Savitribai Phule Pune University

Structure and Syllabus

FOR

B.E. Automobile Engineering
2012 Course

UNDER FACULTY OF ENGINEERING

EFFECTIVE FROM July-2015

Savitribai Phule Pune University

B. E. (Automobile) - 2012 Pattern - Semester – I

(With effect from academic year 2015– 16)

Code	Subject	Teaching Scheme Hrs/week			Examination Scheme (Marks)					
		Lect	Tut.	Pract	In Sem Asse.	Tw	Pr	Or+	End Sem Exam	Total
416488	Automotive Refrigeration and Air Conditioning	3	--	2	30	--	--	50	70	**150**
416489	Automotive Chassis and Systems	3	--	--	30	--	--	--	70	**100**
416490	Machine and Vehicle Dynamics	4	--	2	30	25	--	50	70	**175**
416491	Elective – I	3	--	2	30	25	--	--	70	**125**
416492	Elective –II	3	--	--	30	--	--	--	70	**100**
416493	Vehicle Maintenance and Service Practices	--	--	2	--	--	50	--	--	**50**
416494 A	Project Phase –I*	--	2	--	--	50	--	--	--	**50**
Total of Semester – I		**16**	**02**	**08**	**150**	**100**	**50**	**100**	**350**	**750**

\+ For all Oral heads: Examination will be based on term work and Theory Subject

* Assessment should be carried out by panel of examiners from same Institute

B. E. (Automobile) - 2012 Pattern - Semester – II

Code	Subject	Teaching Scheme Hrs/week			Examination Scheme (Marks)					
		Lect	Tut.	Pract	In Sem Asse.	Tw	Pr	Or	End Sem Exam	Total
416495	Vehicle Performance and Testing.	4	--	2	30	25	50	--	70	**175**
416496	Automotive System Design	4	--	2	30	25	--	50	70	**175**
416497	Elective- III	3	--	--	30	--	--	--	70	**100**
416498	Elective- IV	3	--	--	30	--	--	--	70	**100**
416499	Seminar on In-plant Training Evaluation*	--	--	2	--	50	--	--	--	**50**
416494 B	Project Phase– II	--	6	--	--	100	--	50	--	**150**
Total of Semester – II		**14**	**06**	**06**	**120**	**200**	**50**	**100**	**280**	**750**

* In-plant Training will be performed for a duration of minimum **two weeks**, during winter vacation (after B.E. Sem – I) and will be evaluated by External Examiner in B.E. Semester - II.

Elective-I		**Elective-II**	
Code	**Subject**	**Code**	**Subject**
416491 A	Fundamentals of Computational Fluid Dynamics	**416492 A**	Hybrid and Fuel Cell Vehicle
416491 B	Fundamentals of Finite Element Analysis	**416492 B**	Automotive Materials
416491 C	CAE and Automation	**416492 C**	Automotive Hydraulics and Pneumatics
Elective-III		**Elective-IV**	
416497 A	Automotive NVH	**416498 A**	Transport Management and Motor Industries
416497 B	Off Road Vehicle	**416498 B**	Operation Research
416497 C	Alternative Fuels and Emission Control.	**416498 C**	Open Elective**

****: Open Elective** – BOS Automobile will declare the list of subjects which can be taken under open electives or any other electives that are being taught in the current semester, to the same level, as elective –IV under engineering faculty or individual college and industry can define new elective with proper syllabus using defined framework of elective iv and get it approved from board of studies and other necessary statutory systems in the Savitribai Phule Pune university before 30th November. Without approval from university statutory system, no one can introduce the open elective in curriculum.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-I
(416488) Automotive Refrigeration and Air Conditioning

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416488	Automotive Refrigeration and Air Conditioning	3	--	2	30	70	--	--	50	150

Pre-Requisites

Thermodynamics, Applied Thermodynamics, Heat Transfer

Course Objectives

This course "Automotive Refrigeration and Air Conditioning" is designed with the following objectives in mind:

1. The student shall gain appreciation and understanding of different types of refrigeration cycles, Application of refrigeration and air conditioning.
2. Shall be able to select proper refrigerants considering Environmental effect, Physical effect on human being for automotive application.
3. Student shall gain knowledge of design consideration for the refrigeration and air conditioning also psychrometric properties , Psychrometric table reading etc.
4. Student shall gain knowledge of diagnostic of automotive air conditioning system on vehicle, Trouble shooting , Care taken at the time of repairing and maintenance

Course Outcomes

1. Ability to select proper refrigeration cycle and refrigerant according to application considering economy, Environmental effect, Physical effect on human etc.
2. Ability to design air conditioning system for automotive application in optimum cost.

Unit-I: Refrigeration Fundamentals *06*

Introduction to refrigeration and vapour compression system, cycle diagram (Carnot cycle, Reverse Carnot cycle, Simple vapor compression cycle, bell Coleman cycle), effects of various operating parameters on performance of A/C System, Vapour absorption refrigeration system(No numerical), Applications of refrigeration and air conditioning.

Unit-II: Refrigerants and Air conditioning Components *06*

Environmental concerns/Legislation for automotive A/C systems, types and properties of refrigerants, refrigerant oils, refrigerant piping. Future refrigerants, Air conditioning components: Compressors, Condensers, flow control devices, evaporators – Design guidelines, types, sizing and their installation. Accumulators, receiver driers and desiccants. Refrigerant charge capacity determination.

Unit-III: Air distribution system *06*

Comfort conditions, Air management and heater systems, air distribution modes (Fresh/Recirculation, Face, Foot, Defrost, and Demist), A/C ducts and air filters. Blower fans, Temperature control systems (manual/semiautomatic, automatic). Vehicle operation modes and Cool-down performance.

Unit-IV: Psychrometry *06*

Psychometric properties, tables, charts, Psychometric processes, Processes, Combinations and Calculations, ADP, Coil Condition line, Sensible heat factor, Bypass factor.

Unit-V:Load analysis and control devices ***08***

Load Analysis: Outside and inside design consideration, Factors forming the load on refrigeration and air conditioning systems, Cooling and heating load calculations, Load calculations for automobiles, Effect of air conditioning load on engine performance, Air conditioning electrical and electronic control, pressure switching devices, sensors and actuators.

Unit-VI: Diagnostics, Trouble Shooting, Service and Repair ***04***

Initial vehicle inspection, temperature measurements, pressure gauge reading and cycle testing, leak detection and detectors, Sight glass. Refrigerant safety/handling, refrigerant recovery; recycle and charging, system oil, system flushing, odor removal, retrofitting. Removing and replacing components, Compressor service.

Term Work: The term work shall consist of record of minimum eight experiments from the following: (Experiment No1, 2 and 10 are compulsory)

List of Experiments:-

1.Test on vapor compression test rig.
2. Test on air conditioning test rig.
3. Study of various methods of transport refrigeration systems.
4. Study and demonstration on car and bus air conditioning system.
5. Study of latest trends in automotive refrigeration systems .
6. Study and demonstration of controls in refrigeration.
7. Study of different components with the help of cut sections/models/charts- Compressor, Condenser, Evaporators, Expansion device, Blower fans, Hating systems etc.
8. Study of installation/operations/maintenance practices for refrigeration systems.
9. Study of leak testing and leak detection methods.
10. Visit to maintenance shop of automotive air conditioning and writing report on it.

Text Book:

1.Textbook of "Refrigeration and Air Conditioning" By R. S. Khurmi and J.K.Gupta S. Chand Publication.
2.Steven Daly: "Automotive air conditioning and Climate control systems" Butterworth-Heinemann publications

References:

1. "Principles of Refrigeration"; Roy J Dossat: Pearson Education Inc.
2. "Automotive air conditioning" William H Crouse and Donald L Anglin:
3. "Refrigeration and Air Conditioning"; Arora and Damkondwar: Dhanpatrai and Company.
4. "Refrigeration and Air Conditioning", C.P.Arora: Tata McGraw Hills Pub.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-I
(416489) Automotive Chassis and Systems

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416489	Automotive Chassis and Systems	3	--	--	30	70	--	--	--	100

Pre-Requisites
Theory of Machine, Machine Design

Course Objectives
This course "Automotive Chassis and Systems" is designed with the following objectives in mind:

1. The student shall gain appreciation and understanding function of front axle, types of stub axle, types of steering gear box etc.
2. Shall be able to understand need of suspension and its types, types of tyre, tyre specification, tyre rotation etc.
3. Student shall gain knowledge of design consideration braking system, suspension system and for chassis etc.
4. Student shall gain knowledge of what are different safety systems used in current situation in automobile vehicles.

Course Outcomes
1. Ability to know the steering geometry, what should be the tyre pressure for different vehicle, which type of brakes are best for vehicle.
2. Ability to recognize which safety systems are best for vehicle and also for safety consideration.

Unit-I: Front Axle and Steering System *08*
Functions of front axle, Types of front axle, Construction, Stub axle and Wheel bearing, Front wheel steering Geometry – castor, Camber, King pin inclination, toe-in, toe-out, Centre point Steering, Self returning property, Adjusting and checking of front wheel geometry, Ackerman and Davis steering linkages, Steering system layout, Steering gear boxes.

Unit-II: Vehicle Suspension Systems *08*
Road irregularities and need of suspension system, Types of suspension system, Sprung and unsprung mass, Suspension springs – requirements, types and characteristics of leaf spring, coils spring, rubber spring, air and torsion bar springs, Independent suspension for front and rear, Types, Hydro-elastic suspension, Roll centre, Use of anti-roll bar and stabilizer bar, Shock absorbers – need, operating principles and types, Active suspension.

Unit-III: Wheels and Tyres *04*
Basic requirements of wheels and tyres, Types of road wheels, Construction of wheel assembly, wheel balancing, Tyre construction, material, types, tubeless, cross ply radial type, tyre sizes and designation, Aspect ratio, tyre trade pattern, tyre valve, Tyre inflation pressure, safety precautions in tyres, Tyre rotation and matching, Types of Tyre wear and their causes, Selection of tyres under different applications, tyre retreading hot and cold, factors affecting tyre performance.

