HINDUSTAN UNIVERSITY

HINDUSTAN INSTITUTE OF TECHNOLOGY & SCIENCE

(Estd. u/s 3 of the UGC Act, 1956)

Padur, Kancheepuram District - 603 103.

DEPARTMENT OF AUTOMOBILE ENGINEERING

Regulations Curriculum and Syllabus 2013

M.Tech. AUTOMOBILE ENGINEERING

ACADEMIC REGULATIONS
(M.TECH./ M.B.A. / M.C.A.) (Full - Time / Part - Time)
(Effective 2013-14)

1. Vision, Mission and Objectives

1.1 The Vision of the Institute is "To make every man a success and no man a failure".

In order to progress towards the vision, the Institute has identified itself with a mission to provide every individual with a conducive environment suitable to achieve his / her career goals, with a strong emphasis on personality development, and to offer quality education in all spheres of engineering, technology, applied sciences and management, without compromising on the quality and code of ethics.

1.2 Further, the institute always strives

- To train our students with the latest and the best in the rapidly changing fields of Engineering, Technology, Management, Science & Humanities.
- To develop the students with a global outlook possessing, state of the art skills, capable of taking up challenging responsibilities in the respective fields.
- To mould our students as citizens with moral, ethical and social values so as to fulfill their obligations to the nation and the society.
- To promote research in the field of science, Humanities, Engineering, Technology and allied branches.

1.3 Our aims and objectives are focused on

- Providing world class education in engineering, technology, applied science and management.
- Keeping pace with the ever changing technological scenario to help our students to gain proper direction to emerge as competent professionals fully aware of their commitment to the society and nation.
- To inculcate a flair for research, development and entrepreneurship.

2. Admission

2.1 The admission policy and procedure shall be decided from time to time by the Board of Management (BOM) of the Institute, following guidelines issued by Ministry of Human Resource Development (MHRD), Government of India. The number of seats in each branch of the (M.TECH / M.B.A. / M.C.A.) programme will be decided by BOM as per the directives from Ministry of Human Resource Development (MHRD), Government of India and taking into account the market demands. Some seats for Non Resident Indians and a few seats for foreign nationals shall be made available.

2.2 The selected candidates will be admitted to the (M.TECH / M.B.A. / M.C.A.) programme after he/she fulfills all the admission requirements set by the Institute and after payment of the prescribed fees.

2.3 Candidates for admission to the first semester of the Master's Degree Programme shall be required to have passed an appropriate Degree Examination recognized by Hindustan University.

2.4 In all matters relating to admission to the (M.TECH / M.B.A. / M.C.A.). Programme, the decision of the Institute and its interpretation given by the Chancellor of the Institute shall be final.

2.5 If at any time after admission, it is found that a candidate has not fulfilled any of the requirements stipulated by the Institute, the Institute may revoke the admission of the candidate with information to the Academic Council.

3. Structure of the programme

3.1 The programme of instruction will have the following structure

i) Core courses of Engineering / Technology / Management.

ii) Elective courses for specialization in areas of student's choice

3.2 The minimum durations of the programmes are as given below:

Program	No. of Semesters
M.Tech.(Full-Time)	4
M.Tech.(Part -Time)	6
M.B.A. (Full - Time)	4
M.B.A. (Part - Time)	6
M.C.A.(Full - Time)	6
M.C.A.(Part -Time)	8

Every (M.TECH / M.B.A. / M.C.A.) programme will have a curriculum and syllabi for the courses approved by the Academic Council.

3.3 Each course is normally assigned certain number of credits. The following norms will generally be followed in assigning credits for courses.

- One credit for each lecture hour per week per semester
- One credit for each tutorial hour per week per semester
- One credit for each laboratory practical of three hours per week per semester.
- One credit for 4 weeks of industrial training and
- One credit for 2 hours of project per week per semester.

3.4 For the award of degree, a student has to earn certain minimum total number of credits specified in the curriculum of the relevant branch of study. The curriculum of the different programs shall be so designed that the minimum prescribed credits required for the award of the degree shall be within the limits specified below.

Program	Minimum prescribed credit range
M.Tech. (Full time / Part time)	75 - 85
M.B.A. (Full time / Part time)	85 - 95
M.C.A (Full time / Part time)	115 - 125

3.5 The medium of instruction, examination and the language of the project reports will be English.

4. Faculty Advisor

4.1 To help the students in planning their courses of study and for getting general advice on the academic programme, the concerned Department will assign a certain number of students to a Faculty member who will be called their Faculty Advisor.

5. Class Committee

5.1 A Class Committee consisting of the following will be constituted by the Head of the Department for each class:

(i) A Chairman, who is not teaching the class.

(ii) All subject teachers of the class.

(iii) Two students nominated by the department in consultation with the class.

The Class Committee will meet as often as necessary, but not less than three times during a semester.

The functions of the Class Committee will include:

(i) Addressing problems experienced by students in the classroom and the laboratories.

(ii) Analyzing the performance of the students of the class after each test and finding ways and means of addressing problems, if any.

(iii) During the meetings, the student members shall express the opinions and suggestions of the class students to improve the teaching / learning process.

6. Grading

6.1 A grading system as below will be adhered to.

Range of Marks	Letter Grade	Grade points
95-100	S	10
85 - 94	A	09
75- 84	B	08
65-74	C	07
55-64	D	06
50-54	E	05
< 50	U	00
	I (Incomplete)	–

6.2 GPA & CGPA

GPA is the ratio of the sum of the product of the number of credits C_i of course "i " and the grade points P_i earned for that course taken over all courses "i" registered by the student to the sum of Ci for all "i ". That is,

$$GPA = \frac{\sum_i C_i P_i}{\sum_i C_i}$$

CGPA will be calculated in a similar manner, at any semester, considering all the courses enrolled from first semester onwards.

6.3 For the students with letter grade I in certain subjects, the same will not be included in the computation of GPA and CGPA until after those grades are converted to the regular grades.

6.4 Raw marks will be moderated by a moderation board appointed by the Vice-Chancellor of the University. The final marks will be graded using an absolute grading system. The Constitution and composition of the moderation board will be dealt with separately.

7. Registration and Enrollment

7.1 Except for the first semester, registration and enrollment will be done in the beginning of the semester as per the schedule announced by the University.

7.2 A student will be eligible for enrollment only if he/she satisfies regulation 10 (maximum duration of the programme) and will be permitted to enroll if (i) he/she has cleared all dues in the Institute, Hostel & Library up to the end of the

previous semester and (ii) he/she is not debarred from enrollment by a disciplinary action of the University.

7.3 Students are required to submit registration form duly filled in.

8. Registration requirement

8.1 **(i)** A Full time student shall not register for less than 16 credits or more than 26 credits in any given semester.

8.1 **(ii)** A part time student shall not register for less than 10 credits or more than 20 credits in any given semester.

8.2 If a student finds his/her load heavy in any semester, or for any other valid reason, he/she may withdraw from the courses within three weeks of the commencement of the semester with the written approval of his/her Faculty Advisor and HOD. However the student should ensure that the total number of credits registered for in any semester should enable him/her to earn the minimum number of credits per semester for the completed semesters.

9. Minimum requirement to continue the programme

9.1 For those students who have not earned the minimum required credit prescribed for that particular semester examination, a warning letter to the concerned student and also to his parents regarding the shortage of his credit will be sent by the HOD after the announcement of the results of the university examinations.

10. Maximum duration of the programme

The minimum and maximum period for the completion of various programs are given below.

Program	Min. No. of Semesters	Max. No. of Semesters
M.Tech (Full - time)	4	8
M.Tech (Part - time)	6	10
M.B.A. (Full Time)	4	8
M.B.A. (Part Time)	6	10
M.C.A. (Full - Time)	6	12
M.C.A (Part -Time)	8	14

11. Temporary discontinuation

11.1 A student may be permitted by the Director(academic) to discontinue temporarily from the programme for a semester or a longer period for reasons of ill health or other valid reasons. Normally a student will be permitted to discontinue from the programme only for a maximum duration of two semesters.

12. Discipline

12.1 Every student is required to observe discipline and decorum both inside and outside the campus and not to indulge in any activity which will tend to bring down the prestige of the University.

12.2 Any act of indiscipline of a student reported to the Director (Academic) will be referred to a Discipline Committee so constituted. The Committee will enquire into the charges and decide on suitable punishment if the charges are substantiated. The committee will also authorize the Director(Academic) to recommend to the Vice-Chancellor the implementation of the decision. The student concerned may appeal to the Vice-Chancellor whose decision will be final. The Director (Academic) will report the action taken at the next meeting of the Council.

12.3 Ragging and harassment of women are strictly prohibited in the University campus and hostels.

13. Attendance

13.1 A student whose attendance is less than 75% is not eligible to appear for the end semester examination for that semester. The details of all students who have attendance less than 75% will be announced by the teacher in the class. These details will be sent to the concerned HODs and Director (Academic).

13.2 Those who have less than 75% attendance will be considered for condonation of shortage of attendance. However a condonation of 10% in attendance will be given on medical reasons. Application for condonation recommended by the Faculty Advisor, concerned faculty member and the HOD is to be submitted to the Director (Academic) who, depending on the merits of the case, may permit the student to appear for the end semester examination. A student will be eligible for this concession at most in two semesters during the entire degree programme. Application for medical leave, supported by medical certificate with endorsement by a Registered Medical Officer, should reach the HOD within seven days after returning from leave or, on or before the last instructional day of the semester, whichever is earlier.

13.3 As an incentive to those students who are involved in extra curricular activities such as representing the University in Sports and Games, Cultural Festivals, and Technical Festivals, NCC/ NSS events, a relaxation of up to 10% attendance will be given subject to the condition that these students take prior approval from the officer-in-charge. All such applications should be recommended by the concerned HOD and forwarded to Director (Academic) within seven instructional days after the programme/activity.

14. Assessment Procedure

14.1 The Academic Council will decide from time to time the system of tests and examinations in each subject in each semester.

14.2 For each theory course, the assessment will be done on a continuous basis as follows:

Test / Exam	Weightage	Duration of Test Exam
First Periodical Test*	10%	2 Periods
Second Periodical Test*	10%	2 Periods
Model exam	20%	3 hours
Seminar/ Assignments/Quiz	20%	
End - semester examination	50%	3 Hours

*** Best out of the two tests will be considered.**

14.3 For practical courses, the assessment will be done by the subject teachers as below:

(i) Weekly assignment/Observation note book / lab records - weightage 60%.

(ii) End semester examination of 3 hours duration including viva - weightage 40%

15. Make up Examination/model examination

15.1 Students who miss the end-semester examinations / model examination for valid reasons are eligible for make-up examination /model examination. Those

who miss the end-semester examination / model examination should apply to the Head of the Department concerned within five days after he / she missed examination, giving reasons for absence.

15.2 Permission to appear for make-up examination / model exam will be given under exceptional circumstances such as admission to a hospital due to illness. Students should produce a medical certificate issued by a Registered Medical Practitioner certifying that he/she was admitted to hospital during the period of examination / model exam and the same should be duly endorsed by parent / guardian and also by a medical officer of the University within 5 days.

16. Project evaluation

16.1 For Project work, the assessment will be done on a continuous basis as follows:

Review / Examination	Weightage
First Review	10%
Second Review	20%
Third Review	20%
End semester Examination	50%

For end semester exam, the student will submit a Project Report in a format specified by the Director (Academic). The first three reviews will be conducted by a Committee constituted by the Head of the Department. The end - semester examination will be conducted by a Committee constituted by the Controller of Examinations. This will include an external expert.

17. Declaration of results

17.1 A candidate who secures not less than 50% of total marks prescribed for a course with a minimum of 50% of the marks prescribed for the end semester examination shall be declared to have passed the course and earned the specified credits for the course.

17.2 After the valuation of the answer scripts, the tabulated results are to be scrutinized by the Result Passing Boards of PG programmes constituted by the Vice-Chancellor. The recommendations of the Result Passing Boards will be placed before the Standing Sub Committee of the Academic Council constituted by the Chancellor for scrutiny. The minutes of the Standing Sub Committee along with the results are to be placed before the Vice-Chancellor for approval. After getting the approval of the Vice-Chancellor, the results will be published by the Controller of Examination/ Registrar.

17.3 If a candidate fails to secure a pass in a course due to not satisfying the minimum requirement in the end semester examination, he/she shall register and re-appear for the end semester examination during the following semester. However, the sessional marks secured by the candidate will be retained for all such attempts.

17.4 If a candidate fails to secure a pass in a course due to insufficient sessional marks though meeting the minimum requirements of the end semester examination, wishes to improve on his/ her sessional marks, he/she will have to register for the particular course and

attend the course with permission of the HOD concerned and the Registrar. The sessional and external marks obtained by the candidate in this case will replace the earlier result.

17.5 A candidate can apply for the revaluation of his/her end semester examination answer paper in a theory course within 2 weeks from the declaration of the results, on payment of a prescribed fee through proper application to the Registrar/Controller of Examinations through the Head of the Department. The Registrar/ Controller of Examination will arrange for the revaluation and the results will be intimated to the candidate concerned through the Head of the Department. Revaluation is not permitted for practical courses and for project work.

17.6 The weightage for internal marks in finalizing results and grades shall be waived off after completion of 5 semesters.

18. Grade Card

18.1 After results are declared, grade sheet will be issued to each student, which will contain the following details:

(i) Program and branch for which the student has enrolled.

(ii) Semester of registration.

(iii) List of courses registered during the semester and the grade scored.

(iv) Semester Grade Point Average (GPA)

(v) Cumulative Grade Point Average (CGPA).

19. Class / Division

19.1 Classification is based on CGPA and is as follows:

CGPA $\geq$ 8.0 : **First Class with distinction**

6.5 $\leq$ CGPA < 8.0 : **First Class**

5.0 $\leq$ CGPA < 6.5 : **Second Class.**

19.2 (i) Further, the award of 'First class with distinction' is subject to the candidate becoming eligible for the award of the degree having passed the examination in all the courses in his/her first appearance within the minimum duration of the programme.

(ii) The award of 'First Class' is further subject to the candidate becoming eligible to the award of the degree having passed the examination in all the courses within the below mentioned duration of the programme.

Program	No. of Semesters
M.Tech.(Full-Time)	5
M.Tech.(Part -Time)	7
M.B.A. (Full - Time)	5
M.B.A. (Part - Time)	7
M.C.A.(Full - Time)	7
M.C.A.(Part -Time)	9

(iii) The period of authorized discontinuation of the programme (vide clause 11.1) will not be counted for the purpose of the above classification.

20. Transfer of credits

20.1 Within the broad framework of these regulations, the Academic Council, based on the recommendation of the transfer of credits committee so constituted by the Chancellor may permit students to earn part of the credit requirement in other approved institutions of repute and status in the country or abroad.

21. Eligibility for the award of (M.TECH / M.B.A. / M.C.A.) Degree

21.1 A student will be declared to be eligible for the award of the (M.TECH / M.B.A. / M.C.A.). Degree if he/she has

i) registered and successfully credited all the core courses,

ii) successfully acquired the credits in the different categories as specified in the curriculum corresponding to the discipline (branch) of his/her study within the stipulated time,

iii) has no dues to all sections of the Institute including Hostels, and

iv) has no disciplinary action pending against him/her.

The award of the degree must be recommended by the Academic Council and approved by the Board of Management of the University.

22. Power to modify

22.1 Notwithstanding all that has been stated above, the Academic Council has the right to modify any of the above regulations from time to time subject to approval by the Board of Management.

