Savitribai Phule Pune University
Faculty of Science & Technology

Curriculum/Syllabus

For

Third Year

Bachelor of Engineering

(Choice Based Credit System)

Automobile Engineering

(2019 Course)

Board of Studies - Mechanical and Automobile Engineering

(With Effect from Academic Year 2021-22)

Savitribai Phule Pune University

Board of Studies - Mechanical and Automobile Engineering

Undergraduate Program - Automobile Engineering (2019 pattern)

Course Code	Course Name	Teaching Scheme (Hours / Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	ISE	ESE	TW	PR	OR	Total	TH	PR	TUT	Total
Semester-V														
316481	Numerical & Optimization Methods	3	-	1	30	70	25	-	-	125	3	-	1	4
316482	Heat Transfer	3	2	-	30	70	-	50	-	150	3	1	-	4
316483	Design of Machine Components	3	2	-	30	70	-	-	25	125	3	1	-	4
316484	Automobile Electrical and Electronics	3	2	-	30	70	-	-	25	125	3	1	-	4
302045	Elective I*	3	-	-	30	70	-	-	-	100	3	-	-	3
302046	Digital Manufacturing Laboratory*	-	2	-	-	-	50	-	-	50	-	1	-	1
302047	Skill Development*	-	2	-	-	-	25	-	-	25	-	1	-	1
302048	Audit course V$	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**10**	**1**	**150**	**350**	**100**	**50**	**50**	**700**	**15**	**5**	**1**	**21**
Semester-VI														
316485	Automotive Refrigeration and Air Conditioning	3	2	-	30	70	-	-	25	125	3	1	-	4
316486	Automotive Chassis and Transmission	3	2	-	30	70	-	50	-	150	3	1	-	4
316487	Design of Engine Components	3	2	-	30	70	-	-	25	125	3	1	-	4
316488	Elective II	3	-	-	30	70	-	-	-	100	3		-	3
316489	Automobile Measurement Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
316490	Automotive Hydraulic and Pneumatics Control Laboratory	-	2	-	-	-	50	-	-	50	-	1	-	1
316491	Internship/ Entrepreneurship/ Technical Event	-	4	-	-	-	100	-	-	100	-	4	-	4
302056	Audit course - VI$	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**12**	**14**	**-**	**120**	**280**	**200**	**50**	**50**	**700**	**12**	**9**	**-**	**21**

Elective-I		Elective-II	
302045-A	Advanced Forming & Joining Processes	316488-A	Automotive Aerodynamics and Body Engineering
302045-B	Machining Science and Technology	316488-B	Automotive Materials

Abbreviations: TH: Theory, **PR**: Practical, **TUT**: Tutorial, **ISE**: In-Semester Exam, **ESE**: End-Semester Exam, **TW**: Term Work, **OR**: Oral

Note: Interested students of TE (Automobile Engineering and Mechanical Engineering) can opt for any one of the audit course from the list of audit courses prescribed by BoS (Mechanical and Automobile Engineering)

Instructions

- Practical/Tutorial must be conducted in FOUR batches per division only.

- Minimum number of Experiments/Assignments in PR/ Tutorial shall be carried out **as mentioned in the syllabi** of respective subjects.
- Assessment of tutorial work has to be carried out similar to term-work. The Grade cum marks for Tutorial and Term-work shall be awarded on the basis of **continuous evaluation.**
- $ Audit course is mandatory but non-credit course. Examination has to be conducted at the end of Semesters for award of grade at institute level. Grade awarded for audit course shall not be calculated for grade point & CGPA.
- * Marked subjects are common with TE (Mechanical Engineering) 2019 Course.

316481: Numerical & Optimization Methods					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Tutorial	**1Hr./Week**	**Tutorial**	**1**	**End-Semester**	**70 Marks**
				Term Work	**25 Marks**

Prerequisites: Engineering Mathematics- I, II and III, Programming and Problem Solving

Course Objectives:

1. Understand applications of systems of equations and solve mechanical engineering applications
2. Apply differential equations to solve applications like fluid mechanics, structural, etc.
3. Learn numerical integration techniques for engineering applications
4. Obtain numerical solution to engineering problem using computer programming
5. Apply optimization technique to solve general engineering problem
6. Learn Modern optimization technique for engineering applications

Course Outcomes:

On completion of the course the learner will be able to;

CO1: **Solve** polynomial and regression models using direct or iterative numerical method

CO2: **Evaluate** simultaneous equation using numerical techniques

CO3: **Evaluate** differential equation using numerical techniques

CO4: **Perform** numerical integration for engineering applications

CO5: **Use** optimization techniques for real life engineering problem

CO6: **Understand** the advance optimization technique to solve engineering problem

Course Contents

Unit 1	**Roots of Equation and Regression Analysis**	**07 Hrs.**

Roots of Equation: Bracketing methods: False position method, Open methods: Newton- Raphson method, Secant method, Modified Newton-Raphson, Rate of convergence

Interpolation: Newton's forward and interpolation, Newton's backward interpolation, Lagrange's interpolation, Hermite's Interpolation, Inverse interpolation (Lagrange's method only)

Unit 2	**Simultaneous Equations**	**08 Hrs.**

Gauss Elimination Method with Partial pivoting, Thomas algorithm for Tridiagonal Matrix, Gauss-Seidal method, Jacob iteration method, Relaxation Technique, Eigen values by Power method

Unit 3	**Numerical solution of differential equations**	**08 Hrs.**

Ordinary Differential Equations [ODE]: Taylor series method, Euler Method, Runge-Kutta 4^{th} order method, Boundary Value Problems, Simultaneous equations using Runge-Kutta 2^{nd} order method.

Partial Differential Equations [PDE]: Finite difference method, Simple Laplace method, PDE's Parabolic explicit solution, Elliptic explicit solution.

Unit 4	Numerical Integration	07 Hrs.
Numerical Integration (1D only): Trapezoidal rule, Simpson‟s 1/3rd Rule, Simpson‟s 3/8th Rule, Gaussian Integration **Double Integration:** Trapezoidal rule, Simpson‟s 1/3rd Rule.		
Unit 5	**Optimization Techniques**	**08 Hrs.**
Introduction of optimization, classification of optimization problem Single variable unconstrained optimization- Newton‟s Method, Golden-section search method Constrained Optimization- Simplex Method, Transportation problem (Vogel's Approximation Method only)		
Unit 6	**Modern Methods of Optimization**	**07 Hrs.**
Basic Concept, algorithms and feature of - Genetic algorithms, Simulated annealing, Particle swarm optimization, Ant colony optimization		

Books and other resources

Text Books:

1. Steven C. Chapra, 'Applied Numerical Methods with MATLAB for Engineers and Scientist', Tata Mc-Graw Hill Publishing Co. Ltd.
2. B.S.Grewal,'NumericalMethodsinEngineeringandScience',KhannaPublication
3. B. S. Grewal, 'Higher Engineering Mathematics', Khanna Publication
4. A.K. Malik 'Optimization Techniques' I.K. International Publishing House Pvt. Ltd.

References Books:

1. Erwin Kreyszig, 'Advanced Engineering Mathematics', Wiley India
2. Joe D. Hoffman, 'Numerical Methods for Engineers and Scientists', CRC Press
3. Sheldon M. Ross, 'Introduction to Probability and Statistics for Engineers and Scientists', 5e, by Elsevier Academic Press
4. Deisentoth, Faisal, Ong, 'Mathematics for machine learning', Cambridge University Press.
5. Kandasamy, 'Numerical methods', S Chand
6. V. Rajaraman 'Computer Oriented Numerical Methods' Prentice Hall of India Delhi

Web References:

1. http://nptel.ac.in/courses/111101003/
2. http://nptel.ac.in/courses/111105038/
3. http://nptel.ac.in/courses/111107063/
4. https://nptel.ac.in/courses/112/101/112101298/
5. https://nptel.ac.in/courses/103/106/103106118/

List of Tutorials
Program on any one method of below each topic using any Programming language and validation using a suitable solver 1. Roots of Equation 2. Interpolation 3. Simultaneous Equations 4. Numerical Solutions of Differential Equations 5. Numerical Integration 6. Mini project based on Optimization methods **Instructions for mini project:** 1. For mini project students group size will be 2 to 3. 2. Students should use any programming to solve engineering problems by suitable optimization methods. 3. Use for various modern optimization methods is highly appreciable. 4. Student groups should give the 5-10 min presentation on their mini project. **Note: Tutorials shall be conducted in the computer laboratory.**

316482: Heat Transfer					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3 Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Practical**	**1**	**End-Semester**	**70 Marks**
				Practical	**50 Marks**

Prerequisites: First and Second Law of Thermodynamics, Fluid properties, Continuity equation, Differential and Integral Calculus, Ordinary differential and Partial Differential Equations, Numerical solution for Differential Equations.

Course Objectives: Students shall,

1. Identify the laws for different modes of heat transfer.
2. Understand the properties and economics of thermal insulation and analyze heat transfer through fins and thermal systems with lumped heat capacitance.
3. To study and analyze the natural and forced convective mode of heat transfer in various geometric configurations.
4. To understand and realize various laws with their interrelations and analyze Radiation heat transfer in black and grey bodies/surfaces with or without radiation shields.
5. To analyze various performance parameters for existing heat exchanger and to develop methodologies for designing a heat exchanger under prescribed conditions and for a particular application, with references TEMA standards

Course Outcomes:

On completion of the course, learner will be able to

CO1. **Analyze** the different modes of heat transfer and implement the basic heat conduction equations for steady state one-dimensional thermal system in Cartesian, cylindrical and Polar coordinates

CO2. **Analyze** the heat transfer through extended surfaces (fins) and implement the general heat conduction equation to thermal systems in transient heat conduction and able to select proper thermal insulation.

CO3. **Analyze** the heat transfer rate in natural and forced convection and evaluate through experimentation investigation.

CO4. **Interpret** heat transfer rate by radiation between objects with simple geometries, for black and grey surfaces.

CO5. **Ability** to analyze the boiling and condensation applicable in Heat Exchanger design

CO6. **Design and analysis** of heat transfer equipment and investigation of performance.