Unit-IV: Braking Systems *08*
Function and requirements of braking system, Types of brakes, Elementary theory of shoe brake, drum brake arrangement, disc brake arrangement, self energizing, brake friction material. brake linkages, hydraulic brake system and components, hydraulic brake fluids, air brakes, vacuum servo assisted brake, engine exhaust brake,

parking brakes, dual power brake system, regenerative brake system, fail-safe brake, anti – lock brakes, anti skid brakes, brake efficiency and testing, weight transfer, braking ratio.

Unit-V: Vehicle Safety Systems *04*

Introduction, Electronic stability program system operation, overview, rollover mitigation system overview, active safety and passive safety, latest trends in traffic system for improved road safety, head restraints, introduction to the type of safety glass and their requirements, types of different mirrors and their location.

Unit-VI: Vehicle Chassis *04*

Introduction To chassis, chassis operating condition, chassis frame, vehicle components location. manufacturing processes for chassis, causes of chassis failure.

Text Book:

1. "Automobile Engineering" R. B. Gupta Satya Prakashan New Delhi.
2. "Basic Automobile Engineering" C. P. Nakra Dhanpat Rai Publishing Company (P) Ltd-New Delhi
3. "Automotive Mechanics" N.K. Giri 8th Edition Khanna Publishers New Delhi.

References:

1. "Motor Vehicles", Newton, Steed and Garrot, 13th Edition, Butterworth London
2. "Vehicle and Engine Technology", Heisler, Second Edition SAE International Publication.
3. "Advanced Vehicle Technology", Heisler,Second Edition SAE International Publication.
4. "The Automotive Chassis", J. Reimpell H. Stoll, J.W. Betzler, SAE International Publication.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-I
(416490) Machine and Vehicle Dynamics

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416490	Machine and Vehicle Dynamics	4	--	2	30	70	25	--	50	175

Pre-Requisites

Theory of Machine, Design of Machine Elements.

Course Objectives

This course "Machine and Vehicle Dynamics" is designed with the following objectives in mind:

1. Students should be able to understand balancing of rotating masses, Reciprocating masses and concept of static and dynamic balancing.
2. Students should be able to understand basic concept of vibration, types of vibration, undamped and damped vibration, also different types of damping.
3. Students should be able to understand vehicle coordinate system, performance characteristics of road vehicle for steady state operation and transient operation.

Course Outcomes

1. Ability to balance machine at the time of design by considering all forces.
2. Ability to know acceleration and braking characteristics, effect on vehicle due to various forces.
3. Ability to know what is ride and handling in vehicle design.

Unit-I: Balancing *08*

Balancing of rotating masses in one and several planes, balancing of reciprocating masses in single and multi cylinder engines: in-line, radial and V-type, primary and secondary balancing analysis, concept of direct and reverse cranks method, static and dynamic balancing machines.

Unit-II: Single Degree of Freedom Systems - Free and Damped Vibrations *08*

Fundamentals of Vibration: Elements of a vibratory system, S.H.M., degrees of freedom, modeling of a system, concept of linear and non-linear systems, equivalent spring, linear and torsional systems. Undamped free vibrations: Natural frequency by equilibrium and energy methods for longitudinal and torsional vibrations. Damped free vibrations: Different types of damping, equivalent viscous damping, free vibrations with viscous damping - over damped, critically damped and under damped systems, initial conditions, logarithmic decrement, dry friction or coulomb damping - frequency and rate of decay of oscillations.

Unit-III: Single Degree of Freedom Systems - Forced Vibrations *08*

Forced vibrations of longitudinal and torsional systems, Frequency Response Functions - Simple harmonic excitation, excitation due to reciprocating and rotating unbalance, base excitation, magnification factor, resonance phenomenon and phase difference, Quality Factor, Vibration Isolation, Force and Motion transmissibility.

Unit-IV: Introduction of Vehicle Dynamics *08*

Vehicle coordinate system, earth fixed coordinate system, longitudinal, lateral and vertical vehicle dynamics, vehicle springing system - requirements, sprung mass and unsprung mass.

performance characteristics of road vehicles

a) Steady State Operation: Various external forces acting on vehicle, Nature of the forces and factors affecting the forces, Tractive effort and Power available from the engine, equation of motion, maximum tractive effort, weight distribution, stability of vehicle on slope, road performance curves, acceleration, gradibility and drawbar pull.

b) Transient Operation: Inertia effect, Equivalent mass, Equivalent moment of inertia, Equivalent ungeared system, Time to produce synchronizing during gear change, Effect of engine flywheel on acceleration, Dynamics of vehicles on Banked tracks, Gyroscopic Effects, Net driving power.

Unit-V: Acceleration and Braking Characteristics: 08

Acceleration - Power limited acceleration: Engines, Power Train, And Automatic Transmission. Traction Limited Acceleration: Transverse Weight Shift, Traction Limit, Numerical Treatment.

Braking – Constant Deceleration, Braking Force, Brake Factor, Braking Efficiency And Stopping Distance, Reaction Time And Stopping Time, Braking Applied To Rear Wheels, Front Wheels And All Four Wheels, On Straight And Curved Path, Mass Transfer And Its Effect.

Unit-VI: Handling Mode and Ride Mode: 08

Mathematical model of handling, Fundamental condition for true Rolling Steady State Handling: Slip angle, cornering power, Neutral steer, under steer and over steer, Steady state response, Yaw velocity, Lateral Acceleration, Curvature response and Directional stability.

Transient Handling: Basic principles, differential equations of motions. Vehicle Test for handling performance: Steady state testing, constant speed test, constant steer angle test, Constant radius test. Ride performance criteria: Mathematical modeling of vehicle ride, Excitation sources Vehicle Response Properties: Effects of damping the vibration, vibration absorbers, oscillation centers, active and semi active suspension, orthogonlity of mode shapes, modal analysis.

Term Work: (The Term Work shall consist of any eight experiments of following.)

List of Experiment:

1. Experimental verification of dynamic balancing of rotating masses.
2. To determine the natural frequency of damped vibration of single degree freedom system and to find it's damping coefficient.
3. To verify natural frequency of torsional vibration of two rotor system and position of node.
4. To determine critical speed of single rotor system.
5. To determine resonance frequency of transverse vibration of beam.
6. To determine the frequency response curve under different damping conditions for single degree freedom system of vibration
7. Multi body simulation of steering and suspension components using any of the following mentioned FEA and MBD software's. (Compulsory)
8. To study shock absorber and to plot transmissibility curve.
9. Measurement of vibration parameters like frequency, amplitude, acceleration of any vibrating system by using vibration measuring instruments.
10. Analysis of machine vibration signature using any analysis software.

Software's: Ansys, Abaqus, MSC-Nastran, MSC Adams, Motion Solve, AMESim, CarSim, and Matlab

Text Books:

1. "Mechanical Vibrations", Singh V.P., Dhanpat Rai and Sons, New Delhi
2. "Mechanical Vibrations", Grover, G. K. and Nigam, S. P., Nemchand and Brothers, Roorkee, U.K, India

Reference Books:

1. "Mechanical Vibrations", S. S. Rao Pearson Education
2. "Vibration and Noise for Engineers", Kewal Pujara and R.S. Pujara, Dhanpat Rai and Sons, Delhi
3. "Fundamentals of Vehicle Dynamics", Gillespie Thomas D, SAE USA 1992.
4. "Theory of Ground Vehicles", John Wiley and Sons, Wong J Y, New York, 1978
5. "Tyre and Vehicle Dynamics", Ham B, Pacejka SAE Publication - 2002

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-I
(416492 A) Elective I- Fundamentals of Computational Fluid Dynamics

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416491A	Fundamentals of Computational Fluid Dynamics	3	--	--	30	70	25	--	--	125

Pre-Requisites

Fluid Mechanics, Heat transfer, Numerical methods, Programming Languages.

Course Objectives

This course "Fundamentals of Computational Fluid Dynamics" is designed with the following objectives in mind:

1. Students should be able to model fluid / heat transfer problems and apply fundamental conservation principles.
2. Students should be able to discretize the governing differential equations and domain by Finite Difference Method.
3. Students should be able to solve basic convection and diffusion equations and understands the role in fluid flow and heat transfer.
4. To prepare the students for career in industry in CAE through use of software tools.
5. To prepare the students for research leading to higher studies.

Course Outcomes

1. Ability to analyze and model fluid flow and heat transfer problems.
2. Ability to generate high quality grids and interpret the correctness of numerical results with physics.
3. Ability to use a CFD tool effectively for practical problems and research.
4. Ability to conceptualize the programming skills.

Unit-I Introduction to CFD *8*

CFD – a research and design tool, CFD as third dimension of engineering supplementing theory and experiment, Steps in CFD solution procedure, strengths and weakness of CFD, Flow modelling using control volume - finite and infinitesimal control volumes, Concept of substantial derivative, divergence of velocity, Basic governing equations in integral and differential forms – conservation of mass, momentum and energy (No derivations), Physical interpretation of governing equations, Navier-Stoke's model and Euler's model of equations.

Unit- II Basic Discretization Techniques *10*

Introduction to grid generation (Types of grids such as structured, unstructured, hybrid, multiblock, Cartesian, body fitted and polyhedral etc.), Need to discretize the domain and governing equations, Finite difference approximation using Taylor series, for first order (Forward Difference Approximation, Backward Difference Approximation, Central difference Approximation) and second order (based on 3 node, 4 node and 5 node points),explicit and Implicit approaches applied to 1D transient conduction equation, Couette flow equation ($\frac{\partial p}{\partial x} = 0$) using FTCS and Crank Nicholson's Method, Stability Criteria concept and physical interpretation, Thomas Tri-diagonal matrix solver.

Unit-III Two Dimensional Steady and unsteady heat conduction *8*

Solution of two dimensional steady and unsteady heat conduction equation with Dirichlet, Neumann, robbins and mixed boundary condition – solution by Explicit and Alternating Direction Implicit method (ADI Method), Approach for irregular boundary for 2D heat conduction problems.