HINDUSTAN UNIVERSITY

HINDUSTAN INSTITUTE OF TECHNOLOGY AND SCIENCE

DEPARTMENT OF AUTOMOBILE ENGINEERING

CURRICULUM & SYLLABUS

SEMESTER I

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
Theory							
1	PMA101	Advanced Engineering Mathematics *	3	1	0	4	4
2	PAU101	Automotive Engines and Emission control	4	0	0	4	4
3	PAU102	Automotive Chassis	4	0	0	4	4
4	PAU103	Automotive Transmission	4	0	0	4	4
5	PAU104	Automotive Electrical and Electronics	4	0	0	4	4
6	PAU105	Vehicle Body Engineering	4	0	0	4	4
PRACTICAL							
7	PAU151	Automotive System Components Laboratory	0	0	3	2	3
TOTAL						**26**	**27**

*Common to Aero, CAD, ICE, R&AC, Thermal and M.Tech. Auto

SEMESTER II

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
THEORY							
1	PIC202	Electronic Engine Management System **	4	0	0	4	4
2	PAU201	Automotive System Components Design	4	0	0	4	4
3	PAU202	Vehicle Dynamics and Control	4	0	0	4	4
4	PAU203	Vibration and Noise Control	4	0	0	4	4
5		Elective - I	3	0	0	3	3
6		Elective - II	3	0	0	3	3
PRACTICAL							
7	PAU251	Vehicle Dynamics Laboratory	0	0	3	2	3
TOTAL						**24**	**25**

SEMESTER III

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
THEORY							
1		Elective - III	3	0	0	3	3
2		Elective - IV	3	0	0	3	3
3		Elective - V	3	0	0	3	3
PRACTICAL							
4	PAU351	Modeling and Simulation Laboratory	0	0	3	2	3
5	PAU352	Industrial Training	0	0	4	2	4
6	PAU353	Project Work Phase - I	0	0	12	6	12
TOTAL						**19**	**28**

SEMESTER IV

Sl. No.	Course Code	Course Title	L	T	P	C	TCH
1	PAU451	Project Phase - II	0	0	24	12	24
TOTAL						**12**	**24**

** Common to M.Tech. ICE and M.Tech. Automobile Engineering

Total No. of Credits: 81

ELECTIVE COURSES

SL. NO	COURSE CODE	COURSE TITLE	L	T	P	C	TCH
1	PAU701	Automotive safety	3	0	0	3	3
2	PAU702	Two and Three wheeler Technology	3	0	0	3	3
3	PAU703	Special types of Vehicles	3	0	0	3	3
4	PAU704	Manufacturing and Testing of Vehicle Components	3	0	0	3	3
5	PAU705	Composite Materials and Structures	3	0	0	3	3
6	PAU706	Computational Fluid Dynamics	3	0	0	3	3
7	PAU707	Finite Element Methods in Automobiles	3	0	0	3	3
8	PAU708	Automotive Instrumentation and Embedded System	3	0	0	3	3
9	PAU709	Modern Vehicle Technology	3	0	0	3	3
10	PIC707	Simulation of IC engines**	3	0	0	3	3
11	PAU710	Advanced theory of IC engines	3	0	0	3	3
12	PAU711	Automotive Aerodynamics	3	0	0	3	3
13	PAU712	Vehicle Maintenance	3	0	0	3	3
14	PAU713	Modern Automobile Accessories	3	0	0	3	3
15	PAU714	Alternate Fuels and Energy System	3	0	0	3	3
16	PAU715	Fuel Cell and Applications	3	0	0	3	3
17	PAU716	Rubber Technology for Automobiles	3	0	0	3	3
18	PAU717	Automotive Air conditioning	3	0	0	3	3
19	PAU718	Automotive Sensors and Application	3	0	0	3	3
20	PAU719	Robotics	3	0	0	3	3

**Common to M.Tech ICE and M.Tech Automobile

HINDUSTAN UNIVERSITY
HINDUSTAN INSTITUTE OF TECHNOLOGY AND SCIENCE

M.Tech. AUTOMOBILE ENGINEERING

SEMESTER I

PMA101 ADVANCED ENGINEERING MATHEMATICS

L	T	P	C
3	1	0	4

OBJECTIVES

The subject should enable the students to:

1. Present the mathematical methods of differential and integral calculus and to provide and introduction to differential equations and to vectors
2. Enable you to build a working toolbox of mathematical techniques for differentiating and integrating functions, for solving differential equations and for working with vector quantities.
3. Emphasise the meaning and purpose of these techniques and their use in solving Engineering and Physics problems.

OUTCOME

The students should be able to:

1. The mathematical methods of differential and integral calculus and of some simple solution methods for various types of differential equation.
2. Select and apply appropriate mathematical methods to solve abstract and real-world problems.
3. Show confidence in manipulating mathematical expressions, setting up and solving equations and constructing simple proofs and apply problem solving techniques to familiar and unfamiliar problems

UNIT I CALCULUS OF VARIATIONS **12**

Concept of variation and its properties- Euler's Equation-Functional dependant on first and higher order derivatives - Functional dependant on functions of several independent variables- Isoperimetric problems - Direct methods-Ritz and Kantrovich methods

UNIT II TRANSFORM METHODS **12**

Laplace transform methods for one dimensional wave equation - Displacements in a long string - Longitudinal vibration of an elastic bar - Fourier Transform methods for one dimensional heat conduction problems in infinite and semi-infinite rod

UNIT III ELLIPTIC EQUATIONS **12**

Laplace equation - Properties of Harmonic functions - Solutions of Laplace equation by means of Fourier transform in a half plane in an infinite strip and in a semi-infinite strip

UNIT IV NUMERICAL SOLUTION OF PARTIAL DIFFERENTIAL EQUATIONS 12

Solution of Laplace and Poisson equation on a rectangular region by Lieebmann's method - Diffusion equation by the explicit and Crank Nicolson - Implicit methods - Solution of wave equations by explicit scheme Cubic spline interpolation

UNIT V CONFORMAL MAPPING AND APPLICATIONS 12

The Schwarz - Christoffel transformation - Transformation of boundaries in parametric form - Physical applications - Application to fluid and heat flow

Total: 60

REFERENCES

1. Gupta, A.S. - Calculus of Variations with Applications, Prentice Hall of India(P) Ltd., N e w Delhi, 6th print, 2006
2. Sankar Rao, .K. - Introduction to Partial Differential Equations, Prentice Hall of India(P) Ltd., New Delhi, 5th print, 2004
3. Jain.R.K, Iyengar.S.R.K. - Advanced Engineering Mathematics, Narosa publications 2nd Edition, 2006
4. Grewal, B.S - Numerical Methods in Science and Engineering, Kanna Publications, New Delhi.
5. Kandasamy.P , Thilagavathy. K and Gunavathy, K - Numerical Methods, S Chand and Co., Ltd., New Delhi, 5th Edition, 2007
6. Spiegel , M. R - Theory and problems of Complex Variables with an Introduction to Conformal Mapping and Its applications, Schaum's outline series, Mc Graw Hill Book Co., 1987.

PAU101 AUTOMOTIVE ENGINES AND EMISSION CONTROL

L	T	P	C
4	0	0	4

GOAL

To impart knowledge in development of engine technologies

OBJECTIVES

The course enables the students to:

1. Penetrate deep into engine classification, construction and operation of IC engines with latest technologies
2. Grasp the importance SI and CI engine application in automobiles
3. Understand the performance parameters and testing methodologies.
4. Understand effect of vehicle population and emitted pollutants on human health and environment and various types of emissions.

5. Understand the formation mechanism of various types of pollutants from SI and CI engines.
6. Conceive the significance of emission control methods.
7. Understand the construction and working of emission measuring instruments.
8. Be familiar with emission standards and test procedures.

OUTCOME

The students should be able to:

1. Discern SI and CI engine systems application in automobiles and grasp the basic engine terminologies
2. Understand the necessity of Ignition system SI engines
3. Differentiate the fuel dynamics for SI and CI engines
4. Define the key terms such as carburetion, stoichiometric ratio, Lean burn, stratified, HCCI etc.,
5. Understand the combustion process for both SI and CI engines on liquid and gaseous fuels.
6. Design combustion chambers for diesel engines with reference to variable compression ratios
7. Analyze the air dynamics within the combustion chamber
8. Determine the performance characteristics for both SI and CI engines theoretically.

UNIT I CONSTRUCTION AND OPERATION 12

Constructional details of spark ignition (SI) and compression ignition (CI) engines. Working principles. Two stroke SI and CI engines. Comparison of SI and CI engines and four stroke and two stroke engines. Engine classification, firing order. Otto, diesel and dual cycles, Miller cycle. Introduction to Lean burn engine technologies, charge stratification.

UNIT II SI ENGINES 12

Air fuel ratio requirements - Carburetion - Throttle body injection, Sequential injection.. Function of Components Spark plug, Ignition System - battery coil, magneto coil, Electronic. Combustion in SI Engines - Combustion Chambers, Stages of Combustion - factors affecting flame propagation, Knock in SI engines, variables affecting knocking. Pollution from SI engines.

UNIT III CI ENGINES 12

Diesel fuel injection system, Function of Components, Jerk type pump, Distributor pump, Mechanical and pneumatic Governor, Fuel Injector, Types of nozzle, importance of Swirl, Squish, Turbulence air motion, Combustion in CI Engines - Combustion Chambers, Stages of Combustion, Factors affecting Ignition Delay, Knock in CI engines. Pollution from CI engines

UNIT IV EMISSION CONTROL TECHNIQUES 12

Design of engine, optimum selection of operating variables for control of emissions, EGR, charge stratification, SCR, DPF, Lean NOX catalyst technology. Thermal reactors, secondary air injection, catalytic converters, catalysts, fuel modifications, fuel cells, Two stroke engine pollution control.

UNIT V MEASUREMENT TECHNIQUES EMISSION STANDARDS AND TEST PROCEDURES **12**

NDIR, FID, Chemiluminescent analyzers, Gas Chromatograph, smoke meters, emission standards, driving cycles - USA, Japan, Euro and India. Test procedures - ECE, FTP Tests. SHED Test - Chassis dynamometers, dilution tunnels.

Total: 60

TEXT BOOKS

1. Internal Combustion Engines by V. Ganesan, 2007, Tata Mc Graw Hill
2. Ramalingam K.K., "Internal Combustion Engines", Sci-Tech Publications, 2005.
3. Paul Degobert - Automobiles and Pollution - SAE International ISBN-1-56091-563-3, 1991.

REFERENCES

1. Advanced Engine Technology by Heisler, SAE Publication
2. Edward F. Obert Internal Combustion Engines
3. H.N. Gupta Fundamentals of Internal Combustion Engines by, PHI
4. Mathur and Sharma Intendamental Combustion Engines Dhanpat Rai and Sons 2002
5. John B. Heywood, "Fundamentals of Internal Combustion Engines",
6. AE Transactions- "Vehicle Emission"- 1982 (3 volumes).
7. Marco Nute- " Emissions from two stroke engines, SAE Publication - 1998

PAU102 AUTOMOTIVE CHASSIS

L	T	P	C
4	0	0	4

GOAL

All automobiles have important driveline and structural components. This subject deals with the functions and constructional details of all the chassis components.

OBJECTIVES

The course should enable the student to:

1. Understand various types of layout of vehicles and features and applications.
2. Understand the construction, materials and various types of frames with knowledge on loads acting on frames and testing of frames.
3. Know about the construction, materials and types of front axles. Conceive the significance of front wheel and steering geometry and study steering layouts, steering gear boxes and steering systems.

4. Understand the construction and working of drive line system, final drives, differentials, rear axles, wheels and tires, suspension and brake systems.

5. Problem-Solving in Steering Mechanism, Propeller Shaft, Braking and Suspension Systems are to be done.

OUTCOME

The students should be able to:

1. Differentiate various layouts, analyze the merits and limitations and apply in real time, Analyze frames for real time applications, Dismantle, study, perform corrections and assemble front axles.

2. Dismantle, study, rectify and assemble drive line system, final drive and differential, rear axle, wheels and tires, suspension and brake systems, Realize effects of driving torque, rear end torque, wheel wobble, wheel hop, wheel shimmy, slip angle and turning circle radius.

3. Describe the operation of steering system of crawler tractors and electronic steering system, Be familiar with Ackermann steering system and aware of under steering, over steering, reversible steering and irreversible steering, Realize the inter dependence steering system, brake system and suspension system. Be familiar with various types of springs, design of springs, rigid and independent and compensated suspension systems,

4. Be familiar with various types of rear axles, brake systems, final drives ,ABS and differential', Create virtual and real vehicle models and perform testing.

5. Analyze and solve problems in steering mechanism, propeller shaft, braking and suspension system and suggest design solutions.

UNIT I INTRODUCTION **12**

Types of chassis layout with reference to drives, vehicle frames, various types of frames, Monocoque structure, constructional details, materials, testing of vehicle frames, unitized frame body construction.

UNIT II FRONT AXLE AND STEERING SYSTEM **12**

Types of front axles, construction details, materials, front wheel geometry: castor, camber, king pin inclination, toe-in. conditions for true rolling motion of wheels during steering, steering geometry, Ackermann steering system, constructional details of steering linkages, slip angle, cornering force, different types of steering gear boxes, steering linkages and layouts, turning radius, wheel wobble, power assisted steering, steering of crawler tractors and Electronic Steering System.

UNIT III DRIVE LINE **12**

Effect of driving thrust and torque reactions, Hotchkiss drive, torque tube drive and radius rods, propeller shaft, universal joints, front wheel drive, different types of final drive, double reduction and twin speed final drives, differential principle, construction details of differential unit, non-slip differential, differential locks, differential housings, construction of rear axles, types of loads acting on rear axles, fully floating, three quarter floating and semi floating rear axles, rear axle housing, construction of different types of axle housings, multi axle vehicles, Differential for Tandem drive.

UNIT IV SUSPENSION SYSTEM **12**

Need of suspension system, types of suspension, suspension springs, constructional details and characteristics of leaf, coil and torsion bar springs, independent suspension, rubber suspension, pneumatic suspension, shock absorbers, semi-active and active suspension system. Compensated suspension system, hydro-gas suspension system, wheels and tyres

UNIT V BRAKING SYSTEM **12**

Braking Efficiency and stopping distance, Reaction time, Braking time, Classification of brakes, drum brakes and disc brakes, constructional details, theory of braking, concept of dual brake system, parking brake, material, hydraulic system, vacuum assisted system, air brake system, antilock braking, retarded engine brakes, eddy retarders and electronic braking system.

Total: 60

TEXT BOOKS

1. Heldt.P.M.- "Automotive chassis"- chilton co., New york- 1990
2. Steed W - "Mechanics of road vehicles"- Illiffe books Ltd., london- 1960

REFERENCES

1. Newton Steeds and Garrot- "Motor Vehicles"- Butterworths, London- 2000.
2. Judge A.W- "Mechanism of the Car"- Chapman and Halls Ltd., London- 1986
3. Giles.J.G- "Steering, Suspension and tyres"- Iiiffe Book Co., London- 1988.
4. Crouse W.H- "Automotive Chassis and Body"- McGraw-Hill, New York- 1971.
5. K.K.Ramalingam - "Automobile Engineering" - Scitech Publication, Chennai - 2001

PAU103 AUTOMOTIVE TRANSMISSION

L	T	P	C
4	0	0	4

GOAL

To impart knowledge about the critical importance of the transmission system in an automobile and to create awareness about the evolution, components involved and different types of transmission system widely used in automobiles

OBJECTIVES

The subject should enable the students to:

1. Understand various types of Gear Box, its principle and applications.
2. Understand the construction, principle and the concept of Fluid Coupling & Torque Convertor.
3. Know about the concept of epicyclic gear system and its types, overdrives.