Course Contents		
Unit 1	**Fundamentals of Heat Transfer**	**08 Hrs.**
Basic Concepts: Different Modes and Laws of heat transfer, 3-D heat conduction equation in Cartesian coordinates (with derivation), and its simplified equations, simplified equations in cylindrical and spherical coordinates (simplified equations, no derivation) thermal conductivity, thermal diffusivity, electrical analogy, Thermal contact Resistance. **Boundary and initial conditions:** Temperature boundary condition, heat flux boundary condition, convection boundary condition, radiation boundary condition. **1-D steady state heat conduction without and with heat generation:** Heat conduction without heat generation in plane wall, composite wall, composite cylinder, composite sphere. Heat conduction with heat generation in Plane wall, Cylinder and Sphere with different boundary conditions.		
Unit 2	**Heat transfer through extended surfaces & Transient heat conduction**	**08 Hrs.**
Thermal Insulation – Critical thickness of insulation, Types and properties of insulating materials, Safety considerations in thermal insulation, Economic and cost considerations, Payback period, Numericals on payback period. **Heat transfer through extended surfaces:** Types of fins and its applications, Governing Equation for constant cross sectional area fins, Solution for infinitely long fin (with derivation), adequately long fin with insulated end tip and short fins (no derivation), Fin Efficiency & Effectiveness of fins, estimation of error in Temperature measurement by thermometer. **Transient heat conduction:** Validity and criteria of lumped system analysis, Biot Number, Fourier Number, Time Constant and Response of thermocouple, Use of Heisler Charts for plane wall, cylinder and sphere		
Unit 3	**Convection Heat transfer**	**07 Hrs.**
Principles of Convection: Local and average heat transfer coefficient, Hydrodynamic and Thermal boundary layer for a flat plate and pipe flow. **Forced Convection:** Physical significance of non-dimensional numbers, Empirical correlations for flat plate, pipe flow, and flow across cylinders, spheres, tube banks.		
Unit 4	**Natural Convection**	**07 Hrs.**
Free Convection: Physical significance of non-dimensional numbers, Free convection from a vertical, horizontal surface, cylinder and sphere. Mixed Convection **Boiling and Condensation:** Types of boiling, Regimes of pool boiling, Film wise condensation, Drop wise condensation (No Numerical treatment), Critical heat flux.		
Unit 5	**Heat Exchangers and Equipment Design**	**08 Hrs.**
Heat Exchangers: Classification and applications of heat exchangers, Heat exchanger analysis – LMTD for parallel and counter flow heat exchangers, Effectiveness– NTU method for parallel and counter flow heat exchangers, cross flow heat exchangers, LMTD correction factor, Heat Pipe, Introduction to electronic cooling - Active and passive methods of augmented heat transfer.		

Process Equipment Design: Condenser Design, Introduction to TEMA standards, Design considerations for heat exchangers, Materials of construction and corrosion, Temperature effects, Radiation effects, Economic consideration, Condenser and Heat exchanger design and performance calculations, Design of shell and tube type Heat Exchanger

Unit 6:	**Radiation**	**07 Hrs.**

Radiation: Thermal Radiation; definition of various terms used in radiation mode; Stefan-Boltzmann law, Kirchhoff's law, Planck's law and Wien's displacement law. Intensity of radiation and solid angle; Lambert's law; Radiation heat exchange between two black surfaces, configuration or view factor. Radiation heat exchange between grey surfaces, Electrical analogy for radiation, Radiation shields.

Books & Other Resources

Text Books:

1. Franck P. Incropera, David P. DeWitt – Fundamentals of Heat and Mass Transfer,
2. Y. A. Cengel and A.J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, Tata McGraw Hill Education Private Limited.
3. S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press.
4. R.C. Sachdeva, Fundamentals of Engineering Heat and Mass Transfer, New Age Science.
5. Joshi's Process Equipment Design, by V.V. Mahajani , S.B. Umarji ,Trinity Press

Reference Books:

1. P.K. Nag, Heat & Mass Transfer, McGraw Hill Education Private Limited.
2. M.M. Rathod, Engineering Heat and Mass Transfer, Third Edition, Laxmi Publications, New Delhi
3. V. M. Domkundwar, Heat Transfer, Dhanpat Rai & Co Ltd.
4. A.F. Mills, Basic Heat and Mass Transfer, Pearson.
5. S. P. Venkatesan, Heat Transfer, Ane Books Pvt. Ltd.
6. Holman, Fundamentals of Heat and Mass Transfer, McGraw – Hill publication.
7. M. Thirumaleshwar, Fundamentals of Heat and Mass Transfer, Pearson Education India.
8. B.K. Dutta, Heat Transfer-Principles and Applications, PHI.
9. C.P. Kothandaraman, S. V. Subramanyam, Heat and Mass Transfer Data Book, New Academic Science.
10. Process heat Transfer, D. Q. Kern, Wiley Publication

NPTEL Links:

E books: Links to be provided

1. https://libgen.is
2. http://libgen.li/item/index.php?md5=314BFA11A24C3C1ACFDED2B5AB88E5E9

Links of NPTEL / related videos

1. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
2. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
3. https://www.youtube.com/watch?v=J_zqQcncAu4&index=3&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3

4. https://www.youtube.com/watch?v=SNnd0f3xXlg&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3&index=11
5. https://www.youtube.com/watch?v=SNnd0f3xXlg&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3&index=11
6. https://www.youtube.com/watch?v=lnFjt30goiY&index=18&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3
7. https://www.youtube.com/watch?v=WPr2uFiCMgY&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3&index=35
8. https://www.youtube.com/watch?v=aLwJKZ1Gf3g&list=PL42D75EB85932E7D3&index=1
9. https://www.youtube.com/watch?v=n1go03oIyos&list=PL42D75EB85932E7D3&index=2
10. https://www.youtube.com/watch?v=GgFSBuf3AIE&index=36&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3
11. https://www.youtube.com/watch?v=k2UVufYKwIY&index=39&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

Complete **eight** experiments and **two** assignments (Sr. no.10 to 13).

1. Determination of Thermal Conductivity of insulating powder.
2. Determination of Thermal Conductivity of metal rod.
3. Determination of local and average heat transfer coefficient in Natural Convection.
4. Determination of local and average heat transfer coefficient in Forced Convection.
5. Determination of temperature distribution, fin efficiency in Natural / Forced Convection.
6. Determination of Emissivity of a Test surface.
7. Determination of Stefan Boltzmann Constant.
8. Determination of heat transfer, overall heat transfer coefficient and effectiveness of Plate Heat Exchanger.
9. Study of Pool boiling phenomenon and determination of Critical Heat Flux (CHF).
10. Assignment to solve transient heat transfer problem using Heisler and Grober Charts.
11. Design of heat exchanger for any simple application.
12. Industrial visit to heat treatment industry/ heat exchanger manufacturing industry.
13. Demonstration of dropwise and filmwise condensation.
14. Virtual laboratory: study of the performance of heat exchanger /study of variation of Thermal Conductivity.

Link for Virtual Lab: - https://www.vlab.co.in/

316483: Design of Machine Components					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3 Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Oral**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

Prerequisites: Engineering Mathematics, Engineering Graphics, Solid Mechanics, Engineering Materials, Kinematics of Machines.

Course Objectives:

1. Student shall gain the knowledge and understand the concept of design and steps involved in designing a machine component for manufacturing.
2. Shall be able to select proper materials for different machine components depending on their physical and mechanical properties.
3. Students can understand the different types of failure modes and criteria for design.
4. Students shall gain knowledge of different types of machine components and the design process. e.g., Curved beams, levers, shafts, couplings, keys, power screws, welded joints, bolted joints, riveted, gears etc. and able to design these components for any application.

Course Outcomes:

CO1. **Ability to analyze** the stress and strain of mechanical components and understand, identify and quantify failure modes.

CO2. **Ability to write** basic design equations for automotive components.

CO3. **Ability to decide** optimum design parameters for mechanical systems.

CO4. **Ability to design** any machine component.

CO5. **Enhancement** in proficiency of design and analysis.

Course Contents

Unit 1	**Design Process and design of Machine components**	**08 Hrs.**

Machine Design, Classification, Design procedure, Design Process, Design considerations, Standards and codes, Use of preferred series, Simple stresses in Machine components, Factor of safety, Service factor. Design of Cotter Joint, Design of Knuckle Joint, Levers - hand / foot lever, curved beams of circular cross section, Principal Planes and Principal stresses, Theories of failures, Design of machine components subjected to offset/eccentric/combined loading.

Unit 2	**Design of Shafts, Keys and Couplings**	**07 Hrs.**

Shafts: Transmission shaft, shaft design on the basis of strength and torsional rigidity, A.S. M. E. code for shaft design, design based on lateral rigidity.

Keys and Splines: Design of Parallel and taper key, Design of splines.

Couplings: Flange coupling, flexible coupling.

Unit 3	Design of Power Screws, Bolted, Riveted and Welded joints	08 Hrs.

Power Screw: Forms of threads, torque analysis and design with square and trapezoidal threads, self-locking screw, design of screw jack, design of toggle jack.

Bolted Joints: Basic types of fastenings, Design of bolted joints under tension, eccentrically loaded bolted joint in shear and parallel to axis of bolt, torque requirement for tightening.

Welded Joints: Welding symbols, types of welds, stresses in butt and fillet welds, strength of butt, parallel and transverse fillet welds, eccentric load in plane of weld, welded joints subjected to bending and torsion.

Riveted Joints: Types of rivets, rivet materials, analysis of riveted joints, joint efficiency, failures of riveted joints.

Unit 4	Design for Fluctuating Loads	08Hrs.

Fluctuating stresses, S-N diagram for fatigue loading, Soderberg and Goodman diagrams, Numericals on finite and infinite life, Stress concentration-causes and remedies, Notch sensitivity, Impact loading.

Unit 5	Design of Spur and Helical Gears	07 Hrs.

Spur Gears: Force analysis, Number of teeth, Face width & Beam strength of gear tooth, Incremental dynamic tooth load, Effective load on gear tooth, Estimation of module based on beam strength and wear strength.

Helical Gears: Virtual number of teeth, Tooth proportions, Force analysis, Beam strength and Wear Strength of helical gears, Effective load on gear tooth, Herringbone gears.

Unit 6	Design of Bevel and Worm Gears	07 Hrs.

Bevel Gears: Types, Terminology of bevel gears, Force analysis, Beam strength and Wear strength of bevel gears, Effective load on gear tooth.

Worm Gears: Terminology, Force analysis, Friction in worm gears, Strength rating and wear rating of worm gears, Thermal considerations.

Books and other resources

Text Books:

1. V. B. Bhandari, "Design of Machine Elements", Tata McGraw Hill Publications, New Delhi.
2. Textbook of "Machine Design" By R.S.Khurmi And J.K.Gupta S. Chand Publication, New Delhi.

References Books:

1. J. E. Shigley and C. R. Mischke, "Mechanical Engineering Design", McGraw Hill Inc. New York.
2. M. F. Spotts and T. E. Shoup, "Design of Machine Elements", Prentice Hall International.
3. W. C. Orthwein, "Machine Component Design", West-Pub. Co. and Jaico Pub. House.
4. R. C. Juvinal, "Fundamentals of Machine Components Design", John Wiley and Sons.
5. A. S. Hall, A. R. Holowenko and H. G. Laughlin, "Theory and Problems of Machine Design", Schaum‟s OutlineSeries.

