To,

1. Controller of Examination
2. Central Library in charge

Sub – Copy of Structure and Syllabus of B.Tech. for Semester VII & VIII And M. B. A. Semester I to IV to be implemented from 2016-17.

Sir/Madam

Sending herewith, the copy of Structure and Syllabus of B.Tech. for Semester VII & VIII and M. B. A. Semester I to IV to be implemented from 2016-17.

Thanking you

Dr. M.T. Telsang
Dean Academics

CC to: -

HOD Automobile
HOD Civil
HOD C.S.E.
HOD Electrical
HOD ETC
HOD IT
HOD Mechanical
HOD Science and Humanities
HOD M.B.A.
### B.Tech. (Automobile) Semester – VII

**K. E. Society's**
**RAJARAMBAPU INSTITUTE OF TECHNOLOGY, RAJARAMNAGAR**
**Curriculum Structure**

**B.Tech. (Automobile) Semester – VII**
*(To be Implemented from Year 2016 - 17)*

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course</th>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
<th>Practical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>L</td>
<td>T</td>
<td>P</td>
<td>Credits</td>
</tr>
<tr>
<td>AE4011</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>AE4051</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Program Elective-I</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Program Elective-II</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Open Elective-I</td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>AE4531</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>AE4551</td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>AE4571</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>AE4591</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>13</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

**Total Credits : 24**  **Total Contact Hours / Week : 28 hrs**

ISE: In Semester Evaluation, MSE: Mid Semester Examination, ESE: End Semester Examination

<table>
<thead>
<tr>
<th>Program Elective – I</th>
<th>Program Elective - II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Code</td>
<td>Course</td>
</tr>
<tr>
<td>AE4071</td>
<td>Automotive NVII</td>
</tr>
<tr>
<td>AE4151</td>
<td>Vehicle Aerodynamics</td>
</tr>
<tr>
<td>AE4171</td>
<td>Motor Insurance Practices</td>
</tr>
<tr>
<td>AE4191</td>
<td>Industrial Engineering</td>
</tr>
<tr>
<td>AE4131</td>
<td>Tribology</td>
</tr>
<tr>
<td>AE4211</td>
<td>Automotive Embedded Systems</td>
</tr>
</tbody>
</table>

**Chairman (E.O.S.)**
**Automobile Engg. Dept**
**R.I.T., Rajaramnagar.**
# Curriculum Structure

**B.Tech. (Automobile) Semester – VIII**

(To be Implemented from Year 2016 - 17)

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course</th>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>AE4021</td>
<td>Automotive System Design</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE4041</td>
<td>Vellicic Dynamics</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE4021</td>
<td>Program Elective III</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE4521</td>
<td>Automotive System Design Laboratory</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AE4541</td>
<td>Ethics in Engineering Profession</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>AE4561</td>
<td>Software Proficiency</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>AE4581</td>
<td>Project Phase - II</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total</td>
<td>13</td>
</tr>
</tbody>
</table>

**Total Credits : 26  Total Contact Hours / Week : 30 hrs**

**ISE:** In Semester Evaluation, **MSE:** Mid Semester Examination, **ESE:** End Semester Examination

### Program Elective - III

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course</th>
</tr>
</thead>
<tbody>
<tr>
<td>AE4061</td>
<td>Electric and Hybrid Electric Vehicle Technology</td>
</tr>
<tr>
<td>AE4081</td>
<td>Computational Fluid Dynamics</td>
</tr>
<tr>
<td>AE4101</td>
<td>Vehicle Maintenance Management</td>
</tr>
<tr>
<td>AE4121</td>
<td>Vehicle Instrumentation and Testing</td>
</tr>
<tr>
<td>AE4141</td>
<td>Product Design and Development</td>
</tr>
<tr>
<td>AE4161</td>
<td>Special Purpose Vehicle</td>
</tr>
<tr>
<td>AE4181</td>
<td>Product Lifecycle Management</td>
</tr>
<tr>
<td>AE4201</td>
<td>Automotive Plastics and Composites</td>
</tr>
</tbody>
</table>
AE 4011 ENGINE DESIGN

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L T P Credits</td>
<td>Scheme</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3 -- -- 3</td>
<td>ISE</td>
</tr>
<tr>
<td></td>
<td>MSE</td>
</tr>
<tr>
<td></td>
<td>ESE</td>
</tr>
</tbody>
</table>

RATIONALE:
The internal combustion engines are used in a variety of purposes like automotive, power generation, marine propulsion, locomotives and for many equipments. For this course the focus is limited to automotive engine design. The engine design deals with selection of appropriate type of engine for specific application, selection of engine geometry and types of engine sub systems required for engine. The design of engine components for desired thermal and mechanical strength is essential.

COURSE LEARNING OUTCOMES:
At the end of this course, students will be able to,
1. Apply fluctuating stress theories for real life problems
2. Select proper type of engine for given requirement.
3. Design engine components like cylinder, cylinder block, piston, connecting rod, crank shaft etc.
4. Design valve, gear train, cooling and lubrication systems.
5. Select proper type of bearings.

PRE-REQUISITES:
The pre requisite for study of this subject is as follows : Must have undergone study thermodynamics, heat transfer, kinematic of the machines & mechanisms, strength of materials, internal combustion engines and the students must have adequate knowledge about graphical skills and analytical skills.

CURRICULUM

Unit 1: Design for Fluctuating Loads: 7 hrs
Fluctuating stresses, S-N diagram for fatigue loading, Endurance limit, Endurance strength modifying factors, Stress concentration-causes and remedies, Notch sensitivity, Design for finite and infinite life under reverse stresses, Cumulative damage in fatigue failures, Soderberg and Goodman diagrams, Modified Goodman diagram

(To be implemented from Year 2016-17)
Unit 2: Engine Functional Design:
Selection of engine type, Stroke & Bore, No. of cylinders, cylinder arrangement, Design considerations for Combustion chamber, Engine balancing, Selection of firing order and cooling system.

Unit 3: Engine Component Design:
Design of Crankshaft, cylinder head, cylinder block and Flywheel for multi cylinder engine

Unit 4: Design of valve gear train, cooling & lubrication system:
Design of Valve, rocker arm, Push rod, cam shaft, cam and follower, Design of radiator, water pump, Selection of lubricating oil, design of pump.

Unit 5: Design of Rolling & Sliding Contact Bearing:
Types of rolling contact bearings, static and dynamic load, Strubeck's Equation, Equivalent bearing load, load life relationship, capacities, Bearing life, Load factor, Selection of bearings from manufacturers catalogue, Lubrication and mountings, dismounting and preloading of bearings, Bearing materials and their properties, Bearing types and constructional details, Hydrodynamic theory of lubrication, Raimondi and Boyd method, Design of bearings, bearing performance parameters.

TEXT BOOKS

REFERENCE BOOKS
8. Bearing Manufacturers' Catalogues
AE 4051 FINITE ELEMENT METHOD

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L   T   P   Credits</td>
<td>Scheme</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3   --  --  3</td>
<td>ISE</td>
</tr>
<tr>
<td></td>
<td>MSE</td>
</tr>
<tr>
<td></td>
<td>ESE</td>
</tr>
</tbody>
</table>

RATIONALE:
Basically, finite element methods are a mathematical tool to solve real life problems. This subject is base for the numerical analysis of problems from different disciplines. Comparison with other analysis methods, meshing and formulation of finite element equation, structural, thermal and dynamic analysis, higher order elements is the major contents of the syllabus. As the FEM is approximate method so thumb rules for result interpretation and validation are also considered in this subject.

COURSE LEARNING OUTCOMES:
At the end of this course, students will be able to,
1. Compare FEM with other numerical methods used for engineering analysis.
2. Analyze one dimensional engineering problems by using direct approach.
3. Select appropriate elements for discretization of physical domain.
4. Perform structural, thermal and dynamic analysis using FEM.
5. Use isoparametric formulation for irregular geometries.
6. Test validity of FEA models.

PRE-REQUISITES:
The prerequisite for study of this subject from students end is that, they must have undergone calculus and matrix algebra. The students must have adequate knowledge about theory of elasticity, heat transfer and dynamics, which can be enhanced further.

CURRICULUM

Unit 1. Introduction to FEM  
6 hrs
Basic idea of FEA, Comparison with analytical and experimental methods. Comparison with other numerical methods. Steps in FEA. Direct Stiffness Method.
Discretization - Need, Types of elements, Discretization procedure, element quality checks

Unit 2: Interpolation Polynomial  
6 hrs
Displacement models, simplex, multiplex and complex elements, selection of interpolation polynomial, shape functions, Natural coordinates.

(To be Implemented from Year 2016-17)
Unit 3: Structural Analysis
Basic concepts of Elasticity, Formulation of element characteristic matrix by variational
method. Formulation of FE equation for structural analysis, 1D and 2D elasticity, Truss
analysis.

Unit 4: Thermal Analysis
Formulation of element characteristic matrix- Weighted residual method. Formulation of FE
equation for heat conduction. 1D and 2D heat conduction.

Unit 5: Dynamic Analysis
Introduction, Simple harmonic oscillator, Multi degree freedom system, axial vibration of
rod-consistent mass matrix and lumped mass matrix.

Unit 6: Higher order and isoparametric elements
Higher order 1D and 2D elements, classical interpolation polynomials, Isoparametric
elements - coordinate transformation and mapping, stiffness matrix for isoparametric
elements. Numerical integration. Beam Analysis. Result Interpretation & Verification of
FEA results.

TEXT BOOKS

1. Robert D. Cook, David S. Malkus, Concepts and Applications of FEA, John Willy &
sons,
Publications.
3. C. S. Krishnamurthy, Finite Element Analysis Theory and Programming, Tata
Delhi.

REFERENCE BOOKS

1. Nitin S. Gokhale, Practical FEA, Finite to Infinite, Pune.
Delhi.
3. Erdogan Madenci, Ibrahim Guven, FEA and Applications in Engineering using
ANSYS, Springer.
Jersey.
5. Tirupati R. Chandrupatla, Ashok D. Belegundu, Introduction to Finite Elements in
Engineering, Prentice Hall of India, New Delhi.
7. Dr. P. Seshu, Finite Element Analysis, Prentice Hall
### AE 4531 ENGINE DESIGN AND FINITE ELEMENT ANALYSIS LABORATORY

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
<th>Theory (Marks)</th>
<th>Practical (Marks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
<td>P</td>
<td>Credits</td>
</tr>
<tr>
<td>--</td>
<td>--</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>--</td>
<td>--</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

**RATIONALE:**
Half part of this laboratory course contains practical on engine design in this design of engine components and engine systems will be done. CAD Models of these systems and components will be developed in the modeling software. Again in the programming codes will developed for design of some engine components further these codes can be used for generalize and optimization of design. In second part is related to different types of analysis in analysis software. The second part is supporting the theory of finite element methods. This part covers static and dynamic structural analysis. Analysis of thermal problems will be also covered in this lab course.