4. Gain knowledge about the concepts of hydrostatic drive, its merits & demerits and the electric drive commonly used in buses

5. Understand the construction and working of the most commonly used automatic transmission systems and its advantage over the conventional transmissions.

OUTCOME

The students should be able to:

1 Differentiate various types of gearbox, its working, its advantages & its limitations, Analyze gear ratios for various types of gear boxes for real time applications, Be familiar with epicyclic gear trains, its types, operations, merits & demerits.

2. Describe and analyze the operation of Fluid Coupling & Torque convertor. Realize the performance & output of the Fluid Coupling & Torque convertor under various parameters.

3. Describe the need, working, construction and the principle of overdrives. Describe the concept of hydrostatic drive & be familiar with Jannys hydrostatic drive and also its merits & demerits.

4. Explain the concepts of electric drive & commonly used electric drive in buses. Be familiar with the commonly used automatic transmission systems and to describe the construction & working of the same.

5 Explain the advantages of automatic transmission over the conventional systems.

UNIT I CLUTCH AND GEAR BOX 12

Clutch : Different types of clutches, working principles and constructions, torque capacity and design of Clutch plate.

Gear Box: Performance of vehicle, total resistance to motion, traction and tractive effort, acceleration, calculation of gear ratio, design of three speed gear box, design of four speed gear boxes

UNIT II AUTOMOTIVE TRANSMISSION 12

All spur and internal gear type planetary gearboxes, Ford T-model, Cotal and Wilson Gear box, determination of gear ratios, automatic overdrives.

UNIT III HYDRODYNAMIC DRIVE 12

Fluid coupling: advantages and limitations, construction details, torque capacity, slip in fluid coupling, performance characteristics. Means used to reduce drag torque in fluid coupling.

Principal of torque conversion, single, multi stage and polyphase torque converters, performance characteristics, constructional and operational details of typical hydraulic transmission drives.

UNIT IV HYDROSTATIC DRIVE AND ELECTRIC DRIVE 12

Hydrostatic drives: advantages and disadvantages, principles of hydrostatic drive systems, construction and working of typical hydrostatic drives, Janney Hydrostatic drive.

Electrical drives: advantages and limitations, principles of Ward Leonard system of control Modern electric drive for buses and performance characteristics.

UNIT V AUTOMATIC TRANSMISSION APPLICATIONS **12**

Automatic transmission: relative merits and demerits when compared to conventional transmission, automatic control of gears, study of typical automatic transmissions, Ford and Chevrolet drive, automatic control of gear box. Electronically Controlled Transmission and CVT Case Studies: GM's tapshift Technology, Porsche Tiptronic Technology

Total: 60

TEXT BOOKS

1. Heldt P.M - Torque converters- Chilton Book Co.-1992
2. Newton and Steeds - Motor Vehicle- Illiffee Publisher- 2000

REFERENCE

1. Design Practices, passenger Car Automotive Transmissions- SAE Hand book- 1994

PAU104 AUTOMOTIVE ELECTRICAL AND ELECTRONICS

L	T	P	C
4	0	0	4

GOAL

To make the students to realize the impact of automobile emissions on the environment and expose student to factors affecting the formation and control of automobile pollutants.

OBJECTIVES

The course should enable the student to:

1 Understand construction and working of batteries and accessories

2 Understand the working of starting system.

3 Understand the working of charging system

4. Understand the fundamentals of automotive electronics

5. Understand the working of sensors and activators ormance RISC Architecture.

OUTCOME

The students should be able to:

1. Describe the working of lead acid battery. The operation of lighting system, Horn and Wiper system
2. Describe the condition at starting and behavior of starter during starting and the working and maintenances of starter motor.
3. Describe the working of different starter drive units and the working of onboard diagnostic system, security and warning system.

4. Describe the shunt generator characteristics, working of alternators and bridge rectifiers. Aware of current trends in automotive electronics engine management system.

5. Describe the working of speed sensor ,throttle position sensor, exhaust oxygen level sensor, manifold pressure sensor, crankshaft position sensor, coolant temperature sensor, air mass flow sensor.The working of solenoids, stepper motors and relays.

UNIT I BATTERIES AND ACCESSORIES 12

Principle and construction of lead acid battery, characteristics of battery, rating capacity and efficiency of batteries, various tests on batteries, maintenance and charging. Lighting system: insulated and earth return system, details of head light and side light, LED lighting system, head light dazzling and preventive methods - Horn, wiper system and trafficator.

UNIT II STARTING SYSTEM 12

Condition at starting, behavior of starter during starting, series motor and its characteristics, principle and construction of starter motor, start stop system, working of different starter drive units, care and maintenances of starter motor, starter switches.

UNIT III CHARGING SYSTEM 12

Generation of direct current, shunt generator characteristics, armature reaction, third brush regulation, cutout. Voltage and current regulators, compensated voltage regulator, alternators principle and constructional aspects and bridge rectifiers, new developments, wiring requirements, insulated and earth return systems.

UNIT IV FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS 12

Current trends in automotive electronic engine management system, electro magnetic interference suppression, electromagnetic compatibility, electronic dashboard instruments, onboard diagnostic system, OBD I,II, security and warning system. Electronic ignition and injection systems.

UNIT V SENSORS AND ACTUATORS 12

Types of sensors: sensor for speed, throttle position, exhaust oxygen level, manifold pressure, crankshaft position, coolant temperature, exhaust temperature, air mass flow for engine application, rail pressure, cam position. Solenoids, stepper motors, relay. Sensors for intelligent transport systems. Lighting, wipers, climate control and electronic displays. Sensors for occupant safety .The digital vehicle. Intelligent vehicle systems

Total : 60

TEXT BOOKS

1. Young A.P. & Griffiths. L. "Automotive Electrical Equipment", ELBS & New Press- 1999.

2. William B.Riddens "Understanding Automotive Electronics", 5th edition - Butter worth Heinemann Woburn, 1998.

3. Crouse, W.H "Automobile Electrical Equipment", McGraw-Hill Book Co., Inc., New York, 3rd edition, 1986.

REFERENCES

1. Bechhold "Understanding Automotive Electronics", SAE, 1998.
2. Judge A.W "Modern Electrical Equipment of Automobiles", Chapman & Hall, London, 1992.
3. Kholi.P.L "Automotive Electrical Equipment", Tata McGraw-Hill Co., Ltd., New Delhi, 1975.
4. Robert Bosch "Automotive Hand Book", SAE (5th Edition), 2000.
5. Ganesan.V. "Internal Combustion Engines", Tata McGraw-Hill Publishing Co., New Delhi, 2003.

PAU105 VEHICLE BODY ENGINEERING

L	T	P	C
4	0	0	4

GOAL

To provide the students sound knowledge of the design of the vehicles body for the maximum comfort

OBJECTIVES

The course should enable the students to:

1. Study different types of car and its constructions.
2. Understand the aerodynamics involved in vehicles.
3. Gain knowledge regarding various types of bus and its construction details.
4. Learn the details available in various commercial vehicles.
5. Study the properties of body materials and its corresponding mechanism.
6. Study the design of external body of the vehicles and aerodynamics concepts.

OUTCOME

The students should be able to:

1. Be acquainted with knowledge of different types of cars.
2. Analyse the aerodynamics involved in vehicles.
3. Be familiar with various types of bus and construction details.
4. Be familiar with various types of commercial vehicles..
5. Analyse the properties of body materials and its mechanisms.
6. Design and optimize the external body shapes to have aero dynamic shape.

UNIT I CAR BODY DETAILS **12**

Types: saloon, convertibles, limousine, estate car, racing and sports car. Visibility: regulations, driver's visibility, tests for visibility, methods of improving visibility and space in cars.

Safety: safety design, safety equipments for cars. Car body construction; design criteria, prototype making, initial tests, crash tests on full scale model, Dummies and Instrumentation

UNIT II VEHICLE AERODYNAMICS **12**

Objectives. Vehicle drag and types; various types of forces and moments, effects of forces and moments, side wind effects on forces and moments, Various body optimization techniques for minimum drag, wind tunnel testing: flow visualization techniques, scale model testing, component balance to measure forces and moments.

Effects of rounding sharp front body edges. Effects of different cab to trailer body Forebody pressure distribution. Effects of a cab to trailer body roof height. Commercial vehicle drag reducing devices.

UNIT III BUS BODY DETAILS **12**

Types: mini bus, single Decker, double-decker, two level and articulated bus. Bus body layout; floor height, engine location, entrance and exit location, seating dimensions. Constructional details: frame construction, double skin construction, types of metal sections used, Regulations, Conventional and integral type construction.

UNIT IV COMMERCIAL VEHICLE DETAILS **12**

Types of body; flat platform, drop side, fixed side, tipper body, tanker body, Light commercial vehicle body types. Dimensions of driver's seat relation to controls. Drivers cab design.

UNIT V BODY MATERIALS, TRIM AND MECHANISMS **12**

Steel sheet, timber, plastic, GRP, properties of materials; Corrosion, anticorrosion methods. Selection of paint and painting process. Body trim items. Body mechanisms.

Total: 60

TEXT BOOK

1. J.Powloski - "Vehicle Body Engineering" - Business Books Ltd, London -1989

REFERENCES

1. Giles.J.C. - "Body construction and design" - Liiffe Books Butterworth & Co. - 1971.
2. John Fenton - "Vehicle Body layout and analysis" - Mechanical Engg. Publication Ltd., London - 1982.
3. Braithwaite.J.B. - "Vehicle Body building and drawing" - Heinemann Educational Books Ltd., London - 1977.

PAU151 AUTOMOTIVE SYSTEM COMPONENTS LABORATORY

L	T	P	C
0	0	3	2

GOAL

To impart knowledge in various engine components

OBJECTIVES

The course enables the students to:

1. Experience the skill of dismantling and assembling of engines.
2. Experience the skill of dismantling and assembling of Axles, differential, gear box and transfer case
3. Experience the skill of measuring the heavy duty vehicle frames and light duty vehicle frames.
4. Understand battery testing and maintenance
5. Understand the testing of starting
6. motors and generators.
7. Understand the study of rectifiers and filters.
8. Understand the study of logic gates, adder and flip-flops.
9. Understand the study of SCR and IC timer.

OUTCOME

The students should be able to:

1. Completely dismantle and assemble the engines
2. Calculate the Engine displacement by measuring the Stroke length, bore.
3. Locate the components with the engine for accurate operations
4. Dismantle and assemble axles, differential, gear box and transfer case.
5. Grasp the knowledge of various mechanism of differentials such as epi- cyclic differential, spur gear differentials etc.,
6. Understand the necessity of transfer case mechanism for all wheel drive and differentiate gear box and transfer box
7. Describe the working of starter motor, regulators, cut-outs relay, ignition system.
8. Construct the rectifier circuit using diodes and to know about the necessity in automobiles.
9. To verify various logic gates truth table by using logic gate kit.

LIST OF EXPERIMENTS

ENGINE SYSTEM **10**

1. Dismantling and Assembling of 4 cylinder petrol engine.
2. Dismantling and Assembling of 6 cylinder diesel engine.
3. Study of Engine Auxiliaries
4. Ovality and taper measurement of cylinder bore and engine crank shaft

CHASSIS SYSTEM **15**

Study of:

1. Heavy duty vehicle frame
2. Light duty vehicle frame
3. Steering System
4. Braking System
5. Gear box and Transfer case

ELECTRICAL SYSTEM **10**

1. Testing of batteries and battery maintenance
2. Testing of starting motors and generators
3. Testing of regulators and cut - outs
4. Diagnosis of ignition system faults
5. Study of automobile electrical wiring

ELECTRONIC SYSTEM **10**

1. Study of rectifiers and filters
2. Study of logic gates, adder and flip-flops
3. Study of SCR and IC timer
4. Interfacing A/D converter and simple data acquisition
5. Micro controller programming and interfacing

Total : 45

LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS

ENGINES

1. Four cylinder petrol engine
2. Six cylinder diesel engine
3. Fuel filter, fuel injection pump, injector, carburetor, MPFI component
4. Ignition coil, magneto, electronic ignition system components
5. Water pump, thermostat, radiator, temperature gauge
6. Lub oil pump, pressure relief valve, filter, oil pressure gauge
7. Internal micrometer, external micrometer, dial gauges

CHASSIS

1. Heavy duty vehicle chassis frame
2. Light duty vehicle chassis frame
3. Steering system
4. Steering gear box (Rack and pinion, recirculating ball type)
5. Hydraulic brake system
6. Air brake system
7. Transfer case
8. Gear box (light duty, heavy duty)

ELECTRICAL AND ELECTRONICS

1. Battery, hydrometer, voltage tester
2. Starter motor, regulator, cutout
3. Distributor, ignition coil, spark plug
4. Auto electrical wiring system
5. Rectifiers, filters
6. Amplifier
7. IC timer
8. Data logger

SEMESTER II

PIC202 ELECTRONIC ENGINE MANAGEMENT SYSTEM

L	T	P	C
4	0	0	4

GOAL

To impart knowledge in various engine control systems

OBJECTIVES

The course should enable the students to:

1. Understand the automotive instruments and sensors.
2. Understand the measurement of engine parameter by using sensor.
3. Understand the working Electronic Ignition System.
4. Understand the Principles of Digital Control systems
5. Understand the application of on board diagnosis.

OUTCOME

The students should be able to:

1. Describe the sensor classification and sensor product selection guide and measurements of automotive sensors.
2. Describe the working of Pressure, position, flow, temperature, humidity, speed, acceleration, oxygen, torque, light, distance and level.
3. Differentiate the electronic fuel injection system in SI and CI engines and Describe the advantages of using direct fuel injection over the indirect fuel injection system.
4. Describe the advantages of electronic ignition system over the conventional ignition system.
5. Describe the algorithms for digital controllers

UNIT I SENSORS **12**

Types - Air flow, Pressure, Temperature, Speed Oxygen, Detonation, Position - Principle of operation, Arrangement and material.

UNIT II GASOLINE INJECTION SYSTEM **12**

Open loop and closed loop systems, Mono point, Multi point and Direct injection systems - Principles and Features, Bosch injection systems.

UNIT III DIESEL INJECTION SYSTEM **12**

Inline injection pump, Rotary pump and injector - Construction and principle of operation, Common rail and unit injector system - Construction and principle of operation.

UNIT IV IGNITION SYSTEMS **12**

Ignition fundamentals, Types of solid state ignition systems, High energy ignition distributors, Electronic spark timing and control.

UNIT V ENGINE MAPPING **12**

Combined ignition and fuel management systems. Digital control techniques - Dwell angle calculation, Ignition timing calculation and Injection duration calculation. Hybrid vehicles and fuel cells.

Total: 60

TEXT BOOKS

1. Bosch Technical Instruction Booklets.
2. Tom Denton, Automotive Electrical and Electronic Systems, Edward Amold,1995.

REFERENCES

1. Robert N.Brady, Automotive Computers and Digital Instrumentation, Prentice Hall, 1988.
2. Duffy Smith, Auto Fuel Systems, The god Heart Willcox Company Inc., Publishers, 1987.
3. Heinz Heisler, Advanced Engine Technology. SAE Publications, 1995.

PAU201 AUTOMOTIVE SYSTEM COMPONENTS DESIGN

L	T	P	C
4	0	0	4

GOAL

To make the students understand the design concept and principles of various vehicle system components. These concepts and principles are familiarized for design of components.

