Vel Tech

Rangarajan Dr. Sagunthala

R&D Institute of Science and Technology

(Deemed to be University Estd. u/s 3 of UGC Act, 1956)

M.Tech. Automobile Engineering

with Specialization in

Electric & Hybrid Vehicles / Powertrain Engineering

Curriculum and Syllabus

DEPARTMENT OF AUTOMOBILE ENGINEERING

Department Vision

To be a centre of excellence in the field of automobile engineering by imparting knowledge and skill, enhancing research and development activities with social, ethical and environmental responsibilities to meet domestic and global challenges

Department Mission

- To produce effective and responsible automobile engineering graduates with respect to global requirements by imparting quality education.
- To constantly improve the pedagogical methods to deliver the academic programs with industry-oriented knowledge.
- To focus on learning through the state-of-the-art laboratories that possess a standard set-up to carry out research based education.
- To motivate students to pursue higher education and successfully take-up competitive examinations to reach a better position in their professional career

Vel Tech Rangarajan Dr Sagunthala R & D Institute of Science and Technology

School of Mechanical and Construction

Department of Automobile Engineering

M.Tech. Automobile Engineering With Specialization in Electric & Hybrid Vehicles / Powertrain Engineering

Program Structure

Category	No. of Credits
Foundation Course	04
Program core (No. of courses -6)	21
Specialization Core 18/Elective 12	30
Independent Learning	25
Total Credits	**80**

Foundation Course

Sl. No	Course Code	Course Name	L	T	P	C
1	2160MA201	Applied Statistics and Numerical Methods	3	0	2	4

Program Core

Sl.No	Course Code	Course Name	L	T	P	C
1	2161AU201	Prime Movers and Transmission	3	0	4	5
2	2161AU111	Automotive Mechatronics	2	2	0	3
3	2161AU202	Electric and Hybrid Vehicles	3	0	2	4
4	2161AU112	Two and Three-wheeler Technology	3	0	0	3
5	2161AU113	Automobile Chassis and Body Engineering	3	0	0	3
6	2161AU114	Powertrain Management Systems	3	0	0	3
Total Credits to be earned						21

Specialization courses
Powertrain Engineering Specialization
Specialization Core

Sl. No	Course Code	Course Name	L	T	P	C
1	2161AU203	Engine Combustion and Simulation	3	0	2	4
2	2161AU115	Engine Design and Development	3	0	0	3
3	2161AU116	Powertrain NVH	3	0	0	3
4	2161AU204	Automobile Fuels and Emission	3	0	2	4
5	2161AU205	Engine Testing and Certification	3	0	2	4
No. of credits						**18**

Specialization Electives

Sl. No	Course Code	Course Name	L	T	P	C
1	2162AU111	Automotive HVAC	3	0	0	3
2	2162AU112	Hydrogen and Fuel Cell	3	0	0	3
3	2162AU113	Supercharging and Turbocharging	3	0	0	3
4	2162AU114	Experimental Methods and Optimization Technique	3	0	0	3
5	2162AU115	Vehicle Dynamics	3	0	0	3
6	2162AU116	Engine Materials and Manufacturing	3	0	0	3
7	2162AU117	Tribology	3	0	0	3
8	2162AU118	Materials for Automobile	3	0	0	3
9	2162AU119	Automotive Electrical and Electronic Systems	3	0	0	3
10	2162AU201	Finite Element Analysis	3	0	2	4
	2162AU202	Computational Fluid Dynamics	3	0	2	4
No. of credits						**12**

Total Credits to be earned under Specialization – 30

Electric and Hybrid Vehicles Specialization
Specialization Core

Sl. No	Course Code	Course Name	L	T	P	C
1	2161AU117	Vehicle Mechanics	3	0	0	3
2	2161AU206	Power Electronics for Automobile	3	0	2	4
3	2161AU207	Modelling and Simulation of EHV	3	0	2	4
4	2161AU208	Energy Storage and Management Systems	3	0	2	4
5	2161AU209	Computer Aided Engineering	2	0	2	3
No. of credits						**18**