**PREREQUISITE:**
Prerequisite for this laboratory course is Knowledge of concepts of component design, modeling software and Programming language. Theory of finite element methods is required for analysis software.

**COURSE LEARNING OUTCOMES**
At the end of this course, students will be able to,
1. Design the components and system of engine.
2. Develop the CAD model of engine components.
3. Write the programming codes for design of engine components.
4. Develop finite element model of the static structural problems.
5. Analyze the static and dynamic problems.
6. Analyze the steady state and transient thermal problems.

**PART – 1 ENGINE DESIGN LABORATORY**

**Term Work:**
1. CAD Modeling of existing engine in any modeling software.
2. Design of complete engine for specific application.
3. Development of programming codes for design of engine components.
4. CAD modeling of designed engine.
PART - II  FINITE ELEMENT ANALYSIS LABORATORY

Student has to perform following analysis in ANSYS

1. Static structural analysis
2. Beam analysis
3. Buckling analysis
4. Steady state thermal analysis
5. Modal analysis
6. Nonlinear analysis
7. Fluid flow analysis
8. Coupled field analysis
9. Transient thermal analysis, harmonic analysis
AE 4551 VEHICLE TESTING AND EMISSION LABORATORY

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

**RATIONALE:**
This course is offered as laboratory course at first semester of undergraduate course in Automobile Engineering. The course is designed to make the students aware about various types of measurements and testing that automotive components and automotive systems are required to undergo. It includes the experiments on performance testing of two and four wheelers. The experiments are also included for noise and vibration measurements for vehicles and automotive components. For Emission lab testing of petrol and diesel engines, testing will be carried out to measure various parameters like CO, CO₂, HC, O₂, NOₓ, etc.

**COURSE LEARNING OUTCOMES:**
At the end of the course, the learners will be able to:
1. Comprehend measurement system for automotive testing.
2. Analyze performance of two and four wheelers.
3. Select appropriate sensor for measurement of noise and vibrations in the vehicles.
4. Determine modal parameters of automotive components.
5. Analyze performance of automotive engines.
6. Analyze I. C. Engine emissions
7. Compare I. C. Engine emissions with air fuel ratio.

**PRE-REQUISITES:**
The students are expected to have thorough understanding about different vehicular systems and their functional requirements. In addition to this, they also should have necessary information on general measurement systems and their use.

**CURRICULUM**

Part A: Vehicle Testing (Any Five)

1. Performance testing of a two wheeler using chassis dynamometer
2. On road testing of a four wheeler for acceleration and braking performance
3. Modal Analysis of Automotive components
4. Measurement of noise level inside the vehicle
5. Measurement of vibration inside the vehicle
6. Measurement of damping of Automotive components
7. Application of strain gauges for automotive measurements

(To be implemented from Year 2016-17)
8. Performance testing of a shock absorber
9. Determination of coefficient of friction value for different surfaces

**Part B : Emission Laboratory**

2. Measurement of emission by Infral Red Gas Analyzer (IRGA)
3. Measurement of smoke by Bosch smoke meter
4. Measurement of smoke by Hartridge smoke meter
5. Measurement of petrol engine emissions with the help of multi gas analyzer
AE 4611 MOOC BASED SELF LEARNING COURSE

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L   T  P Credits Scheme</td>
<td>Theory (Marks)</td>
</tr>
<tr>
<td></td>
<td>Max.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

RATIONALE:
One of the graduate attributes as expected by NBA is lifelong learning ability of students. The students should be able to learn independently as learning is a continuous process throughout the lifetime. This one credit course requires the students to complete any MOOC course of four to six weeks of their choice. The students will also be exposed to MOOCs which they may use for their future learning.

COURSE LEARNING OUTCOMES:
At the end of this course student should be able to:
1. Appreciate the use of MOOCs for independent learning.
2. Build confidence to complete a course independently.

PRE-REQUISITES: Motivation for learning

COURSE IMPLEMENTATION:
This course exposes students to use of MOOCs for self-learning. MOOC/online courses of 4-6 weeks offered by online education platforms like Coursera, EdX, NPTEL, QEEE will be offered to the students. Students are required to choose any course of their liking out of the list of the courses to be prepared by the department (typically 10-15) and complete the same. The course topics may not necessarily be of technical nature. The students are required to submit the course completion certificate to the department on completion of the course. Two hours per week are assigned for the course. Students shall report the progress to the respective supervisor during this period.

EVALUATION:
As a part of ISE, assessment students will be based on students’ learning from the MOOC course. Students will have to take tests/quiz as a requirement for certification of the course and complete assignments if any, as well. Student assessment for ISE will be based on following criteria:
1. Student’s progress in the course
2. Grade received by the student for the course
3. Report quality
4. Presentations on learning in front of supervisor and peers
RATIONAL:
This course gives opportunity for the students to offer engineering solutions to a relevant problem by working in a group. Apart from technical knowledge, he/she can explore interpersonal skills as well as ability to plan, execute and justify the tasks. This course brings the awareness about systematic and logical report writing and presentation of the technical efforts.

COURSE LEARNING OUTCOMES:
At the end of the course, student will be able to:
1. Carry out literature survey and identify as well as select a problem.
2. Comprehend and analyze an engineering problem and report findings to provide an appropriate solution.
3. Design an experimental setup or develop an analytical model to analyze the system under consideration.
4. Communicate problem, methodology and outcomes in a systematic and effective way in the form of a technical report.
5. Work as a member and a team leader in engineering teams / multidisciplinary teams.
6. Demonstrate an ability to use different tools and techniques to arrive at a solution to the given problem.
7. Demonstrate ethical behavior while completing the project work within given constraints and while delivering the expected outcomes.

CURRICULUM

Students may undertake their Projects related to -

1. Design, build and test
2. Analytical work
3. Modeling and simulations
4. Industry based projects
5. Laboratory experimentation
6. Application/Implementation of management philosophy

The department always encourages projects which are related to industrial problems or of interdisciplinary nature to provide opportunity for the students to work on real life problems.
GUIDELINES:

1. The Project group in (B.Tech. first Term) seventh semester will continue the project work in (B.Tech. Second Term) eighth semester and complete project in all respect (assembly, testing, fabrication, tabulation, test result etc.).

2. The group should maintain a logbook of activities. It should have entries related to the work done, problems faced, solution evolved etc., duly signed by guide.

3. The guides should regularly monitor the progress of the project work.

4. Assessment of the project for award of ISE marks shall be done by the guide and a departmental committee (consisting of minimum two faculty members) as per the guidelines given by department.

5. The candidate shall submit the synopsis of the project work to the evaluation committee at the starting of FIRST TERM of B. Tech.

6. It shall include the problem definition, literature survey, approaches for handling the problem, finalizing the methodology and estimation of time and cost for the project work and design calculations / experimental design etc.

7. The candidate shall prepare a report of about 30 pages. The report typed on A4 sized sheets and bound in the prescribed format shall be submitted after approval by the Guide and endorsement of the Head of Department. It will be assessed for ISE by the evaluation committee appointed by the Head of the Department.
**RATIONAL**:  
This course is aimed at familiarization of graduate students to industry environment and practices. Students are expected to spend two to three weeks at a manufacturing plant to observe various engineering functions like manufacturing, quality control, production planning and control, design and development and such other relevant functions. They are expected to identify various small and complex technical problems the company experiences, reflect on the possible solutions and internalize the solutions the company plans and implements for the same. This course provides an opportunity of reflective learning for the students. It helps them to bridge the gap between classroom theory and implementation in real environment.

**PRE-REQUISITE**:
The student should have completed Practice School – I (Garage Training) after second year.

**COURSE LEARNING OUTCOMES**:
At the end of the course student will be able to:

1. Describe the industry environment; they were exposed to for two–three weeks.
2. Present the technical and non technical problems they encountered to during the training period and solutions they witnessed.
3. Communicate the learning occurred owing to this specific industry experience.

**GUIDELINES FOR COURSE EXECUTION AND EVALUATION**:

1. Supervisors to be allotted by the Class Monitor before the students start their industry training.
2. An orientation session for the students to be organized by the class monitor towards the end of VIIth semester for Third Year students.
3. This orientation session shall address relevance of industry training, duration, outcomes, evaluation modes and list of companies recommended for such training.
4. The students will be provided with request letter from the department for the purpose of industry training.
5. The class monitor is required to create database of details regarding the training.
6. The supervisors, if possible, are advised to visit the company or make a call to the concerned authority from industry to oversee the ongoing training.
7. The students are required to submit the training completion certificate to the batch supervisors within first two weeks.
8. Students are required to maintain logbook/daily diary to note down important issues/observations during the training period.
9. Individual evaluations shall commence from second week. The evaluations will be based on rubric formed for the same.
10. Simultaneously, the students shall work on Industry Training Report and keep it ready by 6-7th week.
11. The report assessment shall commence from around 8-9th week.
12. In case, the student fails to undergo the course, he/she shall receive XX grade and will have to register for the course, the next semester.
13. Evaluation sheet to be displayed by the supervisors in the last week of semester.
<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
This course focuses on application part with a view to make students able to apply the knowledge gained after studying this subject, in measurement and analysis of noise and vibration in the structures of different kind. The organization of the subject matter includes revision about basics of vibration, study of multi degree of freedom vibrations and torsional vibrations. It also includes information about vibration instrumentation and vibration analysis. Introduction to noise and basic terms related to it, instrumentation for measurement and analysis of the noise in different structures are also included in the syllabus to make the students familiar about noise and its measurement.

COURSE LEARNING OUTCOMES:
At the end of the course, the learners will be able to:
1. Explain basic concepts related to noise and vibration.
2. Formulate mathematical model for multi degree of freedom vibration system.
3. Select transducers for measurement of vibration in automotive/mechanical systems.
4. Select appropriate transducer for measurement of noise in automotive/mechanical systems.
5. Analyze the automotive systems for noise and vibration in them.
6. Identify different sources and apply methods for noise and vibration control in automobiles.

PRE-REQUISITES: Basics of vibrations, Single degree of freedom vibrations, adequate mathematical knowledge.