Unit-IV Application of Numerical Methods to Convection – Diffusion system 10

Convection: first order wave equation solution with upwind, Lax–Wendroff, Mac Cormack scheme, Stability Criteria concept and physical interpretation

Convection –Diffusion: 1D and 2D steady Convection Diffusion system – Central difference approach, Peclet Number, stability criteria, upwind difference approach, 1 D transient convection-diffusion system

Unit-V Incompressible fluid flow 8

Solution of Navier-Stoke's equation for incompressible flow using SIMPLE algorithms and its variation (SIMPLER), Application to flow through pipe, Introduction to finite volume method.

Unit-VI CFD as Practical approach 8

Introduction to any CFD tool, steps in pre-processing, geometry creation, mesh generation, selection of physics and material properties, specifying boundary condition, Physical Boundary condition types such as no slip, free slip, rotating wall, symmetry and periodic, wall roughness, initialising and solution control for the solver, Residuals, analysing the plots of various parameters (Scalar and Vector contours such as streamlines, velocity vector plots and animation). Introduction to turbulence models. Reynolds Averaged Navier-Stokes equations (RANS), k-ϵ, k-ω. Simple problems like flow inside a 2-D square lid driven cavity flow through the nozzle.

Term Work: Any 8 in the given list below (from 1-9) should be performed with mini project (Sr.No.10) compulsory.

List of Experiment:

1 Generation of different meshes
   a. Structured mesh
   b. Unstructured mesh,
   c. Multiblock, etc.
2. Program on 1D transient heat conduction by FTCS OR Crank Nicholson scheme
3. Program on 1-D (first order)wave equation by Upwind scheme and study the impact of CFL number on the stability and solution .
4. Program on 2D Transient Conduction equation / 2D Convection-Diffusion Equation
5. Numerical simulation and analysis of boundary layer over a flat plate (Blausius Equation) are using any CFD software or computer programming.
6. Numerical simulation and analysis of boundary layer for
   a). Developing flow through a pipe
   b) Fully developed flow through a pipe.
7. Numerical simulation and analysis of 2D square lid driven cavity using any CFD software. Effect of Reynolds number on the vorticity patterns.
8. CFD Analysis of external flow: Circular Cylinder or Aerofoil (NACA 0012)
9. CFD analysis of heat transfer in pin fin.
10. Mini project on any practical application. Students should take a problem of their choice and verify the CFD solution with experimental data / research paper.

References:

1. Computational Fluid Dynamics- John D Anderson: The Basics with Applications, McGraw-Hill
2. Computational Fluid Dynamics: J. Tu, G.-H. Yeoh and C. Liu: A practical approach, Elsevier.
3. Introduction to Computational Fluid Dynamics, A. W. Date: Cambridge University Press
4. Computer Simulation of Fluid flow and heat transfer, P.S.Ghoshdastidar: Tata McGraw-Hill.
5. Numerical Simulation of internal and external flows Vol. 1C. Hirsch, Wiley.
6. Computational Fluid Mechanics and Heat transfer, Tannehill, Anderson, and PletcherCRC Press.
7. Methods for Fluid Dynamics,J. H. Ferziger and M. Peric: Computational 3rd Edition, Spri

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B.E. (Automobile) (2012 Course)
Semester-I
(416492 B) Elective I- Fundamentals of Finite Element Analysis

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416491B	Fundamentals of Finite Element Analysis	3	--	--	30	70	25	--	--	125

Pre-Requisites

Mechanics of materials ,Design of Machine Elements (Static and dynamic failure theories),Engineering Graphics ,Computer Programming.

Course Objectives

This course "Fundamentals of Finite Element Analysis" is designed with the following objectives in mind:

1. Students are able to do stress analysis by using software
2. Students are able to bridge the gap between hand calculations for complex geometry.
3. The course provides practical analysis of Automotive components.

Course Outcomes

Upon completion of this course, the student will be able to:

1. Apply mechanics of materials and machine design topics to provide preliminary results used for testing the reasonableness of finite element results.
2. Explain the inner workings of a finite element code for linear stress, displacement, temperature and modal analysis.
3. Interpret the results of finite element analyses and make an assessment of the results in terms of modeling (physics assumptions) errors, discretization (mesh density and refinement toward convergence) errors, and numerical (round-off) errors.

UNIT-I Fundamentals concepts of FEA *08*

Introduction– Brief History of FEM, general fem procedure, applications of fem in various field, advantages and disadvantages of fem, difference between fem and fdm, consistent units system. approximate methods of solving differential equations (ritz method, galerkin method, least square method, collocation and subdomain method).

Review of Solid Mechanics: Stress equilibrium equations, strain-displacement equations, stress-strain-temperature relations, plane stress, plane strain and axisymmetric problems, strain energy, total potential energy. essential and natural boundary conditions

Review of Matrix Algebra: (Vectors, Matrices, Symmetric banded matrix, determinants, inverses), banded skyline solutions. introduction to solvers (sparse solver, iterative solver, pcg etc)

UNIT-II 1D Elements: *08*

Introduction to different approaches used in FEA such as direct approach, Variational approach, weighted residual (Galerkin). Types of 1D element. Displacement function, Global and local coordinate systems, Order of element, primary and secondary variables, shape functions and its properties. Formulation of elemental stiffness matrix and load vector for spring, bar, beam, truss and Plane frame. Transformation matrix for truss and plane frame, Assembly of global stiffness matrix and load vector, Properties of stiffness matrix, half bandwidth, Boundary conditions elimination method and penalty approach, Symmetric boundary conditions, Stress calculations.

UNIT-III 2D Elements: ***06***

Types of 2D elements, Formulation of elemental stiffness matrix and load vector for Plane stress/strain such as Linear Strain Rectangle (LSR), Constant Strain Triangles (CST), Pascal's triangle , primary and secondary variables, properties of shape functions. Assembly of global stiffness matrix and load vector, Boundary conditions, solving for primary variables (displacement), Overview of axi-symmetric elements

UNIT-IV Isoparametric Elements: ***06***

Concept of isoparametric elements, Terms Isoparametric, super parametric and subparametric. Isoparmetric formulation of bar element.

Coordinate mapping - Natural coordinates, Area coordinates (for triangular elements), higher order elements (Lagrangean and serendipity elements). Convergence requirements- patch test, Uniqueness of mapping - Jacobian matrix. Numerical integration – Newton Cotes quadrature, 2 and 3 point Gauss Quadrature, full and reduced integration. Sub-modeling, substructuring.

UNIT-V 1D Steady State Heat Transfer Problems ***06***

Introduction, Governing differential equation, steady-state heat transfer formulation of 1D element for conduction and convection problem, boundary conditions and solving for temperature distribution.

UNIT-VI Dynamic Analysis: ***06***

Types of dynamic analysis, General dynamic equation of motion, point and distributed mass, lumped and Consistent mass, Mass matrices formulation of bar and beam element.

Undamped-free vibration- Eigenvalue problem, Evaluation of eigenvalues and eigenvectors (natural frequencies and mode shapes).

Error Analysis in finite element methods (types of error estimates- Priori error estimates, posteriori error estimates etc.)

Term Work:

List Of Experiments:

The term work shall consist of record of any three from 1 to 4***** and any three from 5 to 8****** assignments of the problems based on following topic:

1. Computer program for stress analysis 2-D truss subjected to plane forces
2. Computer program for modal analysis 1-D beam (simply supported or cantilever beams)
3. Computer program for frames subjected to transverse forces and moments
4. Computer program for 1-D temperature analysis
5. Static stress concentration factor calculation for a plate with center hole subjected to axial loading in tension using FEA software.
6. 2D Forced convection problem using FEA software.
7. Modal analysis of any machine component using FEA software.
8. Stress and deflection analysis of any machine component consisting of 3-D elements using FEA software.

*****1. Students can write the program in any of the programming language such as FORTRAN, C, C++, MATLAB, Python, VB.
2. Minimum number of elements considered should be 10
3. Validate results of the program with analytical method or FEA software such as Abaqus, ANSYS, Msc-Nastran, Optistruct/Radioss, Comsol-Multiphysics

****** 1. Students should do convergence study for all assignment problems.
2. Use different element types from element library
3. If possible use submodel/symmetry option.

Text Books

1. A First Course in the Finite Element Method, Daryl L. Logan
2. Concepts and Applications of Finite Element Analysis, R. D. Cook, et al. , Wiley-India.
3. Finite Element Analysis, S. S. Bhavikatti, New Age International.

Reference Books

1. An Introduction to the Finite element method, J. N. Reddy, Tata McGraw-Hill.
2. Finite Element Procedures, Bathe K. J., Prentice-Hall of India (P) Ltd., New Delhi.
3. The Finite Element Method for Solid and Structural Mechanics, Olek C Zienkiewicz, Robert L Taylor, Butterworth-Heinemann-6th Edition.
4. The Finite Element Method in Engineering, S. S. Rao, Elsevier.
5. Introduction to Finite Elements in Engineering, Chandrupatla T. R. and Belegunda A. D., Prentice Hall India.
6. Text book of Finite Element Analysis, Seshu P., PHI Learning Private Ltd. New Delhi, 2010.
7. Finite Element Analysis, Theory and Practice, Fagan M. J., Pearson Education Limited
8. Finite element methods for Engineers, U. S. Dixit, Cengage Learning.
9. Finite Element Method using MATLAB, Kwon Y. W., Bang H., CRC Press, 1997
10. Roark's Formulas for Stress and Strain, W.C. Young

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-I
(416492 C) Elective I- CAE And Automation

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416491C	CAE And Automation	3	--	--	30	70	25	--	--	125

Pre-Requisites
Computer Aided Machine Drawing, Mathematics, Programming Language

Course Objectives
This course "CAE And Automation" is designed with the following objectives in mind

1. Students should be able to understand the basic analytical fundamentals that are used to create and manipulate geometric models in a computer program.
2. Students should be able to understand integration of CAD, CAE and CAM system.
3. To introduce the students Finite Element Techniques.
4. Introductory exposure of Rapid prototyping to the student.
5. To develop a holistic view of initial competency in engineering design by modern computational methods.
6. To introduce the students Automation and Robot Technology

Course Outcomes
1. Student able to transform, manipulate objects and store and manage data.
2. Learn mathematical basis for geometric modeling of curves and surfaces and their relationship with computer graphics.
3. Learn advanced concepts of feature based modeling and parametric modeling etc.
4. Student able to prepare part programming applicable to CNC machines using software.
5. Student able to solve problem using analysis software
6. Student can use rapid prototyping , Automation and Robotics concepts in any real life applications.