Specialization Electives

Sl. No	Course Code	Course Name	L	T	P	C
1	2162AU119	Automotive Electrical and Electronic Systems	3	0	0	3
2	2162AU120	Automotive Embedded System	3	0	0	3
3	2162AU121	Automotive Thermal Systems	2	2	0	3
4	2162AU122	Electric Drives and Control	3	0	0	3
5	2162AU123	Automotive Diagnostics	3	0	0	3
6	2162AU124	Micro Electro Mechanical Systems	3	0	0	3
7	2162AU125	In Vehicle Networking	3	0	0	3
8	2162AU126	Intelligent Transport Systems	3	0	0	3
9	2162AU127	Automotive Safety	3	0	0	3
10	2162AU128	Plug-in Electric Vehicles in Smart Grid	3	0	0	3
11	2162AU203	Testing and Certification of Electric and Hybrid Vehicles	3	0	2	4
No. of credits						**12**

Total Credits to be earned under Specialization - 30

Independent Learning

Sl. No	Course Code	Course Name	L	T	P	C
1	2163AU405	Project Management/ Online Courses				2
2	2164AU602	Mini Project	0	0	10	5
3	2164AU702	Project	0	0	36	18
Total Credits to be earned						**25**

Complimentary Course: (No Credit)

1. Industrial Interaction /Conference/ Publishing Articles

FOUNDATION COURSE

2160MA201 APPLIED STATISTICS AND NUMERICAL METHODS

L	T	P	C
3	0	2	4

Course Category: Foundation Course

Course Outcomes

Upon the successful completion of the course, student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the basics of probability, random variables and standard probability distributions with applications	K2
CO2	Understand the two-dimensional random variables and their applications like joint probability distributions, marginal density functions, expectation, covariance, correlation and regression	K2
CO3	Apply the Analysis of Variance (ANOVA) for experimental design – one factor experiment and the techniques CRD and RBD	K3
CO4	Apply the numerical methods for solving Ordinary Differential Equations (ODEs) – single-step and multi-step finite-difference numerical methods	K3
CO5	Apply the numerical methods for solving Partial Differential Equations (PDEs) – finite-difference numerical methods for parabolic, elliptic and hyperbolic PDEs	K3

UNIT I RANDOM VARIABLES, PROBABILITY DISTRIBUTIONS AND APPLICATIONS L – 9P-6

Random variables and their applications –discrete and continuous random variables – mean, variance and moments of random variables - probability density and distribution functions – moment generating functions and applications – modelling with Binomial, Poisson, Normal, Exponential distributions and their applications.

PRACTICALS

List of Experiments

1. Probability problems and plotting the binomial distribution with MATLAB
2. Probability problems and plotting the Poisson distribution with MATLAB
3. Probability problems and plotting the normal distribution with MATLAB
4. Probability problems and plotting the exponential distribution with MATLAB

UNIT II TWO-DIMENSIONAL RANDOM VARIABLES AND THEIR APPLICATIONS L - 9 P-6

Two-dimensional random variables and their applications - joint distribution functions – marginal distributions and marginal density functions – applications of marginal density functions – independent random variables – mathematical expectation, covariance and applications – correlation, regression and engineering applications.

PRACTICALS

List of Experiments

1. Plotting the bivariate normal distribution with MATLAB
2. Finding correlation and plotting regression lines with MATLAB

UNIT III DESIGN OF EXPERIMENTS L-9P-6

Design of experiments – Basic principles – Replication, randomization and local control – ANOVA – one-way classification– Completely Randomized Design (CRD) and applications – two-way classification –Randomized Block Design (RBD) and applications– Solving experimental design problems with CRD and RBD.

PRACTICALS

List of Experiments

1. Solving one-way classification problems using ANOVA with MATLAB
2. Solving two-way classification problems using ANOVA with MATLAB

UNIT IVNUMERICAL METHODS FOR ORDINARY DIFFERENTIAL EQUATIONS L - 9 P-6

Single Step methods – Euler's method – Modified Euler's method –Runge-Kutta method of fourth order for solving first and second order ODEs - multi-step methods – Milne's and Adams-Bashforth predictor corrector methods for solving first order ODEs – applications.