Design Data Books:

1. P.S. G. College of Technology, Coimbatore, "Design Data Handbook"
2. K. Mahadevan, K. Balveera Reddy, "Design Data Handbook"

Term Work
Practical Contents:- **(1)** Six assignments based on above units. (One assignment on each unit) A. Design of Levers, Design for Offset/Eccentric Loads B. Design of Shaft and Coupling C. Design of Welded, Bolted and Riveted Joints D Design for Fluctuating Loads. E. Design of Spur gear and Helical gear F. Design of bevel and worm gear. **(2)** Design report and sheet based on (a) Design of Cotter joint/Knuckle joint and (b) Design of Power Screw. It will consist of two half imperial size (A2) sheets. One sheet is based assembly drawing with part list and other sheet is based on drawings of individual components. **Note: Oral questions can be asked on Design process, design procedure and application of all the components.**

316484: Automobile Electrical & Electronics					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	03 Hr./Week	Theory	03	In-Semester	30 Marks
Practical	02 Hr./Week	Oral	01	End-Semester	70 Marks
				Oral	25 Marks

Prerequisite Courses: Basic Electronics Engineering, Basic Electrical Engineering, Electrical and Electronics Engineering, Applied Thermodynamics.

Course Objectives

1. Acquire basic knowledge automotive electrical systems.
2. Gain knowledge of different batteries and related parameters.
3. Recall basics of automotive starting, charging and ignition System
4. Understand different types of sensor and actuators used in vehicle.
5. Illustrate the working of electronic control of SI and CI engine management systems.
6. Memorize advancements in driver assist systems.

Course Outcomes On completion of the course, learner will be able to,

CO1. **Recite** the basic knowledge of automotive electrical systems.
CO2. **Select** suitable battery for particular application.
CO3. **Recognize** the different components of starting, charging and ignition system.
CO4. **Classify** sensors/actuators according to physical parameters for speed, pressure, flow and temperature.
CO5. **Differentiate** in SI and CI engine management systems.
CO6. **List** different driver assist systems used for passenger safety and comfort.

Course Contents

Unit 1	**Automotive Electrical Systems**	**08Hrs**

Introduction to Automotive electricity generation, storage & distribution systems, wiring harness, 12/24/42 volt system, Connectors and its types, positive earth and negative earth, earth return and insulated return systems, Introduction of Controlled Area Networks (CAN) and LIN Communication. Instrument Cluster, types of indication in the cluster, Driver information systems.
Electromagnetic Interference (EMI), Electromagnetic Susceptibility (EMS), Electromagnetic Compatibility (EMC)- Need, Types, Methods of Coupling, Sources of EMI, Testing Methods, Related ISO / CISPR / SAE / AIS Standards and Few Case studies.

Unit 2	**Energy Storage Systems**	**08 Hrs.**

Types of batteries- Lead acid battery, Nickel-based batteries -Nickel Manganese Cobalt (NMC), Nickel Cobalt Aluminum (NCA), sodium-based batteries, and
Lithium-based batteries – Li-ion & Li-poly, Lithium-Cobalt oxide (LCO), Li-ion Manganese Oxide (LMO), Lithium iron Phosphate (LFP), metal-air battery, zinc chloride battery, Ultracapacitors,
Battery-characteristics & parameters, Battery ratings, Battery Performance, Battery capacities, Battery efficiency, Battery tests, Battery failures, Recycling of batteries.

Unit 3	**Starting, Charging and Ignition System**	**08 Hrs.**

Starting system - requirements, principle and construction of starter motor, types of starters, starter motor drives, switches, starter motor characteristics, and design considerations,
Charging system - construction and working of alternator, rectification, types of voltage regulators, Cutout relay, alternator characteristics, and design considerations.
Ignition System- Battery ignition system, components details and working, Electronic and distributor-less ignition systems, coil-on-plug ignition systems, Spark plugs, types, construction & characteristics.

Unit 4	Automotive Sensors and Actuators	07 Hrs.

Engine sensors: Manifold Absolute Pressure sensor, Knock sensor, Coolant and Intake Air temperature Sensor, Exhaust Oxygen level sensor, Throttle position sensor, Accelerator pedal position sensor and Crankshaft position sensor, Mass Air flow sensor.
Chassis Control :- Steering wheel angle sensor, Vibration and acceleration sensors, Speed and RPM sensors, torque sensors, Load Cell, Proximity Sensor, Rain Sensor, Crash Sensor for actuation of SRS Airbag.
Actuators- Solenoids, stepper motors and relays, piezo actuators,

Unit 5	Engine Management System	07 Hrs.

Layout and working (open loop and closed loop control), SI Engine Management System: group and sequential injection strategies, Injection Methods-TBI, MPFI and GDI, fuel system components, cold and warm start system, idle speed control, acceleration / deceleration and full load enrichment and fuel cut-off and spark timing control.
Diesel Engine (CI) Management System: Fuel quantity (Spill control), Injection timing control, Idle speed control, CRDI and advancements, fuel control MAPs.

Unit 6	Advanced Driver Assist Systems	07 Hrs.

ABS system with layout and working, Driver state monitoring (DSM), Supplementary Restraint System of air bag system, Seat belts- Retractor, Pretensioner and Load Limiter, Adaptive Cruise control, Automatic Emergency Braking, Collision avoidance system.
Vehicle security systems alarms, Keyless Entry system, Introduction to Global Positioning Systems, Lane Departure Warning System, Tire Pressure Monitoring System, Smart parking assist system (SPAS), Advance Front Lighting Systems (AFS), Head-up Display (HUD).

Books & Other Resources

Text Books:

1. P. L. Kohli, “Automotive Electrical Equipments”, Tata McGraw Hill Pub. Co. Ltd.
2. Tom Denton, “Automobile Electrical & Electronic Systems”, 3rd Edition, Elsevier Butterworth-Heinemann
3. William B. Ribbens, “Understanding Automotive Electronics”, 6th Edition, Newnes an imprint of Elsevier Science.

Reference Books:

1. Allan W. M. Bonnick, “Automotive Computer Controlled Systems”, Butterworth-Heinemann.
2. V. A. W. Hilliers, “Fundamentals of Automotive Electronics”, Hatchin, London.
3. Tomwather J. R., Cland Hunter, “Automotive Computer & Control System”, Prentice Inc. NJ
4. Robert N. Brandy, “Automotive Computers& Digital Instrumentation”, Prentice Hall Eaglewood, Cliffs, NJ
5. Young, Griffithe, “Automobile Electrical & Electronic Equipments”, The English Language Book Co., London.
6. Henry W. Ott, “Electromagnetic Compatibility Engineering”, John Wiley & Sons Inc., Publication
7. Clayton R. Paul “Introduction to Electromagnetic Compatibility”, John Wiley & Sons Inc., Publication

Guidelines for Laboratory Conduction
The student shall complete the following activity as a Term Work
The Termwork shall consist of completion of Practicals, Self-learning Study Assignments. **Practical**: (**Any two** experiments from **Sr. No 01 to 03**, **any five** experiments **from Sr. No 04 to 10**, **any one** experiment from **Sr. No 11 to 12**) 1. Study & demonstration of automotive electrical and electronic systems with its detailed layout. 2. Demonstration of dash board panel instruments & controls. 3. Demonstration of headlight beam alignment. 4. Testing of automotive battery. 5. Demonstration and testing of alternators. 6. Demonstration and testing of starter motors. 7. Demonstration and testing of CDI/HT Coil and armature. 8. Testing of auto electrical components on multifunctional tester. 9. Testing & cleaning of spark plug. 10. Testing of any one vehicle electronic component for EMI and EMS. 11. Study of fault codes, scan tools & diagnosis process for fault finding in the ECU. 12. Visit to any authorized service station for On Board Diagnosis.

302045-A: Advanced Forming and Joining Processes					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3 Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisite Courses: Manufacturing Processes, Engineering Materials and Metallurgy, Machine shop

Course Objectives:

1. To understand advances in sheet metal forming operations
2. To understand the advanced special metal forming processes.
3. To understand weld metallurgy and weld characterization techniques.
4. To understand and describe various advanced solid state welding processes.
5. To classify and describe various advanced welding processes.
6. To know about sustainable manufacturing and its role in manufacturing industry

Course Outcomes:

On completion of the course, learner will be able to

CO1. ANALYSE the effect of friction in metal forming deep drawing and IDENTIFICATION of surface defects and their remedies in deep drawing operations

CO2. ASSESS the parameters for special forming operation and SELECT appropriate special forming operation for particular applications

CO3. ANALYSE the effect of HAZ on microstructure and mechanical properties of materials

CO4. CLASSIFY various solid state welding process and SELECT suitable welding processes for particular applications

CO5. CLASSIFY various advanced welding process and SELECT suitable welding processes for particular applications.

CO6. UNDERSTAND the principles of sustainable manufacturing and its role in manufacturing industry.

Course Contents

Unit 1	**Mechanics of Sheet Metal Forming**	**08 Hrs.**

Theory of plasticity – yield criteria-work of plastic deformation- Sheet Metal Forming-Formability studies-conventional processes, Effect of friction in forming operation, Experimental techniques of evaluation of friction in metal forming, deep drawing, analysis (Numerical), surface defects identification and remedies, introduction to Forming simulation, Challenges in Forming.

Unit 2	**Special Forming Processes**	**08 Hrs.**

Special Forming Processes: HVF, HERF (Explosive Forming) techniques- super plastic forming techniques-Hydro forming-Stretch forming, Laser beam forming-principles and process parameters-Advantages, limitations and applications of different forming processes. Orbital forging-Isothermal-Hot and cold isostatic pressing-High speed extrusion, Water hammer forming, Incremental Sheet forming, Magnetic Pulse forming, Metal Spinning, Electro Hydraulic Forming, Micro forming.