OBJECTIVES

The course should enable the students to:

1. Know about various types of materials, properties of materials and various applications of the materials, and computer aided application.
2. Know about the fits, clearance and tolerances concepts, also the design of the helical springs.
3. To know about design procedure to design piston and its parts, cylinder and cylinder block, lubrication of piston assembly.
4. Understand the designing the parts of connecting rod and crankshaft,
5. Understand the design aspects of Inlet and exhaust valves, valve mechanism, and also the materials for the valves.
6. Learn design calculation of various types of clutches.
7. Understand the performance of vehicles and design of gear box.
8. Study various loads, moments and stresses on frame members and suspensions..

9. Learn the details about front axle and steering systems.

10. Understand the design of final drive and rear axle.

OUTCOMES

The students should be able to:

1. Application of the materials, CAD application in the Automobile industry.

2. Differentiate between the concepts of Fits, Clearance and Tolerance and to Design the helical springs and its application.

3. Design the cylinder block and cylinder parts based on the engine specification of and also based on the engine application.

4. Design the piston and its parts based on the engine specification of and also based on the engine application.

5. Design the connecting rod and its parts based on the engine specification of and also based on the engine application.

6. Design the crankshaft and its parts based on the engine specification of and also based on the engine application also with the balancing weight of the crankshaft.

7. Design the valves and its mechanism for both the inlet and exhaust valve based on the engine specification of and also based on the engine application.

8. Apply the knowledge gained through various design of clutches for modifications.

9. Be familiar with various types of loads, stresses acting on frame and suspension of vehicles..

10. Be familiar with design of front axle and steering systems, final drive and rear axle.

(REVIEW - NOT FOR EXAMINATION)

Engineering materials and their physical properties applied to design, selection of materials, factor of safety, endurance limit, notch sensitivity, principles of design optimization. Types of tolerances and fits, design considerations for interference fits, surface finish, surface roughness. Shafts and springs.

UNIT I DESIGN OF CYLINDER AND PISTON ASSEMBLY 12

Choice of material for cylinder and piston, piston friction, piston slap, design of cylinder, piston, piston pin, piston rings, piston failures, lubrication of piston assembly.

UNIT II DESIGN OF CONNECTING ROD, CRANKSHAFT 12

Material for connecting rod, determining minimum length of connecting rod, small end and big end design, shank design, design of big end cap bolts, connecting rod failures, balancing of I.C. Engines, significance of firing order, material for crankshaft, design of crankshaft under bending and twisting, balancing weight calculations.

UNIT III DESIGN OF VALVES AND FLYWHEEL 12

Design aspects of intake and exhaust manifolds, inlet and Exhaust valves, valve springs, tappets, valve train. Materials and design of flywheel.

UNIT IV VEHICLE FRAME, SUSPENSION AND STEERING SYSTEMS **12**

Study of loads, moments and stresses on frame members, computer aided design of frame for passenger and commercial vehicles, computer aided design of leaf springs, coil springs and torsion bar springs. determination of optimum dimensions and proportions for steering linkages ensuring minimum error in steering.

UNIT V DESIGN OF DRIVE LINE SYSTEM **12**

Analysis of loads, moments and stresses at different sections of front axle, bearing load calculation, design details of full floating, semi-floating and three quarter floating rear shafts and rear axle housings. Design of propeller shaft, design details of final drive gearing.

Total: 60

TEXT BOOKS

1. R.K. Jain, "Machine Design", Khanna Publishers, New Delhi, 1997.
2. "Design Data Book", PSG College of Technology, Coimbatore, 2000.
3. P.M.Heldt "High Speed Combustion Engines", Oxford-IBH Publishing Co., Calcutta, 1965.
4. Giri.N.K- "Automobile Mechanics"- Khanna Publisher, New Delhi- 2002

REFERENCES

1. A.Kolchin and V.Demidov, "Design of Automotive Engines", MIR Publishers, Moscow, 1984.
2. Sundararaja Murthy T.V "Machine Design", Khanna Publishers, New Delhi, 1991.
3. Steeds. W -"Mechanics of Road Vehicles"- Illiffe Books Ltd., London- 1990
4. Giles.K.G - Steering, Suspension and tyres"- Illiffe Books Ltd., London - 1988
5. Newton Steeds & Garret- "Motor Vehicle"- Illiffe Books Ltd., London - 2000
6. Heldt.P.M- "Torque converter" - Chilton Book Co., New York - 1982
7. Dean Averns - "Automobile Chassis Design"- Illiffe Books Ltd - 1992

PAU202 VEHICLE DYNAMICS AND CONTROL

L	T	P	C
4	0	0	4

GOAL

To impart knowledge in Dynamic characteristics of vehicles.

OBJECTIVES

The course should enable the students to:

1. Enhance the knowledge in vibration of vehicles due to dynamic conditions.
2. Grasp the importance of the comfort and safe riding characteristics.

3. Understand the vehicle performance parameters and various testing methodologies.

4. Understand the functions of Various Control Systems involved the Vehicle in dynamic condition

OUTCOME:

The students should be able to:

1. Perceive the significance of Vibration analysis and to determine fundamental frequency by applying Dunkerley's and Rayleigh's methods

2. Analyze the reactions of each wheels subjected to various loads and stability of the vehicles for various road conditions.

3. Analyze the Calculate tractive effort and reactions for different drives and Solve problems based on vehicle handling characteristics

4. Acquire knowledge over the influence of performance parameters on ride characteristics

UNIT I VEHICLES HANDLING CHARACTERISTICS 12

sprung mass frequency, wheel hop, wheel wobble, wheel shimmy, choice of suspension spring rate, calculation of effective spring rate, vehicle suspension in fore and aft, roll axis and vehicle under the action of side forces, tyre, dynamics, ride characteristics power consumed by a tyre. Oversteer, under steer, steady state cornering, effect of braking, driving torques on steering, effect of camber, transient effects in cornering.

UNIT II STABILITY OF VEHICLES 12

Load distribution, stability on a curved track, slope and a banked road, calculation of tractive effort and reactions for different drives.

UNIT III LONGITUDINAL AND LATERAL DYNAMICS 12

Aerodynamic drag force - Longitudinal tire force - Rolling resistance - Calculation of normal tire forces - Lateral Systems - Dynamic Model in Terms of Error with Respect to Road, Yaw Rate and Slip Angle.

UNIT IV DRIVELINE CONTROL SYSTEM 12

Speed control - cylinder cut - off technology, Gear shifting control - Traction / Braking control, brake by wire - Adaptive cruise control, throttle by wire. Anti-Lock Brake Systems, Steering - Power steering, collapsible and tilt able steering column - steer by wire. Independent All Wheel Drive Torque Distribution

UNIT V SUSPENSION CONTROL SYSTEM 12

Semi-Active Suspension Model - Performance of Semi-Active Suspension Systems. Active Automotive Suspensions - Hydraulic Actuators for Active Suspensions Analysis of Vibrations in the Sprung Mass Mode and Unsprung Mass Mode - Verification Using Quarter Model Half-Car and Full-Car Suspension Models.

Total : 60

TEXT BOOKS

1. Rajesh Rajamani - Vehicle dynamics and control, Springer 2005
2. Giri N.K - Automotive Mechanics, Khanna Publishers, 2002.
3. Rao J.S and Gupta. K "Theory and Practice of Mechanical Vibrations", Wiley Eastern Ltd., New Delhi -2, 2002.

REFERENCES

1. Heldt.P.M -"Automotive Chassis"- Chilton Co., New York- 1992
2. Ellis.J.R - "Vehicle Dynamics"- Business Books Ltd., London- 1991
3. Giles.J.G.Steering - "Suspension and Tyres", Illiffe Books Ltd., London- 1998
4. Ham B, Pacejka - Tyre and Vehicle Dynamics - SAE Publication - 2002.
5. Gillespie T.D, "Fundamentals of Vehicle Dynamics", SAE USA 1992.

PAU203 VIBRATION AND NOISE CONTROL

L	T	P	C
4	0	0	4

GOALS

The students will be able to understand the sources of vibration and noise in automobiles and make design modifications to reduce the vibration and noise and improve the life of the components.

OBJECTIVES

The course should enable the students to:

1. Understand the various types of vibration with damping and without damping.
2. Understand the Various types of noise and it's measurement and analysis techniques.
3. Understand the various sources of noise from automobiles.
4. Understand the various noise controlling techniques.
5. Understand the various noise from mechanical components and it's suppressing techniques.

OUTCOME

The students should be able to:

1. Classification of vibration of free, forced, undamped , damped, linear , non linear vibration Response of damped and undamped systems under harmonic force, analysis of single degree and two degree of freedom systems, torsional vibration, Determination of natural frequencies.
2. Introduction to amplitude, frequency, wavelength and sound pressure level, Addition, subtraction and averaging decibel levels, Noise dose level, legislation, measurement and analysis of noise, Measurement environment, equipment, frequency analysis, tracking analysis, sound quality analysis.

3. Noise Characteristics of engines, engine overall noise levels, assessment of combustion noise engine radiated noise, intake and exhaust noise, Assessment of mechanical noise, accessory contributed noise, transmission noise, aerodynamic noise, tyre noise, brake noise.

4. Vibration isolation by tuned absorbers, untuned viscous dampers. Damping treatments, application dynamic forces generated by IC engines, engine isolation, Crank shaft damping, Modal analysis of the mass elastic model shock absorbers.

5. Methods for control of engine noise, combustion noise, mechanical noise, predictive analysis Noise Suppressing Techniques like palliative treatments and enclosures, automotive noise control principles. Sound in enclosures, sound energy absorption, sound transmission through barrier

UNIT I INTRODUCTION **12**

Single degree of freedom, two degree of freedom, free, forced and damped vibrations modeling and simulation studies, model of an automobile, magnification factor, transmissibility, vibration absorber. Two degree of freedom system. modal analysis.

UNIT II NUMERICAL METHODS **12**

Approximate methods for determining fundamental frequency, Dunkerleys lower bound, Rayleighs upper bound, Holzer method for closed coupled system and branched system.

UNIT III CONTROL TECHNIQUES **12**

Vibration isolation, tuned absorbers, untuned viscous dampers, damping treatments, application dynamic forces generated by IC engines, engine isolation, crank shaft damping, modal analysis of the mass elastic model shock absorbers.

UNIT IV AUTOMOTIVE NOISE SOURCES **12**

Noise Characteristics of engines, engine overall noise levels, assessment of combustion noise, assessment of mechanical noise, engine radiated noise, intake and exhaust noise, engine accessory contributed noise, transmission noise, aerodynamic noise, tyre noise, brake noise.

UNIT V SOURCE OF NOISE AND CONTROL **12**

Methods for control of engine noise, combustion noise, mechanical noise, predictive analysis, palliative treatments and enclosures, automotive noise control principles, sound in enclosures, sound energy absorption, sound transmission through barriers

Total : 60

TEXT BOOKS

1. Singiresu S.Rao - "Mechanical Vibrations" - Pearson Education, ISBM -81-297-0179-0 - 2004.

2. Kewal Pujara "Vibrations and Noise for Engineers, Dhanpat Rai & Sons, 1992.

PAU251 VEHICLE DYNAMICS LABORATORY

L	T	P	C
0	0	3	2

GOALS

The students will be able to understand the basics of vibration characteristics of the mechanical and Automotive components as well as to know about Mathematical software and MBS software.

OBJECTIVES

The course should enable the students to:

1. Testing of natural frequency.
2. Measurement of displacement velocity and acceleration.
3. Whirling of Shafts.
4. Critical Speed Determination.
5. Measurement of Front Wheel Geometry.
6. Introduction to MATLAB- SIMULINK solving simple MCK problems
7. Conversion of Analog to Digital and Digital to Analog
8. Study of LS Dyna / Adams

OUTCOME

The students should be able to:

1. To find the natural frequency of the given material
2. Using various sensors to find displacement, Velocity and acceleration with the use of Mathematical software.
3. Using circular rod to find its maximum permissible location of bending while it is getting rotated.
4. Using circular rod to find its maximum permissible location of bending while it is getting rotated from its axis shift from original axis.
5. Using wheel alignment equipments to find a front wheel geometry of Toe in/out, Caster, Camber/King Pin Inclination and Included angle.
6. Using MATLAB- SIMULINK software to solve simple mechanical systems.
7. Using data card to find D/A to A/D convertor
8. Using Multi Body dynamics software to solve simple Car model.

LIST OF EXPERIMENTS

1. Testing of natural frequency 6
2. Measurement of displacement velocity and acceleration 6

3.	Whirling of Shafts	6
4.	Critical Speed Determination	6
5.	Camber angle measurement	6
6.	Introduction to MAT Lab - Simulink, solving simple MCK problems	3
7.	Conversion of Analog to Digital and Digital to Analog	6
8.	Study of LS Dyna / Adams	6
		Total : 45

THE LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS

a.	Four Wheeler Chassis Dynamometer	- 1 No.
b.	Shock absorber test rig	- 1 No.
c.	Measuring Devices - Displacement, Velocity and acceleration	- 1 No.
d.	Piston and Valves	- 5 Nos.
e.	A/ D Converter	- 1 Nos.
f.	D / A Converter	- 1 No.
g.	MAT Lab Software	- 30 Users
h.	Adams / L.S. Dyna	- 30 Users

SEMESTER III

PAU351 MODELING AND SIMULATION LABORATORY

L	T	P	C
0	0	3	2

GOAL

To impart knowledge about the modeling of various Automotive Engine components & the various analysis of the same with the relevant modeling & analysis software.

OBJECTIVES

The subject should enable the student to model & analyze various engine components, according to the specifications

OUTCOMES

The students should be able to model the various engine components, for the given specifications & to analyze the same for various load & temperature conditions, such as

1. Piston.
2. Piston pin & rings.
3. Connecting Rod.
4. Inlet & Exhaust valves.
5. Camshaft.
6. Crankshaft.
7. Balancing weight of Crankshaft.

LIST OF EXPERIMENTS:

Modeling and Analysis of following IC Engine Parts

1.	Piston	6
2.	Piston Pin and Piston Rings	6
3.	Connecting Rod	6
4.	Inlet and Exhaust Valves	6
5.	Camshaft	6
6.	Crankshaft	6
7.	Balancing weight of Crankshaft	9
		Total : 45

LIST OF EQUIPMENTS

(for a batch of 30 students)

1.	Computer Notes	-	30 Nos.
2.	Software like Pro/E, CATIA and ANSYS	-	30 Nos.

PAU352 INDUSTRIAL TRAINING

L	T	P	C
0	0	4	2

Students should undergo Industrial visit to reputed Industrial visit for a period of 4 weeks (minimum) during the vacation period at the end of 2nd semester. Examination will be conducted along with the 3rd semester as a practical subjects. Students should prepare a Report and presentation seminar for the exam.

ELECTIVE COURSES

PAU701 AUTOMOTIVE SAFETY

L	T	P	C
3	0	0	3

GOAL

The student will be able to know about the various safety aspects and safety components in the vehicle for the safety of the driver, passengers and the pedestrians.

OBJECTIVES

The course should enable the students to:

1. Know about the basics about the vehicle.
2. Understand the safety aspects in the vehicle.
3. Know and understand the various safety aspects.
4. To get the knowledge in sensors provided in the vehicle to avoid the crash and to detect the defects in the vehicle.
5. To know about the comfort and convenience system.

OUTCOME

The students should be able to:

1. Know about the design of the bumper for safety.
2. Know about the concept of crumble zone, and also the effect of acceleration and deceleration of the vehicle in the compartment of the vehicle.
3. Know the various types of safety aspects such as active and passive safety

4. Know the active safety components, passive safety components such as air bags, seat belts.

5. Know the working of the compartment while moving of the vehicle, collapsible steering, tiltable steering column, collision avoidance system, front, rear vehicle detection system, and the braking system.