CURRICULUM

Unit 1: Fundamentals of Vibration
Introduction, Basic concepts, causes, effects and applications, equation of motion: Methods, MDOF vibrations, equation of motion, matrix formulation, influence coefficients

(To be Implemented from Year 2016-17)
Unit 2: Multi Degree of Freedom Vibrations
Matrix method, Matrix iteration method, Mode shape orthogonality, torsional vibrations- two rotor and three rotor systems, geared system, Stodola’s method, discrete and continuous systems

Unit 3: Vibration Measurement
Introduction and relevance, measurement system and its elements, vibration transducers, impact hammers, exciters, signal conditioners, calibration of vibration transducers, time and frequency domain plots, measurement standards, logarithmic decrement method, half power bandwidth method

Unit 4: Vibration analysis
Relevance, procedure, continuous and discrete systems, methods for continuous systems, Euler’s beam theory, modal analysis, modal parameters, experimental modal analysis- impact hammer testing, shaker testing,

Unit 5: Noise and its measurement
Introduction, Basic terms, Sources, decibels, adding decibels, subtracting background noise, weighting networks, Measurement standards, Noise measurement parameters, Noise measurement techniques, Sound level meters, Microphones: Types and Selection

Unit 6: Transportation Noise and Vibration

TEXT BOOKS

1. V.P. Singh, Mechanical Vibrations, Dhanpat Rai and Co. Pvt. Ltd., Delhi
2. S. S. Rao, Mechanical Vibrations, New Age International (P) Ltd., New Delhi
3. A.G. Ambekar, Mechanical Vibrations and Noise Engineering, PHI learning private limited

REFERENCE BOOKS


(To be implemented from Year 2016-17)
Program Elective - I
AE4151 VEHICLE AERODYNAMICS

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory (Marks)</td>
</tr>
<tr>
<td>L   T   P</td>
<td>Credits</td>
</tr>
<tr>
<td>3   --   --</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
The main objective of this course is to introduce the concepts of aerodynamics of motor vehicle, different shapes of vehicle, lift and drag analysis, wind tunnel testing etc. This study helps the students for the design of vehicle body with main goals to reduce vehicle drag, minimize noise level and undesired lift forces.

 COURSE LEARNING OUTCOMES:
At the end of course student will be able to:
1. Apply basic principles of aerodynamics for the design of vehicle body.
2. Calculate lift and drag of automotive models
3. Describe the physics of fluid flow over vehicle body and its optimization techniques.
4. Use wind tunnels for testing the vehicles.
5. Apply Computational fluid dynamics (CFD) tool for aerodynamics study.

PRE-REQUISITES: Fluid Mechanics, Fluid Dynamics.

CURRICULUM

Unit-1 Fundamentals of Aerodynamics 6 hrs

Unit-2 Aerodynamic drag of cars 6 hrs
Cars as a bluff body, Flow field around car, Aerodynamic drag and its types, various forces and moments & its effects on performance, analysis of aerodynamic drag, drag coefficient of cars, strategies for aerodynamic development for low drag profiles.

Unit-3 Stability safety & comfort 6 hrs
The origin of forces and moments and its effects, vehicle dynamics under side wind, Force and Moment coefficients, Safety limit, dirt accumulation on vehicle, wind noise, Air flow

(To be implemented from Year 2016-17)

Unit-4 Shape optimization of car  
Front end modification, front and rear wind shield angle, Boat tailing, Hatch back, fast back and square back, air flow patter around individual component, Dust flow patterns at the rear, Effects of gap configuration, effect of fasteners.

Unit-5 Wind Tunnel for Automotive Aerodynamics  
Introduction - Principle of wind tunnel technology, Limitation of simulation, Measuring equipment and transducers, Pressure measurement, velocity measurements, Flow visualization techniques, Road testing methods.

Unit-6 Computational Fluid Dynamics (CFD)  
Introduction to governing equations, solution methodology, discretization techniques, Boundary Conditions, CFD pre and post processing techniques, Different plots.

TEXT BOOK


REFERENCE BOOKS

RATIONAL:
Motor vehicle accidents are still a leading cause of death, even if the trend has somewhat declined over the past 20 years. Motor insurance gives protection to the vehicle owner against damages to his/her vehicle and pays for any Third Party Liability determined as per law against the owner of the vehicle. Third Party Insurance is a statutory requirement. The owner of the vehicle is legally liable for any injury or damage to third party life or property caused by or arising out of the use of the vehicle in a public place. This course covers all the procedures of motor insurance and accident claims along with applications of IT and fraud management and internal audit. With rising opportunities in the motor insurance sector, the students will be well placed to contribute to the industry effectively.

COURSE LEARNING OUTCOMES:
At the end of this course, students will be able to -
1. Classify motor vehicle insurances.
2. Discuss applications of insurance principles in vehicle insurance.
3. Describe various forms in motor vehicle insurance.
4. Discuss MACT in detail.
5. Analyze fraud management and internal audit in relation with motor vehicle insurance.

PRE-REQUISITE: Basic Automobile Engineering.

CURRICULUM

Unit 1: Principles of Insurance and Motor Insurance:

6 hrs

History of Insurance, Business of Insurance – Transfer of Risk, Classification of Insurance – Life & General Insurance, Market Role of Specialist (e.g. Surveyor)

History of Motor Insurance – Law and Practice of Motor Insurance in India – Applicability of Principles of Insurance – Total Loss (TL) / Constructive Total Loss (CTL) / Theft Claims –
Unit 2: Type of motor vehicles, documents and policies:
6 hrs

Unit 3: Motor Insurance Claims:
6 hrs

Unit 4: Marketing in Motor Insurance:
6 hrs


Unit 5: IT Applications in Motor Insurance:
6 hrs
Importance of Analytics and IT Intervention – IT Intervention and Competition – IT Intervention and Data Analytics – Need for and Importance of Statistics – TAC as Data Depository – TAC as National Repository for Statistical Data.
Unit 6: Fraud Management and Internal Audit: 6 hrs

TEXT BOOKS


REFERENCE BOOKS

2. Lemaire Jean, Automobile Insurance – Actuarial Model, Springer
3. Georges Dionne HEC, Montreal, Automobile Insurance: Road Safety, New Drivers, Risks, Insurance Fraud and Regulation, Springer
5. IRDA website https://www.irdai.gov.in
Program Elective - I
AE 4191 INDUSTRIAL ENGINEERING

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
<th>Theory (Marks)</th>
<th>Practical (Marks)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scheme</td>
<td>Max.</td>
<td>Min. for Passing</td>
</tr>
<tr>
<td>L   T   P</td>
<td>Credits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3   --  --</td>
<td>3</td>
<td>ISE</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MSE</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ESE</td>
<td>50</td>
</tr>
</tbody>
</table>

RATIONALE:
Industrial Engineering is the science of engineering things to make them efficient, along with reducing production costs and improving the quality of the products and services. Industrial engineers use principles of engineering, mass production and technology to help companies find ways to offer services or create a product efficiently. Skills of industrial engineering are applied to virtually every industry possible. This occupation can be termed versatile in the kind of work and the industries in which its expertise can be put to use. Students can apply Industrial Engineering concepts in the industry to improve productivity & optimization.

COURSE LEARNING OUTCOMES:
At the end of this course student should be able to:
1. Apply the Industrial Engineering concept in the industrial environment.
2. Apply demand forecasting techniques and work design concepts.
3. Demonstrate the knowledge of designing plants and controlling production.
4. Optimize the resources of an organization and improve productivity.
5. Apply Project Management concepts in real time projects.


CURRICULUM

Unit 1: Industrial Organisation 5 hrs
Introduction to Industrial Engineering - Concepts - History and Development of Industrial engineering - Roles of Industrial Engineer - Applications - Productivity - Factors affecting productivity - Increasing productivity of resources - Kinds of productivity measures.

Unit 2 Demand Forecasting & Elements of Cost 6 hrs
Macro and micro economics - Demand and supply - Factors influencing demand - Elasticity of demand - Demand forecasting - Time series - Exponential smoothing casual forecast -

(To be implemented from Year 2016-17)

Unit 3: Work Study
Introduction to work study – Method study – Time study – stopwatch time study – Standard data - Method Time Measurement (M-T-M) – Work sampling – Ergonomics, Gilberets’ contributions; micro-motion study, principles of motion economy; work measurement – stopwatch time study, work sampling, standard data, PMTS; job evaluation, merit rating, incentive schemes, and wage administration. MOST Technique, Introduction to Value Engineering.

Unit 4: Facility Design & Material Handling
Facility Location Factors and Evaluation of Alternate Locations; Types of Plant Layout; Computer Aided Layout Design Techniques; Assembly Line Balancing (Numerical)
Material Handling: Principles, Types of Material Handling Devices; Stores Management, Inventory models-basic model, production model, price discount model, ROL, ABC analysis

Unit 5: Production Planning and Control

Unit 6: Project Management
Meaning, Scope and objectives, phases in project. Project organization Project planning and control techniques. CPM and PERT, Time cost trade off. Risk management in projects. Project feasibility analysis and criteria for project evaluation-NPV and IRR.

TEXT BOOKS


REFERENCE BOOKS

5. I. C. Jhamb, Work study and Ergonomics, Everest Publication, Pune
7. ArunVishwanath, Industrial Engineering and Management, SCITECH Publication
### RATIONALE:
The course aims to introduce the basic concepts of lubrication, friction and wear. Tribology for automotive engineering is important for applications like engine, clutches and brakes. The friction coupling between tyre surface and road surface is also an interesting area. The course is expected to prepare the students for further research in this area from view point of automotive engineering.

### COURSE LEARNING OUTCOMES:
At the end of course student will be able to:
1. Analyze the solid surfaces and their interactions
2. Apply lubrication, friction and wear theories in practice.
3. Compare liquid and gas lubrication.
4. Select appropriate surface treatment to reduce the friction.

### PRE-REQUISITES: Chemistry, Thermodynamics, Fluid Mechanics.

### CURRICULUM

**Unit 1: Introduction to Tribology**
6 hrs
Introduction to Tribology, Tribology in Design, Tribology in industry, Lubricants-properties, physical and chemical, lubricants standards, types of additives, extreme pressure lubricants. Lubrication – introduction, basic modes of lubrication. Types of sliding contact bearings. Comparison of sliding and rolling contact bearing.

**Unit 2: Friction and Wear**
6 hrs
Friction - Laws of friction - Friction classification - Causes of friction, Theories of Dry Friction, Friction Measurement, Stick-Slip Motion and Friction Instabilities,

Unit 3: Hydrodynamic lubrication

Unit 4: Hydrostatic Lubrication
Principle of Hydrostatic lubrication, arrangement for constant pressure and constant flow, Hydrostatic bearings- Design of hydrostatic bearings, Load carrying capacity and flow requirement, Energy losses. Hydrostatic Squeeze Film Lubrication

Unit 5: Elastohydrodynamic Lubrication and Gas lubrication
Elastohydrodynamic lubrication between two contacting bodies and its application. Gas lubrication- Reynolds equation for Gas lubrication.