PRACTICALS

List of Experiments

1. Solving first-order ODEs using R-K method with MATLAB
2. Solving second-order ODEs using R-K method with MATLAB
3. Solving systems of differential equations using R-K method with MATLAB

UNIT V NUMERICAL METHODS FOR PARTIAL DIFFERENTIAL EQUATIONS L – 9P-6

Classification of partial differential equations - initial and boundary value problems in engineering - finite difference method for second order PDE – wave equation – heat equation – Laplace equation - explicit method for wave equation - Schmidt method and Bendre-Schmidt method for heat equation – Gauss-Seidel iteration method for Laplace equation.

PRACTICALS

List of Experiments

1. Solving initial-boundary problems for parabolic PDE with MATLAB

Total Periods =45 + 30

REFERENCE BOOKS:

1. V. Sundarapandian, `Probability, Statistics and Queueing Theory', PHI, New Delhi, 2016.
2. R. Panneerselvam, `Design and Analysis of Experiments', PHI, New Delhi, 2017.

3. S.R.K. Iyengarand R.K. Jain, ` Numerical Methods', New Age International, 2009.
4. S. Ross, `A First Course in Probability', Pearson Education India, New Delhi, 2013.
5. D.C. Montgomery, ` Design and Analysis of Experiments', Wiley, New Jersey, 2008.
6. S.S. Sastry, `An Introduction to Numerical Methods', PHI, New Delhi, 1995.
7. B.S. Grewal, `Numerical Methods in Engineering and Science', Khanna, New Delhi, 2015.

Sample Assessment Questions:

UNIT-1

Theory:

1. Suppose the duration X in minutes of long distance calls from your home follows exponential distribution with PDF

$$f(x)=\begin{cases}\frac{1}{3}e^{-\frac{x}{3}} & \text{for } x>0\\ 0 & \text{elsewhere}\end{cases}$$

   (a) Find $P(X>5)$.
   (b) Find $P(3\le X\le 6)$.
   (c) Find the mean of X and variance of X.
2. The monthly demand for Allwyn watches is known to have the following probability distribution:

Demand	1	2	3	4	5	6	7	8
Probability	0.08	0.12	0.19	0.24	0.16	0.10	0.07	0.04

   (a) Determine the expected demand for watches.
   (b) Compute the variance.

Practical:

1. Suppose that a balanced coin is to be flipped 20 times. Model this with a binomial distribution and plot the probability mass function and cumulative distribution. Find also the probability of observing
   (a) ten heads,
   (b) at least 10 heads
   (c) between 8 and 12 heads.
2. An electric bulb manufacturer reports that the average life-span of 100W bulbs is 1100 h with a standard deviation of 100 h. Assume that the life-hours distribution is normal.
   (a) Plot the probability density function.
   (b) Find the percentage of bulbs that will last at least 1000 h.
   (c) Find the percentage of bulbs with life-time between 900 h and 1200 h.

UNIT-2

Theory:

1. The joint probability density function (PDF) of X and Yis given by

$$f(x,y)=\begin{cases}4e^{-2x}y & \text{if } x>0,\ 0<y<1\\ 0 & \text{otherwise}\end{cases}$$

   (a) Find the marginal density functions of X and Y.
   (b) Determine the means of X and Y.
   (c) Check if X and Y are independent.