UNIT I INTRODUCTION **9**

Design of the body for safety, Energy equation, Engine location, Deceleration of vehicle inside passenger compartment, Deceleration on impact with stationary and movable obstacle, Concept of crumble zone, Safety sandwich construction.

UNIT II SAFETY CONCEPTS **9**

Active safety: Driving safety, Conditional safety, Perceptibility safety, Operating safety- Passive safety: Exterior safety, Interior safety, Deformation behaviour of vehicle body, Speed and acceleration characteristics of passenger compartment on impact.

UNIT III SAFETY EQUIPMENTS **9**

Seat belt, Regulations, Automatic seat belt tightener system, Collapsible steering column, Tiltable steering wheel, Air bags, Electronic system for activating air bags, Bumper design for safety, Antiskid braking system, Regenerative Braking System, Cruise Control, Adaptive Cruise Control Devices.

UNIT IV COLLISION WARNING AND AVOIDANCE **9**

Collision warning system, Causes of rear end collision, Frontal object detection, ear vehicle object detection system, Object detection system with braking system interactions, Driver Fitness Detection.

UNIT V COMFORT AND CONVENIENCE SYSTEM **9**

Steering and mirror adjustment, Central locking system , Garage door opening system, Tyre pressure control system, Rain sensor system, Environment information system, Manual and Automated Wiper System, GPS.

Total : 45

TEXT BOOK

1. Bosch - "Automotive Handbook" - 5th edition - SAE publication - 2000.

REFERENCES

1. J.Powloski - "Vehicle Body Engineering" - Business books limited, London - 1969.

2. Ronald.K.Jurgen - "Automotive Electronics Handbook" - Second edition- McGraw-Hill Inc., - 1999.

PAU702 TWO AND THREE WHEELER TECHNOLOGY

L	T	P	C
3	0	0	3

GOAL

The aim of this subject is to make the students to know and understand the constructional details operating characteristics and vehicle design aspects

OBJECTIVES

The course should enable the students to:

1. Understand the Two stroke SI engine, four stroke SI engine; merits and demerits. Symmetrical and unsymmetrical port timing diagrams.
2. Understand the Types of scavenging processes, Fuel system, Lubrication system. Magneto coil and battery coil spark ignition system.
3. Understand the construction and working of electronic ignition system, starting system; kick starter system.
4. Understand the types of clutches, gear box and shock absorbers etc.
5. Understand the types of brakes, wheels, tyres and tubes.
6. Understand the constructions and case studies of two and three wheelers and maintenance of vehicles.

OUTCOME

The students should be able to:

1. Differentiate various layouts, analyze the merits and limitations and apply in real time.
2. Dismantle study, perform corrections and assemble the various parts of the vehicle.
3. Describe the maintenance procedures of various systems like steering systems, braking system, suspension system and engine etc.
4. Dismantle study, rectify and assemble drive line system, final drive and differential, rear axle, wheels and tires, suspension and brake systems.
5. Realize effects of maintenance and minimize the consumption of petroleum based fuels.
6. Describe the maintenance procedures of various electrical systems like battery, starter motor, alternator, D.C motor etc.
7. Be familiar with maintenance procedures of engine, cooling system and lubrication system, checking and servicing of dash board instruments.
8. Be familiar with wheel alignment, computerized alignment and wheel balancing, and door locks and window glass actuating system maintenance.

UNIT I POWER UNIT **9**

Two stroke SI engine, four stroke SI engine; merits and demerits. Symmetrical and unsymmetrical port timing diagrams. Types of scavenging processes; merits and demerits, scavenging pumps. Rotary valve engine. Fuel system. Lubrication system. Magneto coil and battery coil spark ignition system, electronic ignition system. Starting system; Kick starter system.

UNIT II CHASSIS AND SUB-SYSTEMS **9**

Mainframe and its types. Chassis and shaft drive, Clutch for Two and Three Wheelers, Single, multiple plates and centrifugal clutches. Gear box and gear controls. Panel meters and controls on handle bar.

UNIT III BRAKES, SUSPENSION, WHEELS AND TYRES **9**

Drum brakes, Disc brakes, Front and rear brake links, Layouts. Front and rear suspension systems. Shock absorbers. Spoked wheel, Cast wheel, Disc wheel, Disc types. Analysis of fatigue strength, torsional stiffness and lateral stability on wheel frames. Tyres and tubes.

UNIT IV RACING TWO WHEELERS **9**

Case study of major Indian models of motorcycles, scooters and mopeds. TVS mopeds and motorcycles, Hero Honda motorcycles, Bajaj scooters and motorcycles, Yamaha, Enfield motorcycles, Six Speed Vehicles, Servicing and maintenance,

UNIT V THREE WHEELERS **9**

Case study of Indian models. Auto rickshaws, Pickup van, Delivery van and trailer. Maintenance: daily, Weekly, Monthly, Fault tracing.

Total : 45

TEXT BOOK

1. Irving.P.E. - Motor Cycle Engineering - Temple Press Book, London - 1992.

REFERENCES

1. The Cycle Motor Manual - Temple Press Limited, London - 1990
2. Encyclopedia of Motorcycling - 20 volume Marshall, Cavensih, UK - 1989
3. Brayant R.V,Vespa - Maintenance and Repair Series - S.Chand & Co., New Delhi - 1986.
4. Raymond Broad Lambretta - A Practical Guide to maintenance and repair - S.Chand & Co., New Delhi - 1987.

PAU703 SPECIAL TYPES OF VEHICLES

L	T	P	C
3	0	0	3

GOAL

At the end of the course students will be able to know The recent trends in power plants, Noise and pollution control, Vehicle operation and control and Vehicle automated tracks in combat vehicles, earth moving vehicles etc.,

OBJECTIVES

The course should enable the students to:

1. Understand the trends in power plants in military and combat vehicles
2. Understand the Suspension brakes and safety of heavy vehicles
3. Conceive the significance of emission control methods in two and three wheelers.
4. Understand the vehicle operation and control of farm vehicles
5. Understand the vehicle automated tracks.

OUTCOME

The students should be able to:

1. Know about the combat vehicles.
2. Describe the working of stratified charged/lean burn engines.
3. Describe the working of drive line in combat vehicles and earth moving vehicles compared with commercial vehicles.
4. Describe the construction of farm equipments.
5. Describe the working of power trains in heavy vehicles and able to analyse the ride characteristics of tractors.

UNIT I TRACTORS AND FARM EQUIPMENTS **9**

Classification and power required - Design consideration - Ride and stability characteristics power plants and transmission - Farm equipments.

UNIT II EARTH MOVING MACHINES **9**

Construction and operation aspects of Bull dozers, Scrapers, Dumpers, Loaders, Mobile cranes, Road rollers, Elevators and Elevating graders. Selection criteria of prime movers for dumpers and front end rollers based on vehicle performance characteristics.

UNIT III MILITARY AND COMBAT VEHICLES **9**

Special requirements like power, fuel strength and impact resistance tanker, Gun carrier and transport vehicle.

UNIT IV CLASSIFICATION AND REQUIREMENTS OF HEAVY VEHICLES **9**

Power plants - Converter match curves, chassis and transmission (epicyclic). Selection criteria for universal joints.

UNIT V OTHER SPECIAL VEHICLES **9**

Harbor and Airport Vehicles, Fire Station Vehicles, Jib cranes, Vibratory compactors, Borewell Machines, Concrete mixtures - Constructional Details.

Total : 45

TEXT BOOK

1. Construction planning, Equipment and Methods - Robert L. Peurifoy, William B. Ledbrtter, Clifford J. Schexnayder - McGrawHill, Fifth Edition.

REFERENCES

1. Motor cycle - M. Michaeal Griffer
2. A. Gurevich and E.Soreking, Tractors Mir Publishers, Moscow, 1967.
3. V. Rodichev & G. Rodicheva, Tractors and automobiles, MIR Publishers, Moscow.

PAU704 MANUFACTURING AND TESTING OF VEHICLE COMPONENTS

L	T	P	C
3	0	0	3

GOAL

To make the students to realize and understand various manufacturing processes like forming, milling, casting and moulding involved in production of automotive components.

OBJECTIVES

The course should enable the students to:

1. Understand the powder metallurgy manufacturing process.
2. Understand the forming process in which various automotive components , manufacturing process
3. Understand the casting & machining process in which various automotive components manufacturing process
4. Understand the various gear manufacturing process
5. Understand recent trends in automotive manufacturing process

OUTCOME

The students should be able to:

1. Process flow chart , Production of metal powders and Manufacturing of friction lining materials for clutches and brakes as well as Testing and inspection of PM parts.
2. Various Forging process of valves, connecting rod, crank shaft, cam shaft, propeller shaft, transmission gear blanks, foot brake linkage, steering knuckles.

   Various extrusion process of manufacturing transmission shaft, steering worm blanks, brake anchor pins, rear axle drive shaft, axle housing spindles, piston pin and valve tappets.

   Various Hydro forming Process of manifold, tail Lamp housing. , auto body panels
3. Various casting process of cylinder block, liners, flywheel, piston rings, bearing bushes and liners, piston, carburetor and other small auto parts.

   Various Machining process of connecting rods, crank shafts, cam shafts, pistons, piston pins, piston rings, valves, front and rear axle housings, flywheel, Honing of cylinder bores, copy turning and profile grinding machines.
4. Various Gear Manufacturing process like milling, Hobbing and shaping Gear finishing and inspection process.
5. Various process like Powder injection moulding - Shot peen hardening , Production of aluminum MMC, Plasma spray coating, Squeeze casting, aluminum composites.

UNIT I CYLINDER BLOCK AND CYLINDER HEAD 9

Casting practice and special requirements, Materials, Machining, Methods of testing, Cylinder liners - Mat, Types and Manufacture.

UNIT II PISTON ASSEMBLY AND DRIVE SYSTEMS 9

Types, requirements, Casting, Forging, Squeeze casting, Materials, Machining, Testing, manufacture piston rings - Material, Types and manufacture - Surface treatment, Bimetallic pistons, Articulated pistons.Requirements, Materials, Forging practice, Machining, Balancing of crankshaft, Testing, CR, CS, CAS, VT.

UNIT III CASTING MACHINING AND MANUFACTURING 9

Pressure die casting of carburetor and other small auto parts. Machining of connecting rods - valves - front and rear axle housings - flywheel - Honing of cylinder bores - copy turning and profile grinding machines. Gear milling, Hobbing and shaping - Gear finishing and inspection.

UNIT IV COMPUTER INTEGRATED MANUFACTURING 9

Integration of CAD, CAM and Business functions CIM- Networking, CNC programming for machining of I.C.Engines Components.

UNIT V QUALITY AND TESTING 9

SPC - Introduction to ISO 9000, ISO 14000, TS 16949, its importance, BIS codes for testing various

types of engines, Equipments required, Instrumentation, Computer aided engine testing, metrology for manufacturing I.C.Engine Components, In situ measurement - Telemetry and sensors.

Total : 45

REFERENCES

1. Grover, M.P., CAD/CAM, Prentice Hall of India Ltd., 1985.
2. Heldt, P.M., High speed internal combustion engines, Oxford & IBH Publishing Co., 1960.
3. Judge, A.W., Testing of high speed internal combustion engines, Chapman & Hall., 1960.
4. Richard, W., Heine Carl R. Loper Jr. and Philip, C., Rosenthal, Principles of Metal Casting, McGraw-Hill Book Co., 1980.
5. IS: 1602 - 1960 Code for testing of variable speed internal Combustion engines for Automobile Purposes, 1966.
6. SAE Handbook, 1994.
7. P.Radhakrishnan and S.Subramaniayn, CAD/CAM/CIM, New Age International (P) Limited, Publishers, 1997.
8. Mikett P.Groover, Automation, production Systems and Computer - Integrated Manufacturing Printice Hall of India Private Limited, 1999.

PAU705 COMPOSITE MATERIALS & STRUCTURES

L	T	P	C
3	0	0	3

GOALS

This subject introduces to the students the different types of composite materials, their properties and applications

OBJECTIVES

The course should enable the students to:

1. Understand the different types of composite materials, their properties and applications.
2. Understand Polymer matrix composites
3. Understand Metal matrix composites
4. Understand Ceramic matrix Composites
5. Understand Advances in composites

OUTCOME

The students should be able to:

1. Define the properties, classification and applications of composites in the Industries. Composite materials over conventional materials.

2. Understand Polymer matrix composites
3. Understand Metal matrix composites
4. Understand Ceramic matrix Composites
5. Understand Advances in composites

UNIT I INTRODUCTION TO COMPOSITES **9**

Fundamentals of composites - Need for composites - Enhancement of properties - Classification of composites - Matrix-Polymer matrix composites (PMC), Metal matrix composites (MMC), Ceramic matrix composites (CMC) - Reinforcement - Particle reinforced composites, Fibre reinforced composites. Applications of various types of composites.

UNIT II POLYMER MATRIX COMPOSITES **9**

Polymer matrix resins - Thermosetting resins, thermoplastic resins - Reinforcement fibres - Rovings - Woven fabrics - Non woven random mats - Various types of fibres. PMC processes - Hand lay up processes - Spray up processes - Compression moulding - Reinforced reaction injection moulding - Resin transfer moulding - Pultrusion - Filament winding - Injection moulding. Fibre reinforced plastics (FRP), Glass fibre reinforced plastics (GFRP).

UNIT III METAL MATRIX COMPOSITES **9**

Characteristics of MMC, Various types of Metal matrix composites Alloy vs. MMC, Advantages of MMC, Limitations of MMC, Metal Matrix, Reinforcements - Particles - Fibres. Effect of reinforcement - Volume fraction - Rule of mixtures. Processing of MMC - Powder metallurgy process - Diffusion bonding - Stir casting - Squeeze casting.

UNIT IV CERAMIC MATRIX COMPOSITES **9**

Engineering ceramic materials - Properties - Advantages - Limitations - Monolithic ceramics - Need for CMC - Ceramic matrix - Various types of Ceramic Matrix composites- oxide ceramics - Non oxide ceramics - Aluminium oxide - Silicon nitride - Reinforcements - Particles- Fibres- whiskers. Sintering - Hot pressing - Cold Isostatic Pressing (CIP) - Hot isostatic pressing (HIP).

UNIT V APPLICATION AND ANALYSIS OF COMPOSITES **9**

Carbon /carbon composites - Advantages of carbon matrix - limitations of carbon matrix Carbon fibre - Chemical vapour deposition of carbon on carbon fibre perform. Sol-gel technique. Composites for aerospace applications. Testing of Composite Materials.

Total : 45

TEXT BOOKS

1. Mathews F.L. and Rawlings R.D., "Composite materials: Engineering and Science", Chapman and Hall, London, England, 1st edition, 1994.
2. Chawla K.K., "Composite materials", Springer - Verlag, 1987

REFERENCES

1. Clyne T.W. and Withers P.J., "Introduction to Metal Matrix Composites", Cambridge University Press, 1993.
2. Strong A.B., "Fundamentals of Composite Manufacturing", SME, 1989.
3. Sharma S.C., "Composite materials", Narosa Publications, 2000.
4. "Short Term Course on Advances in Composite Materials, Composite Technology Centre, Department of Metallurgy", IIT- Madras, December 2001.

PAU706 COMPUTATIONAL FLUID DYNAMICS

L	T	P	C
3	0	0	3

GOALS

To introduce numerical modeling and its role in the field of heat transfer and fluid flow. To enable the students to understand the various discretization methods and solving methodologies. To create confidence to solve complex problems in the field of heat transfer and fluid dynamics by using high speed computers.