Unit 6: Surface Engineering
Surface Layers, surface engineering for wear and corrosion resistance, surface coatings, selection coating, Properties and parameters of coatings.

TEXT BOOKS

1. B.C. Majumdar, Introduction to Tribology of Bearings, S. Chand and Company Ltd., 2010.

REFERENCE BOOKS

Program Elective - I  
AE 4211 AUTOMOTIVE EMBEDDED SYSTEMS

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
An advanced embedded system in automobiles has increased rapidly in the past two decades. The technological innovations of the embedded system within the vehicle are being ambitiously challenged to make the vehicle energy efficient, network savvy and safer. Every year automobile manufacturers pack embedded systems into their cars for different functionalities like ignition, security and audio systems and that there will be huge demand for more engineers working on automotive embedded systems and related services. This course covers all the aspects of automotive embedded electronics with hands-on experience, and will be industry-ready. In fact, almost any systems where there is a need to control certain processes, to obtain information from external sources, and interpret collected information.

COURSE LEARNING OUTCOMES:
At the end of this course, students will be able to
1. Illustrate automotive embedded systems and their features.
2. Identify & describe advanced automotive sensory system.
3. Explain various embedded systems like AUTSSAR, JASPAR etc.
4. Evaluate the impact of PIC Microcontrollers on the new trends impacting future distributed automotive embedded systems.
5. Review & implement the different case studies of automotive embedded systems.

PRE-REQUISITES: Different Automotive Control Systems & brief introduction about ECUs

CURRICULUM

Unit 1: Introduction to Automotive Embedded Systems 6 hrs
Overview of present-day embedded products, Basic building blocks of embedded systems, Automotive Systems Overview, Embedded Technology in Automotive Industry, Embedded System Development Process - Tool Chain and Cross Compilation
Unit 2: PIC Microcontrollers
PIC18F4520 MCU. Architecture, Features, Memory and memory map, I/O ports, Timers and CCP Devices, ADC, Interrupts, Instruction format, Addressing Modes, Instruction Set, Programming with MPLAB IDE.

Unit 3: Automotive Sensory System

Unit 4: Embedded C & Coding Standards to Automotive/ PIC18 Programming in C

Unit 5: Automotive Communication Systems
Communication interface with ECUs: Interfacing techniques. Relevance of internet protocols, such as TCP/IP for automotive applications. Wireless LANs standards, such as Bluetooth, IEEE802.11x. Communication protocols for automotive applications. Automotive Buses: Use of various buses such as CAN, LIN, FlexRay, Recent trends in Automotive buses (Such as OBDII, MOST, IEEE, IELLI, D2B, and DS1). Application of Telematics in Automotive: Global Positioning Systems (GPS) and General Packet Radio Service (GPRS), for use in an automotive environment.

Unit 6: Case studies
Design of Embedded Systems using the PIC microcontroller, for applications in the area of Communications, Automotives & industrial control.
* ABS (an Anti-lock Braking System) is a safety system which prevents the wheels on a motor vehicle from locking while braking, includes a microcontroller.
* "Car with remote control" This project includes a simple transmitter and receiver. One microcontroller is located inside the car and the other inside the remote.
* "Smart Car" This project includes two sensors. The two sensors are connected to the microcontroller and transmitting a comprehensive data on: fuel consumption, a distance to travel relatively to the fuel consumption elapsed trip time a trip distance. All the information can be displayed on the LCD.
TEXT BOOKS


REFERENCES BOOKS

1. Dominique Paret Translated by Roderick Riesco, Multiplexed Networks for Embedded Systems CAN, LIN, Flexray, Safe-by-Wire, John Wiley & Sons Ltd.
Program Elective - II
AE 4231 TRANSPORT MANAGEMENT

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Scheme</td>
</tr>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
Amongst various transport modes, motor transport has dominant position within the transport sector. This growing importance of motor transport is also reflected in the steady increase in the modal share of motor transport in the movement of freight and passengers. The emergence of road transport as the dominant transport mode is attributable to some of its unique qualities such as easy accessibility, flexibility of operation, door-to-door service and reliability. Industrial development is also largely dependent on the transport sector. The transport sector, therefore, occupies a prominent place on the development agenda of a country. By keeping some of these objectives in mind, the subject Transport Management is essential to learn. The subject covers the motor vehicle act covering the control of automobiles on the road, taxation structure, vehicle insurances, safety factors, bus & goods transport operations and advanced traffic management systems in brief.

COURSE LEARNING OUTCOMES:
At the end of course student will be able to:
1. Describe the motor vehicle act & central motor vehicle rules.
2. Illustrate motor vehicle insurance & taxation.
3. Analyze the passenger & goods transport operations.
4. Identify advanced techniques in traffic management.

PRE-REQUISITES: NIL

CURRICULUM

Unit 1: Motor Vehicle Act

(To be implemented from Year 2016-17)
Unit 2: Motor Vehicle Taxation
6 hrs.

Unit 3: Motor Vehicle Insurance
6 hrs.
Significance & types, Comprehensive, Third party, Furnishing of particulars of vehicles involved in accident, Award of the claims tribunal, MACT (Motor Accident Claims Tribunal), Accident claims procedure, Solacium Fund, Hit & Run case, Duty of driver in case of accident, Surveyor & Loss Assessor, Surveyor’s report including post accident procedures.

Unit 4: Passenger Transport Operation
8 hrs.
Structure of passenger transport organizations, Introduction to road corporation Act, Typical depot layouts, requirements, Typical depot layouts, Problems on fleet management, Fleet maintenance, significance of Motor Transport Workers Act, Bus & Crew Scheduling, Personnel & training - training for drivers & conductors, passenger amenities, advertisement, Theory of fares, Basic principles of fare charging, Differential rates for different types of services, Depreciation & debt charges, operation cost, Revenues, Economics & records, Management Information System (MIS) in passenger transport operation.

Unit 5: Goods Transport Operation
4 hrs.
Structure of goods transport organizations, Scheduling of goods transport, Freight calculations, M.I.S. in goods transport operation, Storage & transportation of petroleum products.

Unit 6: Advanced Techniques in Traffic Management
6 hrs.
Advance Techniques in Traffic Management: Vehicle & traffic navigation system, GPS, advanced traffic control devices, Intelligent Transport System, awareness on new road infra (four lane, six lane roads), their rules, parking & lane disciplines, Turnaround time for a trip and importance from business perspective, etc.

TEXT BOOKS


REFERENCE BOOKS


(To be implemented from Year 2016-17)
8. Richard Iles, Public Transport in Developing Countries, Elsevier.

WEBSITES

1. http://www.transportindia.in
3. http://www.mahtranscom.in
Program Elective – II
AE 4251 AUTOMOTIVE HVAC

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
<td>P</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
This is an era of luxurious automobiles where market demands more comfort and safety. When we focus on comfort, ventilation and air-conditioning share is more. Refrigeration in transport vehicle plays a vital role for carrying goods far away with same quality, without changing its environmental conditions or by freezing/deep freezing the goods. With this concern automotive heating, ventilation and air-conditioning course may add value and develop skills required for automotive industry.

COURSE LEARNING OUTCOMES
At the end of course student will be able to:
1. Design refrigeration system for refrigerated vehicle.
2. Apply psychometric concepts in design of HVAC of an automobile.
3. Analyze automotive HVAC system.
4. Explain troubleshooting methods and maintenance of automotive HVAC system.

PRE-REQUISITE: Basic refrigeration cycles, refrigerants, load on air conditioning system etc.

CURRICULUM

Unit 1 Fundamentals of Automotive Refrigeration and Air Conditioning 6 hrs
Basic Refrigeration and air conditioning types, refrigerant types (Automotive refrigerants) and selection, Modes of Refrigeration in refrigerated transport vehicle, Schematic layout of a refrigeration system - Transport refrigeration. Layout of Air conditioning system, Location of air conditioning components in a car.

Unit 2 Components of Automotive HVAC and Climate Control 6 hrs
HVAC unit, Compressor, Condenser and high pressure Service ports, AC tubing, Thermostatic expansion valve. Controlling Evaporator Temperature(modes of control), Controlling Circuits-Air Circuits & Refrigerant circuits & Electrical circuits etc. Insulation in car air conditioning and refrigerated vans and carriers.

(To be Implemented from Year 2016-17)
Unit-3 Air conditioning - Heating System

Unit 4 Psychrometry and Load Calculation
6 hrs
Comfort, Factors forming the load on refrigeration & air conditioning systems - Cooling & heating load calculations - Load calculations for automobiles - Effect of air conditioning load on engine performance, Effects of direct solar radiations and air velocity on the load estimation. Estimation of cooling down time (cool down curves, heat up curves)

Unit 5 Air Routing and Temperature Control
6 hrs
Objectives, Evaporator core air flow Through the Dash Recirculation Unit, Automatic temperature control, Duct system, Controlling flow, Vacuum reserve, Testing the air control and handling systems (descriptive treatment only). Quick cooling and air recirculation systems. Air distribution systems in various types of passenger and transport vehicles.

Unit 6 Air conditioner maintenance and Service
6 hrs
Servicing heater systems removing and replacing components, Refrigerant leak detection methods Trouble shooting of air conditioning systems, Compressor Service. Preventive maintenance, Performance Testing and Validation of HVAC System at Vehicle level

TEXT BOOKS

2. Boyce H. Dwiggins, Automotive Air Conditioning, S. Chand (G/L) & Company Ltd; 8th Revised Edition

REFERENCE BOOKS

3. Paul Lang, Automotive Air Conditioning, C.B.S. Publisher & Distributor, (Delhi, 1991)
RATIONALE:
The main objective of this course is to introduce the concept and principle of vehicle safety and its considerations for vehicle safety design. At the end of the course, the students can have a better understanding of the vehicle collisions, nature of injuries to occupants and pedestrians and safety measures.

COURSE LEARNING OUTCOMES:
At the end of the course the student will be able to:

1. Comprehend application of passive and active safety for vehicle.
2. Describe importance of ergonomics in automotive safety and human response to impact
3. Design vehicle safety systems
4. Describe various regulations of vehicle safety and safety testing methods.
5. Apply principle of collision to vehicle crash mechanism

PREREQUISITES: Basics of vehicle body structures, Strength of materials.

CURRICULUM

Unit-1 Introduction
Importance of vehicle safety, active and passive safety, energy equation, engine location, Driver assistance systems in automobiles, exterior & interior safety.

