torque, Effect of Tractive Forces on Cornering, transient handling, road testing
7. Suspensions
Automotive Suspension, Functions of Automotive Suspension System, Suspension Model, Conventional Suspension System, Semi-active Suspension Systems and Control, Active Suspension System and Control
8. Steering System
Steering Principles and Layouts, Steering Systems, Wheel alignment Angles
9. Roll Over
Quasi-static Rollover Of A Rigid Vehicle, Quasi-static Rollover Of A Suspended Vehicle, Transient Roll Over, Roll Over Demonstrations
10. Tyre testing and tyre modelling techniques

Laboratory Practice

1. Introduction to ADAMS/View, ADAMS/CAR
2. Kinematic and Dynamic Simulation of Simple Mechanisms Using ADAMS
3. Geometric Modelling, Template Creation in ADAMS
4. Road Modelling
5. Building Car Models
6. Acceleration, Braking, Suspension and Handling Simulation
7. Tyre Modelling

8. Lumped Modelling of Vehicles
9. Solving Lumped Model equations using MATLAB/Simulink
10. Driving manoeuvres using driving simulator
11. Visiting proving grounds to observe
 - a. Instrumentation for road testing of vehicles
 - b. Data Collection and Interpretation

Teaching and Learning Methods

1. Theoretical Knowledge [~30% of module time]
 - a. Face to face lectures from a module leader- 30 hours
 - b. Case study teaching and discussion from a practicing engineer- 6 hours

36 hours
2. Laboratory Practice (Skills) [~ 25% of module time]
 - a. Learning vehicle dynamic problem solving through the use of commercial software tools – ADAMS/ MATLAB/SIMULINK
 - b. Visiting Proving Ground

30 hours
3. Application Orientation and Problem Solving [45% of module time]
 - a. Reading
 - b. Research
 - c. Written Examination
 - d. Assignment Solving and Documentation

54 hours

Method of Assessment

Part-A

Written Examination [50% Weightage]

At the end of the module, normally on the last day of the last week of the module, written examination is conducted to test students' understanding of taught theoretical concepts. The question paper will comprise either or a combination of the following:

- 6 questions, out of which 5 questions need to be answered
- Practical laboratory work
- Presentations
- Field work
- Creation of a physical model

The marks scored by the student will be scale down to 50% weight.

Part –B

Assignment [50% Weightage]

Students are required to submit word processed assignment report on formally announced last day of the module. Assignment tests students' problem solving skills based on taught concepts. The assignment is assessed for 100 marks but scored marks is scaled down to 50%

Assessment				
Learning Outcomes	1	2	3	4
Part A	X	X	X	
Part B	X	X	X	X

Both written examination scripts and assignment reports will be double marked/valued

Re-assessment

A minimum of 40 % marks in the written examination and a minimum of 40% marks in the assignment are required for a pass in the module.

A student failing in any one of the components or both is considered as FAIL in the module. A failed student is required to retake the module at the next opportunity. A maximum of 3 attempts including the original are allowed.

Date of Last Amendment

May -2009

3. MODULE RESOURCES

Essential Reading

1. Module Notes

Recommended Reading

Books

1. Gillespie TD, *Fundamentals of vehicle dynamics*, Society of Automotive Engineers (SAE), 1992
2. W. Milliken & D. Milliken, *Race Car Vehicle Dynamics*, Society of Automotive Engineers (SAE), 1995
3. W. Milliken & D. Milliken, *Chassis Design – Principles and Analysis*, Society of Automotive Engineers (SAE) , 2002
4. J.Y. Wong. *Theory of Ground Vehicles*, John Wiley & Sons. 3rd edition, 2001
5. Ellis JR, *Vehicle Dynamics*, Mechanical Engineering Publications, 1969
6. Rahnejat H, *Multi-body Dynamics-Machines*, Vehicle and Mechanisms, Mechanical Engineering Publications, 1998
7. Blundell and Harty, *The Multibody Systems Approach to Vehicle Dynamics*, Elsevier Science, 2004
8. G. Genta., *Motor Vehicle Dynamics. Modeling and Simulation*, World Scientific. 1997

Journals

International Journal of Vehicle Mechanics and Mobility

International **J**ournal of **V**ehicle Systems Modelling and Testing

Magazines

Automotive Engineering International, Autocar INDIA, Overdrive

Internet Sites

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Laboratory

Hardware: PCs

Software: MSC.ADAMS, MATLAB/SIMULINK

Software Manual: MSC.ADAMS

4. MODULE ORGANISATION

Module Leader

Name	Dr. S.R. Shankapal
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Date and Time of Examination

As per time table

Subject Quality and Approval Information

Subject Quality Group / Subject Board	Mechanical and Automotive Engineering
Subject Assessment Board	Postgraduate Engineering Programmes
Shortened title	VDHS
Date of approval by MARP	May 2009