OBJECTIVES

The course should enable the students to:

1. To introduce numerical modelling and its role in the field of heat transfer and fluid flow.
2. To enable the students to understand the various discretisation methods and solving methodologies.
3. To create confidence to solve complex problems in the field of heat transfer and fluid dynamics by using high speed computers.

OUTCOME

The students should be able to:

1. Know the equations governing fluid flow and heat transfer.
2. Understand the process of converting the PDE to difference equations using various discretisation techniques.
3. Appreciate the tools available for solving the algebraic equations.
4. Appreciate the problems associated with discretisation of incompressible flow
5. Solve the practical problems associated with Fluid Flow and Heat Transfer using commercial software.

UNIT I GOVERNING EQUATIONS AND BOUNDARY CONDITIONS 9

Basics of computational fluid dynamics - Governing equations of fluid dynamics - Continuity, Momentum and Energy equations - Chemical species transport - Physical boundary conditions - Time-averaged

equations for Turbulent flow - Turbulence -Kinetic -Energy Equations - mathematical behavior of PDEs on CFD: Elliptic, Parabolic and Hyperbolic equations.

UNIT II DISCRETIZATION AND SOLUTION METHODOLOGIES 9

Methods of Deriving the Discretization Equations - Taylor Series formulation - Finite difference method - Control volume Formulation - Spectral method. Solution methodologies: Direct and iterative methods, Thomas algorithm, Relaxation method, Alternating Direction Implicit method.

UNIT III HEAT CONDUCTION, CONVECTION AND DIFFUSION 9

Finite difference and finite volume formulation of steady/transient one-dimensional conduction equation, Source term linearization, Incorporating boundary conditions, Finite volume formulations for two and three dimensional conduction problems, Finite volume formulation of steady one-dimensional convection and Diffusion problems, Central, Upwind, Hybrid and power-law schemes - Discretization equations for two dimensional convection and diffusion.

UNIT IV CALCULATION OF FLOW FIELD 9

Representation of the pressure - Gradient term and continuity equation - Staggered grid - Momentum equations - Pressure and velocity corrections - Pressure - Correction equation, SIMPLE algorithm and its variants. Turbulence models: Mixing length model, Two equation (k-) models.

UNIT V APPLICATION AND ANALYSIS OF CFD 9

Case Studies: Thermal Analysis on flow of Lubrication, Fuel and Coolant Flow, Thermal analysis of Engine Compartment and extreme flow conditions

Total : 45

TEXT BOOKS

1. Versteeg, H.K, and Malalasekera, W., "An Introduction to Computational Fluid Dynamics: The Finite Volume Method", Longman, 1998
2. Ghoshdastidar, P.S., "Computer Simulation of flow and heat transfer", Tata McGraw-Hill Publishing Company Ltd., 1998.

REFERENCES

1. Patankar, S.V., "Numerical Heat Transfer and Fluid Flow", McGraw-Hill, 1980. Ane-Books2004 Indian Edition.
2. Muralidhar, K and Sundarajan .T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 1995.
3. Bose, T.K., "Numerical Fluid Dynamics", Narosa publishing House, 1997.
4. Muralidhar, K and Biswas "Advanced Engineering Fluid Mechanics", Narosa Publishing House, New Delhi, 1996.
5. Anderson, J.D., "Computational fluid dynamics - the basics with applications", 1995

PAU707 FINITE ELEMENT METHODS IN AUTOMOBILES

L	T	P	C
3	0	0	3

GOAL

To understand the principles involved in discretization and finite element approach and to learn to form stiffness matrices and force vectors for simple elements

OBJECTIVES

The course should enable the students to:

1. Understand the basics of Engineering problems ,Mathematical modeling of FEA
2. Understand the finite element formulations of Boundary Value problems.
3. Understand ONE dimensional FEA
4. Understand TWO dimensional FEA
5. Understand Dynamic Analysis using FEM

OUTCOME

The students should be able to:

1. To know the various engineering problems, formulate mathematical modeling and know engineering applications of FEA. .To know about various methods like Weighted residual methods, General weighted residual statement, Weak formulation of the weighted residual for formulations of Boundary Value Problem
2. To know about statement, Comparisons, Piecewise continuous trial functions like a bar finite element. To know functional and differential forms of Principle of stationary total potential, Rayleigh Ritz method , Piecewise continuous trial functions To know finite element method and Choice of the elements
3. To know general form of total potential for 1-D applications , Generic form of finite element equations To know various bar elements like Linear element, Quadratic element, To know Nodal approximation , Development of shape functions To know to solve Truss and Beam element problems.
4. To know approximation of geometry and field variable of 3 nodded triangular elements, Four nodded rectangular elements , Higher order elements .To know Generalized coordinates approach to nodal approximations, Difficulties To know Natural coordinates and coordinate transformations To know triangular and quadrilateral elements and Iso-parametric elements
5. To know Structural mechanics applications in 2-dimensions - Elasticity equations , Stress strain relations , Plane problems of elasticity, Element equations -,Assembly. To know need for quadrature formulae, Transformations to natural coordinates To know Gaussian quadrature and solving problems in plane stress, plane strain and axi symmetric applications.

INTRODUCTION (Not for examination) **5**

Solution to engineering problems - mathematical modeling - discrete and continuum modeling - need for numerical methods of solution - relevance and scope of finite element methods - engineering applications of FEA.

UNIT I INTRODUCTION TO FINITE ELEMENT FORMULATION OF BOUNDARY VALUE PROBLEMS **9**

Weighted residual methods -General weighted residual statement - Weak formulation of the weighted residual statement -Comparisons - Piecewise continuous trial functions - Example of a bar finite element - Functional and differential forms - Principle of stationary total potential - Rayleigh Ritz method - Piecewise continuous trial functions - Finite element method- Choice of the elements - Application to bar element.

UNIT II ONE DIMENSIONAL FINITE ELEMENT ANALYSIS **9**

General form of total potential for 1-D applications - Generic form of finite element equations - Linear bar element - Quadratic element -Nodal approximation - Development of shape functions - Element matrices and vectors - Example problems - Extension to plane truss- Development of element equations - Assembly - Element connectivity - Global equations - Solution methods - Beam element - Nodal approximation - Shape functions - Element matrices and vectors - Assembly - Solution - Example problems.

UNIT III TWO DIMENSIONAL FINITE ELEMENT ANALYSIS **9**

Introduction - Approximation of geometry and field variable - 3 nodded triangular elements - Four nodded rectangular elements - Higher order elements - Generalized coordinates approach to nodal approximations - Difficulties - Natural coordinates and coordinate transformations - Triangular and quadrilateral elements - ISO-parametric elements - Structural mechanics applications in 2-dimensions - Elasticity equations - Stress strain relations - Plane problems of elasticity - Element equations - Assembly - Need for quadrature formule - Transformations to natural coordinates - Gaussian quadrature - Example problems in plane stress, plane strain and ax symmetric applications.

UNIT IV DYNAMIC ANALYSIS USING FINITE ELEMENT METHOD **9**

Introduction - Vibrational problems - Equations of motion based on weak form - Longitudinal vibration of bars - Transverse vibration of beams - Consistent mass matrices - Element equations - Solution of eigenvalue problems - Vector iteration methods - Normal modes - Transient vibrations - Modeling of damping - Mode superposition technique - Direct integration methods.

UNIT V APPLICATIONS IN HEAT TRANSFER & FLUID MECHANICS **9**

One dimensional heat transfer element - Application to one-dimensional heat transfer problems- Scalar variable problems in 2-Dimensions - Applications to heat transfer in 2-Dimension - Application to problems in fluid mechanics in 2-D.

Total : 45

TEXT BOOKS

1. Chandrupatla T.R., and Belegundu A.D., Introduction to Finite Elements in Engineering, Pearson Education 2002, 3rd Edition.
2. David V Hutton "Fundamentals of Finite Element Analysis"2004. McGraw-Hill Int. Ed.
3. P.Seshu, "Text Book of Finite Element Analysis", Prentice-Hall of India Pvt. Ltd., New Delhi, 2007. ISBN-978-203-2315-5.

REFERENCES

1. Rao S.S., The Finite Element Method in Engineering, Pergammon Press, 1989
2. Logan D.L., A First course in the Finite Element Method, Third Edition, Thomson Learning, 2002.
3. Robert D.Cook., David.S, Malkucs Michael E Plesha , "Concepts and Applications of Finite Element Analysis", 2003.
4. Ed. Wiley.Reddy J.N., An Introduction to Finite Element Method, McGraw-Hill International Student Edition, 1985.
5. O.C.Zienkiewicz and R.L.Taylor, The Finite Element Methods, Vol.1. The basic formulation and linear problems, Vol.1, Butterworth Heineman, 5th Edition, 2000.
6. J.N.Reddy, "An Introduction to the Finite Element Method", McGraw-Hill International Editions (Engineering Mechanics Series), 1993.ISBN-0-07-051355-4

PAU708 AUTOMOTIVE INSTRUMENTATION AND EMBEDDED SYSTEMS

L	T	P	C
3	0	0	3

GOAL

To make the students to understand the instruments involved in measurement of various automotive parameters and a basic knowledge on embedded systems.

OBJECTIVES

The course should enable the students to:

1. Understand measurement characteristics.
2. Understand the working of automotive instruments.
3. Know about the measurement analysis.
4. Understand the working of embedded systems.
5. Understand the working of real time operating system(RTOS)

OUTCOME

The students should be able to:

1. Describe the classification of instrument and characteristics of instruments.

2. Describe the static and dynamic analysis, experimental error analysis, and statistical analysis.
3. Describe the working of modern automotive instrumentation and computerized instrumentation system.
4. Describe the measurements of fuel quantity, coolant temperature, oil pressure, vehicle speed.
5. Describe the working of display devices and information system
6. Describe the operation of onboard and off board diagnostics, occupant protection system and warning system
7. Describe the working of gas analyzers, smoke tester, gas chromatography and spectrometry
8. Describe the measurement of pH and review of basic measurement techniques.
9. Describe the working of serial communication using i2c,CAN,USB buses and parallel communication using ISA,PCI
10. Describe the basics of basic concepts of RTOS, basics of real time and embedded system operating systems.

UNIT I MEASUREMENT CHARACTERSTICS **9**

Instrument Classification, Characteristics of Instruments - Static and dynamic, experimental error analysis, Systematic and random errors, Statistical analysis, Uncertainty, Experimental planning and selection of measuring instruments, Reliability of instruments.

UNIT II AUTOMOTIVE INSTRUMENTATION **9**

Modern automotive instrumentation - Computerized instrumentation system, multiplexing, sampling and advantages - Measurements - Fuel quality, coolant temperature, oil pressure vehicles speed. Display devices - LED, LCD, VFD, CRT and types, CAN network, the glass cockpit and information system.

Onboard diagnostics - Fault code displays. Off board diagnostics - Engine data display, expert system occupant protection system - Airbag deployment system security and warning systems.

UNIT III MEASUREMENT ANALYSIS **9**

Chemical, thermal, magnetic and optical gas analysers, measurement of smoke, dust and moisture, gas chromatography, spectrometry, measurement of pH, Review of basic measurement techniques.

UNIT IV INTRODUCTION TO EMBEDDED SYSTEM **9**

Introduction to functional building blocks of embedded systems - Register, memory devices, ports, timer, interrupt controllers using circuit block diagram representation for each categories - Devices & buses for devices network - Serial communication using I2C, CAN, USB buses - parallel communication using ISA, PCI - device drivers in a system - Serial port & parallel port.

UNIT V REAL TIME OPERATING SYSTEM (RTOS) **9**

Introduction to basic concepts of RTOS, Basics of real time & embedded system operating systems,

RTOS - Interrupt handling, task scheduling; embedded system design issues in system development process - Action plan, use of target system, emulator, use of software tools.

Total: 45

TEXT BOOKS

1. William B.Riddens -Understanding Automotive Electronics, 5th edition- Butter worth Heinemann Woburn- 1998
2. Rajkamal, 'Embedded System - Architecture, Programming, Design', Tata McGraw Hill, 2003.
3. Daniel W. Lewis 'Fundamentals of Embedded Software', Prentice Hall of India, 2004.
4. Holman, J.P., Experimental methods for engineers, McGraw-Hill, 1988
5. Raman, C.S., Sharma, G.R., Mani, V.S.V., Instrumentation Devices and Systems, Tata McGraw Hill, New Delhi, 1983.

REFERENCES

1. Bechhold- Understanding Automotive Electronics- SAE- 1998.
2. David E. Simon, 'An Embedded Software Primer', Pearson Education, 2004.
3. Frank Vahid, 'Embedded System Design - A Unified hardware & Software Introduction',John Wiley, 2002.
4. Sriram V. Iyer, Pankaj Gupte, 'Embedded Real Time Systems Programming', Tata McGraw Hill, 2004.
5. Steve Heath, 'Embedded System Design', II edition, Elsevier, 2003.
6. Doeblin, Measurement System Application and Design, McGraw Hill, 1978.

PAU709 MODERN VEHICLE TECHNOLOGY

L	T	P	C
3	0	0	3

GOAL

At the end of the course students will be able to know The recent trends in power plants, Noise and pollution control in automobiles, Vehicle operation and control and Vehicle automated tracks.

OBJECTIVES

The course should enable the students to:

1. Understand the trends in power plants
2. Understand the Suspension brakes and safety.
3. Conceive the significance of emission control methods.
4. Understand the vehicle operation and control
5. Understand the vehicle automated tracks

OUTCOME

The students should be able to:

1. Know about the hybrid vehicles, battery vehicles and magnetic track vehicles.
2. Describe the working of stratified charged/lean burn engines and hydrogen engines.
3. Describe the working of air suspension and closed loop suspension system.
4. Describe the working of antiskid braking system, regenerative braking safety cage and passenger comfort system.
5. Describe the internal and external pollution control through alternate fuels and power plants.
6. Describe the working of catalytic converters and particulate filters.
7. Describe about noise pollution, measurement and control.
8. Describe the computer control for pollution and noise control for fuel economy.
9. Describe the working of transducers, actuators and information technology for receiving proper information and operation of the vehicle like optimum speed and direction.
10. Describe the preparation and maintenance of proper road network and national highway network with automated roads and vehicles.
11. Describe the working of vehicle operation for safe and fast travel by using satellite.

UNIT I TRENDS IN POWER PLANTS **9**

Hybrid vehicles - Stratified charged / lean burn engines - Hydrogen engines - Battery vehicles - Electric propulsion with cables - Magnetic track vehicles. Tuned Manifold for Race Cars

UNIT II SUSPENSION BRAKES AND SAFETY **9**

Air suspension - Closed loop suspension - Antiskid braking system, Retarders, Regenerative braking safety cage - Air bags - Crash resistance - Passenger comfort

UNIT III NOISE & POLLUTION **9**

Reduction of noise - Internal & external pollution control through alternate fuels / power plants - Catalytic converters and filters for particulate emission.

UNIT IV VEHICLE OPERATION AND CONTROL **9**

Computer control for pollution and noise control and for fuel economy - Transducers and actuators - Information technology for receiving proper information and operation of the vehicle like optimum speed and direction.

UNIT V VEHICLE AUTOMATED TRACKS **9**

Preparation and maintenance of proper road network - National highway network with automated roads and vehicles - Satellite control of vehicle operation for safe and fast travel.

Total: 45

TEXT BOOK

1. Heinz Heisler, "Advanced Vehicle Technology" - Arnold Publication.

REFERENCES

1. Beranek.L.L., Noise reduction, McGraw Hill Book Co., Inc., Newyork, 1993.
2. Bosch Hand Book, 3rd Edition, SAE, 1993.

PIC707 SIMULATION OF IC ENGINES

L	T	P	C
3	0	0	3

GOAL

To understand combustion phenomenon inside the cylinder and its computer simulation.