<table>
<tr><td></td><td>2. Let X and Y be two independent random variables with means 5 and 10, and standard deviations 2 and 3, respectively. Obtain the correlation coefficient between $U = 3X + 4Y$ and $V = 3X - Y$.</td></tr>
<tr><td></td><td>Practical:</td></tr>
<tr><td></td><td>1. The Fuel Economy Guide published by the Department ofEnergy reports that for the 1998 compact cars the average city mileage is 22.8with standard deviation 4.5, the average highway mileage is 31.1 with standarddeviation 5.5. In addition, the correlation coefficient between the city and highway mileage is 0.95.
(a) Using MATLAB, find the percentage of 1998 compact cars that give city mileage greaterthan 20 and highway mileage greater than 28.
(b) Using MATLAB, find the percentage of 1998 compact cars that give city mileage lower than 18 and highway mileage lower than 30.</td></tr>
<tr><td rowspan="3">UNIT-3</td><td>Theory:</td></tr>
<tr><td>1. Explain the three basic principles of the Design of Experiments.
(a) Replication
(b) Randomization
(c) Local Control
2. What are the advantages and disadvantages of the Completely Randomized Design (CRD)?
3. What are the advantages and disadvantages of the Randomized Block Design (RBD)?</td></tr>
<tr><td>Practical:</td></tr>
<tr><td></td><td>1. Consider the experimental design problem giving per hectare yield for three varieties of wheat, each grown in four plots:
<table>
<tr><td rowspan="2">Plots of Land</td><td colspan="3">Variety of Wheat</td></tr>
<tr><td>A_1</td><td>A_2</td><td>A_3</td></tr>
<tr><td>1</td><td>6</td><td>5</td><td>5</td></tr>
<tr><td>2</td><td>7</td><td>5</td><td>4</td></tr>
<tr><td>3</td><td>3</td><td>4</td><td>3</td></tr>
<tr><td>4</td><td>8</td><td>7</td><td>4</td></tr>
</table>
(a) Using MATLAB, set up the ANOVA table for this model using CRD.
(b) Also, work out F-ratio and test at 5% level of significance, whether there is significant difference among the average yields in the 3 varieties of wheat.</td></tr>
<tr><td rowspan="3">UNIT-4</td><td>Theory:</td></tr>
<tr><td>1. Applying Runge-Kutta fourth order method, solve the first-order differential equation $y' = x + y$ with $y(0) = 1$ at $x = 0.2, 0.4$.
2. Given the first order ODE $y' = x^2(1 + y)$ and $y(1) = 1, y(1.1) = 1.233$, $y(1.2) = 1.548, y(1.3) = 1.979$, evaluate $y(1.4)$ by Adams-Bashforth numerical method.</td></tr>
<tr><td>Practical:</td></tr>
</table>

<table>
<tr><td></td><td>1. Consider the nonlinear pendulum given by
$y'' = -\sin(y)$ with $y(0) = 0.1,\ y'(0) = 0.1$
Plot the trajectory for the above nonlinear model with the Runge-Kutta fourth order method using MATLAB.
2. Consider the Van der Pol oscillator defined by
$y'' - \mu(1 - y^2)y' + y = 0$ with $\mu = 1,\ y(0) = 0.2,\ y'(0) = 0.2$
Plot the trajectory for the above nonlinear model with the Runge-Kutta fourth order method using MATLAB.</td></tr>
<tr><td rowspan="4">UNIT-5</td><td>Theory:</td></tr>
<tr><td>1. Using Schmidt method, find the numerical solutions of the heat equation $u_t = 0.5u_{xx}$
with the boundary conditions $u(0,t) = u(4,t) = 0$ and the initial conditions $u(x,0) = x(4-x),$ taking $\Delta x = 1.$ Find the values of uup to $t = 5.$
2. The function u satisfies the wave equation $u_{tt} = u_{xx},$
the initial conditions $u(x,0) = \frac{1}{8}\sin \pi x,\ u_t(x,0) = 0$ for $0 \le x \le 1,$ and the boundary conditions $u(0,t) = u(1,t) = 0$ for $t > 0.$ Use the explicit scheme to calculate u for $x = 0\ (0.1)\ 1$ and $t = 0\ (0.1)\ 0.5.$</td></tr>
<tr><td>Practical:</td></tr>
<tr><td>1. Consider the heat equation:
$\pi^2 \frac{\partial u}{\partial t} = \frac{\partial^2 u}{\partial x^2},\ (0 \le x \le 1,\ t \ge 0).$
At x = 0 and x = 1, the solution satisfies the boundary conditions:
$u(0,t) = 0$
$\pi e^{-t} + \frac{\partial u}{\partial x}(1,t) = 0.$
Using MATLAB, compute the numerical solution of the PDE with 20 equally spaced mesh points and determine the surf plot of the solution.</td></tr>
</table>

PROGRAM CORE

2161AU201	PRIME MOVERS AND TRANSMISSION	L	T	P	C
		3	0	4	5

Course Category: Program core

Self-Learning Content:
Mechanisms-Inversions-Slider Crank Mechanism-Springs-Helical and leaf springs-Cams-Types of Cams and Followers-Cam profile-Frictional force – Laws of friction-Sliding and Rolling Friction-Power Transmission-Gears-Terminology, Spur, Helical and Bevel Gears, Gear Trains-Belt drives (types)-Chain drives.