Unit 3	Weld Metallurgy	07 Hrs.
Weld Metallurgy: Weld thermal cycles and their effects, effects of pre and post weld heat treatments, concept of HAZ, concept of weldability and its assessment. Welding of dissimilar materials, Weld characterization, Weld decay and weld sensitization, Introduction to ASME, ASWE, IS Welding Standards, (welding skill levels).		
Unit 4	**Solid State Welding Processes**	**07 Hrs.**
Solid State Welding Processes: Cold pressure welding, Diffusion bonding, Explosive welding, Ultrasonic welding, Friction stir welding, Forge welding, Roll welding and Hot pressure welding processes - features, advantages, limitations and applications, Advances in adhesive bonding, cladding.		
Unit 5	**Advanced Welding Processes**	**08 Hrs.**
Advanced Welding Processes: Electrogas, electroslag welding, Atomic hydrogen welding, Electron beam welding, Laser Beam welding - principle, working and applications, Cold Metal Transfer - concepts, processes and applications, Underwater welding, Welding automation in aerospace, nuclear and surface transport vehicles, Robotic Welding, Plasma Arc Welding, Plasma Transferred Arc Welding.		
Unit 6	**Sustainable Manufacturing**	**07 Hrs.**
Sustainable Manufacturing: Introduction to sustainability and drivers for sustainable development and sustainable manufacturing, fundamentals of sustainable manufacturing, various tools, factors of sustainability, Principles of Life Cycle Assessment (Goal, Scope and Life Cycle Inventory), Approaches, Role in Industry 4.0, Green Manufacturing, Environment protection norms, ISO 14000, recycling techniques, safety norms in forming and welding, socio-economic aspects, case study on waste recycling, material recycling, etc.		

Books and other resources

Text Books:

1. Sindo Kou, “Welding Metallurgy”, Wiley Publications Second Edition
2. Dr. V. D. Kodgire and S. V. Kodgire, “Material Science & Metallurgy For Engineers”, Everest Publication
3. William D. Callister, “Materials Science and Engineering an Introduction”, Jr, John Wiley & Sons, Inc**.**
4. O.P. Khanna, " Welding Technology", Dhanpat Rai & Sons Publications Edition 2015
5. Dr. R. S. Parmar,"Welding Processes and Technology", Khanna Publications Edition 2017
6. J. Paulo Davim, " Sustainable Manufacturing", Wiley Publications Edition 2010

References Books:

1. Z. Marciniak , J.L. Duncan, "Mechanics of Sheet Metal Forming",Butterworth Heinemann-2002
2. Dr. Sadhu Singh, "Theory of Plasticity and Metal Forming Processes", Khanna Publishers Edition 2008
3. O.P. Khanna, " Engineering Metallurgy", Dhanpat Rai & Sons Publications
4. Ali Hasan - Islam Nawaz, "Advanced Welding Technology", SCITECH Publications India Pvt. Ltd. Edition 2018
5. Dr. K. S. Yadav, "Advanced Welding Technology"', Rajsons Publications Pvt. Ltd.

6. Tool and Manufacturing Engineers' Handbook: Forming V by Charles Wick Publisher : Society of Manufacturing Engineers; 4th edition (1 Aug. 1996)
7. Dornfeld and David, "Green Manufacturing" - *Fundamentals and Applications, DOI 10.1007/978.1.4419.6016.0_2, Springer Science +Business Media, New York 2013*.
8. R. Ganesh Narayanan, Jay S Gunasekera,"Sustainable Material Forming and Joining", by CRC Press2020

Web References:

1. NPTEL Course on "Forming" by Dr. R. Chandramouli, IIT Madras
2. NPTEL Course on "Welding Engineering" by Dr. D. K. Dwivedi, IIT Roorkee
3. NPTEL Course on "Advances in welding and joining technologies" by Prof. SwarupBag IIT Guwahati.
4. NPTEL Course on "Welding Metallurgy" by Prof. Pradeep K. Jha, IIT Roorkee
5. NPTEL Course on "Sustainability through Green Manufacturing System – An Applied Approach" by Prof. Deepu Philip IIT Kanpur and Dr. Amardeep Singh Oberaoi, NIT Jalandar.

302045-B: Machining Science and Technology					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3 Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Mechanics, Gear terminology, Material properties, Degree of freedom.

Course Objectives:

1. To know about fundamentals of metal cutting process, tool wear and tool life
2. To impart the knowledge of machining phenomenon like milling, gear and thread manufacturing, grinding, super finishing, etc.
3. To understand the basic concepts, importance and functions of Jigs, Fixtures.
4. To prepare list of operations, tools, set of manufacturing instructions and selection of quality assurance method.
5. To generate CNC program for appropriate machining processes like. turning and milling

Course Outcomes: On completion of the course, learner will be able to

CO1. **Understand** metal cutting principles and mechanics of metal cutting and tool life.
CO2. **Describe** features of gear and thread manufacturing processes.
CO3. **Select** appropriate grinding wheel and demonstrate the various surface finishing processes.
CO4. **Select** appropriate jigs/fixtures and to draw the process plan for a given component.
CO5. **Select and evaluate** various parameters of process planning.
CO6. **Generate** CNC program for Turning / Milling processes and generate tool path using CAM software

Course Contents

Unit 1	**Mechanics of Metal Cutting**	**08 Hrs.**

Introduction to metal cutting, Elements of machining process, Geometry of single-point cutting tool, Orthogonal and Oblique cutting processes, Chip formation, Types of chips, Chip thickness ratio, Process parameters and their effect on machining, chip breakers, Merchant's Circle of forces analysis – forces and energy calculations, power consumed – MRR- Effect of Cutting variables on forces, Concept of Machinability-Factors affecting machinability, Machinability Index, Tool Life, Tool life equation of Taylor, Tool wear and its types, Factors affecting on tool life.

Unit 2	**Gear and Thread Manufacturing**	**07 Hrs.**

Introduction, Materials of gears, Methods of gear manufacturing-casting, forging, forming etc, milling of gears (indexing methods and numerical), Helical gear cutting, Gear Shaping and Gear hobbling, Gear inspection. **Thread Manufacturing:** Various methods of thread manufacturing**,** thread rolling, die threading & tapping, Thread milling, Thread grinding etc.

Unit 3	**Grinding & Surface finishing**	**08 Hrs.**

Types and Operations of grinding machines, Grinding wheel– Shapes, Designation and selection, Abrasives & classification, Bond & bonding, Grit, Grade & Structure of wheels, Types of grinding wheels, mounting of grinding wheels, Glazing and loading of wheels, Dressing and truing of wheels, Balancing of wheels, Diamond wheels. **Super-finishing processes** – Introduction to Honing, Lapping, Buffing and Burnishing. (Construction, working and controlling parameters)

Unit 4	Jigs and Fixtures	08 Hrs.

Significance and purpose of jigs and fixtures and their functions in the manufacturing processes, Concept of degree of freedom, 3-2-1 principle of location. General guidelines to design jigs and fixtures, advantages of jigs and fixtures.

Jigs- Definition, Elements of jig with the types, Location guidelines, Principles of clamping, Principles of guiding, Channel jig, Template jig, Plate jig, Angle plate jig, Turn over jig, Box jig, Latch type jig.

Fixtures: Definition. Elements of fixtures, Location guidelines, Principles of clamping, Principles of setting element, turning fixture, welding fixture, Milling fixture, Assembly and Inspection fixtures.

Unit 5	Process Planning	06 Hrs.

Introduction- methods of process planning, drawing interpretation, material evaluation, steps in process selection, production equipment and tooling selection, process parameters calculation for various production processes, Selection of jigs and fixtures, selection of quality assurance methods, documents for process planning, Economics of process planning, case studies.

Unit 6	CNC Programming	08 Hrs.

CNC Programming-CNC part programming adaptable to suitable controller. Steps in developing CNC part program. CNC part programming for Lathe Machine – Threading & Grooving cycle (Canned cycle). CNC part programming for Milling Machine - Linear & circular interpolation, milling cutter, tool length compensation & cutter radius compensation. Pocketing, contouring & drilling, subroutine and Do loop using canned cycle.

Books and other resources

Text Books:

1. A Text Book of Production Technology, P. C. Sharma, S.Chand Publications
2. A Text Book of Manufacturing Technology, R. K. Rajput, Laxmi Publications (p) LTD
3. A Text book of Manufacturing Technology, Metal Cutting and Machine Tools, P. N. Rao, Vol. 2, 2nd edition, Tata McGraw Hill Publishing Co. Ltd, New Delhi, 2002
4. Elements of Workshop Technology, Vol-II, S. K. Hajra Chaudhary, Media Promoters &Publications Pvt Ltd.
5. S. K. Sinha, CNC Programming using Fanuc Custom Macro B, McGraw-Hill Professional

References Books:

1. Theory of Metal Cutting, M. C. Shaw, 1st Edition, Oxford and I.B.H. publishing, 1994
2. Jigs & Fixtures, P.H. Joshi, Third edition, McGraw Hill, 2017
3. Production Technology Manufacturing Systems VOL-I & II, R. K. Jain, Khanna Publishers
4. Production Technology –HMT, Tata McGraw Hill publication
5. An Expert Process Planning System, Chang, T. C., Addison Wesley Longman, 1990
6. Process Planning- Design/Manufacture Interface, Scallan P, Butterworth-Heinemann, 2003
7. CNC Machines, B. S. Pabla, M. Adithan, New Age International, 2018
8. Manufacturing Science, Amitabh Ghosh and AshokKumar Mallik, Affiliated East-West Press, 2010

Web References:

1. https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-
2. https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-32.pdf
3. https://nptel.ac.in/content/storage2/courses/112105127/pdf/LM-34.pdf
4. https://nptel.ac.in/courses/112/107/112107143/

302046: Digital Manufacturing Laboratory					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Construction and operating of conventional machine tools, principles of machining and forming processes, cutting tool and machining parameters, programming languages like C, Python etc., basics of 3D printing.

Course Objectives:

1. To acquire skills to handle conventional machines and machining of a component.
2. To prepare manual part program for given component as per ISO standards and acquire skills to operate CNC machine.
3. To acquire skills to use Additive manufacturing technology.
4. To understand cutting tool parameters for conventional and CNC machines.
5. To understand usage of Digital Manufacturing tools for process simulation of manufacturing processes.
6. To understand types of jigs and fixtures and acquire skills to use jigs &fixture for any given component
7. To understand use of programming languages to prepare Online Calculator/Catalogue for selection of cutting parameters
8. To understand parameters for CNC retrofitting and reconditioning.

Course Outcomes: On completion of the course, Student will be able to

CO1. CREATE a given component using conventional machines, CNC machines and Additive Manufacturing Techniques.
CO2. ANALYZE cutting tool parameters for machining given job.
CO3. UNDERSTAND simulation of manufacturing process using Digital Manufacturing Tools.
CO4. SELECT and DESIGN jigs and Fixtures for any given component.
CO5. CREATE program for selection of cutting parameters.
CO6. UNDERSTAND parameters for CNC retrofitting and reconditioning.

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work;

1. Demonstration of cutting tool geometry and nomenclature of the tools used in conventional and CNC machines.
2. Machining of a mechanical component using conventional machines such as lathe, drilling, milling, grinding and any additional machine tool or processes as per requirement. Manufacturing drawing with appropriate geometrical and dimensional tolerances, detailed process planning to be included.
3. Preparing manual CNC part program using G Codes and M Codes as per ISO (DIN 66025) and RS274 standards for CNC lathe/mill machine.
4. Machining of mechanical component using CNC machine (Lathe/Mill/HMC/VMC). Manufacturing drawing with appropriate geometrical and dimensional tolerances, detailed process planning to be included.