OBJECTIVES

The subject should enable the student to

1. Understand the C/H/N/O system, flame temperature, the different types of reaction occurring in an engine, while combustion.
2. Understand the simulation in an SI engine with fuel air as working medium.
3. Know about how the pressure is being getting developed in an engine.
4. Understand the simulation of a 2 stroke engine.
5. Understand the simulation in an CI engine with fuel air as working medium.

OUTCOME

The students should be able to:

1. Know about the heat of reaction in an engine.
2. Know about how the complete combustion occurring in an engine.
3. Know about the adiabatic flame temperature for constant volume and constant pressure process for combustion.
4. Know the deviation between an actual and an air standard cycle of an IC engine.
5. Know the concept of fuel vaporization and its effect in the performance of an engine during combustion.
6. Know the working of an engine during part-throttle and full throttle condition.
7. Know the concept of progressive combustion, gas exchange process during combustion.
8. Know how the computer coding is done to understand the concept of combustion in an IC engine.

9. Know about the simulation in a 2 stroke engine such as scavenging.

10. Know the main difference between an SI and CI engine, and to know about the heat transfer and gas exchange process.

UNIT I INTRODUCTION **9**

Simulation principles - Simulation exercises using computers. Validation of models.

UNIT II COMBUSTION PROCESS - GENERAL **9**

Heat of reaction - Adiabatic flame temperature - Temperature change due to fuel vaporization

UNIT III COMBUSTION AND HEAT TRANSFER IN ENGINES **9**

Combustion in diesel engines - Heat transfer in engines - Heat transfer correlations.

UNIT IV C.I. AND S.I. ENGINE SIMULATION **9**

Simulation of Otto cycles under full load and part load and supercharged conditions.

UNIT V TWO STROKE ENGINE SIMULATION **9**

Engine and Porting geometry, Gas flow, Scavenging.

Total : 45

TEXT BOOKS

1. Ganesan.V - Computer Simulation of spark ignition engine process, - Universities Press (I) Ltd, Hyderabad - 1996.

2. Ganesan .V - Computer Simulation of compression ignition engine process - Universities Press (I) Ltd., Hyderabad - 2000.

REFERENCES

1. Ashley S. Campbell, Thermodynamic Analysis of Combustion Engines, John Wiley and Sons, 1980.

2. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 1995.

3. V.Ganesan, Computer Simulation of Compressed Ignition Engine Processes, Universities Press, 2002..

4. Gordon P. Blair, The Basic Design of two-Stroke engines, SAE Publications, 1990.

5. Horlock and Winterbone, The Thermodynamics and Gas Dynamics of Internal Combustion Engines, Vol. I & II, Clarendon Press, 1986.

6. J.I.Ramos, Internal Combustion Engine Modeling, Hemisphere Publishing Corporation, 1989.

7. J.N.Mattavi and C.A.Amann, Combustion Modeling in Reciprocating Engines, Plenum Press, 1980.

PAU710 ADVANCED THEORY OF I.C. ENGINES

L	T	P	C
3	0	0	3

GOAL

To provide the students with the understanding of the significance of various process in IC Engines.

OBJECTIVES

The course should enable the student to:

1. Develop knowledge in various cycles, such as otto, diesel stirling and brayton cycles.
2. Understand the combustion process in engines.
3. Learn about the basic concepts of engine simulation.
4. Learn advances in I.C. engines.
5. Know about various electronics used in engines.

OUTCOME

The students should be able to:

1. Compare with various cycles with actual cycles..
2. Be familiar with combustion reactions and stiochiometry.
3. Optimize the concepts of engine simulation governing equations.
4. Evaluate performance and emission characteristics of engines
5. Apply appropriate electronic system in engine to needs.

UNIT I CYCLE ANALYSIS **9**

Otto, Diesel, dual, Stirling and Brayton cycles, Comparison of air standard, Fuel air and actual cycles, Simple problems on the above topics.

UNIT II COMBUSTION **9**

Combustion reactions and stoichiometry, Heat of reaction, adiabatic flame temperature in constant pressure and constant volume systems, Fuels for internal combustion engines and their properties, Premixed and diffusion combustion as applicable to SI and CI engines, Concepts of burning rate and flame velocity, Fuel spray characteristics and combustion in diesel engines.

UNIT III COMBUSTION MODELLING **9**

Basic concepts of engine simulation, Governing equations, Simulation of various engine processes for SI and CI engines. Adiabatic flame temperature, Heat release calculations. Thermodynamic and Fluid mechanic based models.

UNIT IV ADVANCES IN IC ENGINES **9**

LHR engines, Surface ignition concept and multi fuel engines, Stratified charge and lean burn engines, Performance and emission characteristics, Merits and demerits.

UNIT V ELECTRONIC ENGINE MANAGEMENT **9**

Computer control of SI & CI engines for better performance and low emissions, Closed loop control of engine parameters of fuel injection and ignition, Combined ignition and fuel management systems. Digital control techniques - Dwell angle calculation, Ignition timing calculation and Injection duration calculation

Total : 45

TEXT BOOKS

1. Ganesan .V - "IC Engines" - Tata McGraw-Hill, 2003.
2. John B. Heywood, "Internal Combustion Engine Fundamentals", McGraw-Hill Automotive Technology Series ISBN 0-07-1000499-8, 1988.

REFERENCES

1. Ganesan .V - 'Computer Simulation of Spark Ignition Processes' - Universities Process Ltd, Hyderabad - 1993.
2. Ganesan.V. - Computer Simulation of compression ignition engines - Orcent Longman - 2000.
3. Richard Stone - "Introduction to IC Engines" - 2nd edition - Macmilan - 1992.

PAU711 AUTOMOTIVE AERODYNAMICS

L	T	P	C
3	0	0	3

GOAL

To provide the students with basic principles of aerodynamics for the design of vehicle body.

OBJECTIVES

The course should enable the students to:

1. Understand the fundamentals of fluid mechanics related to vehicles.
2. Understand the aerodynamics drag of cars.
3. Learn about the shape optimization of cars.
4. Equip with the knowledge of vehicle handling.
5. Understand the principle of wind tunnel technology.

OUTCOME

The students should be able to:

1. Deal with various flow phenomenon related to vehicles.
2. Be familiar with types of drag force and be able to analyze aerodynamic drag.
3. Optimize various shape configurations in automobiles.

4. Learn in detail about vehicle handling.

5. Involve the principle of wind tunnel technology and also various measurement techniques involved in it.

UNIT I INTRODUCTION **9**

Scope, historical developments, fundamental of fluid mechanics, flow phenomenon related to vehicles, external and Internal flow problem, resistance to vehicle motion, performance, fuel consumption and performance potential of vehicle aerodynamics, engine cooling requirement, air flow to passenger compartment, duct for air conditioning, cooling of transverse engine and rear engine.

UNIT II AERODYNAMIC DRAG OF VEHICLE **9**

LCV and HCV as a bluff body, flow field around Vehicle, drag force, types of drag force, analysis of aerodynamic drag, drag coefficient of cars, strategies for aerodynamic development, low drag profiles.

UNIT III SHAPE OPTIMIZATION OF CARS **9**

Front end modification, front and rear wind shield angle, boat tailing, hatch back, fast back and square back, dust flow patterns at the rear, effects of gap configuration, effect of fasteners.

UNIT IV VEHICLE HANDLING **9**

The origin of forces and moments on a vehicle, lateral stability problems, methods to calculate forces and moments - vehicle dynamics under side winds, the effects of forces and moments, characteristics of forces and moments, dirt accumulation on the vehicle, wind noise, drag reduction in commercial vehicles.

UNIT V WIND TUNNELS FOR AUTOMOTIVE AERODYNAMICS **9**

Introduction, principle of wind tunnel technology, limitation of simulation, stress with scale models, full scale wind tunnels, measurement techniques, equipment and transducers, road testing methods, numerical methods.

Total : 45

TEXT BOOK

1. Hucho.W.H. - "Aerodynamic of Road Vehicles" - Butterworths Co., Ltd., - 1997.

REFERENCES

1. A. Pope - "Wind Tunnel Testing"- John Wiley & Sons - 2nd Edition, New York - 1974.

2. Automotive Aerodynamic: Update SP-706 - SAE - 1987

3. Vehicle Aerodynamics - SP-1145 - SAE - 1996.

PAU712 VEHICLE MAINTENANCE

GOAL

At the end of the course, the students will be able to have a complete knowledge of the vehicle maintenance procedures and acquire skills in handling situations where the vehicle is likely to fail.

OBJECTIVES

The course should enable the students to:

1. Understand the complete knowledge of the vehicle maintenance procedures and acquire skills in handling situations where the vehicle is likely to fail.
2. Understand various types of maintenance of vehicles and features and applications.
3. Objective of the preventive maintenance program is to minimize breakdowns, unscheduled repairs, and undue wear and tear.
4. Ensure maximum vehicle availability for customers with minimum interruptions due to unscheduled repairs and breakdowns.
5. Minimize the consumption of petroleum based fuels and assure fuel security and accountability;
6. Minimize the cost of fuel used by the fleet and provide safe, convenient fueling access for fleet customers.

OUTCOME

The students should be able to:

1. Differentiate various layouts, analyze the merits and limitations and apply in real time.
2. Dismantle study, perform corrections and assemble the various parts of the vehicle.
3. Describe the maintenance procedures of various systems like steering systems, braking system, suspension system and engine etc.
4. Dismantle study, rectify and assemble drive line system, final drive and differential, rear axle, wheels and tires, suspension and brake systems.
5. Realize effects of maintenance and minimize the consumption of petroleum based fuels.
6. Describe the maintenance procedures of various electrical systems like battery, starter motor, alternator, D.C motor etc.
7. Be familiar with maintenance procedures of engine, cooling system and lubrication system, checking and servicing of dash board instruments.
8. Be familiar with wheel alignment, computerized alignment and wheel balancing, and door locks and window glass actuating system maintenance.

UNIT I MAINTENANCE OF RECORDS AND SCHEDULES 9

Importance of maintenance, preventive (scheduled) and breakdown (unscheduled) maintenance, requirements of maintenance, preparation of check lists. Inspection schedule, Maintenance of records, log sheets and other forms, safety precautions in maintenance.

UNIT II POWER PLANT REPAIR AND OVERHAULING 9

Dismantling of power plant and its components. Cleaning methods. Inspection and checking. Repair and reconditioning methods for all engine components. Maintenance of ignition system, fuel injection system, cooling system,- lubrication system. Power plant trouble shooting chart.

UNIT III MAINTENANCE, REPAIR AND OVERHAULING OF THE CHASSIS 9

Maintenance, servicing and repair of clutch, fluid coupling, gearbox, torque converter, propeller shaft. Maintenance of front axle, rear axle, brakes, steering systems. Tyre maintenance.

UNIT IV MAINTENANCE AND REPAIR OF VEHICLE BODY 9

Body panel tools for repairing. Tinkering and painting. Use of soldering, metalloid paste.

UNIT V MAINTENANCE AND REPAIR OF ELECTRICAL SYSTEMS 9

Care, maintenance, testing and trouble shooting of battery, starter motor, dynamo, alternator and regulator. Transistorized regulator problems.

Total : 45

TEXT BOOK

1. John Doke "Fleet Management", McGraw-Hill Co. 1984.
2. A.W.Judge, Motor Vehicle Servicing, 3rd Edition, Pitman Paperpack, London , 1969.
3. W.Crouse, Everyday Automobile repair, Intl.student edition, TMH, New Delhi, 1986.
4. Ernest Venk., Edward spicer, Automotive maintenance and trouble shooting, D.B. Taraporevala Sons, Bombay, 1963

REFERENCE

1. James D Halderman - Advanced Engine Performance Diagnosis - PHI - 1998. Service Manuals from Different Vehicle Manufacturers
2. Stator Abbey, Automotive steering, braking and suspension overhaul, pitman publishing, London, 1971.
3. Frazee, fledell, Spicer,-Automobile collision Work, American technical publications, Chicago, 1953.
4. John Dolce, Fleet maintenance, Mcgraw Hill, Newyork, 1984
5. A,W.Judge, Maintenance of high speed diesel engines, Chapman Hall Ltd., London, 1956.
6. V.L.Maleev, Diesel Engine operation and maintenance, McGraw Hill Book CO., Newyork, 1995.
7. Vehicle servicing manuals.
8. Ernest Venk., Edward spicer, Automotive maintenance and trouble shooting, D.B. Taraporevala Sons, Bombay, 1963
9. S. Abbey, Automotive Transmission servicing and overhaul, Sir Issac Pitman, London, 1971.

PAU713 MODERN AUTOMOBILE ACCESSORIES

L	T	P	C
3	0	0	3

GOAL

To impart knowledge about the various advances, improvements, construction & application of accessories in a modern automobile.

OBJECTIVES

The course should enable the students to:

1. Understand the use of Electronics in the Fuel delivery in SI & CI engines.
2. Understand the Ignition (Closed loop) system, Catalytic convertor & Particulate traps.
4. Know about the air conditioning & heating systems.
3. Know about the Pneumatic & active suspension control system.
5. Gain knowledge about various safety & security systems such as Airbags, Seat belts, ABS, EBS.
6. Know about various Comfort systems such as Navigation systems, power steering, power windows etc.

OUTCOME

The students should be able to:

1. Understand & Analyze the working & advantage of the use of Electronics in Fuel delivery systems.
2. Be familiar with the working of Emission control systems & its merits.
3. Understand the concept & working of the Air conditioning and also the components involved.
4. Explain the Suspension & its control systems.
5. Be familiar with the various safety systems & its modern evolutions such as Airbags, Seat belts, ABS.
6. Understand the components involved and the working of various comfort systems in the modern automobile.

UNIT I ENGINE MANAGEMENT SYSTEMS **9**

Electronically controlled SI and CI engine fuel injection systems, related hardware and software. Closed loop ignition system. Catalytic converters and particulate traps.

UNIT II CHASSIS **9**

Active suspension control, Pneumatic suspensions. Rheological Suspension, Electronic Braking System, Fail safe Braking System, ABS

UNIT III HEATING AND AIR CONDITIONING **9**

Principles of vehicle air conditioning and heating. Vapor Absorption Air conditioning, vapor compression air conditioning CO, CO2 level monitoring inside the cabin

UNIT IV COMFORT AND CONVENIENCE **9**

Adaptive cruise control, car entertainment, power windows, navigation system, adaptive noise control, electric seats, driver information system. power windows, power steering.

UNIT V SAFETY AND SECURITY SYSTEMS **9**

Airbags, seat belt tightening system, collapsible and tiltable steering column, Anti theft system, anti lock braking system, electronic stability control system/traction control system, roll over protection system.

Total : 45

TEXT BOOKS

1. Tom Denton - "Automobile Electrical and Electronic Systems" - Edward Arnold, London - 1995.
2. Eric Chowanietz - 'Automotive Electronics' - SAE International USA - 1995.

REFERENCE

1. Bosch Automotive Hand Book - 5th Edition - SAE Publication, USA - 2000.

PAU 714 ALTERNATIVE FUELS AND ENERGY SYSTEM

L	T	P	C
3	0	0	3

GOAL

To provide the students with the knowledge of alternate fuels and the changes in the engine design and to understand various energy systems for use in the automobiles.

OBJECTIVES

The course should enable the students to:

1. Gain knowledge of various alternate fuels.
2. Understand properties, performance and emission characteristics of Alcohols.
3. Know about Natural gas, LPG, hydrogen and biogas.
4. Study in depth of various vegetable oils used for engines.
5. Know about Electric vehicle.