Course Outcomes
Upon the successful completion of the course, student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Estimate prime movers performance on the basis of thermodynamic cycles and test rig	K3
CO2	Categorize, interpret and understand the fuel supply system required for petrol and diesel engines	K2
CO3	Describe the construction and operation of different transmission systems	K2
CO4	Explain the requirements and outline the working of drive line systems	K2
CO5	Analyze new technical challenges and advancements in power trainsystems	K2

UNIT I: POWER TRAIN FUNDAMENTALS L - 9 P-6
Automobiles and Systems - Engine Classification - S.I and C.I Engine Operating Cycles - Two and Four Stroke Engines - Scavenging - Turbocharger - Performance and Emission Parameters - Firing order - Port/Valve Timing Diagram(Demonstration) - Efficiency Improvements - Pollution - Emission Standards - Power Transmission Systems.

List of Experiments:
1. Determination of Thermal Efficiency of the Engine.
2. Measurement of Specific Fuel Consumption of the Engine.
3. Measurement of Regulated Emission from an Engine.

List of Demonstrations:
1. Construction and working of Two and Four Stroke Engines
2. Determination of Port/Valve Timing Diagram

UNIT II: AIR INDUCTION SYSTEMS AND FUEL INJECTION SYSTEM L – 9P-6
SI Engines: Fuel Tank - Fuel Filter - Fuel Pump - Air Cleaner/Filter - Carburettor –Types - Petrol Injection Systems - TBI, MPFI and GDI-CI Engines: Injection System – Types - Air & Solid Injection Systems – CRDI - Fuel Injectors - Super Charging and Turbo Charging – Fuel Vaporizer

List of Experiments:
1. Calibration of Fuel Injection Pump.
2. Adjustment of Fuel Injector Opening Pressure.

List of Demonstrations:

1. Demonstration of Petrol Supply Systems.
2. Demonstration of Diesel Supply Systems.

UNIT III: TRANSMISSION SYSYTEM L – 9P-6

Clutch - Fluid Coupling - Construction and Function - Decoupling of Power, Speed and Torque Characteristics of Power Transmission - Gear Box - Different Types of Gear Boxes - Determination of Gear Box Ratios for Different Vehicle Applications - Torque Converters - Automatic Transmission - CVT.

List of Experiment:

1. Determination of the Gear Ratios of the given Gear Box.

List of Demonstration:

1. Demonstration on Construction and Function of Clutch.

UNIT IV: DRIVE LINE SYSTEMS L – 9P-6

Effect of Driving Thrust and Torque Reaction-Hotchkiss Drives-Torque Tube Drive-Radius Rods, Propeller Shaft-Universal Joints-Final Drive-Rear Axle-Rear Axle Construction: Full Floating, Three Quarter Floating and Semi-Floating Arrangements-Differential: Conventional Type &Non-Slip Type-Differential Locks.

List of Experiment:

1. Determination of the Rear Axle Ratios of the given Rear Axle.

List of Demonstration:

1. Demonstration on Construction and Function of Differential.

UNIT V: ADVANCED POWERTRAIN TECHNOLOG L – 9P-6

Low Heat Rejection (LHR) Engine-Dual Fuel/Multi Fuel Engines-Camless Engine-VVT-Homogeneous Charge Compression Ignition (HCCI)-Homogeneous &Stratified GDI-Controlled Auto-Ignition (CAI).

List of Experiment:

1. Performance and emission test on LHR engine.

DESIGN, IMPLEMENT and OPERATE (DIO) - PROJECT P-30

Project-Based Learning on prime movers and transmission

Total Periods =45 + 30 +30

REFERENCE BOOKS:

1. V. Ganesan, 'Internal Combustion Engines', Tata McGraw Hill Book Co, Eighth Reprint, 2010.
2. J.B. Heywood, 'Internal Combustion Engine Fundamentals', McGraw Hill Book Co., 2006.
3. M.L. Mathur and R.P.Sharma, 'Internal Combustion Engines', DhanpatRaiPublicatuions (P) Ltd., 2007.
4. Challen Bernard, 'Diesel Engine Reference Book', Oxford Butterworth, Heinemann, 1999.
5. T. K. Garrett, K. Newton and W. Steeds, 'Motor Vehicle', Butterworth, Heinemann, 13th Edition, 2000.