5. Demonstration of Additive Manufacturing technology (from modelling to printing) (Batchwise)
6. Demonstration of the usage of Digital Manufacturing tools for process simulation of manufacturing processes like casting, forging, sheet metal, plastic processing (free / open source software)
7. Demonstration of various types of jigs and fixtures, and a case study on design and use of Jigs & Fixture for any given component.
8. Preparing Online Calculator/Catalogue for selection of cutting parameters by using programming languages like C, Python etc.
9. Study on CNC retrofitting and reconditioning
10. Visit to an Industry which uses advanced manufacturing processes

Please note following instructions regarding Laboratory Conduction:

1. Sr. No. 1 to 7are mandatory and any 2 from Sr. No. 8 to 10.
2. Practical are to be performed under the guidance of concerned faculty member.
3. Journal should consist of Job Drawing, Process Sheet and Program, appropriate write-up and shall be part of term work submission.

302047: Skill Development					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**TW**	**25 Marks**

Prerequisites: Students should have knowledge of Construction and working of IC engine / compressor / gear box / centrifugal pump/tail stock. Working principles of any type of mechanism / power plants. Working of electric and hydraulic systems of 4 wheeler vehicle. Working of machine tools, engine and transmission of different automotive and home appliances. Advanced manufacturing processes. Solid mechanics and design of machine elements.

Course Objectives:

Students shall

1. Develop the skills required in an industry such as design, development, assembly & disassembly.
2. Develop the skills required for fault diagnose of engine and transmission of different automotive and various home appliances.
3. Develop the skills required for maintenance of any machine tool.
4. Create awareness about industrial environment.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **Apply** and analyze the knowledge for assembly & disassembly of various machines.
CO2. **Design** and development of machine parts or any new product.
CO3. **Evaluation** of fault & diagnosis of machine tool, engine and transmission of different automotive and home appliances.
CO4. **Develop** a programming code required for design of m/c components.
CO5. **Identify** and understand the various activities performed in an industry.

Course Contents

1. Assembly and Disassembly of any of the following mechanical systems/ subsystems: bicycle (geared), e-Bikes, e-Motor Cycles, Drones, Flying devices, gear box, IC engines, centrifugal pump etc.
2. Assembly- Disassembly / Fault diagnosis of home appliances such as mixer, grinder, washing machine, fan, ovens, gas geyser, chopping machine, kneading machine, exercise machines, etc.
3. Development and demonstration of working/animation model of any mechanism.
4. Design a circuit of electric and hydraulic system of 4 wheelers and its verification.

   OR

   Circuit design /PCB design using software for control of BLDC electric motors used in e-Vehicles.
5. Undertake total preventive maintenance for any machine tool or mechanical system.
6. Visit to an industry for awareness about preventive maintenance.
7. Use of ergonomic principles for the design of hand tools, control in automobile dashboards, human operated mobile devices.

8. Use of alternative materials in the construction of daily activity machine and tool components
9. Interpretation of Drawings; Exercises in identifying the type of production, extracting important functional dimensions, checking the number of parts in an assembly. Checking and listing missing dimensions.
10. Exercises in -preparation of detailed production drawings as per BIS standard of simple machine parts having relevant notes and indications (limits/tolerances, surface finish, the process of production, relevant tools, materials, measuring instruments).

Documentation activity for above shall not be restricted to generation of 2D/3D CAD Drawings with dimensions (wherever applicable), Exploded View which will also incorporate assembly process, Flowchart of Maintenance Work etc. but can be beyond.
Skill Development Documentation Diary must be maintained by every student.

302048: Audit Course V		
Teaching Scheme	**Credits**	**Examination Scheme**
	Non-Credit	

GUIDELINES FOR CONDUCTION OF AUDIT COURSE

Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self-learning is being pursued by the students 'in true letter and spirit'.

- If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from third year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

Selecting an Audit Course

List of Courses to be opted (Any one) under Audit Course V

- Professional Ethics and Etiquette
- Engineering Economics
- Foreign Language (preferably French/Chinese)

The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BoS.

Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

Assessment of an Audit Course
• The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary. • During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course. • On the satisfactory submission of assignments, the institute can mark as “Present” and the student will be awarded the grade AP on the mark sheet.

316485: Automotive Refrigeration and Air Conditioning					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Oral**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

Prerequisites: Thermodynamics, Applied Thermodynamics, Heat Transfer

Course Objectives: Students are expected to,

1. The student shall gain appreciation and understanding of different types of refrigeration cycles, application of refrigeration and air conditioning.
2. The student shall be able to select proper refrigerants considering Environmental effect, Physical effect on human being for automotive application.
3. The student shall be able to select proper human comfort conditions.
4. The student shall gain knowledge of design consideration for the refrigeration and air conditioning also psychrometric properties, psychrometric table reading etc.
5. The student shall be able to solve load calculations problems.
6. The 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: On completion of the course, learner will be able to,

CO1. **Analyze** different types of refrigeration cycles.
CO2. **Evaluate** proper refrigerants considering Environmental effect, Physical effect on Human.
CO3. **Ability** to select proper human comfort conditions. .
CO4. **Compute** load calculations problems.
CO5. **Design** air conditioning system for automotive application in optimum cost.
CO6. **Analyze** different refrigeration and Air- conditioning equipments

Course Contents

Unit 1	**Refrigeration Fundamentals**	**08 Hrs.**

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 2	**Refrigerants & Air conditioning Components**	**08 Hrs.**

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 3	**Air distribution system**	**07 Hrs.**

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 4	Psychrometry	07 Hrs.
Moist air as a working substance, Psychrometric properties of air, Use of Psychrometric tables and charts, Processes, Combinations and Calculations, ADP, Coil Condition line, Sensible heat factor, Bypass factor.		
Unit 5	**Load analysis & control devices**	**08 Hrs.**
Load Analysis: Outside & inside design consideration, Factors forming the load on refrigeration & air conditioning systems, Cooling & heating load calculations, Load calculations for automobiles, Effect of air conditioning load on engine performance, Air conditioning electrical & electronic control, pressure switching devices, sensors & actuators.		
Unit 6	**Diagnostics, Trouble Shooting, Service & Repair**	**07 Hrs.**
Initial vehicle inspection, temperature measurements, pressure gauge reading & cycle testing, leak detection & detectors, Sight glass. Refrigerant safety/handling, refrigerant recovery; recycle & charging, system oil, system flushing, odor removal, retrofitting. Removing & replacing components, Compressor service.		

Books and other resources

Text Books:

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

References Books:

1. Roy J Dossat: "Principles of Refrigeration"; Pearson Education Inc.
2. William H Crouse and Donald L Anglin: "Automotive air conditioning"
3. Arora and Domkondwar "Refrigeration and Air Conditioning";: Dhanpat rai and Company.
4. C. P. Arora: "Refrigeration and Air Conditioning", Tata McGraw Hills Pub.
5. Paul Wissler: "Automotive air conditioning" Reston Publishing Co. Inc.

Term Work

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

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 & bus air conditioning system.
5. Study of defrosting methods.
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.

316486: Automotive Chassis and Transmission					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**03 Hr./Week**	**Theory**	**03**	**In-Semester**	**30 Marks**
Practical	**02 Hr./Week**	**Practical**	**01**	**End-Semester**	**70 Marks**
				Practical	**50 Marks**

Prerequisite Courses: Applied Thermodynamics, Automotive Electrical and Electronics.

Course Objectives

1. Understand types of vehicle layouts, front axle and steering systems.
2. Gain knowledge of suspension systems.
3. Describe the types of wheels, tyres and braking systems.
4. Acquire the basic knowledge of Clutches and Gearbox.
5. Explain the effect of drive ratio and differential.
6. Memorize the basics of automatic transmission.

Course Outcomes On completion of the course, learner will be able to,

CO1. **Classify** vehicle layouts according to different engine locations and ILLUSTRATE the working of front axle and steering systems.

CO2. **Define** key elements of suspension system

CO3. **Select** wheels, tyres for particular application and RECITE basics of braking systems.

CO4. **State** the significance of clutch and gearbox in automobile.

CO5. **Summarize** the working of final drive, differential and drive line components

CO6. **Evaluate** performance characteristics of fluid flywheel, torque converter and epicyclic gearbox and AQUIRE basic knowledge of CVT and Automatic Transmission.

Course Contents

Unit 1	**Vehicle Layouts, Front Axle and Steering Systems**	**07 Hrs.**

Introduction, Classification of automobile, Types of chassis layout with reference to power plant locations and type of drive, Types of chassis- fully forward, semi forward, Truck or bus chassis, two & three wheeler chassis layout.

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 2	**Vehicle Suspension Systems**	**07 Hrs.**

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 3	Wheels, Tyres and Braking Systems	08 Hrs.

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. 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 4	Clutches & Gear Box	08 Hrs.

Clutches: Principle, Functions, General requirements, Torque capacity, Types of clutches, Cone clutch, Single-plate clutch, Diaphragm spring clutch, Multi-plate clutch, Centrifugal clutch, Electromagnetic clutch, Lining materials, Over-running clutch, Clutch control systems.

Gear Box: Necessity of gear box, Resistance to motion of vehicle, Requirements of gear box, Functions of gear box, Types, Sliding mesh, Constant mesh, Synchromesh. Principle, construction and working of synchronizing unit, Requirements & applications of helical gears, Gear selector mechanism, Two wheeler gear box, Lubrication of gear box, Overdrive gears, Performance characteristics.

Unit 5	Drive Lines, Final Drive & Rear Axle	07 Hrs.

Effect of driving thrust and torque reaction, propeller shaft-universal joints, hooks and constant velocity U.J., Drive line arrangements – Hotchkiss drive & torque tube drive,

Purpose of final drive & drive ratio, Different types of final drives, need of differential, Constructional details of differential unit, Non-slip differential, Differential lock, Differential housing, Function of rear axle, Construction, Types of loads acting on rear axle, Axle types - semi-floating, full floating, three quarter floating, Axle shafts, Final drive lubrication.

Unit 6	Automatic Transmission	08 Hrs.

Fluid Flywheel, Torque convertor: Operating principle, Construction and working of fluid flywheel, Characteristics, Advantages & limitations of fluid coupling, Torque convertor, and construction and working of torque converter, Performance characteristics, Comparison with conventional gear box.

Epicyclic Gear Boxes : Simple epicyclic gear train, Gear ratios, Simple & compound planet epicyclic gearing, Epicyclic gear boxes, Wilson epicyclic gear train - Construction and operation, Advantages, Clutches and brakes in epicyclic gear train, compensation for wear, performance characteristics.