Unit-2 Ergonomics and Human response to Impact
Importance of Ergonomics in Automotive safety, Locations of controls, Anthropometry, Human impact tolerance, Determination of Injury thresholds, Severity Index, Study of comparative tolerance, Application of Trauma for analysis of crash injuries. Injury criteria’s and relation with crash and modeling and simulation studies in dummy.

Unit-3 Vehicle Safety Systems
Restraints systems used automobiles, Types of safety belts, Head restraints. Air bags used in automobiles, Collapsible steering column, Importance of Bumpers in automobiles,

(To be implemented from Year 2016-17)
Damageability criteria in bumper designs, Safety glass and their requirements. Rear view mirrors and their assessment. Warning devices, Hinges and latches etc. Steering and mirror adjustment, central locking system, tire pressure control system, rain sensor system, environment information system. Design of safety systems.

**Unit-4 Rear Crash Safety**

6 hrs
Head Restraint Position during Normal Driving, Study of procedure to evaluate Occupant Interaction with seat in rear crashes, Role of seat in Rear crash safety, Performance criteria for different seats, Human and dummy responses for Pendulum impacts to the Back Effectiveness of Self-Aligning Head Restraints in preventing whiplash, Energy absorptions properties of Head Restraints, Introduction to RUPD (Rear under rum protection device).

**Unit-5 Vehicle safety regulations & testing**

6 hrs

**Unit-6 Collision Warning and Avoidance**

6 hrs
Collision warning system, causes of collision, frontal object detection and rear vehicle object detection system, object detection system with braking system interactions

**TEXT BOOKS**


**REFERENCES**

Program Elective- II

AE 4091 DESIGN OF VEHICLE OPERATED FARM EQUIPMENTS

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
As major Indian population is involved in farming so it is one of the biggest market for engineering products like tractors and farm equipments. This subject will provide opportunity to budding Automobile Engineers to deal with different systems of tractor and farm equipments. It helps to improve employability of students in one of the fastest growing tractor and farm equipment industries.

Prerequisites: Machine Design, IC engine, Chassis and Transmission system.

COURSE LEARNING OUTCOMES:
At the end of the course the student will be able to:
1. Apply the fundamental design concepts for design of tractor and farm equipments.
2. Analyze the important supplementary systems in the tractors.
3. Select the different system for particular type of farm application.
4. Compare the performance of tractors related to various attachments.

CURRICULUM

Unit 1: General design of Tractors
Functional requirements, Classification of tractors and their selection, Main components of tractor, Safety rules, Tractor controls and the starting of the tractor engines, General engine design, Performance characteristics.

Unit 2: Systems of Agricultural Tractor:
Engine system, Cooling system, Lubricating system, and Fuel supply system, Layout, Load distribution, Transmission system & Drive line, Running Gear, Steering system, Braking system, Wheels & Tyres.

Unit 3: Attachments of tractor
Hydraulic system, Three point linkages, Automatic position and draft control systems, Tractor hitch control, Belt pull Traction control unit, Auxiliary Systems, Draw bar, Power Take off Shaft, Trailers and body tipping mechanism.

(To be implemented from Year 2016-17)
Unit 4: Tractor Mechanics / Performance

Unit 5: Machinery for tillage and crop cultivation
Tillage, Types of tillage, Tillage attachments, Mould board plough, attachments, mould board shapes and types, Disc plough, Types of disc ploughs, Subsoiler plough, Rotary plough, Disc harrows, Drag harrows, Cultivators – types – construction, cold crushers and levellers.

Unit 6: Seeding, Harvesting and Threshing Machinery
Methods of sowing, Types of seed drills and planters, Calibration of Seed Drill, Harvesting, Harvesting methods, Mowers, Threshing machine, Special Threshers and strippers, Plant protection equipments.

TEXT BOOKS


REFERENCE BOOKS

1. E.L.barger, J.B.Liljedahl, W.M.Carleton, E.G.Mckibben, Tractors & Their Power Units.
Program Elective – III
AE 4273 AUTOMOTIVE PRODUCTION SYSTEMS

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scheme</td>
<td>Theory (Marks)</td>
</tr>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
The course aims at providing study required to successfully plan and develop production systems in the field of the automotive industry. Students are familiar with current manufacturing and engineering technologies and able to expand their professional knowledge. Automotive engineers design, test and develop vehicles and/or components from concept to production, and are involved in improving the vehicle manufacturing. This course is for those who want to become design / production engineer in the automotive industry, to undertake the challenges of modern vehicle design and work in industry as part of teams generating the next phase of road vehicles. As such the course consists of all the necessary elements to ensure preparedness for the various roles of the modern automotive engineer.

COURSE LEARNING OUTCOMES:
At the end of the course the student will be able to:
1. Design jig and fixture for manufacturing mechanical component.
2. Appreciate the need of Reverse Engineering in today’s engineering context and identify various elements of Reverse Engineering.
4. Design and select press for different press operations performed while developing automotive component.

PREREQUISITES: Manufacturing Technology / Processes and Workshop Technology.

CURRICULUM

UNIT 1 Jig & Fixture Design
Principle of location, locating devices, bush location, design principles for location purposes, clamping, clamping devices, design principles common to jigs and fixtures, drilling jigs, milling fixtures, design principles, lathe fixture, grinding fixture, assembly fixture, indexing jigs and fixtures.

(To be implemented from Year 2016-17)
UNIT 2 Reverse Engineering
Application of Reverse Engineering. Overview of Reverse Engineering for Mechanical Components: Scanning Phase, Data Manipulation, Various Reverse Engineering Hardware, Stitching Software, Scanned Data Acquisition and Data Structure, Contacting & Contact-Less Scanning, Point Cloud Data Format (IGES), STL Data Format (STL), Data Processing, Surfacing From Point Cloud, Generation Of Tool Path From Point Cloud Data, Rapid Prototyping From Point Cloud Data, Neutral Formats Used For Data Transfer.

UNIT 3 FMS/CIM
Introduction to FMS- development of manufacturing systems - benefits - major elements - types of flexibility - FMS application and flexibility - single product, single batch, n - batch scheduling problem - knowledge based scheduling system.

UNIT 4 Press Tool Design
Press operation, Press working equipment, rating of press, requirement of press tool design, press tool components, press selection, clearance, cutting forces, methods of reducing, cutting forces, maximum diameter of piercing, banking die design, piercing die design, bending method, design considerations.

UNIT 5 MRP/JIT
Spread of JIT movement, Toyota production system, global implication of JIT, design development and management of JIT manufacturing systems.

UNIT 6 3 D Printing & Rapid Prototyping
3 D PRINTING / rapid prototyping/ Additive manufacturing Basics, 3D printing process, Different 3D printing technologies and materials, 3D printers from entry level to high end industry standard, CAD/CAM software, 3D scanning, Outsourcing.
RAPID PROTOTYPING: Laminated object manufacturing, Vacuum casting, Resin injection, Applications of RPT, Surface roughness terms.

TEXT BOOKS


REFERENCE BOOKS

RATIONALE:
Painting provides excellent aesthetics to the automobile. It also protects vehicle body from corrosion. Now-a-days it becomes an important part of automobile industry. This subject deals with important aspects of automotive painting and coating technology. It will help to build employability of students in automobile paint and coating industry.

COURSE LEARNING OUTCOMES:
By the end of this course, students will be able to -
1. Discuss important elements of paint and coatings.
2. Select methods, tools and equipments for painting and coatings.
3. Identify defects in painting.
4. Discuss importance of safety and cleanliness during painting and coating processes.

PRE-REQUISITE: NIL

CURRICULUM

Unit 1. INTRODUCTION 6 hrs
Definition and objectives, History, Elements of paints, Pigments, Resin, Solvent, Paint drying, Paint drying characteristics, Drying forms and film meshwork, Automobile Paints, Automotive and Automotive Paint Market.

Unit 2. METHODS OF PAINT AND COATING 6 hrs

Unit 3. REFINISHING FACILITIES, EQUIPMENT AND TOOLS 6 hrs
Refinish paint and OE paints, difference, painting and drying facilities, painting equipment and tools, painting accessories.

(To be implemented from Year 2016-17)
Unit 4. REPAINTING PROCESS 6 hrs
Types of repainting process, surface treatment stage, colour matching, top coat preparation, top coat process, polishing and final touch up, repainting of resign bumpers.

Unit 5. PAINT AND COATING DEFECTS, CAUSES AND CORRECTIONS 6 hrs
Defects occurring during painting and immediately after drying, defects occurring with time, corrections for paint finish defects. In-plant Repairs of coatings

Unit 6. SAFETY AND CLEANLINESS 6 hrs
Paint and solvent Toxicity and its prevention, fire hazards associated with paints and solvents, health and safety, hazardous decomposition products, control of spills.

TEXT BOOKS


REFERENCE BOOKS

4. Paint Handbook by Department of Defense, USA.
B.Tech. (Automobile) Semester – VII & VIII

B.Tech. (Automobile) Semester – VIII

AE 4021 AUTOMOTIVE SYSTEM DESIGN

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONAL:
The design and manufacturing for most of the vehicles we use in our everyday life have in some way involved the work of an automobile design engineer. The automobile engineer has either been directly involved in the design and development process of the product and/or in the design and development process of the manufacturing vehicle. Furthermore, the global competition has increased the demands for efficiency and functionality in automotive sector. This course of study aims to develop ability of student to design and build complex engineering automotive systems, understand the systematic implication of design decisions, understand design challenges and apply design theory.

COURSE LEARNING OUTCOMES:
At the end of course student will be able to:
1. Design automotive clutch and gear box system.
2. Design automotive control system viz. brake & steering system.
3. Design automotive suspension system.
4. Design final drive, axle and propeller shaft for automotive application.


CURRICULUM

Unit 1: System Design 4 hrs
System design approach, requirements of systems design, historical perspective of system design, design considerations for system design, design for machining, design for assembly - statistical analysis of tolerances, future trends in system design.

Unit 2: Design of Clutch 8 hrs
Design requirements of friction clutches, selection criterion, torque transmission capacity, types of friction material, uniform pressure and wear theory. Design of single plate clutch, multi-plate clutch, centrifugal clutch design consisting of weight of shoes, size etc., Cone Clutch Design.
Unit 3: Design of Gear Box 6 hrs
Types of gear box, Selection of gear ratios & final drive ratio, Design of gears, shafts, splines and housing, design considerations of epicycle gear box.

Unit 4: Design of Suspension System 6 hrs
Requirements of a suspension system, types of suspension spring, material for springs, design of close coiled helical springs, design of semi-elliptical leaf spring, cantilever leaf spring, selection of materials for leaf spring, design of damper for automotive application.