UNIT-I Computer Graphics and Techniques for Geometric Modeling *08*

Curves:-Introduction, analytic curves, line, circle, parabolas, hyperbolas, ellipses, conics, synthetic curves, hermite cubic spline, bezier curve, b-spline curve, numerical on above topic.

Surfaces:-Introduction, Surface Representation, analytic surfaces, synthetic surfaces, hermite bicubic surface, bezier surfaces, b-spline surfaces, coons surface. no analytical treatment.

Solids: Introduction, Geometry and Topology, solid representation, boundary representation, euler's equation, constructive solid geometry, boolean operation for csg, hybrid modeling, feature based modeling, parametric modeling, constraint based modeling, mass, area, volume calculation.

UNIT-II Transformation in Computer Graphics *06*

Transformation-Introduction, formulation, translation, rotation, scaling, reflection homogenous representation, concatenated transformation, mapping of geometric models, inverse transformations

Projections: Orthographic, isometric, and perspective. introduction to open gl and commands required for the transformation.

UNIT-III Computer Aided Engineering *08*

CAE: Introduction and its automobile related applications.

FEA: Introduction, stress, and equilibrium, boundary condition, strain - displacement relations, stress-strain relation, temperature effects, potential energy and equilibrium: - rayleigh-ritz method, galerkin‟s method.

One Dimensional Problem: Finite Element Modelling, coordinate and shape function, potential energy approach, galerkin approach, assembly of global stiffness matrix and load vector, properties of stiffness matrix, finite element equations, quadratic shape function, temperature effects .
Trusses: Introduction, 2d trusses, assembly of global stiffness matrix. introduction, constant strain triangle problem, modeling and boundary conditions.

UNIT-IV Computer Aided Manufacturing *06*

CAD hierarchy, integrating cad, nc and cam, nc programming using g and m codes adoptable to fanuc controller for lathe and milling, generative programming on cnc, dnc, adaptive control system, cim,capp, introduction of rapid prototyping and its techniques.

UNIT-V Introduction to Automation *06*

Types of automation, transfer line mechanism, geneva mechanism, group technology, automated guided vehicles, automatic storage and retrieval system, introduction to flexible manufacturing system

UNIT-VI Robot Technology *06*

Classification and structure of robotic systems point-to-point robotic systems, continuous path robotic system. configurations of robotic system, joints, drives, controller, types of end effectors mechanical, magnetic, pneumatic etc., industrial applications of robots, introduction to robot programming, programming languages.

Term Work

The term work shall consist of record of all assignments of problems based on the following topics:

1. Transformation programs using suitable languages i.e. C++, VB, OPENGL,MATLAB etc.
2. Stress and deflection analysis of two dimensional truss using finite element package.
3. Stress and deflection analysis of any Automobile component consisting of 2-D elements using finite element package.
4. Stress and deflection analysis of any Automobile component consisting of 3-D elements using finite element package.
5. Tool path generation using CAM software and Manufacturing on CNC.
6. Demonstration on any one industrial robot or Industrial visit to automation plant.
7. Assignment on Robot gripper design/ Robot programming.

Reference Books

1. "CAD/CAM - Theory and Practice", Ibrahim Zeid and R. Sivasubramanian Tata McGraw Hill Publishing Co. 2009
2. “Mastering CAD/CAM” Ibraim Zeid, Tata McGraw Hill Publishing Co. 2000
3. "Introduction to Finite Elements in Engineering”, Chandrupatla T.R. and Belegunda A.D. - Prentice Hall India.
4."Applied Finite Elements Analysis” ,Segerling L.J., John Wiley and Sons.
5. "Introduction to CAD/CAM", Rao P.N., Tata McGraw Hill Publishing Co.
6."Automation, production systems and computer integrated manufacturing", Groover M.P, Prentice Hall of India
7." Robotics" ,Yoram Koren McGraw Hill Publishing Co.
8. "Robot Technology Fundamentals", James G. Keramas, Delmar Publishers.
9. "Robotics Technology and Flexible Automation", S.R.Deb, Tata McGraw Hill.
10. "Finite Element Analysis" (Procedures in Engineering), Lakshiminarayana H. V., University Press, 2004.
11." Finite Element Analysis for Engineering and Technology", Chandrupatla T. R.,University Press, 2009.
12. "Text book of Finite Element Analysis", Seshu P. PHI Learning Private Ltd. New Delhi, 2010.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-I
(416492 A) Elective II- Hybrid and Fuel Cell Vehicle

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416492A	Hybrid and Fuel Cell Vehicle	3	--	--	30	70	--	--	--	100

Pre-Requisites
Automotive Transmission, Automotive Electrical and Electronics

Course Objectives
This course "Hybrid and Fuel Cell Vehicle " is designed with the following objectives in mind:

1. The student shall gain appreciation and understanding about lay out of electric vehicle and different components of electric vehicle.
2. Shall be able to know architecture and power plant specifications of hybrid vehicle and performance parameter of hybrid vehicle.
3. Student shall gain knowledge of types of fuel cell and characteristics of fuel cell.

Course Outcomes
1. Depth knowledge about hybrid vehicle
2. Students are able to design hybrid vehicle

Unit -I: Electric Vehicles and Motors *06*
Electric vehicle, introduction, components, advantages, disadvantages, applications, vehicles. DC motors series wound- shunt wound- compound wound and separately excited motors AC motors Induction- synchronous- brushless DC motor- switched reluctance motors.

Unit -II: Hybrid Vehicles and Propulsion Methods *06*
Introduction to hybrid vehicles performance characteristics of road vehicles; calculation of road load- predicting fuel economy- grid connected hybrids.

Unit -III: Hybrid Architecture and Power Plant Specifications *06*
Series configuration locomotive drives- series parallel switching- load tracking architecture. Pre transmission parallel and combined configurations Mild hybrid- power assist- dual mode- power split- power split with shift- Continuously Variable transmission (CVT)- wheel motors. Grade and cruise targets- launching and boosting- braking and energy recuperation- drive cycle implications.

Unit -IV: Sizing the Drive System and Energy Storage Technology *06*
Matching electric drive and ICE; sizing the propulsion motor; sizing power electronics. Battery basics; lead acid battery; different types of batteries; battery parameters.

Unit-V: Fuel Cells *06*
Fuel cell characteristics- fuel cell types – alkaline fuel cell- proton exchange Membrane; direct methanol fuel cell- phosphoric acid fuel cell- molten carbonate fuel cell- solid oxide fuel cell- hydrogen storage systems- reformers- fuel cell EV- super and ultra capacitors- PEM fuel cell vehicles.

Unit -VI: Nonelectric Hybrid Systems *06*
Short term storage systems flywheel accumulators. continuously variable transmissions hydraulic accumulators hydraulic pumps/motors- pneumatic hybrid engine systems operation modes.

Text Books:

1. ''The Electric Car: Development and Future of Battery- Hybrid and Fuel Cell Cars", Mike Westbrook- M H Westbrook- British library Cataloguing in Publication Data.
2. ''Electric and Hybrid Vehicles",Robin Hardy- Iqbal Husain- CRC Press.
3. "Propulsion Systems for Hybrid Vehicles" ,John M. Miller Institute of Electrical Engineers- London.
4. "Alternative Fuels", S.S.Thipse, Jaico publications

Reference Books:

1. Energy Technology Analysis Prospects for Hydrogen and Fuel Cells- International Energy Agency- France.
2. Handbook of Electric Motors- Hamid A Toliyat- Gerald B Kliman- Marcel Decker Inc.

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B.E. (Automobile) Part I (2012 Course)
Semester-I
(416492 B) Elective II-Automotive Materials

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416492B	Automotive Materials	3	--	--	30	70	--	--	--	100

Pre-Requisites
Engineering Metallurgy, Material science

Course Objectives
This course "Automotive materials " is designed with the following objectives in mind:
1. The student shall gain appreciation and understanding Material properties chart and all parameters of chart.
2. Shall be able to know different types of electric and magnetic materials also non metallic materials.
3. Student shall gain knowledge of various surface treatment used in automobile industries.
4. Student shall gain knowledge of modern materials comes such as shape memory alloy etc.

Course Outcomes
1. Ability to select material of material from the material properties chart with considering such parameter modulus density, strength density and modulus strength.
2. Ability to select material for the automotive components.

Unit-I:Material Property Charts and Selection Criteria *08*
Material Property Charts: Modulus-density, strength-density, modulus strength, specific stiffness and specific strength ,fracture toughness, modulus fracture.

Selection Criteria- Shape factor, elastic extrusion, elastic body and twisting, failure, bending and twisting, efficiency of standard sections, material limits and shape factors .

Unit-II:Elctrical and Magnetic materials: *04*
P and N tcype semiconductors, single crystals, soft and hard magnets, superconductors, MEMS materials , nano materials.

Unit-III: Non-metallic materials *06*
Composite materials, ceramics, plastics -Introduction, an overview of processing, their characteristic features, types and applications.

Unit-IV:Surface Modification of Materials *06*
Mechanical surface treatment and coating - case hardening and hard facing , thermal spraying, vapor deposition,ion implantation, diffusion coating ,electroplating and electro-less , conversion coating ,ceramic and organic coatings , diamond coating.

Unit-V: Modern Materials and Alloys *06*
Super alloys, refractory metals , shape memory alloys, dual phase steels, micro alloyed, high strength low alloy steel, transformation induced plasticity (trip) steel, merging steel ,smart materials, metallic glass , quasi crystal and nano crystalline materials., metal foams.

Unit–VI: Materials selection for automotive components *06*
Criteria of selecting materials for automotive components viz cylinder block, cylinder head, piston, piston ring, gudgeon pin, connecting rod, crank shaft, crank case, cam, cam shaft, engine valve, gear wheel, clutch plate,

axle, bearings, chassis, spring, body panel - radiator, brake lining etc. application of non-metallic materials such as composite, ceramic and polymers in automobile.