OUTCOME

The students should be able to:

1. Apply various alternate fuels appropriately to the needs.

2. Learn in details about methanol and ethanol usage, storage, chemical structure, pros and cons.

3. Be acquainted with the knowledge of natural gas, LPG, hydrogen and biogas.

4. Evaluate the performance characteristics of various vegetable oils.

5. Be familiar with electric and hybrid vehicles.

UNIT I INTRODUCTION **9**

Need for alternate fuel, Availability and properties of alternate fuels, general use of alcohols, LPG, Hydrogen, Ammonia, CNG and LNG, Vegetable oils and biogas, Merits and demerits of various alternate fuels, Introduction to alternate energy sources. Like EV, Hybrid, Fuel cell and solar cars.

UNIT II ALCOHOLS AND OXYGENATES **9**

Properties as engine fuel, Alcohols and gasoline blends, Performance in SI engine, Methanol and gasoline blends, Combustion characteristics in CI engines, Emission characteristics, Oxygenates, Performance in SI & CI Engines.

UNITIII NATURAL GAS, LPG, HYDROGEN AND BIOGAS **9**

Availability of CNG, properties, Modification required using in engines, Performance and emission characteristics of CNG using LPG in SI & CI engines, Performance and emission of LPG. Hydrogen; Storage and handling, Performance and safety aspects.

UNIT IV VEGETABLE OILS **9**

Various vegetable oils for engines, Esterification, Performance in engines, Performance and emission characteristics, Bio diesel and its characteristics

UNIT V ELECTRIC, HYBRID, FUEL CELL AND SOLAR CARS **9**

Layout of an electric vehicle, Advantage and limitations, Specifications, System components, Electronic control system, High energy and power density batteries, Hybrid vehicle, Fuel cell vehicles, Solar powered vehicles.

Total : 45

TEXT BOOK

1. Richard.L.Bechfold - Alternative Fuels Guide Book - SAE International Warrendale - 1997.

REFERENCES

1. Maheswar Dayal - "Energy today & tomorrow" - I & B Horishr India - 1982.

2. Nagpal - "Power Plant Engineering" - Khanna Publishers - 1991.

3. " Alcohols as motor fuels progress in technology" - Series No.19 - SAE Publication USE - 1980.

4. SAE paper nos. 840367, 841333, 841334, 841156, Transactions, SAE, USA.

PAU715 FUEL CELLS AND APPLICATIONS

L	T	P	C
3	0	0	3

GOAL

To impart knowledge about the concept & working of the Fuel Cells, its construction, types and its application in automobiles, impact on its performance.

OBJECTIVES

The course should enable the students to:

1. Understand various types of Fuel Cells, its principle, construction & working.
2. Understand the automotive applications of Fuel Cells, improvements & advances & commonly used types.
3. Know about the various components & its performance characteristics in a fuel cell vehicle.
4. Gain knowledge about the different types of fuels used in Fuel Cells and the concept of Fueling.
5. Do an analysis & comparative study of fuel cells with other types of alternate fuels.

OUTCOME

The students should be able to:

1. Understand the types & working of different types of Fuel Cells.
2. Analyze the thermodynamics & electrochemical kinetics of fuel cells.
3. Be familiar with the automotive applications of Fuel Cells.
4. Update himself to the current advances in Fuel Cell Vehicle Technologies.
5. Be familiar with the various components of the fuel cells
6. Understand the performance characteristics of the Fuel cells.
7. Be familiar with the various types of Fueling techniques followed in the Fuel cells.
8. Do a comparative study of the Fuel cells with other Alternate Fuels.

UNIT I FUEL CELLS TYPES **9**

Introduction - working and types of fuel cell - Polymer Electrolyte Membrane (PEM) Fuel Cells Direct Methanol Fuel Cells, Phosphoric Acid Fuel Cells, Molten Carbonate Fuel Cells, Solid Oxide Fuel Cells, Regenerative Fuel Cells Alkaline Fuel Cells - low, medium and high temperature fuel cell, Liquid and methanol types, Proton exchange membrane fuel cell solid oxide, Hydrogen fuel cells - Thermodynamics and electrochemical kinetics of fuel cells.

UNIT II FUEL CELLS FOR AUTOMOTIVE APPLICATIONS **9**

Fuel cells for automotive applications - Technology advances in fuel cell vehicle systems - Onboard hydrogen storage - Liquid hydrogen and compressed hydrogen - Metal hydrides, Fuel cell control system - Alkaline fuel cell - Road map to market.

UNIT III FUEL CELL COMPONENTS AND THEIR IMPACT ON PERFORMANCE 9

Fuel cell performance characteristics - Current/voltage, Voltage efficiency and power density, ohmic resistance, Kinetic performance, Mass transfer effects - Membrane electrode assembly components, Fuel cell stack, Bi-polar plate, Humidifiers and cooling plates.

UNIT IV FUELING 9

Hydrogen storage technology - Pressure cylinders, Liquid hydrogen, Metal hydrides, Carbon fibers - Reformer technology - Steam reforming, Partial oxidation, Auto thermal reforming - CO removal, Fuel cell technology based on removal like bio-mass.

UNIT V FUEL CYCLE ANALYSIS 9

Introduction to fuel cycle analysis - Application to fuel cell and other competing technologies like battery powered vehicles, SI engine fueled by natural gas and hydrogen and hybrid electric vehicle.

Total : 45

TEXTBOOKS

1. Fuel Cells for automotive applications - professional engineering publishing UK. ISBN 1-86058 4233, 2004.
2. Fuel Cell Technology Handbook SAE International Gregor Hoogers CRC Press ISBN 0-8493-0877-1-2003.

PAU716 RUBBER TECHNOLOGY FOR AUTOMOBILES

L	T	P	C
3	0	0	3

GOAL

To suppress vibration characteristic of the moving vehicle to get better ride and handling characteristics using of Rubber

OBJECTIVES

The course should enable the students to:

1. Understand the various plastics and rubber materials used for selection process in Automobile Components.
2. Understand the physical characteristics of rubbers.
3. Understand the vibration observing principle and design calculation.
4. Study the sealing property and mechanism of rubber components in Automobiles.
5. Study various types of rubber component manufacturing.

OUTCOMES

The students should be able to:

1. Select the rubber component according to the suitable design criteria. .
2. Grouping of materials according to property of the selection.
3. Calculate complete design of the rubber components for the vibration isolation.
4. Use the components to various sealing areas..
5. Deeper knowledge in manufacturing of rubber components.

UNIT I INTRODUCTION **9**

Identification of plastics / rubber components in automobiles - function - selection criteria.

UNIT II STRUCTURE-PROPERTY RELATIONSHIP OF RUBBER **9**

Resilience, creep, hysteresis and damping, stability, set and stress relaxation, behavior in dynamic applications.

UNIT III VIBRATION AND RUBBER SPRING **9**

Principle of vibration isolation - rubber mounts - spring design - comparison with metallic springs - shape factor and its effect - forced and free vibrations with damping - typical mounts, compounding and manufacture.

UNIT IV FLUID SEALINGS AND FLEXIBLE COUPLINGS AND HOSES **9**

Seals for static and dynamic applications - effect of heat / oil ageing - frictional behavior - fundamental of seal ability.

UNIT V COMPOUNDING AND MANUFACTURE **9**

Types of couplings - specification and selection - torque vs deflection relationships - brake fluid / hydraulic hoses, materials and manufacture.

Total : 45

TEXTBOOK

1. Freakley,P.K., and Payne,A.R., Theory and Practice of Engineering with Rubber, Applied Science Publishers Ltd.

REFERENCES

1. Hobel,E.F., Rubber Springs Design.
2. Blow,C.M. and Hepburn,C., Rubber Technology and Manufacture.

PAU717 AUTOMOTIVE AIR CONDITIONING

L	T	P	C
3	0	0	3

GOAL

To Enable the student to understand the components of the automotive air-conditioning and their functions and the latest developments in this field.

OBJECTIVES

The course should enable the students to:

1. Understand the fundamentals of air conditioning system.
2. Be familiar with the components of automotive air conditioning system.
3. Understand the properties of the different refrigerant.
4. To motivate students to involve in air conditioner maintenance and service.

OUTCOME

The students should be able to :

1. Identify and describe the basic principles of air conditioning system.
2. Apply the concept of heating systems in air conditioner.
3. Describe the working principles of the components of the automotive air conditioning system.
4. Identify and describe the current developments relating to the automotive air conditioning.

UNIT I AIRCONDITIONING FUNDAMENTALS 9

Basic air conditioning system - Location of air conditioning components in a car, Schematic layout of a refrigeration system, Compressor components, Condenser and high pressure service ports, Thermostatic expansion valve, Expansion valve calibration, Controlling evaporator temperature, Evaporator pressure regulator, Evaporator temperature regulator.

UNIT II AIR CONDITIONER - HEATING SYSTEM 9

Automotive heaters, Manually controlled air conditioner, Heater system, Automatically controlled air conditioner and heater systems, Automatic temperature control, Air conditioning protection, Engine protection. HVAC

UNIT III REFRIGERANT 9

Containers handling refrigerants, Tapping into the refrigerant container, Refrigeration system diagnosis, Diagnostic procedure, Ambient conditions affecting system pressures.

UNIT IV AIR ROUTING AND TEMPERATURE CONTROL 9

Objectives, evaporator airflow through the re-circulating unit, Automatic temperature control, Duct system, Controlling flow, Vacuum reserve, Testing the air control and handling systems. CO, CO2 monitoring inside the cabin

UNIT V AIR CONDITINING SERVICE **9**

Air conditioner maintenance and service, Servicing heater system removing and replacing components, Trouble shooting of air controlling system, Compressor service.

Total : 45

TEXT BOOK

1. William H. Crouse and Donald L. Anglin - "Automotive Air conditioning" - McGraw Hill Inc. - 1990.

REFERENCES

1. Mitchell information Services, Inc - "Mitchell Automatic Heating and Air Conditioning Systems" - Prentice Hall Ind. - 1989.
2. Paul Weiser - "Automotive Air Conditioning" - Reston Publishing Co., Inc., - 1990.
3. MacDonald, K.I., - "Automotive Air Conditioning" - Theodore Audel series - 1978
4. Goings.L.F. - "Automotive Air Conditioning" - American Technical services - 1974.
5. Boyce H.Dwiggins - "Automotive Air Conditioning" - Delmar - 2002

PAU718 AUTOMOTIVE SENSORS AND APPLICATION

L	T	P	C
3	0	0	3

GOAL

This module enables the students to interface sensors in modern automotive electronic systems. The students will be taught automotive sensors, characterization, sensor selection, interfacing, sensing, data logging and data processing for specified applications.

OBJECTIVES

The course should enable the students to:

1. Understand the automotive instruments and sensors.
2. Understand the measurement of engine parameter by using sensor.
3. Understand the working of actuators.
4. Understand the working of chassis for sensors.
5. Understand the application of intelligent sensors.

OUTCOME

The students should be able to:

1. Describe the sensor classification and sensor product selection guide.
2. Describe the measurements of automotive sensors.

3. Describe the working of Pressure, position, flow, temperature, humidity, speed, acceleration, oxygen, torque, light, distance and level.
4. Describe the principles of actuation control.
5. Describe the working of stepper and DC motor.
6. Describe working of relays and solenoids.
7. Describe the working of adaptive cruise control, traction control, braking control, steering and stability by using sensors.
8. Describe the intelligent transport system using sensors.
9. Describe working of the lighting, wipers, climate control and electronic displays using sensors.
10. Describe the Sensors role in occupant safety.
11. Describe the working of digital vehicle and intelligent vehicle system.

UNIT I INTRODUCTION **9**

Introduction to automotive sensors and instrumentation, Market perspective for sensors and instrumentation techniques. Sensor electronics and techniques. Overview of sensor measurements .Sensor linearization and characterization. Sensor classification. Signals and systems. Sensor product selection guide.

UNIT II SENSORS FOR ENGINES **9**

Sensors and interfacing- Pressure, position, flow, temperature, humidity, speed, acceleration, oxygen, torque, light, distance and level.

UNIT III ACTUATORS AND CONTROLLERS **9**

Principles of actuation and control. DC motors, stepper motors. Relays and solenoids. Hydraulic and pneumatic, Components for electronic engine management system, open and closed loop control strategies, PID control, Look up tables, introduction to modern control strategies like Fuzzy logic and adaptive control. Parameters to be controlled in SI and CI engines

UNIT IV SENSORS FOR CHASSIS **9**

Sensors and interfacing techniques for Engine control, adaptive cruise control, braking control, traction control, steering and stability.

UNIT V INTELLIGENT SENSORS **9**

Sensors for intelligent transport systems. Lighting, wipers, climate control and electronic displays. Sensors for occupant safety .The digital vehicle. Intelligent vehicle systems

Total : 45

TEXT BOOKS

1. E Q Doebelin, Measurement Systems, Application and Design, 4th edition, McGraw-Hill, 2002

2. William B. Ribbens, Understanding Automotive Electronics, 5th edition, Newnes, 2006

3. Ronald k. Jurgen, Automotive Electronics Handbook, 2nd edition, McGraw-Hill, 2007

PAU719 ROBOTICS

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GOAL

Technological change and Automation are un avoidable in Industry. This subject enable the student to understand about Robotics, its application, components.

OBJECTIVES

The course should enable the students to:

1. Understand Automation and Robotics with preserve and future application.
2. Study the various components, constructional aspects of Industrial Robotics.
3. Understand various motions and coordinations.
4. Understand the activating system and components and sensor of a Robot.
5. Understand the application of robots in manufacturing relating to automobile industry.

OUTCOME

The students should be able to:

1 Select tools for required application.

2 Configure robots with components and devices..

3. Solve kinematics problems.
4. Able to make automation modules based on sensor in put.
5. Able to design and fabricate small robots for material handling, spray painting, spot welding, assembly, inspection etc.,

UNIT I INTRODUCTION **9**

Automation and Robotics, CAD/CAM and Robotics - An over view of Robotics - present and future applications - classification by coordinate system and control system.

UNIT II COMPONENTS OF THE INDUSTRIAL ROBOTICS **9**

Function line diagram representation of robot arms, common types of arms. Components, Architecture, number of degrees of freedom -requirements and challenges of end effectors, determination of the end effectors, comparison of Electric, Hydraulic and Pneumatic types of locomotion devices.

UNIT III MOTION ANALYSIS **9**

Homogeneous transformations as applicable to rotation and translation - problems. Manipulator Kinematics: Specifications of matrices, D-H notation joint coordinates and world coordinates Forward and inverse kinematics - problems.

UNIT IV ROBOT ACTUATORS AND FEED BACK COMPONENTS **9**

Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Feedback components: position sensors - potentiometers, resolvers, encoders - Velocity sensors.

UNIT V ROBOT APPLICATION IN MANUFACTURING **9**

Material Transfer - Material handling, loading and unloading- Processing - spot and continuous arc welding & spray painting - Assembly and Inspection.

Total: 45

TEXT BOOKS

1. Groover M P, Industrial Robotics, Pearson Edu.
2. Mittal R K & Nagrath I J, Robotics and Control, TMH.

REFERENCES

1. Robotics, Fu K S, McGraw Hill.
2. An Introduction to Robot Technology, Coiffet and M. Chaironze, Kogam Page Ltd. 1983 London.
3. Robotic Engineering, Richard D. Klafter, Prentice Hall
4. Robot Analysis and Intelligence, Asada and Slow time, Wiley Inter-Science.
5. Introduction to Robotics, John J Craig, Pearson Edu.
6. Robot Dynamics & Control - Mark W. Spong and M. Vidyasagar, John Wiley & Sons (ASIA) Pvt. Ltd.