Principle of semi-automatic & automatic transmission, Fully automatic transmission, Semi-automatic transmission, Hydraulic control system, Continuous variable transmission (CVT) – operating principle, basic layout and operation, Advantages and disadvantages.

Books & Other Resources

Text Books:

1. Kripal Singh, "Automobile Engineering-Vol. 1", 13th Edition, Standard Publishers Distributors.
2. N. K. Giri, "Automotive Mechanics", Khanna Publishers, Delhi, Eighth Edition
3. C. P. Nakra ,"Basic Automobile Engineering", Dhanpat Rai Publishing Company (Pvt) Ltd.

Reference Books:

1. Bosch "Automotive Handbook", Robert Bosch GmbH, Germany.
2. W. H. Crouse and D. L. Anglin ,"Motor Vehicle Inspection",
3. Ramlingam , "Automobile Engineering" (Anna University)
4. Josepf Heitner , "Automotive Mechanics".
5. J.G .Giles "Vehicle Operation and Performance".
6. George Pieters, Barbara Pieters, "Automotive Vehicle Safety".
7. Jousha H. M, "Engine performance Diagnosis and Tune up Shop Manual".
8. Newton, Steed & Garrot, "Motor Vehicles", 13th Edition, Butterworth London
9. W. Judge, "Modern Transmission", Chapman & Hall Std., 1989,
10. Chek Chart, "Automatic Transmission", A Harper & Raw Publications,
11. Heisler, "Vehicle and Engine Technology", Second Edition, SAE International Publication

Web Refrences:

1. https://nptel.ac.in/courses/107/106/107106088/
2. https://nptel.ac.in/courses/107/103/107103084/

Guidelines for Laboratory Conduction

The student shall complete the following activity as a Term Work

The Termwork shall consist of completion of Practicals, Study Assignments. Practical examination shall be based on the Termwork undertaken during the semester.

Practical: (**Any 8** Experiments from Experiments **No. 1 to 10**.**Experiment No.)**

1. To Study different vehicle layouts.
2. Demonstration of steering, suspension & braking system used in automobiles.
3. Adjustments, overhauling, and repair of Two Wheeler Clutch
4. Adjustments, overhauling, and repair of Four Wheeler Clutch (Light / Heavy Duty Vehicle).
5. Adjustments, overhauling, and repair Constant Mesh Gearbox and Synchromesh Gearbox.
6. Adjustments, overhauling, and repair of Drive Line (Universal Joint, Propeller Shaft, Slip Joint).
7. Adjustments, overhauling, and repair of Final Drive & Differential.
8. Demonstration and study different types of Front and Rear Axles.
9. To study Fluid Flywheel and Torque Converter.
10. To study Continuous Variable Transmission (CVT).
11. Any One Visit from Below
    a) Visit to Vehicle Service Station to Study Power Transmission of Vehicle
    b) Visit to any Automotive Industry for Vehicle Transmission / Assembly Line

316487: Design of Engine Components					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3 Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
Practical	**2 Hrs./Week**	**Oral**	**1**	**End-Semester**	**70 Marks**
				Oral	**25 Marks**

Prerequisites: The basics of engine operations considering thermal and mechanical considerations, learnt in subjects IC Engine, Heat Transfer and Kinetics of Machinery. The basics of material properties and its relationship on basis of failure modes with different theories of failure. The design criteria and standards learnt in the subject Design of Machine Component. The preferred sizes and series, tolerances and types of fits. Roots of equations, Interpolation rule.

Course Objectives: Students shall

1. Understand the various design considerations, design procedure and select materials for a single cylinder engine.
2. Calculate the stresses on engine components due to various types of loads and failure
3. Analyze engine components subjected to static loading and their failure points
4. Design various engine components such as liner, piston, connecting rod, crankshaft, flywheel, journal bearings etc.

Course Outcomes: On completion of the course, learner will be able to

CO1. **Design and analyze** the components of single cylinder engine.
CO2. **Design** piston, crankshaft, and connecting rod under static loading conditions.
CO3. **Analyze** different stresses induced in the parts of crankshaft and connecting rod and apply its knowledge to design them.
CO4. **Evaluate** dimensions of different engine components under static loading conditions.
CO5. **Understand** valve gear mechanism, engine cooling system and engine testing methods in order to apply its knowledge to design and analyze the faults of complete single cylinder engine.
CO6. **Apply** the design and development procedure for elementary design of single cylinder engine.

Course Contents

Unit 1	**Design of Cylinder and Piston**	**08 Hrs.**

Materials of different engine components, Stresses in cylinder wall of IC engine, Design of cylinder liner, cylinder head and studs of cylinder head, Design of piston head, piston ribs, piston cup, piston ring, piston barrel, piston skirt and piston pin.

Unit 2	**Design of Connecting rod and Crankshaft**	**08 Hrs.**

Introduction to connecting rod, Buckling of connecting rod, Selection of cross-section for connecting rod, Design of big and small end bearings, Design of big end cap and bolts, Whipping stress in connecting rod.

Introduction to crankshaft, Types of crankshaft and their construction, Design of center crankshaft at Top-Dead Centre position and at angle of maximum torque position.

Unit 3	Design of Valve Mechanism and Engine Systems	07 Hrs.
Introduction to Valve-gear mechanism, Design of valves, Ports, Rocker arm, Valve spring, Tappet, Push rod, Follower, Cam, Cam shaft. Design of lubricating system, Design of lubricating oil cooling system, Design of engine cooling system.		
Unit 4	**Design of Flywheel**	**07 Hrs.**
Introduction to flywheel, Flywheel and Governor, Torque analysis of flywheel, Coefficient of fluctuation of energy of flywheel, Design of solid disk and rimmed flywheel, Stresses in rimmed flywheel.		
Unit 5	**Design of Bearings**	**08 Hrs.**
Sliding Contact Bearing: Basic modes of lubrication, Petroff's equation, Sommerfeld number, effect of temperature, Bearing design- Selection of parameters. Rolling Contact Bearing: Types of Rolling-contact Bearings, Static and dynamic load carrying capacities, equivalent bearing load, load life relationship, selection of bearing life, selection of rolling contact bearings.		
Unit 6	**Engine Selection and Testing**	**07 Hrs.**
Selection of engine type on the basis of Stroke and Bore, Number of cylinders, Cylinder arrangement and on considerations of combustion chamber. Engine Testing Equipment: Mechanical fuel pump testing, Cylinder power balance, Exhaust gas CO and HC analyzer, Oscilloscope engine analyzers, and Distributor dwell-angle		

Books and other resources

Text Books:

1. Bhandari V.B., Design of Machine Elements, Tata McGraw Hill Publication Co. Ltd.
2. R. S. Khurmi, J.K. Gupta, "A Text Book of Machine Design" Edition 11, Eurasia Publishing House.
3. S. P. Patil, "Mechanical System Design", Jaico Publications.

References Books:

1. V. L. Maleev, "I. C. Engine", McGraw Hill Book Co. Ltd., New Delhi, Second Edition
2. J.B. Heywood, "I. C. Engine Fundamentals", McGraw Hill Book Co., New Delhi.
3. Joseph E. Shigley & Larry D. Mitchell, "Mechanical Engineering Design", Sixth Edition, McGraw-Hill International Book Company
4. George E. Dieter, "Engineering Design- A Material and Processing Approach", Second Edition, McGraw-Hill International Edition
5. Paul H. Black & O. Eugene Adams Jr., "Machine Design", Third Edition, McGraw-Hill International Edition.
6. Juvinal R.C., Fundamentals of Machine Components Design, John Wiley and Sons.
7. Willium C. Orthwein, Machine Components Design, West Publishing Co. and Jaico Publications House.
8. C. S. Sharma and KamleshPurohit, Design of Machine Elements, PHI Learing Pvt. Ltd.
9. Design Data - P.S.G. College of Technology, Coimbatore.
10. Bhandari, V. B. Machine Design data book, Tata McGraw Hill Publication Co. Ltd.
11. K. Mahadevan, K. Balveera Reddy, Design Data Handbook for Mechanical Engineers, CBS Publishers.

Term Work		
The student shall complete the following activity as a Term Work; 1.) The term work shall consist of an assembly and detailed drawing of single cylinder engine on A1 size sheet. The assembly drawing must be with a bill of material and overall dimensions. The drawings of individual components must have least two views of each components. The Project should be assigned to a practical batch. Manufacturing tolerances, surface finish symbols and geometric tolerances should be specified for important surfaces. A design report giving all necessary calculations of the design of all engine components should be submitted in a separate file. Design data book shall be referred for selection of materials and standard components for given loading conditions. 2.) 3D modeling of at least five major components of engine. (by using any modeling software.).		
Web References:		
S N	**Topic Title**	**NPTEL video Link**
UNIT 3: Design of Valve Mechanism and Engine Systems		
1	Engine Components introduction-I	https://www.youtube.com/watch?v=yI6bGBiL9Fw&list=PLyqSpQzTE6M9G2SNxKfsVEjcM9MlJau4F&index=4
3	Engine Components introduction-II	https://www.youtube.com/watch?v=2XIdT7G3UGo&list=PLyqSpQzTE6M9G2SNxKfsVEjcM9MlJau4F&index=5
UNIT 4: Design of Flywheel		
1	Flywheel and Governor	https://www.youtube.com/watch?v=OlZXxPVpmBs
2	Torque analysis of flywheel	https://www.youtube.com/watch?v=oZhR1HPdvR4&list=RDCMUC640y4UvDAlya_WOj5U4pfA&start_radio=1&rv=oZhR1HPdvR4&t=2844
3	Turning Moment Diagram	https://www.youtube.com/watch?v=swgvKwyOnYk
4	Design of solid disk and rimmed flywheel	https://www.youtube.com/watch?v=wZ-mX1wSWXg
UNIT 5: Design of Bearing		
1	Boundary Lubrication	https://www.youtube.com/watch?v=cMYO-yBBXgg&list=PLbMVogVj5nJRCfyN1QEiBsNFek8d00kWw&index=12
2	Sliding Contact Bearing	https://www.youtube.com/watch?v=ALPKXoclcaw
3	Hydrodynamic Lubrication	https://www.youtube.com/watch?v=45CcdjPrxoM&list=PLbMVogVj5nJRCfyN1QEiBsNFek8d00kWw&index=14
4	Design of Hydrodynamic Journal Bearings	https://www.youtube.com/watch?v=K55JYbDa5XE&list=PLbMVogVj5nJRCfyN1QEiBsNFek8d00kWw&index=42
5	Rolling Contact Bearing:	https://www.youtube.com/watch?v=64EfZpMuOho
6	Selection of rolling contact bearings.	https://www.youtube.com/watch?v=vGl7nQUbWGM
UNIT 6: Engine Selection and Testing		
1	Four-stroke & Two-stroke engines	https://www.youtube.com/watch?v=zTt8cfH_qT8&list=PLT7nZHsCM2mxVhbXn7BeHTXg4w7btBf5I&index=2
2	Classification of IC engines	https://www.youtube.com/watch?v=2QPo2WcdkTg&list=PLT7nZHsCM2mxVhbXn7BeHTXg4w7btBf5I&index=3
3	Problems on IC engine	https://www.youtube.com/watch?v=bBxpgPKNABU&list=PLT7nZHsCM2mxVhbXn7BeHTXg4w7btBf5I&index=29

316488-A: Automotive Aerodynamics and Body Engineering					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: Automobile engineering, Fluid Mechanics, Heat Transfer

Course Objectives:

1. Identify various forces and moments associated with aerodynamics.
2. Gain thorough understanding of the different types of vehicles.
3. To understand the physics of fluid flow over vehicle body and its optimization techniques.
4. State and illustrate applications of ergonomics and safety in the designing of vehicle body.
5. To select appropriate process for designing of vehicle body with aesthetic appearance.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **Identify** various forces and moments associated with aerodynamics

CO2. **Understand** the physics of fluid flow over vehicle body and its optimization techniques

CO3. **Develop** the approach of Experimental and Computational technique for vehicle aerodynamics

CO4. **Achieve** thorough understanding of the different types of vehicles

CO5. **Illustrate** applications of ergonomics and safety in the designing of vehicle body

CO6. **Excel** appropriate process for designing of vehicle body with aesthetic appearance.