Text Books

1. "Material Science and Engineering- An introduction", Callister W.D. (2006) , Wiley –Eastern.
2. "Physical Metallurgy", Raghavan, V., (2003) ,Prentice Hall of India.

Reference Books

1. "Materials Selection in Mechanical Design", Michael F. Ashby, Butterworth Heinemann,2005.
2. "Mechanical Behavior of Materials", Thomas H. Courtney, (2000) McGraw Hill.
3. "Engineering Materials and their Applications", Flinn R. A. and Trojan P. K. (1999), Jaico.
4. "Surface Engineering for wear resistance", Kenneth Budinski– (1988) Prentice Hall.
5. "Introduction to physical metallurgy"Avner S.H., (2006) –Tata McGraw Hill.
6. "Materials Science and Metallurgy", DanielYesudianC, Scitech Publications(Indian ,2004.)

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-I
(416492 C) Elective II- Automotive Hydraulics and Pneumatics

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416492C	Automotive Hydraulics and Pneumatics	3	--	--	30	70	--	--	--	100

Pre-Requisites
Fluid Mechanics

Course Objectives
This course "Automotive Hydraulics and Pneumatics " is designed with the following objectives in mind:

1. To understand Pressure Control Valves.
2. To understand Hydraulic Symbols – ANSI Symbols
3. To understand Hydraulic Circuits
4. To understand Fundamentals of Pneumatics

Course Outcomes
1. Students can acquire characteristics of the fluid and air.
2. Students should be conversant with design, operation and use of hydraulic pneumatic machines

Unit-I:Introduction to Fluid Power *08*
Types of hydraulic fluids , functions of hydraulic fluids, specification of oil as per iso, lubrication capability, demulsibility, additives in hydraulic fluids, factors influencing the selection of a fluid, advantages of a fluid power system, basic components of a hydraulic system, basic components of a pneumatic system, comparison of different power systems, effect of temperature on fluids.

Governing principles and laws: Pascal's law, force power and force displacement relations , practical applications of pascal's law and evaluate the parameters ,types, properties, selection. additives, effect of temperature and pressure on hydraulic fluid. seals, sealing materials, compatibility of seal with fluids. types of pipes, hoses, material, quick acting couplings. pressure drop in hoses/pipes. fluid conditioning through filters, strainers, sources of contamination and contamination control, heat exchangers.

Unit-II: Distribution of Fluid Power and Hydraulic Pumps *06*
Selection of hydraulic conductors , burst pressure and working pressure, common types of fittings used in fluid power , hoses used in fluid power , the use of rotary joints and quick couplings , Typical specification of a hydraulic pipe, flared fitting and compression fitting, factors influencing the selection of hoses.

Classification of Pumps based on- displacement , delivery and motion , Differences between positive displacement pumps and non-positive displacement with Performance curves, working and construction of gear, vane and piston pumps, mechanical, volumetric and overall efficiency of pumps (numerical treatment), performance parameters of gear, vane and piston pumps.

Unit-III: Hydraulic Actuators *08*
Classification, types of hydraulic cylinders - single-acting cylinders, gravity-return single-acting cylinder, spring-return single-acting cylinder, double-acting cylinder, telescopic cylinder, tandem cylinder, graphical symbols of different linear actuators, classification of dcvs based fluid path, classification of dcvs based on the control method, classification of dcvs based on the construction of internal moving parts of check valves. shuttle valves, two-way valves, three-way valves. Four-way valves. Advantages of a poppet valve and Disadvantages, graphic symbols for various types of direction control valves, and its applications, working principle of solenoid-actuated valves.

Unit-IV Hydraulics Circuit: *08*

Control of a Single-Acting and Double-Acting Hydraulic Cylinder Hydraulic Cylinder, Regenerative Cylinder Circuit, Load-Carrying Capacity During Extension, Pump-Unloading Circuit, Double-Pump Hydraulic System, Counterbalance Valve Application, Hydraulic Cylinder Sequencing Circuits, Locked Cylinder Using Pilot Check Valves, Cylinder Synchronizing Circuits, Speed Control of a Hydraulic Cylinder

Unit - V Pneumatics *08*

Principle of Pneumatics: Laws of compression, types of compressors, selection of compressors, Comparison of Pneumatics with Hydraulic power transmissions, Types of filters, regulators, lubricators, mufflers, dryers, Pressure regulating valves, Direction control valves, two way, three way, four way valves. Solenoid operated valves, push button, Pneumatic actuators-rotary, reciprocating. Air motors- radial piston, vane, axial piston ,Basic pneumatic circuit, Direct and indirect control of single and double acting cylinder.

Unit- VI Typical Automotive Applications *06*

Hydraulic tipping mechanism, power steering, fork lift hydraulic gear, hydro-pneumatic suspension (Air suspension), Clutch actuating System, Pneumatic circuit to control the door of vehicle, air brake and maintenance and trouble shooting of pneumatic circuits

Accumulators: Types, applications of accumulators**.** Accumulator as a hydraulic shock absorber

Reference Books:

1. Pneumatic Systems,S. R. Majumdar, Tata McGraw Hill 1996.
2. Oil Hydraulics- Principle and Maintenance, S. R Majumdar, Tata McGraw Hill 2002.
3. Industrial Hydraulics,J. J. Pipenger, McGraw Hill
4. Industrial Fluid Power, Pinches, Prentice hall
5. Basic Fluid Power,D. A. Pease, Prentice hall
6. Hydraulics and Pneumatics, H. L. Stewart, Industrial Press

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Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-I
(416495) Vehicle Maintenance and Service Practices

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416495	Vehicle Maintenance and Service Practices	--	--	2	--	--	--	50	--	50

Course Objectives

This course "Vehicle Maintenance and service practice " is designed with the following objectives in mind:

1. The student shall gain appreciation and understanding various types of maintenance completed at service station
2. Shall be able to know procedure required for wheel alignment and wheel balancing.
3. Student shall gain knowledge of dismantling and assembly of two wheeler single cylinder engine.
4. Student shall gain knowledge of CNG and LPG kit.

Course Outcomes

1. Ability to check and adjust wheel alignment and wheel balancing.
2. Ability to trouble shoot various automotive systems used in vehicle.

Term Work:

List of Experiments: All the experiments are compulsory.

1. Visit to Service Station to study computerized wheel alignment.
2. To check and adjust wheel balancing by using computerized wheel balancing machine
3. Trouble shooting of multi cylinder petrol/diesel engine
4. Dismantle and assemble of two wheeler single cylinder four stroke engine.
5. Trouble shooting of braking system.
6. Visit to fuel injection pump testing station.
7. Dismantling and assembly of carburetor.
8. Demonstration of CNG/LPG kit.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-I
(416496A) Project Phase –I

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416496A	Project Phase –I	--	2	--	--	--	50	--	--	50

1. Objective

1. To embed the skill in group of students (strictly four) to work independently on a topic/ problem/ experimentation selected by them and encourage them to think independently on their own to bring out the conclusion under the given circumstances of the curriculum period in the budget provided with the guidance of the faculty.
2. To encourage creative thinking process to help them to get confidence by planning and carrying out the work plan of the project and to successfully complete the same, through observations, discussions and decision making process.
3. The project may be in-house, sponsored by an Industry.

2. Project Load

Maximum two groups of four students per group, shall work under one faculty member of department. A group of one student is strictly not allowed.

3. Project Definition

Project work shall be based on any of the following:

I. Fabrication of product/ testing setup of an experimentation unit/ apparatus/ small equipment, in a group.
II. Experimental verification of principles used in Mechanical Engineering/ Automobile Engineering Applications.
III. Projects having valid database, data flow, algorithm, and output reports, preferably software based.

4. Project Term Work

The term work under project submitted by students shall include:

1. **Work Diary:** Work Diary maintained by group and countersigned by the guide weekly. The contents of work diary shall reflect the efforts taken by project group for
   a. Searching suitable project work
   b. Brief report preferably on journals/ research or conference papers/ books or literature surveyed to select and bring up the project.
   c. Brief report of feasibility studies carried to implement the conclusion.
   d. Rough Sketches/ Design Calculations
   e. Synopsis

The group should submit the synopsis in following form.

i. Title of Project
ii. Names of Students
iii. Name of Guide
iv. Relevance
v. Present Theory and Practices
vi. Proposed work
vii. Expenditure
viii. References

2. The synopsis shall be signed by the each student in the group, approved by the guide(along with external guide in case of sponsored projects) and endorsed by the Head of the Department
3. **Presentation:** The group has to make a presentation in front of the faculty of department at the end of semester.

5. Assessment:

Assessment should be carried out by panel of examiners from same institute

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-II
(416495) Vehicle Performance and Testing

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416495	Vehicle Performance and Testing	4	--	2	30	70	25	50	--	175

Pre-Requisites

Automotive Transmission, Machine and vehicle Dynamics , Automotive chassis and systems

Course Objectives

1. Vehicle performance parameters are key indication of vehicle property so learner must gain brief knowledge regarding that.
2. Student should aware from the tracks used for vehicle testing and must understood the testing procedure.
3. Students will get brief knowledge regarding safety systems, EMI and sensors used for automotive functioning.
4. To understand several vehicle components testing procedure, malfunction in components and remedies on that is also one of the main objective.

Course Outcomes

1. Students are able to find performance of on road vehicle
2. Students will acquire knowledge of laboratory testing of vehicle

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Unit-I: Vehicle Performance Parameters *08*

Vehicle Performance parameters: Fuel economy, acceleration, deceleration, gradability, top speed, handling, comfort, life durability, EGR systems, Impact of vehicular systems on performance: Suspension system, Steering system, Brakes, Tyres, carriage unit. Catalytic converters function andconstruction, Lambda close loop control system for gasoline vehicles.

Unit-II: Drive train and Component testing **08**

Vehicular transmission performance: comparison of automotive clutches, epicyclic transmission, torque converter, final drive and differential. testing of vehicle components: clutch, gear box (for noise and shifting force), brake testing, wheels and tyre testing – tyre wear pattern identification and causes.