Unit 5: Design of Brake System 6 hrs
Design of Mechanical brakes, hydraulic brakes, stopping distance, design of internal shoe brake, effect of expanding mechanism of shoes on total braking torque, calculation of mean lining pressure and heat generation during braking operation, braking of vehicle moving in a curved path.

Unit 6: Final Drive, Axles & Propeller Shafts Design 6 hrs
Design of final drive & differential gearing, Design of front & rear axles, Design of Propeller shafts for bending, torsion & rigidity, Design of universal joints and slip joints.

TUTORIAL

Tutorials should be based on design of automotive systems. Course teacher is supposed to prepare tutorial plan at the beginning of semester.

TEXT BOOKS


REFERENCE BOOKS

1. V. B. Bhandari, Design of Mechanical Elements, Tata McGraw Hill.
B.Tech. (Automobile) Semester – VII

AE 4041 VEHICLE DYNAMICS

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory (Marks)</td>
</tr>
<tr>
<td></td>
<td>Max.</td>
</tr>
<tr>
<td>1. T P Credits</td>
<td>Schemes</td>
</tr>
<tr>
<td>4 -- -- 4</td>
<td>ISE 20</td>
</tr>
<tr>
<td></td>
<td>MSE 30</td>
</tr>
<tr>
<td></td>
<td>ESE 50</td>
</tr>
</tbody>
</table>

RATIONALE:
This course deals with mechanics and dynamics of a road vehicle and thus equips him/her for a research oriented career in automotive industry. The knowledge and skills gained are equally important for design and development challenges in the industry. By applying the knowledge of this course, the student shall be able to predict behavior of the vehicle for given situation/set of data.

COURSE LEARNING OUTCOMES:
At the end of the course, students will be able to:
1. Appreciate significance of vehicle dynamics for a typical road vehicle.
2. Calculate dynamic longitudinal and transverse axle load transfer for a vehicle in motion.
3. Determine the acceleration and braking performance of a vehicle when provided with specifications.
4. Evaluate handling characteristics of a vehicle for given set of data.
5. Apply ride concepts while designing a suspension system for a vehicle.
6. Evaluate the tire performance.

PRE-REQUISITES: Dynamics of Machines and Automotive Chassis Systems.

CURRICULUM

Unit 1: Axle Load Transfer & Road Loads
Coordinate systems, Dynamic axle load transfer, Aerodynamics, Rolling resistance, Total road loads

Unit 2: Acceleration & Braking Performance
Power limited acceleration and Traction limited acceleration

Unit 3: Braking Performance
Basic equations, Braking forces, Tyre road friction, Brake proportioning, ABS systems, Braking efficiency, Rear wheel lock up, Pedal force gain
Unit 4: Handling Characteristics
Low speed cornering, High speed cornering, Cornering equations, Understeer gradient, Static margin, Suspension effects on cornering, Experimental measurements of understeer gradient

9 hrs

Unit 5: Ride Characteristics
Ride dynamic system, Excitation sources, Vehicle suspension properties, Suspension isolation, Suspension stiffness, Suspension damping, Suspension non-linearities, Active control, Wheel hop resonances, Rigid body bounce/pitch motions, bounce/pitch frequencies, Olley criterion, dynamic index.

9 hrs

Unit 6: Tire Dynamics
Tire Construction - Tire behavior - Squirm, etc - Longitudinal slip - Slip angle definitions - Tire models and force generation - Pure slip - Combined Slip.

6 hrs

TEXT BOOKS


REFERENCE BOOKS

1. Pacejka H. B., Tyre and Vehicle Dynamics, Butterworth Hienmann
AE4521 AUTOMOTIVE SYSTEM DESIGN LABORATORY

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Theory (Marks %)</td>
</tr>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

RATIONALE:
Basically, automobile system design lab deals with clutch system design including shaft design, hub design, spring design, flange design, lining material selection etc. Also another design project is complete automotive gear box design including gear ratio finding, shaft design, gear selector design, bearing selection etc.

COURSE LEARNING OUTCOMES:
At the end of course, the student will be able to:
1. Design automotive clutch system.
2. Design automotive gear box.

PRE-REQUISITES:
Students must have knowledge of strength of material, machine design. The students must have adequate knowledge about graphical skills and analytical skills and modeling software which can be enhanced further.

CURRICULUM

1. Design & working details and assembly drawing of automotive clutch system.
   Shall comprise of:
   • Functional design of clutch
   • Design of clutch shaft, hub and flange
   • Design of damper springs
   • Design of sectors, rivets etc.
   • Design of pressure plate assembly
   • Design for linkage mechanism
   • Details and assembly drawing

2. Design & working details and assembly drawing of automotive gear box.
   Shall comprise of:
   • Calculation of gear ratios
   • Determination of number of teeth on gear pair
   • Determination of gear reductions
   • Design of gear pairs
   • Design of shafts
   • Selection of bearings
   • Details and assembly drawing

Note. Students have to use any modeling software for drawing sheets (No manual drawing is allowed)
AE 4541 ETHICS IN ENGINEERING PROFESSION

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

RATIONALE:
An engineering professional requires sound ethical background so as to achieve success in his / her professional life. This course aims to introduce the students to various ethical practices that should be followed in an engineering profession. There have been instances of practices followed by the industry that border from dubious to outright unethical. Looking at the sensitive nature of engineering as a profession, the complexities that rise out of issues such as IPR, non-disclosure agreements, safety of the product, environmental impacts of products and processes, the course intends to equip students with awareness about ethical practices to be followed by them, while working as professionals.

COURSE LEARNING OUTCOMES:
At the end of the course student will be able to:
1. Demonstrate knowledge of ethical practices and professional expectations.
2. Analyse and evaluate practices carried out in the industry on the basis of ethicality.

PRE-REQUISITES: NIL

TERM WORK

The students will conduct following activities.
1. Discussion on the concept of values, morals and ethics. The students in groups of 4-6 will prepare a presentation and present it.
2. Students will work in groups and discuss various ethical codes available for engineers – (NPSE, ASME, IIE, IEEE, etc.). They will then collectively come up with a code of ethics for automobile engineers.
3. Each group will be given one situation pertaining to engineering ethics. The group has to come up with a solution for the same.
4. Discussion of application of ethics in Engineering. Each group will give a 5 min presentation on examples of ethics in engineering.
5. Continuation of above activity.
6. Based on activity 3 & 4, each group has to evolve an ethical decision making process.
7. Students will be given a specific issue / topic in activity 5. They will have to prepare and present a case study on the same.
8. Continuation of case study presentation. (minimum 30 minutes presentation per group)
9. Group discussion on non-disclosure agreements and ethics. Specific reading material to be provided to the students for discussion.

10. Students will discuss the concept of ethics in research and apply the same to any research project/mini project they have taken up.

11. Videos/ clips pertaining to relevant topics will be shown to students to initiate thinking and discussion on various topics.

12. An expert lecture to be organized on engineering and professional ethics.

*Note: Activity number 12 can be arranged at any number as per availability of expert lecturer/guest.
Videos/ clips pertaining to relevant topics can be shown to students to initiate thinking and discussion on various topics.

**Evaluation Guidelines**

The following activities will be evaluated as a part of ISE.

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Activity</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Presentation on values, morals and ethics</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Application of ethics in Engineering presentation</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Decision making process</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Case study presentation</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Application of ethics to mini project</td>
<td>10</td>
</tr>
</tbody>
</table>

The evaluation will take place on parameters like appropriate content, ethical consideration, etc.

**TEXTBOOK**


**REFERENCE BOOKS**


**AE 4561 SOFTWARE PROFICIENCY**

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td>--</td>
</tr>
<tr>
<td>--</td>
<td>--</td>
</tr>
</tbody>
</table>

**RATIONALE:**
The platform for innovation is built on a foundation of design optimization, performance data management, and process automation. Analysis software is an enterprise simulation solution for rapid design exploration and decision-making. These are the most comprehensive CAE solutions in the industry. Analysis software provides a tightly integrated suite of best-in-class tools for modeling, analysis, optimization, visualization, reporting, and performance data management. Now-a-days these software are the integral part of CAD and CAE solutions for research and development department of industry. This course provides training on analysis and simulation software like ANSYS, Hyperworks. It covers theoretical aspects of software as well as hands on practices.

**PREREQUISITE:** Finite Element Methods, Static and Dynamics, Fluid and Thermal Engineering.

**COURSE LEARNING OUTCOMES:**
At the end of course, the student will be able to:

1. Develop Finite element model of engineering problems.
2. Select appropriate solution settings of analysis software.
3. Apply different post processing techniques to interpret the results.
4. Optimize the engineering problems using FEA software.

**CURRICULUM**

This course covers following topics in any analysis software like ANSYS, Hyperworks.

Basics of software- Tool bars and menus, General analysis procedure, Creating solid model and finite element model, defining materials and boundary conditions.

Meshing- different types of elements, 1D, 2D and 3D meshing, Auto mesh, element quality checks.

(To be Implemented from Year 2016-17)
Structural analysis - linear static structural analysis, 1D, 2D, & 3D analysis, nonlinear analysis, material nonlinearity, geometric nonlinearity and contact analysis. Dynamic analysis, modal analysis, harmonic analysis, transient structural analysis, buckling analysis.
Time history post processor,

Thermal and fluid flow analysis - steady state thermal analysis, transient thermal analysis, fluid flow analysis.

Coupled field analysis - fluid and structural and thermal structural analysis.
AE 4581 PROJECT PHASE – II

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
This course gives opportunity for the students to offer engineering solutions to a relevant problem by working in a group. Apart from technical knowledge, he/she can explore interpersonal skills as well as ability to plan, execute and justify the tasks. This course brings the awareness about systematic and logical report writing and presentation of the technical efforts.

COURSE LEARNING OUTCOMES:
At the end of the course student will be able to:

1. Carry out literature survey and identify as well as select a problem
2. Comprehend and analyze an engineering problem and report findings to provide an appropriate solution.
3. Design an experimental setup or develop an analytical model to analyze the system under consideration.
4. Communicate problem, methodology and outcomes in a systematic and effective way in the form of a technical report.
5. Work as a member and a team leader in engineering teams/multidisciplinary teams.
6. Demonstrate an ability to use different tools and techniques to arrive at a solution to the given problem.
7. Demonstrate ethical behavior while completing the project work within given constraints and while delivering the expected outcomes.

GUIDELINES

1. Phase-II is an extension of Project Phase – I of seventh semester in consultation with the project coordinator and project guide.
2. A Detailed Analysis/Modelling/Simulation/Design/Problem Solving/Experiment/ Survey is a MUST to complete the project work and an effort leading to paper publication or patenting will be appreciable.
3. A working model or prototype or design document is to be submitted for end semester evaluation.
4. A project report is required to be submitted at the end of the semester in the required format.
5. Review presentations will be held throughout the semester.