Course Contents

Unit 1	**Fundamental of Vehicle Aerodynamics**	**07 Hrs.**

Scope of study, History of vehicle aerodynamics, Present and future trends, Flow phenomenon related to vehicle: external and internal flow, Development of drag & lift on Aerofoil, Aerodynamic drag and its types and various forces and moments, Resistance to vehicle motion, the passenger car as bluff body, Flow field around car, Analysis of drag: Possible approaches, Physical mechanisms, Local origins, Drag & Lift.

Unit 2	**Vehicle Aerodynamics and Shape Optimization**	**08 Hrs.**

Drag fractions and their local origins: optimization of car bodies for low drag, Aerodynamics performance improvement using front and rear end modification, windshield and A-pillar, roof, spoilers, Wheel & wheel housings, attachments. Strategies for body shape development: Objectives, Detail Optimization, Shape optimization, Facelift, Adaptation of attachments, Forecasting and expert systems. Water and dirt accumulation on vehicle.

Unit 3	**Wind Tunnels and Wind Noise**	**08 Hrs.**

Scope, Fundamentals of wind tunnel technique, Limitations of Simulation, Tests with reduced scale models, Existing Automobile Wind tunnels. Introduction to CFD methodology – Application to vehicle aerodynamics. Wind noise: Mechanism of generation and transmission, Design features.

Unit 4	Car and Bus Body Details	08 Hrs.
Car body: Types- Saloon, Convertibles, Limousine, Estate Van, Racing and sport cars. Regulations, Drivers visibility, Tests for visibility, Methods of improving visibility, Space in cars, safety design, car body construction, front assembly, Roof Assembly, Under floor, bonnet etc. Bus body: Types - Mini Bus, Single Dekker, double Dekker, two levels, split level and articulated bus. Bus body layout – floor height, Engine Locations, Entrance cum exit location, Seating dimensions, seating layouts, passenger comfort. Construction details: frame construction, double skin construction, types metal sections used – regulations, conventional & integral type construction, Emergency door location, luggage space location.		
Unit 5	**Commercial Vehicle Body Details**	**07 Hrs.**
Types of bodies: - flat platform, drop side, fixed side, tipper body, tanker body. Light construction vehicle body types, dimensions of driver seat in relation to control, driver cabin design, design of chassis frame.		
Unit 6	**Body Loads & Ergonomics**	**07 Hrs.**
Idealized structure, structural surfaces, shear panel method, symmetric & asymmetric vertical loads in car, longitudinal load and load distribution on vehicle structure. Ergonomics and anthropometry, Drivers work station- Design of driver seat for comfort and safety, Types of seat used in automobiles, Types of safety belts, Use of energy absorbing system in automobiles, Impact protection from steering controls, Importance of Bumper in automobile.		
Books and other resources		
Text Books: Text Book: 1. J. Powloski, “Vehicle Body Engineering”, Business Books Ltd., London. 2. W.H. Hucho, "Automotive aerodynamics"		
References Books: 1. John Fenton, “Vehicle Body Layout & Analysis”, Hutchinson, London. 2. Sydney F. Page, “Body Engineering”, Chapman & Hill Ltd., London, 3rd Edition 3. J.G. Giles, “Body Construction and Design”, Vol. 6, llefe Books/Butterworth & Co. London 4. P. L. Kohli, “Automotive Chassis & Body”, Papyrus Publishing House, New Delhi. 5. Dr. V. Sumantran and Dr. Gino Sovram, Vehicle Aerodynamics Published by SAE International. 6. John Fenton, “Handbook of Automotive Body Construction and Design Analysis” Professional Engineering Publishing.		

316488-B: Automotive Materials					
Teaching Scheme		**Credits**		**Examination Scheme**	
Theory	**3 Hrs./Week**	**Theory**	**3**	**In-Semester**	**30 Marks**
				End-Semester	**70 Marks**

Prerequisites: The basics of materials considering thermal and mechanical considerations, learnt in subjects Engineering Materials & Metallurgy, Solid Mechanics. The Design basics learnt in the subjects Design of Machine Component and Engine Components. The basic structure of Automobile body and components

Course Objectives: Students shall

1. Understand the importance of different classes of materials in making of automobiles
2. Analyze the improving efficiency of automobiles through proper selection of materials and processing methods.
3. Understand the recent trends used in making of various automotive components.

Course Outcomes: On completion of the course, learner will be able to

CO1. **Identify** the need for new alternative materials to improve efficiency of automobiles**.**
CO2. **Analyze** different material requirements for various types of automobiles.
CO3. **Evaluate** the role of different classes of materials for various automotive systems
CO4. **Select** proper material while designing any automotive subsystem
CO5. **Select** advanced materials for specific automobile components
CO6. **Apply** Ashby charts for material selection

Course Contents

Unit 1	**Conventional and Recent Materials of Automobile**	**08 Hrs.**

Body design concepts with a focus on light weighting, Considerations in the use of Steel and Aluminium for car bodies. Evolution of casting technology, extrusion and sheet forming for making of car bodies for hatchback, utility vehicles, racing cars and heavy vehicles. Need to shift to new materials and risks in adopting new materials.

Unit 2	**Material for Automotive Interior**	**08 Hrs.**

Various high performance plastics and composites used in making of dashboards and their processing. Materials used in Flooring, dashboard silencer, headliner, door trim, baffles, rear shelf and their functionality. Car seat-considerations and materials used. Airbag-materials used and their testing.

Unit 3	**Materials for Automotive Exterior**	**08 Hrs.**

Application of various new materials including various types of composites in making of car bodies, bonnet, Alloy wheels and the processing method/s used to shape these parts. Reinforcement of fibres in composites - Woven fabrics - Non woven random mats - Various types of fibres in PMC processes - Hand lay-up processes - Spray up processes - Compression moulding - Reinforced reaction injection moulding -Resin transfer moulding -pultrusion- Filament winding - Injection moulding. Fibre reinforced plastics (FRP), Glass fibre reinforced plastics (GFRP)(Introduction only)

Unit 4	Automotive Paints & Glass	07 Hrs.
Introduction to glass, properties and composition. Various approaches in tempering of glass for improved toughness and shatter resistance. **Paint technology:** basic concepts and sequences of application and current trends Use of nanoparticles in paints to make self cleaning, scratch resistant paints, nano coatings for corrosion resistance.		
Unit 5	**Automotive Smart Materials**	**07 Hrs.**
Relevance of smart materials in the automobile industry, Use of Electro- or magneto-rheological engine mounts, new trends in engines, **Suspension systems**: Use of MR fluids and ER fluids in dampers. **Fuel Injector materials:** high melting point materials-Use of ceramics as fuel injectors. **Sintered Friction materials:** Powder metallurgy process for making disc brake pads		
Unit 6	**Selection of Automotive Materials**	**07 Hrs.**
Introduction to Ashby charts selection of materials for different systems in automobiles. Case studies for materials developments by Ferrari, Land Rover, Honda, and FIAT in the making of a automobiles.		
Books and other resources		
References Books: 1. Mathews F.L. and Rawlings R.D., "Composite materials: Engineering and Science", Chapman and Hall, London, England, 1st edition, 1994. 2. Chawla K.K., "Composite materials", Springer - Verlag, 1987		

316489: Automobile Measurement Laboratory					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Basics of Linear measurements and working principles of metrological instrument

Course Objectives:

1. Develop necessary skills for calibration and testing of different gauges and instruments.
2. Apply fundamentals of measuring methods for the measurement of different component.
3. Design limits gauges.
4. Understand the advances in Metrology such as use of CMM.

Course Outcomes: On completion of the course, learner will be able to-

CO1. **Understand** the methods of measurement, standards of measurement and calibration process.

CO2. **Evaluate** causes of errors in Vernier callipers, micrometers by performing experiments in standard metrological conditions to reduce uncertainty in measurement.

CO3. **Measure** the dimensional accuracy using Comparator and limit gauges and appraise their usage in actual measurement or comparison with standards set to reduce measurement lead time

CO4. **Examine** surface Textures, surface finish, using equipment's like optical flat / interferometers.

CO5. **Analyze** threaded component geometry by using metrological instruments.

Term Work

The student shall complete the following activity as a Term Work

Experiment No. 1, 3, 5 and 10 are mandatory. Perform any four from Experiment No. 2, 4, 6, 7,8,9,11,12.

1. Introduction to metrology and its importance in automobile engineering.
2. Introduction to calibration process and calibration of metrological instrument. Example – dial gauge, micrometre, vernier(any one)
3. Determination of linear / angular dimensions of automobile part using vernier calliper, screw gauge, dial gauge, height gauge, micrometre.
4. Determination of error in linear / angular measuring instruments.
5. Measurement of spur gear parameters used in automobile using gear tooth vernier calliper.
6. Verification of dimensions and geometry of given components using electrical/mechanical/optical/pneumatic comparator in context of manufacturing.
7. Measurement of automobile screw thread parts parameters using two wire or three-wire method (floating carriage micrometre)
8. Demonstration of surfaces inspection using optical flat / interferometers. Students should also draw the fringe pattern.
9. Determination of geometry / dimensions of given composite object / single point tool using profile projector and its application.