Unit-III: Vehicle testing *08*

Vehicle Testing - Road test, free acceleration test, coast down test, passer by noise test, road load data acquisition for vehicle.

Test tracks: Proving ground testing, high speed track, pavement track, corrugated track, mud track, steering pad, gradient track, deep wading through shallow water

Laboratory testing:Testing on chassis dynamometer, transition testing (Euro III onwards), accelerated testing, virtual testing, evaporative emission testing, oil consumption testing, endurance test, high speed performance test.

Unit-IV: Comfort, Convenience and Safety *08*

Seats: types of seats, driving controls accessibility, and driver seat anthropometry. Steering: steering column angle, collapsible steering, and power steering. Adaptive cruise control, navigation system, adaptive noise control, driver information system.

Safety: Motor vehicle safety standards, active safety, passive safety, bio-mechanics Structural safety, energy absorption, ergonomic consideration in safety.

Unit-V: Collisions and Crash Testing *08*

Crash testing: Human testing, dummies, crashworthiness, pole crash testing, rear crash testing, vehicle to vehicle impact, side impact testing, crash test sensors, sensor mounting, crash test data acquisition, braking distance test.

Unit-VI: Noise Vibration and EMI *08*

Noise and vibration: Mechanism of noise generation, engine noise and vibration, causes and remedies on road shocks, wind noise and measurement.

Automobile testing instrumentation: Sensors types and selection, instrumentation for functional tests, model test and full scale testing.

Term Work: (Any nine out of which experiment 10 is compulsory)

List of Experiment

1. Estimation of power requirement for vehicle propulsion by taking actual vehicle example.
2. Perform coast down test to find vehicle inertia.
3. On road fuel consumption test at different speeds.
4. Brake efficiency measurement
5. Pass- by noise test.
6. Free acceleration test.
7. Vibration measurement in passenger compartment
8. Laboratory testing of vehicle on chassis dynamometer for performance
9. Laboratory testing of vehicle on chassis dynamometer for emission.
10. Report based on visit to vehicle testing and research organization.
11. On road emission testing of petrol and diesel vehicles for PUC/RTO

Reference Books:-

1. “Automotive Handbook”, Bosch
2. “Engine Testing Theory and Practice”, Michel Plint.
3. “Motor Vehicle Inspection”, W. H. Crouse and D. L. Anglin
4. “Automobile Engineering” (Anna University) Ramlingam
5. “Automobile engineering”, Kripal Singh
6. “Automotive Mechanics”Josepf Heitner
7. ARAI vehicle emission test manual
8. Inspection SAE handbook vol 2 and 3
9. “Vehicle Operation and Performance”, J.G .Giles,.
10. “Automobile engineering” Kripal Singh
11. ” Automotive Vehicle Safety”, George Pieters Barbara Pieters,
12. “Aerodynamics of road vehicles” , Wolt, Heinrich Hucho,
13. Engine performance Diagnosis and Tune up Shop Manual”, Gousha H. M..
14. “Automobile Engineering”, Rangawala

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B.E. (Automobile) (2012 Course)
Semester-II
(416496) Automotive System Design

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect.	Tut	Pract.	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416496	Automotive System Design	4	--	2	30	70	25	--	50	175

Pre-Requisites
Machine Design , Theory of Machine

Course Objectives
This course "Automotive System Design" is designed with the following objectives in mind:

1. The student shall gain appreciation and understand the design function in Automobile Engineering, steps involved in designing of various parts like clutch, gearbox, propellershaft, axles, suspension etc.
2. Shall be able to choose proper materials for different vehicle components depending on their physical and mechanical properties.

Course Outcomes
1. Ability to analyze the vehicle design requirements of various components and system.
2. Ability to decide optimum design parameters for Automotive systems.
3. Enhancement in proficiency of CAD software for designing Automotive systems and drawings.

Unit-I: Design of Clutches *08*
Design requirements of friction clutches, selection criterion, torque transmission capacity, lining materials, Design of single plate clutch, multi-plate clutch and centrifugal clutch.

Unit-II: Design of Gearbox *08*
Selection of gear ratios and final drive ratio, numerical on 3- speed and 4- speed gearbox.

Unit-III: Design of Propeller Shafts and Axles *08*
Design of propeller shafts for bending, torsion and rigidity, Design of universal joints and slip joints, final drive, Design of live and dead axles.

Unit-IV: Brake Systems *08*
Design of hydraulic braking system, internal expanding shoe brake and disc brake, design of master and wheel cylinder and piping design.

Unit-V: Design of Suspension and Steering System *08*
General design considerations of suspension system, design of helical and leaf springs for automobile suspension system, design considerations of belleville springs, elastomeric springs, design considerations of steering system and vehicle frame design.

Unit-VI: Statistical Consideration in Design and Optimization *08*
Ergonomics and aesthetic design, statistics in design, design for natural tolerances, statistical analysis, and mechanical reliability. introduction to design optimization of mechanical elements, adequate and optimum design, methods of optimization, johnson's method of optimum design-simple problems in optimum design like axially loaded members.

Term Work:

List of Experiment:

1. Design of automotive clutch assembly and component drawing using any drafting software. (Two full imperial sheets along with design calculations report) consists 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
    - Details and assembly drawing

2. Design of automotive gear box along with reverse gear (Two full imperial sheets along with design calculations report) consists 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

3. Design of suspension spring and its analysis using any analysis software.

Reference Books:

1. “Mechanical System Design”, S.P. Patil 2nd edition, Jaico Publishers.
2. “Automobile Mechanics”, N. K. Giri, Khanna Publishers Delhi.
3. “Auto Design” , R. B. Gupta, Satya Prakashan New Delhi.
4. “Design of Machine Elements”, V. B. Bhandari., Tata McGraw-Hill Publishing Company Ltd., New Delhi.
5. “Optimum Design of Mechanical Elements”R.C. Johnson,
6. “Introduction to Optimum Design”, John Wiley and Sons. J.S. Arora, McGraw-Hill Book Company Ltd
7. “Design of machine Elements”, M. F. Spotts and T.E. Shoup, Seventh Edition, Pearson Education.
8. “An Introduction to Modern Vehicle Design”,Julian Happian – Smith, Butterworth Heinemann
9. “Mechanical Engineering Design”, Joseph E. Shigley and Larry D. Mitchell, Fourth Edition, McGraw-Hill.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-II
(416497 A) - Elective III- Automotive NVH

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect	Tut	Pract	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416497A	Automotive NVH	3	--	--	30	70	--	--	--	100

Pre-Requisites
Theory of Machine.

Course Objectives
1. Students should be able to understand role of Noise, Vibration and harshness in Automobile.
2. Students should be able to understand basic concept of vibration, types of vibration, undamped and damped vibration, also different types of damping.
3. Students should be able to understand fundamental of noise, noise measurement techniques.
4. Student should know the physical and psychological effect of vibration and noise.
5. Student should be able to understand different types of noise and vibrations control techniques.
6. Student should know the various sources on noise and vibration in automobile.

Course Outcomes
1. Ability to know the physical and psychological effect of noise and vibration.
2. Ability to measure vehicle noise with using various instruments.
3. Ability to know various sources of noise in automobile.

Unit-I: Introduction to NVH *06*
Noise, Vibration and Harshness (NVH) and its role in automotive design and development. Physiological effects of noise and vibration, sources of vibration and noise in automobiles, Basic concepts of vibration, time period, frequency, SHM, types of vibration, Natural frequency, resonance, damping, mathematical models.

Unit-II: Basics of Vibration Analysis *06*
Formulating the equations of motion - linear and torsional system. Damped and undamped single degree of freedom system (Numerical treatment), undamped two degree of freedom systems derivation, coordinate coupling(derivation), generalized coordinates.

Unit-III: Vibration Control and Measurement Techniques *06*
Different types of dampers, vibration absorbers, centrifugal pendulum, dry friction ,untuned viscous, vibration isolation. vibration measurement instrument , vibrometer , velocity pick-ups, frequency measurement instrument. one applications: isolation of the engine from vehicle structure and control of torsional oscillation amplitudes in engine crankshaft.

Unit-IV: Noise Fundamentals *08*
Fundamentals of acoustics – general sound propagation – structure borne sound and air borne sound, plane wave propagation - wave equation, specific acoustic impedance, acoustic intensity, spherical wave propagation – acoustic near and far fields, reference quantities, the decibel scale, relationship among sound power, sound intensity and sound pressure level, summation of pure tones, decibel addition, subtraction and averaging (numerical treatment), effects of reflecting surfaces on sound propagation, octave band analysis, anatomy of human ear, mechanism of hearing, loudness, weighting networks, equivalent sound level.

Unit-V: NVH Measurements *04*
Vibration and Noise Standards – Pass/Drive by noise, noise from stationary vehicles, interior noise in vehicles, NVH measurement tools and techniques, Modal parameter (natural frequency, mode shape and damping) estimation techniques, signal and system analysis.

Unit-VI: Automotive Noise Sources and Control Techniques 06

Methods for control of engine noise, transmission noise, intake and exhaust noise, aerodynamic noise, tyre noise, brake noise. noise control strategy, noise control at source – along the path – isolation, damping, balancing, resonators, absorption, barriers and enclosures.

Reference Book

1. "Mechanical Vibrations", Singh, V.P., Dhanpat Rai and Sons, New Delhi
2. "Mechanical Vibrations", Grover, G. K. and Nigam, S. P., Nemchand and Brothers, Roorkee, U.K, India
3. "Mechnical Vibrations and Noise Engineering", Ambekar, A. G., Prentice Hall of India, New Delhi, 2006.
4. "Mechanical Vibrations", S. S. Rao Pearson Education.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-II
(416497 B) -Elective III-Off Road Vehicles

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect	Tut	Pract	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416497B	Off Road Vehicles	3	--	--	30	70	--	--	--	100

Course Objectives

The course is designed by considering following objectives:

1. Student should knowledge about various types of off road vehicles.
2. Student should knowledge about earth moving machine and tractors.
3. Student should know the various types construction equipments are there.

Course Outcomes

1. Student will get knowledge about Application of hydrolic and pneumatic circuit in off road vehicle.

Unit-I: Classification and Requirements of Off Road Vehicles *04*

Introduction, pretest, history and overview of an off-road machines, construction layout, capacity and applications. power plants, chassis and transmission, multi-axle vehicles.