(To be Implemented from Year 2016-17)
6. The review presentations and project report should contain the individual work allocation & contribution, estimated & actual time schedule with charts (PERT/GANTT), literature survey, drawings, analysis report in addition to the details of project work carried out.

7. Project work done at industry should be duly supported by certificate from the industry. The supervisor should visit the industry site for review of project work.

Guidelines for Project Report:

The candidate shall prepare a report of 60 – 80 pages. The report typed on A4 sized sheets and bound in the prescribed format shall be submitted after approval by the Guide and endorsement of the Head of Department. It will be assessed for term work by the evaluation committee appointed by the Controller of Examination.

The project report shall be typed with 1.5 spacing on A4 bond paper. Figures, graphs, annexure etc. be added as per requirement. The report should be written in the following format:

1. Title sheet
2. Declaration Sheet
3. Certificate
4. Acknowledgement
5. List of figures / photographs / graphs / tables
6. Abbreviations
7. Abstract / final synopsis
8. Contents
9. Text with usual scheme of chapters
10. Discussion of the results and conclusion
11. Bibliography (The source of illustrative matter be acknowledged clearly at appropriate place)
12. Appendices if any
Program Elective - III
AE 4061 ELECTRIC AND HYBRID ELECTRIC VEHICLE TECHNOLOGY

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>Max.</td>
<td>Min. for Passing</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
Electric and hybrid electric vehicles are being seen as substitutes for conventional IC engine powered vehicles. In view of current and future transportation challenges, HEV technology is poised for significant growth. Policy initiatives of Government of India like NEMMP and FAME encourage this technology and help penetrate into the market. Research is going on to find solutions to the current limitations of this technology. This course shall equip the students to avail emerging opportunities in the area of HEV technology in automotive industry.

COURSE LEARNING OUTCOMES:
At the end of this course, students will be able to,
1. Appreciate the need of EVs and HEVs in today's transportation context and identify various elements EVs and HEVs.
2. Describe and compare EV and HEV technology.
3. Design an electric vehicle for given requirements.
4. Design a hybrid electric vehicle for given requirements.
5. Elaborate fuel cell technology for vehicular application.

PRE-REQUISITES: Automotive Power train and Electric Machines

CURRICULUM

Unit 1: Motivation
Course introduction, Transportation scenario, contemporary issues like emission norms and CAFÉ standards, WTW analysis, GoI initiatives and conventional drivetrain

Unit 2: Electric Vehicles: Technology and Design
Conceptual illustration, various configurations of EVs, Traction motor characteristics, performance estimation of EVs, Design considerations and sizing of elements

Unit 3: Hybrid Vehicle Technology
Hybrid electric drivetrain, Classification, Operating modes, Various architectures of HEVs,

(To be implemented from Year 2016-17)
Parallel hybrid drivetrain with torque coupling and speed coupling

Unit 4: Design of HEVs
Control strategies, Design principles for series hybrid electric drive train, Sizing of elements of series and parallel hybrid electric drive trains

Unit 5: Energy Sources and Propulsion
Batteries for EVs and HEVs, Battery Management, Ultra capacitors, Mechanical flywheel, Electric drives for EVs and HEVs

Unit 6: Fuel Cell Vehicles
Fuel cell concept and characteristics, Fuel cell technology for EVs and HEVs, Hydrogen storage and reforming

TEXT BOOK


REFERENCE BOOKS

Program Elective – III
AE 4081 COMPUTATIONAL FLUID DYNAMICS

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
The Computational Fluid Dynamics is a combination of physics, numerical mathematics, and, to some extent, computer sciences employed to simulate fluid flows and heat transfer. Nowadays, CFD is playing an important role in design, optimization and research in automobile engineering because of its ability to simulate the systems where controlled experiments are difficult or impossible to perform. This course is based for developing the algorithm for CFD codes which can be used for fluid flow and heat transfer analysis. In this course, more focus is on creating the background for developing FDM algorithms for steady and unsteady fluid flow and heat transfer analysis.

PRE-REQUISITE: Fluid mechanics and heat transfer, vector algebra and numerical method.

COURSE LEARNING OUTCOMES
At the end of the course, the students will be able to:
1. Describe the physical significance of the governing equations for fluid dynamics and heat transfer.
2. Develop finite difference implicit & explicit algorithms for fluid flow and heat transfer problems.
3. Analyze the errors & stability in CFD discretization schemes.
4. Select appropriate grid generation methods for CFD analysis.
5. Apply different CFD Techniques to various fluid flow problems.

CURRICULUM

Unit 1. Basics of CFD

(To be implemented from Year 2016-17)
Unit 2. Governing Equations
Continuity, Navier-Stokes equation, Energy equation, Integral and differential analysis, Euler's equation and boundary conditions.

Unit 3. Finite Difference Method
Finite difference approximation, difference equations, Implicit approximation, Explicit approximation, Domain discretization, types of mesh and quality of mesh.

Unit 4. Geometry Modeling and Grid Generation
Practical aspects of computational modeling of flow domains, Grid Generation, Types of mesh and selection criteria, Mesh quality, Key parameters and their importance. Problems on discretization and modeling of simple equations.

Unit 5. Grid Transformation
General transformation equation, Stretched grids, Elliptic and adaptive grids, Unstructured grid structure.

Unit 6. CFD Techniques
Lax-Wendroff technique, MacCormack's technique, Relaxation technique, ADI technique, Pressure correction technique. Applications of CFD.

TEXT BOOK


REFERENCE BOOKS

5. Dr. Suhas Patankar, Numerical Methods in Fluid Flow & Heat Transfer.
Program Elective - III
AE 4101 VEHICLE MAINTENANCE MANAGEMENT

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
Vehicle maintenance management should have an overall view of the detail aspects of various systems of automobile and their maintenance. This course provides a broad knowledge about the management after sales and service. Interested students may avail an opportunity to make career in the field of Vehicle Maintenance Management.

COURSE LEARNING OUTCOMES:
At the end of this course, the students will be able to:
1. Understand the basic concepts of maintenance & dealership management.
2. Apply a management tools for showroom and service sector automobile industry.
3. Apply the concept of management in parts ordering and servicing.

PRE-REQUISITES: Automotive Diagnosis

CURRICULUM

Unit 1. Maintenance Management
Preventive (scheduled) and breakdown (Unscheduled) maintenance, requirements of maintenance, preparation of check Lists, Inspection schedule, maintenance of records, log sheets.

Unit 2. Dealership Management

Unit 3. Showroom Management
Contemporary showroom management. Institutionalizing, structuring and monitoring the sales process, managing the showroom floor and the sales team. Retail developments and industry trends.
Unit 4. Service Management  
6 hrs  
Service management, process and fundamentals, repair order analysis, productivity and efficiency, scheduling, loading, warranties and service retention.

Unit 5. Part Management  
6 hrs  
Parts management, inventory control, staffing and productivity, ordering parameters, parts marketing, merchandising, retailing and trade activities.

Unit 6. Multibrand Workshop Management  
6 hrs  
Multibrand servicing workshops and their management, Customer Satisfaction tracking tools & various techniques.

TEXT BOOKS

3. KVS Madaan (2009), Fundamentals of Retailing, Tata McGraw Hill, New Delhi Other

REFERENCE BOOK

1. Gibson G. Vedamani (2003), Retail Management, Jaico Publishing House, New Delhi
Program Elective – III
AE 4121 VEHICLE INSTRUMENTATION AND TESTING

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L T P Credit</td>
<td>Scheme</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3 - - 3</td>
<td>ISE</td>
</tr>
<tr>
<td></td>
<td>MSE</td>
</tr>
<tr>
<td></td>
<td>ESE</td>
</tr>
</tbody>
</table>

RATIONALE:
The objective of this course is to make the students use the measurement system in general and specific instrumentation that is essential for performance testing of four wheelers, two wheelers, automotive components and automotive systems.

COURSE LEARNING OUTCOMES:
At the end of course student will be able to:
1. Explain the performance parameters related to performance analysis of automotive and mechanical systems.
2. Select appropriate sensors and measurement system for performance testing of components and systems.
3. Identify and use the equipments for performance testing of two and four wheelers.
4. Evaluate performance of vehicular systems, automotive components and two and four wheelers.

PRE-REQUISITES: Generalized measurement system, parameters for performance testing of mechanical and automotive systems.

CURRICULUM

Unit 1: Measurement Systems 6 hrs
Importance of measurement, generalized measurement system, types and selection, automotive measurements, applications, characteristics of measuring system, Analysis of experimental data, errors in measurement, Data Acquisition system – Types and selection

Unit 2: Transducers, Signal Conditioners and Output Devices 6 hrs
Transducers for Automotive Applications - selection and types, Measurements using strain gauges, Amplifiers - Classifications and application in automobile filters types, analog and digital type DAS Indicators, Output devices, Signal Analysis

Unit 3: Performance testing of automotive systems 6 hrs
Performance requirements, Performance parameters, testing equipments, test standards, testing of clutches, brakes, gearboxes

(To be implemented from Year 2016-17)
Unit 4: Vehicle Testing
Need and importance of vehicle testing, Vehicle Performance parameters, On Road test, Vehicle testing on test tracks, Laboratory testing, designing test procedure, Virtual testing, test procedure and test standards

Unit 5: Vehicle Component Testing
Need and importance of component testing, Standards, types of tests, performance parameters requirement of measurement system and sensors, selection of sensors

Unit 6: Crash testing
Need and importance, vehicle safety-introduction, Human testing, Cadaver testing, Animal testing, NCAP rating, Types of crash testing, crash test sensors, sensor mounting, crash test data acquisition.

TEXT BOOKS

2. T.G. Beckwith and Buck, Mechanical Measurements, Oxford and IBH Publishing House, New Delhi, 1995

REFERENCE BOOKS

1. A.W. Judge, Engineering Precision Measurement, Chapman and Hall Ltd., Essex Street W.C., 1951,
4. Bosch Automotive Handbook
5. Motor Vehicle Manual ECE, EEC, FMVSS, AIS, CMVR, ADR
Program Elective – II
AE 4141 PRODUCT DESIGN AND DEVELOPMENT

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONAL:
The course is relevant to final year Automobile Engineering students from the viewpoint of the knowledge that they should acquire about the design and development of the Automotive / Industrial products. The curriculum of the course is designed to cover some aspects of product design and development such as, conceptualization, creativity techniques, product development techniques, creative aesthetic and ergonomic considerations, problem solving, economic considerations, Intellectual Property Right (IPR) etc. The course outcomes will ensure that the graduates are equipped with adequate knowledge for understanding the details of product design and development process.