10. Limit gauges: concepts, uses and applications of GO-NO GO gauges, Taylor's principle and design of gauges (numerical).
11. Measurement of engine cylinder bore diameter using dial bore gauge.
12. Determination of given geometry using coordinate measuring machine (CMM) and its usage in Automotive industry.

Books and other resources

Text Books:

1. Jain R.K., Engineering Metrology, Khanna Publication.
2. I. C. Gupta, Engineering Metrology, DhanpathRai.
3. Bewoor A. K. and Kulkarni V. A., Metrology and Measurements, McGraw hill Publication.

Reference Books:

1. Narayana K.L., Engineering Metrology.
2. Galyer J.F &Shotbolt C.R., Metrology for engineers
3. Judge A.W., Engineering Precision Measurements, Chapman and Hall
4. Francis T. Farago, Mark A. Curtis, Handbook of dimensional measurement
5. Connie Dotson, Fundamentals of Dimensional Metrology, ThamsonPubln., 4th Edition.

Online Education resources: viz. NPTEL web site:

1. https://nptel.ac.in/courses/112106179
2. www.nptelvideos.in/2012/12/mechanical-measurements-and-metrology.html
3. www.me.iitb.ac.in/~ramesh/courses/ME338/metrology6.pdf;nptel.ac.in/courses/110101010/;
4. https://freevideolectures.com › Mechanical › IIT Madras
5. https://nptel.ac.in/courses/112107143/37;

316490: Automotive Hydraulic and Pneumatics Control Laboratory					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**2 Hrs./Week**	**Practical**	**1**	**Term Work**	**50 Marks**

Prerequisites: Hydraulic fluids, Relay logic and Ladder Logic/PLC programming

Course Objectives:

1. To study fluid power generation and conversion systems.
2. To study working principles of control devices and accessories.
3. To study selection of different components from manufactures' catalogues.
4. To study how to simulate and design fluid power systems.
5. To study digitalization of fluid power system.

Course Outcomes:

On completion of the course, learner will be able to

CO1. **Identify** various components of hydraulic system
CO2. **Select** pump and actuators for fluid operated systems
CO3. **Selection** of appropriate components required for hydraulic and pneumatic systems using manufactures' catalogues
CO4. **Analyses** and simulate hydraulic and pneumatic systems for automobile applications
CO5. **Design** a hydraulic/ pneumatic system according to the requirements in automobiles
CO6. **Develop** and apply knowledge to various applications in automobiles

Term Work

The student shall complete the following activity as a Term Work Journal;
Term Work of the Student shall be evaluated based on the completion of Practical, Industrial Visit Report and Group Assignment.
Practical: The student shall complete the following Practical in laboratory.

1. Study and identify the components and draw its ISO symbols used in hydraulic and pneumatic system
2. Analyse the performance of actuators mounted on hydraulic trainer.
3. Analyse the performance of Gear/Vane/Piston pump
4. Analyze the performance of compressor, FRL unit, special valves and accessories of pneumatics
5. Analyze the performance of control valves used in hydraulics and pneumatics.
6. Study of accessory used in hydraulic systems
   a. Reservoirs
   b. Accumulators: weight loaded, spring loaded, gas loaded.
   c. Intensifier
   d. Fluid conductors/pipes; pipe fittings
   e. Demonstration of electro hydraulic circuit/accumulator/intensifier
7. Following experiments to be done on pneumatic trainer
   a. Automatic reciprocating circuit
   b. Speed control circuit/Flow control valve
   c. Pneumatic circuit involving Shuttle valve/ Quick exhaust valve / Two pressure valve

d. Electro pneumatic circuits

8. Following experiments to be done on hydraulic trainer
   a. meter in and meter out circuit
   b. sequencing circuit
9. A) Industrial visit. (Especially Automotive workshop.)
   B) Trouble shooting of fluid power system of automobiles.
10. Design of any hydraulic and pneumatic systems used in automobile (steering, brake, etc.)

Books and other resources

Text Books:

1. Esposito A, Fluid Power with application, Prentice Hall
2. Majumdar S.R, Oil Hydraulic system- Principle and maintenance ,Tata McGraw Hill
3. Majumdar S.R, Pneumatics Systems Principles and Maintenance ,Tata McGraw Hill
4. Stewart H. L, Hydraulics and Pneumatics , Taraporewala Publication

References Books:

1. Pipenger J.J, Industrial Hydraulics, McGraw Hill
2. Pinches, Industrial Fluid Power, Prentice Hall
3. Yeaple, Fluid Power Design Handbook
4. Andrew A. Parr, Hydraulics and Pneumatics, Elsevier Science and Technology Books
5. ISO - 1219, Fluid Systems and components, Graphic Symbols
6. Standard manufacturing catalogues
7. Fundamentals of Pneumatics, Vol I, II and III. FESTO
8. Fundamentals of fluid power control John Watton Cambridge University press 2012
9. Introduction to Fluid power Thomson PrentcieHaIl 2004
10. Hydraulic Control Systems Herbert E. Merritt John Wiley and Sons, Inc

Web References:

URL links:

1. https://nptel.ac.in/courses/112/106/112106175/
2. http://ndl.iitkgp.ac.in/document/QXBqK1czOUpyM3FlamVjTmREMWFEUFdEb25sZ01FZVRtZmhWNXlobUZ0MFJ0Zk1kU1dSYmEwK1RSZG1FMUNDNQ
   Fluid Power Control: Web-Course
   Module-01
   Module-02
   Module-03
   Module-04

Links of Video Lectures:

1. https://nptel.ac.in/courses/112/106/112106300/
2. https://www.digimat.in/nptel/courses/video/112105047/L01.html

Recommended on line courses: https://nptel.ac.in/course.html

316491: Internship/ Entrepreneurship/ Technical Event					
Teaching Scheme		**Credits**		**Examination Scheme**	
Practical	**4Hrs/week**	**Practical**	**04**	**TW**	**100 Marks**

Prerequisites: Basic knowledge of automobile systems, manufacturing processes, vehicle maintenance and overhauling

Course Objectives:

1. To encourage and provide opportunities for students to get professional/personal experience.
2. To learn and understand real life/industrial/ enterprise situations.
3. To get familiar with various tools and technologies used in industries or enterprise
4. To nurture professional and societal ethics.
5. To create awareness of social, economic and administrative considerations in the working environment.

Course Outcomes:

On completion of the course, learners should be able to

CO1. **Demonstrate** professional competence through Industry Internship (II)/ Entrepreneurship Development Programme (EDP)/Technical Event (TE).

CO2. **Apply** knowledge gained through II/EDP/TE to complete academic activities in a professional manner.

CO3. **Select** appropriate technology and tools to solve given problem.

CO4. **Demonstrate** abilities of a responsible professional and use ethical practices in day to day life.

CO5. **Creating** network and social circle, and developing relationships with related professional.

CO6. **Analyze** various career opportunities and decide carrier goals.

Guidelines:

For course compliance, students should complete any one of the following module.

Duration:

Industrial Internship/EDP is to be completed after semester 4 and before commencement of semester 5 (in summer vacation) OR after semester 5 and before commencement of semester 6 (in winter vacation) of at least 2 to 4 weeks; and it is to be assessed and evaluated in semester 6.

Module 1: Industrial Internship

1. Student may choose to undergo Internship at Govt. Organizations/Private medium or large scale industry
2. Students may choose Internship through Internshala,
3. Students must maintain an Internship Diary/Internship Workbook during their internship.
4. The paper bound report on training must be submitted by the student in the beginning of 6^{th} semester along with a certificate from the company where the student took training.
5. Each student should give a 30-minute presentation on their internship work in front of the other students during practical hours.
6. Institute / Department/T and P Cell have to assist the students for finding Industries for the training

Module 2: Entrepreneurship Development Program (EDP)

1. Student may choose to undergo EDP organized by Govt. Organizations/Private organization
2. Students must maintain a diary during their EDP.
3. The paper bound report on training must be submitted by the student in the beginning of 6th semester along with a certificate from the company where the student took training.
4. Each student should give a 30-minute presentation on their EDP work in front of the other student during practical hours.
5. Institute / Department/T and P Cell have to assist the students for finding EDP

Module 3: Participation in National and International Technical Event

1. Student may participated in National and International competition such as SAE SUPRA, BAJA, Efficycle, TIFAN, Tractor design etc.
2. Students must maintain a record of their work in event
3. The paper bound report on training must be submitted by the student in the beginning of 6th semester along with a necessary certificates/documental proof
4. Each student should give a 30-minute presentation on their technical event and their work in front of the other students during practical hours.

Recommended evaluation

1. Post Internship Internal Evaluation -50 Marks
2. Internship Diary/Workbook, Internship Report, feedback from external internship supervisors/faculty advisor - 50 Marks

Reference:

1. https://www.aicte-india.org/sites/default/files/AICTE%20Internship%20Policy.pdf
2. https://internship.aicte-india.org/
3. https://www.ediindia.org/
4. https://mced.co.in/
5. https://www.sae.org/attend/student-events

302056: Audit Course VI		
Teaching Scheme	**Credits**	**Examination Scheme**
	Non-Credit	

GUIDELINES FOR CONDUCTION OF AUDIT COURSE

Faculty mentor shall be allotted for individual courses and he/she shall monitor the progress for successful accomplishment of the course. Such monitoring is necessary for ensuring that the concept of self-learning is being pursued by the students 'in true letter and spirit'.

- If any course through Swayam/ NPTEL/ virtual platform is selected the minimum duration shall be of 8 weeks.
- However if any of the course duration is less than the desired (8 weeks) the mentor shall ensure that other activities in form of assignments, quizzes, group discussion etc. (allied with the course) for the balance duration should be undertaken.

In addition to credits courses, it is mandatory that there should be an audit course (non-credit course) from third year of Engineering. The student will be awarded grade as AP on successful completion of the audit course. The student may opt for any one of the audit courses in each semester. Such audit courses can help the student to get awareness of different issues which make an impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Students can choose one of the audit courses from the list of courses mentioned. Evaluation of the audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not considered in the calculation of the performance indices SGPA and CGPA. Evaluation of the audit course will be done at institute level itself.

Selecting an Audit Course

List of Courses to be opted (Any one) under Audit Course VI

- Business and Sustainable Development
- Management Information System
- International Business

The titles indicated above are subject to change in time to come and such an alteration (if any) should be brought to the notice of the BOS.

Using NPTEL Platform: (preferable)

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Students can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with a certificate.

Assessment of an Audit Course
• The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary. • During the course students will be submitting the online assignments. A copy of the same can be submitted as a part of term work for the corresponding Audit course. • On the satisfactory submission of assignments, the institute can mark as “Present” and the student will be awarded the grade AP on the mark-sheet.