Unit-II: Earth Moving Machines and Tractors *08*

Different types of earth moving equipments and their applications. Bulldozers, cable and hydraulic dozers. Crawler track, running and steering gears, scrapers, drag and self powered types - Dump trucks and dumpers - Loaders, single bucket, multi bucket and rotary types - Power and capacity of earth moving machines.

Tractors: General description, specification and functions, light, medium and heavy wheeled tractors, crawler tracks mounted / wheeled-bull dozers, tilt dozers and angle dozers, front end loaders, factors affecting efficiency of output of tractors, simple problems, merits and demerits.

Unit-III: Scrappers, Graders, Shovels and Ditchers *06*

Scrappers, elevating graders, motor graders, self powered scrappers and graders, power shovel, revolving and stripper shovels ,drag lines, ditchers, capacity of shovels.

Unit-IV: Farm Equipments, Military and Combat Vehicles *06*

Power take off, special implements. Special features and constructional details of tankers, gun carriers and transport vehicles.

Unit-V: Vehicle Systems and Features *06*

Brake system and actuation – OCDB and dry disc caliper brakes. 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-VI: Vehicle Evaluation Mobility *06*

Soil-Vehicle Mechanics, characteristics of soils, nominal ground pressure, mean maximum pressure. the mobility index (mi), vehicle cone index (vci) and rated cone index (rci), mobility number, dynamic behavior and traction on wet soil, traction performance and factors affecting traction performance.

Reference Books:

1. “Construction Equipment and its Management”, Sharma, S.C.,.
2. “Farm Machines and Equipments”, Nakra C.P., Dhanparai Publishing company Pvt. Ltd. 2003
3. “Theory of Ground Vehicles”, Wong J Y, John Wiley and Sons, New York, 1978
4. “Construction Planning and Equipment”, Satyanarayana. B., standard publishers and distributors, New Delhi.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-II
(416497 C) -Elective III-Alternative Fuel And Emission Control

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect	Tut	Pract	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416497C	Alternative Fuel And Emission Control	3	--	--	30	70	--	--	--	100

Pre-Requisites
Thermodynamics, Applied Thermodynamics.

Course Objectives
The course is designed by considering following objectives:
1. Create an awareness about alternative fuels and their need.
2. Student should be able to differentiate the conventional fuels and Alternative fuels.
3. Student should get the knowledge about application of alternative fuels .
4. Student should understand the Emission norms up to Bharat Stage IV.
5. Student should get knowledge of emission from different automotive vehicles and its control.

Course Outcomes
1. Ability to understand the importance of Alternative Fuels, its properties and their application.
2. Student Should be able to select an alternative fuel for specific application.
3. Student should get knowledge of emission norms.
4. One should be able to identify the emission parameters from engine emission, its causes and remedies.

Unit-I: Conventional Fuels and Need for alternative fuels *08*
Estimate of petroleum reserve and availability - comparative properties of fuels- diesel and gasoline, quality rating of si and ci engine fuels, fuel additives for si and ci engines. thermodynamics of fuel combustion - introduction to chemical thermodynamics, chemical reaction - fuels and combustion, enthalpy of formation and enthalpy of combustion, first law analysis of reacting systems, adiabatic flame temperature. need for alternative fuels, applications, types etc.

Unit-II: Alternative Fuels I – Gaseous Fuels and Biofuel *06*
Introduction to CNG, LPG, ethanol, vegetable oils, bio-diesel, biogas, Hydrogen and HCNG. Study of availability, manufacture, properties, storage, handling and dispensing, safety aspects, engine/vehicle modifications required and effects of design parameters performance and durability.

Unit–III: Alternative Fuels II - Synthetic Fuels *06*
Introduction to Syngas, DME, P-Series, GTL, BTL, study of production, advantages, disadvantages, need, types, properties, storage and handling, dispensing and safety, discussion on air and water vehicles.

Unit–IV: Emission Control (SI Engine) *06*
Emission formation in S.I. engines - Hydrocarbons, carbon monoxide, oxides of nitrogen, polyneculear aromatic hydrocarbon, effects of design and operating variables on emission formation in spark ignition engines, controlling of pollutant formation in engines exhaust after treatment, charcoal canister control for evaporative emission control, emissions and drivability, positive crank case ventilation system for ubhc emission reduction.

Unit-V: Emission Measurement and Control (CI Engine) *06*
Chemical delay, intermediate compound formation, pollutant formation on incomplete combustion, effect of design and operating variables on pollutant formation, controlling of emissions, emissions and drivability, exhaust gas recirculation, exhaust after treatment – doc, dpf, scr and lnt. measurement and test procedure (ndir analyzers, fid, chemiluminescence nox analyzer, oxygen analyzer, smoke measurement, constant volume sampling, particulate emission measurement, orsat apparatus.)

Unit-VI: Health effects of Emissions from Automobiles 04

Emission effects on health and environment. Emission inventory, ambient air quality monitoring, Emission Norms: As per Bharat Standard up to BS – IV.

Reference Books:

1. "Alternative Fuels", Dr. S. S. Thipse, Jaico publications.
2. "Engine Emission", B.P Pundir, Narosa publication.
3. "Internal Combustion Engines", V .Ganesan, Tata McGraw Hill.
4. "Automotive Emission Control", Crouse, W.M. and. Anglin, A.L, McGraw Hill.
5. "IC Engines", Dr. S. S. Thipse, Jaico publications.
6. "Engine Emissions, pollutant formation", G.S .Springer and D.J. Patterson, Plenum Press.
7. ARAI vehicle emission test manual.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-II
(416498 C) -Elective IV-Transport Management And Motor Industry

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect	Tut	Pract	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416498A	Transport Management And Motor Industry	3	--	--	30	70	--	--	--	100

Objectives

The students will be able to:

1. Study and fill up the forms required as per Motor Vehicle Act.
2. Prepare small project reports of bus / goods transport organization enabling him to work in different organizations like MSRTC, private organization.
3. Start SSI unit or may be able to work as service provider.
4. Understand; prepare the different documents used in transport organization. If necessary, he can modify the ideas of documentation.
5. Enter in the business of buying and selling of old and new vehicles.
6. Create awareness of ideal driving which includes safety, legal aspects.
7. Understand the purpose of research institutes in India, which are working on Advancements of automobiles rather than adopting the idea of reverse engineering. Stress due to traffic jam, night driving.

Course Outcomes

1. Students are able acquire in depth knowledge about the new motor vehicle act.
2. Students are able to create opportunities of providing service to the passengers or goods transport business.

Unit-I: Motor Vehicle Act *06*

Short titles and definitions, laws governing to use of motor vehicle and vehicle transport, licensing of drivers and conductors, registration of vehicle, state and interstate permits, traffic rules, signals and controls, accidents, causes and analysis, liabilities and preventive measures, rules and regulations, responsibility of driver, public and public authorities, offences, penalties and procedures, different types of forms, government administration structure, personnel, authorities and duties, rules regarding construction of motor vehicles. new motor vehicle act.

Unit-II: Taxation *06*

Objectives, structure and methods of laving taxation, onetime tax, tax exemption and tax renewal.

Unit-III: Insurance *06*

Insurance types and significance, comprehensive, third party insurance, zero depth insurance, furnishing of particulars of vehicles involved in accident, mact (motor accident claims tribunal), solatium fund, hit and run case, duty of driver in case of accident, surveyor and loss assessor, surveyor's report estimation and valuation of vehicle: role of surveyor procedure of survey and valuation of vehicle.accident survey report. importance of warranty system and protection of law: how to deal with defects, benefits of warranty system.

Unit-IV: Passenger Transport Operation *06*

Structure of passenger transport organizations, typical depot layouts, requirements and problems on fleet management, fleet maintenance, planning - scheduling operation and control, personal and training- for drivers and conductors, public relations, propaganda, publicity and passenger amenities, parcel traffic., theory of fares-basic principles of fare charging, differential rates for different types of services, depreciation and debt charges,

operation cost and revenues, economics and records working of various state transport organizations.(MSRTC, BEST)

Unit-V: Goods Transport Operation 06

Structure of goods transport organizations, scheduling of goods transport, management information system (mis) in passenger / goods transport operation, storage and transportation of petroleum products.

Unit-VI: Advance Techniques in Traffic Management and Motor Industry 08

Traffic navigation, global positioning system functions and role of automobile industry: the automobile industry in india (collection of data of various companies) various research organizations like-central institute of road transport, automotive research association of india, vehicle research, development and establishment, central road research institute and petroleum conservation and research association.

References Book:

1. P. Sudarsanam. Passenger Amenities in STU CIRT, Pune
2. P. Sudarsanam. Fare structure in STU CIRT, Pune
3. P. Sudarsanam. Bus station Management CIRT, Pune.
4. P. Sudarsanam Bus and Crew scheduling CIRT, Pune.
5. O.P. KhannaIndustrial Organization and Management , Dhanpat Rai and sons
6. P.G. Patankar.Director.Compedium of Transport Terms, CIRT, Pune
7. Bharat Kalaskar Vahan Mitra Sanjivini Prakashan, Pune
8. Book Of The Car -Drive Publications Limited Automobile Association

Motor Vehicle Acts

1. Motor Vehicle Act, 1988 Home Department (M .S.)
2. Central M. V. Rules 1989 Home Department (M .S.)

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-II
(416498 B) -Elective IV-Operation Research

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect	Tut	Pract	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416498B	Operation Research	3	--	--	30	70	--	--	--	100

Course Objective

This course "Operations Research" is designed with the following objectives in mind:

1. Students will be well grounded in the mathematical, engineering, and modeling skills that are the basis for operations research, and they will be prepared to apply those skills to the efficient design, analysis, operation and control of complex systems.
2. Operations research helps in solving problems in different environments that needs decisions. The module covers topics that include: linear programming, Transportation, Assignment and Pert and CPM etc.

Course Outcomes

1. This module aims to introduce students to use quantities methods and techniques for effective decisions making.
2. Model formulation and applications that are used in solving business decision problems.