COURSE LEARNING OUTCOMES:
At the end of the course, the learners will be able to:
1. Apply various product development techniques
2. Apply concept generation processes, creativity and innovative techniques and problem solving methods.
3. Design a product by applying Aesthetic and Ergonomic design considerations.
4. Explain the importance of IPR in the design and development of new products
5. Explain the effects of human factors on the design and development of a product

PRE-REQUISITES: The students are required to be familiar with the general engineering design procedure and should have awareness about engineering design and its relevance in development of automotive products.

CURRICULUM

Unit 1. Introduction
Introduction to product design, classification / specifications of products, Product life cycle, bath tub curve, Product mix, Generic product development process, various phases of product development -planning for products, establishing markets, market segments, relevance of market research, Modern product development process, Innovative thinking, Morphology of design and methods, Historical development in automotive design.

(To be implemented from Year 2016-17)
Unit 2. Industrial Product Design Considerations  
6 hrs
Functional design, basic design concepts, Aesthetic and Ergonomic design considerations, Anthropometry, Man-Machine interaction, Comfort criteria, Psychological and Physiological considerations, Ergonomic design of industrial products such as machine tools, testing equipments, work stations, automobiles etc.

Unit 3. Creativity and Innovative Techniques  
6 hrs
Creative thinking, conceptualization and problem solving methods. Concept of form follows the function. Theory of inventive problem solving (TRIZ), generating design concepts, systematic methods for designing.

Unit 4. Product Design  
6 hrs
Design methods for manufacturing, maintenance, transportation and assembly, value engineering, value analysis, legal factors and social issues. Engineering ethics and issues of society related to design of products, effect of technological developments in car design, role of materials in design, current trends in design.

Unit 5. Product Development Techniques  
6 hrs

Unit 6. Product Development Economics and Intellectual property  
6 hrs
Elements of economic analysis, economic analysis process, sensitivity analysis, Product Life cycle cost management. Standards and Legal requirements. Types of Intellectual property, overview of Patents, patent registration process, Licensing, users classification, Case studies.

TEXTBOOKS


REFERENCE BOOKS

5. Williams Tim, EMC for Product Designers, Elsevier
6. Chitale A.K., Product Design and Manufacturing, PHI Learning, New Delhi
Program Elective – III
AE 4161 SPECIAL PURPOSE VEHICLES

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>1</th>
<th>3</th>
<th>Credits</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T</td>
<td>P</td>
<td>Scheme</td>
<td>Theory (Marks)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Max.</td>
</tr>
<tr>
<td>ISE</td>
<td>20</td>
<td></td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>MSE</td>
<td>30</td>
<td>30</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>ESE</td>
<td>50</td>
<td>20</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
Special purpose vehicles play a vital role in the efficient operation of off road vehicle industry worldwide. The number and complexity of special purpose vehicle increase day by day. It consists of various type off-road vehicles such as Scrappers, Graders, Shovels, Ditchers, Cranes and Military vehicles with their design features. As this course may open doors of off-road vehicle industry for interested students, it has been included in the curriculum of Automobile Engineering.

COURSE LEARNING OUTCOMES:
At the end of this course, students will be able to:
1. Classify the different type of special purpose vehicles with its applications.
2. Suggest various types of features for given special purpose vehicle.
3. Explain the constructional and working features of various special purpose vehicles.
4. Apply the fundamental concepts of automotive engineering related to design of special purpose vehicles.

PRE-REQUISITES: Fundamental concept of Automobile Engineering.

CURRICULUM

Unit 1: Classification and Requirements of Special Purpose Vehicles 4 hrs
Construction layout, capacity and applications, Power Plants, Chassis and Transmission, Multiaxle vehicles

Unit 2: Features of Special Purpose Vehicles 7 hrs
Body hoist and bucket operational hydraulics. Hydro-pneumatic suspension cylinders. Power steering system, Kinematics for loader and bulldozer operational linkages, Safety features, safe warning system for dumper. Design aspects on dumper body, loader bucket and water tank of sprinkler.
Unit 3: Earth Moving Machines
Earthmovers like dumpers, loaders - single bucket. Multi bucket and rotary types - bulldozers, excavators, backhoe loaders, scrapers, drag and self powered types, Bush cutters, tree dozer, rippers etc. - Power and capacity of earth moving machines.

Unit 4: Scrapers, Graders, Shovels and Ditchers
Scrapers, Elevating Graders, Motor graders, Self powered scrapers and graders, Power shovel, Revolving and stripper shovels - drag lines - ditchers - capacity of shovels.

Unit 5: Military and Combat Vehicles
Types of Army Vehicles, Weights, and Speeds, Special features and constructional details of tankers, Gun carriers and transport vehicles, Terrains Vehicles.

Unit 6: Cranes and Derricks
Types of Cranes Generally used in the Workplace, Components of cranes, Crane and Derricks configuration, Stability against overturning, Analysis of Eight Hazards, Crane safety programs.

TEXT BOOKS

3. Abrosimov K., Brat h r.g.a and Katleyer K., Road Making Machinery, MIR Publishers, Moscow, 2006.

REFERENCE BOOKS

Program Elective – III
AE 4181 PRODUCT LIFECYCLE MANAGEMENT

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>----</td>
<td>----</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Rationale:
Product Lifecycle Management (PLM) is an environment in which information technology tools and processes allow a company increased access to product definition data to better develop, manage and support their products. It is a collection of interconnected technologies that enable companies to make better business decisions throughout the lifecycle of a product. PLM defines and controls data collection processes, integration, transformation, analysis, and visualization processes; from establishing a product's requirements, to the design, manufacturing, maintenance, and recycling of the product.

Course Learning Outcomes:
At the end of the course, the student will be able to
1. Identify the need of PLM.
2. Interpret the product development process.
3. Create and document the Product data.
4. Examine the product for product modeling.
5. Use basic PLM software.

Pre-Requisite: Engineering Graphics and CAD modeling softwares

Curriculum

Unit 1. PLM Basics

Unit 2. Product Development Process
Integrated Product Development Process - Conceive – Specification, Concept design, Design - Detailed design, Validation and analysis (simulation), Tool design, Realize - Plan manufacturing, Manufacture, Build/Assemble, Test (quality check), Service - Sell and Deliver, Use, Maintain and Support, Dispose – Disposal of product, Concurrent Engineering, Product & Process Systemization.
Unit 3. Product Data Management (PDM) Technology 8 hrs
Product Data Management – An Introduction to Concepts, Benefits and Terminology, PDM functions, definition and architectures of PDM systems, Product Data Interchange, PDM acquisition and implementation. Information authoring tools (e.g., MCAD, ECAD, and technical publishing). Core functions - Data Vaults, Document and Content Management, Workflow and Program Management. Functional applications – Software Configuration Management.

Unit 4. Product Modeling 6 hrs
Product Modeling - Definition of concepts - Fundamental issues – Role of Process chains and product models - Types of product models – model standardization efforts-types of process chains - Industrial demands. Foundation technologies and standards (e.g. visualization, collaboration and enterprise application integration).

Unit 5. PLM Software Basics 5 hrs
Business Objects. FSC, FCC, EBOM, MBOM, BMIDE, Change Management, Workflow Management (action handler/rule handler), Modules in Teamcenter.

Unit 6. Recent Advances 5 hrs
PLM XML, PLM Tools, PLM implementation cases in various industry verticals. Multisite Collaboration, Internet Based design, Intelligent Information Systems - Knowledge based product and process models - Applications of soft computing in product development process – Advanced Database Design for Integrated Manufacturing.

TEXT BOOKS


REFERENCE BOOKS


(To be implemented from Year 2016-17)


Program Elective - III
AE 4201 AUTOMOTIVE PLASTICS AND COMPOSITES

<table>
<thead>
<tr>
<th>Teaching Scheme</th>
<th>Evaluation Scheme</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RATIONALE:
The automotive industry faces many challenges, including increased global competition, the need for higher performance vehicles, a reduction in costs and tighter environmental and safety requirements. The development of materials and processes to facilitate the use of composites in high-volume automotive applications is also still a big challenge. The main advantages that composites offer to automotive applications are in cost reduction, weight reduction, recyclability and excellent crash performance compared with traditional steels. This course will help the students to learn the various aspects of plastics and composites with its existing and future scope in automotive field.

COURSE LEARNING OUTCOMES:
At the end of course the students will be able to:
1. Enlist various properties of automotive plastics and composite.
2. Explain reinforcement techniques in plastics and composites.
3. Evaluate and justify suitable plastics and composites for automotive components.
4. Suggest recycling processes for plastics and composites.

PRE-REQUISITE: Material Science

CURRICULUM

1. **Unit 1: Introduction**
   Need of plastics and composites, Significance in automotive field, Use of plastics and composites in car and light vehicles, Constituents of composites, Overview of recent automotive use of advanced composites.

2. **Unit 2: Important Plastics and Composites**
   Classifications, Styrene-based thermoplastics, Thermosets, Polyamides, PUR, Polymer matrix composite, Glass fibre reinforced polymers, Carbon fibre reinforced polymers, Metal Matrix Composites (MMC), Fibre reinforced composites, Laminated composites, Disperse composites,

(To be implemented from Year 2016-17)

3. **Unit 3: Reinforcements of Plastics and Composites**  
   Need of Reinforcement, reinforcement materials, Fiber materials for composites, Matrix materials, Fillers used in reinforcements of plastics, Functions of filler, Manufacturing methods of plastics and composites, Parameters affecting properties of composites, Effect of fiber length, Critical fiber length, Common defects in molding and composite products.

4. **Unit 4: Micromechanical Behaviour of Lamina and Laminate of Composites**  
   Stress-strain relations for anisotropic, orthotropic materials, Biaxial strength criteria for an orthotropic lamina, lamina properties and micromechanics: Mechanics of materials and elasticity approach, Tensile and compressive strength in fiber direction and failure of fibre composites, Strength under combined stresses, Analysis of laminates: Lamination theory, Laminate properties, Thermal and hygroscopic analysis, Laminate stress analysis, Laminate strength and failure, Interlaminar stresses.

5. **Unit 5: Testing and Safety Requirements**  
   Awareness for plastic & composites auto components test, Interior and exterior parts tests. Uniaxial and multiaxial, mechanical testing of thick section composite materials, Crash tests, active and passive safety systems, Car exterior impact, IMDS, Awareness of IMDS regulatory requirements for plastic & composites, Pedestrians/ Cyclists/ Soft nose.

6. **Unit 6: Recycling and disposal of Plastics and Composites**  

**TEXT BOOKS**


**REFERENCE BOOKS**