Unit-I: Introduction to Operation Research *06*

Definitions, Phases of Operation Research and applications .Linear Programming Problems: mathematical formulation, standard form, basic solutions, feasible solutions, optimal solutions, graphical and simplex methods, two phase and big-M methods.

Unit-II: Assignment Problem: *06*

Formulation, hungarian method, unbalanced problem, assignment for maximization, traveling salesman problem.

Unit-III: Transportation Problem *06*

Formulation of Transportation model, basic feasible solution by nwc rule, lce method and vogel approximation method, unbalanced problem, degeneracy in transportation.

Unit-*IV: CPM and PERT* *06*

Network construction, CPM-determination of critical path and total elapsed time, concept of slack and float, PERT-Estimation of project duration and variance analysis about the completion of projects. **Sequencing**: Processing of 2 jobs on N machines, 3 jobs on N machines and graphical procedure for 2 jobs on M machines

Unit-V: Queuing Theory *06*

Types and characteristics, steady state analysis of M/M/1 and concept of M/M/K model. Games Theory: formulation of games, characteristics of games, two-person zero sum game, maximin/minimax principle, saddle point, solution for (2x2) game, dominance property, graphical solution for (2xn) and (nx2) games.

Unit-VI: Replacement Problem *06*

Basic concept of replacement of items that deteriorate with time, costs involved replacement procedure with and without consideration of time value of money, replacement of items that fail suddenly, group replacement.

Reference Books:

1. Operations Research, S.D.Sharma Kedarmath, Ramnath and co.
2. Operations Research and Introduction, Taha S A McMillian.
3. Principles of Operations Research, Philips, Ravindran and Soeberg PHI.
4. Introduction to Operations Research, Hiller and Liberman McGraw Hill V Edn.
5. Operation Research A.M.Natarajan, P Balasubramani, A Tamilarawari

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B.E. (Automobile) (2012 Course)
Semester-II
(416499) Seminar and In-plant Training Evaluation

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect	Tut	Pract	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416499	Seminar and In-plant Training Evaluation	--	--	2	--	--	50	--	--	50

Industrial Training

- Student shall undergo industrial training for a minimum period of two weeks during winter vacations (after B.E. Sem – I).
- The industry in which industrial training is taken should be a medium or large scale industry
- The paper bound report on training must be submitted by the student in the beginning of 8th semester along with a certificate from the company where the student took training.
- Every student should write the report separately.
- Institute / Department/T and P Cell have to assist the students for finding Industries for the training.
- Students must take prior permission from Department before joining for Industrial Training.

OR

EDP (Entrepreneurship Development Program)

- Student has to participate in Entrepreneurship Development Program for a minimum period of One week during winter vacations (after B.E. Sem – I).
- Every student must submit the paper bound report based on the program in the beginning of 8th semester along with a certificate (Course / Program completion) from the program organizers.
- Every student should write the report separately.
- Institute / Department may arrange Entrepreneurship Development Program at their campus.
- Students must take prior permission from Department before attending any Entrepreneurship Development Program.

Seminar and In-plant Training Evaluation

Term work assessment by external examiner through presentation by student.

Savitribai Phule Pune University

B.E. (Automobile) (2012 Course)
Semester-II
(416494 B) Project Phase-II

Code	Subject	Teaching Scheme (Weekly Load in hrs)			Examination Scheme (Marks)					
		Lect	Tut	Pract	Theory		TW	PR	OR	Total
					In Sem	End Sem				
416494B	Project Phase -II	--	06	--	--	--	100	--	50	150

Project Report:

For standardization of the project reports the following format should be strictly followed.

1. Project report should be of **50 to 60** pages.
2. The report must be **Three hard bound**.
3. The footer must include the following: Institute Name, Automobile Engineering **Times New Roman 10 pt.** and centrally aligned.
4. Page number as second line of footer, **Times New Roman 10 Pt**, centrally aligned.
5. Print the manuscript using
    a. Letter quality computer printing.
    b. The main part of manuscript should be **Times New Roman 12 pt**. with alignment - justified.
    c. Use 1.5 line spacing.
    d. Entire report shall be in one Chapter.
6. Use the paper size **8.5'' × 11'' or A4 (210 × 197 mm).** Please follow the margins given below.

Margin Location	Paper 8.5'' × 11''	Paper A4 (210 × 197 mm)
Top	1''	25.4 mm
Left	1.5''	37 mm
Bottom	1.25''	32 mm
Right	1''	25.4 mm

7. All paragraphs will be 1.5 line spaced with a one blank line between each paragraph. Each paragraph will begin with without any indentation.
8. Section titles should be bold with 14 pt typed in all capital letters and should be left aligned.
9. Sub-Section headings should be aligning at the left with 12 pt, bold and Title Case (the first letter of each word is to be capitalized).
10. Illustrations (charts, drawings, photographs, figures) are to be in the text. Use only illustrations really pertinent to the text. Illustrations must be sharp, clear, black and white. Illustrations downloaded from internet are not acceptable.
    a. Illustrations should not be more than two per page. One could be ideal
    b. Figure No. and Title at bottom with 12 pt
    c. Legends below the title in 10 pt
    d. Leave proper margin in all sides
    e. Illustrations as far as possible should not be photo copied.
11. Photographs if any should of glossy prints.
12. Please use SI system of units only.
13. Please number the pages on the front side, centrally below the footer
14. References should be either in order as they appear in the thesis or in alphabetical order by last name of first author
15. Symbols and notations if any should be included in nomenclature section only
16. Following will be the order of report

I. **Cover page and Front page as per the specimen on separate sheet**
II. **Certificate from the Institute as per the specimen on separate sheet**
III. **Acknowledgements**
IV. **List of Figures**
V. **List of Tables**
VI. **Nomenclature**
VII. **Contents**
VIII. **Abstract** (A brief abstract of the report not more than **120 words**. The heading of abstract i.e. word "Abstract" should be **bold, Times New Roman, 12 pt** and should be typed at the **centre**. The contents of abstract should be typed on new line without space between heading and contents. Try to include one or two sentences each on **motive, method, key-results** and **conclusions** in Abstract

1. Introduction
2. Literature Survey/ Theory
3. Design/ Experimentation/ Fabrication/ Production/ Actual work carried out for the same.
4. Observation Results
5. Discussion on Results and Conclusion
6. References should be given in the body of the text and well spread. No verbatim copy or excessive text from only one or two references. If figures and tables are taken from any reference then indicate source of it. Please follow the following procedure for references.

Reference Books

Collier, G. J. and Thome, J. R., Convective boiling and condensation, 3rd ed., Oxford University Press, UK,1996, pp. 110 – 112.

Papers from Journal or Transactions

Jung, D. S. and Radermacher, R., Transport properties and surface tension of pure and mixed refrigerants, *ASHRAE Trans*, 1991, 97 (1), pp. 90 – 98.

Bansal, P. K., Rupasinghe, A. S. and Jain, A. S., An empirical correction for sizing capillary tubes, *Int. Journal of Refrigeration*, 1996, 19 (8), pp.497 – 505.

Papers from Conference Proceedings

Colbourne, D. and Ritter, T. J., Quantitative assessment of flammable refrigerants in room air conditioners, Proc. Of the Sixteenth International Compressor Engineering Conference and Ninth International Refrigeration and Air Conditioning Conference, Purdue University, West Lafayette, Indiana, USA, 2002, pp. 34 – 40.

Reports, Handbooks etc.

United Nations Environmental Programme, Report of the Refrigeration, Air Conditioning and Heat Pumps,Technical Option Committee, 2002, Assessment - 2002.

ASHRAE Handbook: Refrigeration, 1994 (Chapter 44)

Patent

Patent no, Country (in parenthesis), date of application, title, year.

Internet

www.(Site) [Give full length URL]

Important Notes

1. Project group should continue maintaining a diary for project and should write about (a) Books referred (b) Company visited (c) Person contacted (d) Computer work done (e) Paper referred (f) Creative thinking.
2. Students are expected to publish a paper on the project either in various paper contests or at least within department.
3. The Diary along with Project Report shall be assessed at the time of oral examination.
4. One copy of the report should be submitted to Institute/ Department, One copy to University.

Term Work evaluation

1. The project term work shall be evaluated on the basis of reviews. In Second semester Three reviews are to be taken and evaluated for total 60 marks (20 marks each)
2. The final presentation shall be taken in front of external examiner and to be evaluated for 40 marks
    - 10 marks for presentation for group,
    - 15 marks for quality of the project work.
    - 15 marks for quality of the project report.

Oral Examination

Oral examination shall be conducted with final presentation of the project. The distribution of marks shall be

- 15 marks for contribution of the student in the project work
- 15 marks shall be awarded for achieving the objectives of the project set forth.
- 20 marks for Question/ Answer

The external examiner shall be preferably Industrial expert in the same field or senior teaching faculty from other University. In case, the external examiner is appointed by the college authorities, the bio data of the external examiner must be sent to “The Chairman Board Of Studies in Automobile Engineering” so that the examiner shall be included in the Panel of Examiners for the Project oral.

Savitribai Phule Pune University

A Project Report on (TNR, 16pt, centrally aligned)

Title (TNR, 27pt, Bold, Centrally Aligned,Title Case)

By (TNR, 16pt, Centrally Aligned)
Mr. Student's Name (TNR, 16pt, Centrally Aligned)

Guided by (TNR, 16pt, Centrally Aligned)
Guide's Name (TNR, 16pt, Centrally Aligned)

Institute
Logo

Department of Automobile Engineering
Name of the Institute
[2014-15](TNR, 22pt, Title Case Centrally Aligned)

Savitribai Phule Pune University

Name of the Institute

Institute
Logo

C E R T I F I C A T E

This is to certify that *Mr. Sagar Patil* ---------., has successfully completed the Dissertation entitled "Design and analysis of……..." under my supervision, in the partial fulfillment of Bachelor of Engineering - Automobile Engineering(Branch)of Savitribai Phule Pune University.

Date :

Place :

Guide's Name
Guide

_____
Head
Department and
Institute Name

External Examiner

Seal

_____
Principal,
Institute Name