Sample Assessment Questions:

UNIT-1	**Theory:**
	1. Briefly discuss about the performance characteristics of diesel engine. Describe the emission characteristics of SI and CI engine.
	Practical:
	3. Determine the thermal efficiency of the given engine at different loads of operation. 4. Estimate the TFC and BSFC of the given engine at different loads of operation.
UNIT-2	**Theory:**
	1. What is GDI? How does GDI system work? Explain with a neat sketch. 2. Draw a neat and labeled diagram of Common Rail Diesel Injection (CRDI) system for modern automobile engines and explain its working. 3. With a neat sketch discuss the construction and working of distributor type fuel injection pump.
	Practical:
	1. Calibrate the given jerk type Fuel Injection Pump 2. Adjust the injector opening pressure (IOP) of the given single hole nozzle to 260 bar and compare the injection characteristics of the injector with IOP of 220 bar.
UNIT-3	**Theory:**
	1. With the aid of neat sketches describe the constructional features of diaphragm type clutch. Discuss the advantages and disadvantages of the diaphragm clutch over clutch employing helical springs. 2. What is fluid coupling? Explain its constructional details. Draw and explain its performance curves. 3. Draw a sketch of a Chevrolet "Turbo glide" transmission. Also discuss about the types of CVT.
	Practical:
	1. Determine the Gear Ratios of the given Synchromesh Gear Box. 2. Determine the Gear Ratios of the given Constant Gear Box.
UNIT-4	**Theory:**
	1. Describe about Hotchkiss drive and Torque tube drive with sketches. 2. (i) Discuss in detail about constant velocity universal joints with sketches. (ii) Discuss about radius rods and stabilizer bar with respect to mounting and functions. 3. Explain about the construction and working of semi-floating, three-quarter floating and fully floating axles with neat sketches.
	Practical:
	1. Determine the Rear Axle Ratio of the given Rear Axle.
UNIT-5	**Theory:**
	1. Explain the concept of adiabatic engine. Compare the performance of a LHR engine and conventional engine? 2. What is HCCI engine? Explain the performance and emission characteristics of HCCI engine.
	Practical:
	1. Conduct the performance and emission test on the given LHR engine
DIO	**Sample Project Titles**

PROJECT	1. Design and development of Turbo-compound engine.
	2. Development of a semi-automatic clutch using compressed air.
	3. Helmet controlled ignition system for two wheeler rider safety.
Guidelines to select and carry out the project:	
Step 1(Identify):	Conceive/identify a problem or an innovative idea for the improvement of the existing technology on prime movers and transmission system.
Step 2(Design):	Design the system/component as per the technical requirements
Step 3(Implement):	Fabricate the system/ device as per the design carried out in step 2
Step 4(Operate):	Assemble and test the system/device so developed
EXAMPLE: Title of the project: **Development of a semi-automatic clutch using compressed air**	
Idea	• To prevent the damage to gear box components • To reduce the driver effort required to disengage the clutch By a clutch operated by compressed air. To operate the clutch pneumatically the following components are required: 1. Air compressor and cylinder 2. Double acting pneumatic cylinders 3. Solenoid operated, spring return DCV
Design	Design double acting pneumatic cylinder: For single plate clutch, 1. According to uniform wear theory, Force required to disengage the clutch has to calculated $T = n\mu F(R_o + R_i)/2$ From this equation force required to disengage the clutch can be calculated. 2. Then diameter of the cylinder or size of the double acting pneumatic cylinder has to be determined by using again the pressure force relation. i.e Pressure = Force/Area From this diameter of the cylinder or size of the double acting pneumatic cylinder can be determined.
Implement	Fabricate the pneumatic operated clutch system with air compressor and cylinder, double acting pneumatic cylinders, solenoid operated spring return DCV, hose pipe and switch.
Operate	Operate and test the system for which it is intended.

2161AU111	AUTOMOTIVE MECHATRONICS	L	T	P	C
		2	2	0	3

Course Category: Program Elective

Self-Learning Content: Fundamentals of electrical, electronics and Automotive Engineering.

Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the basic components of automotive mechatronics and control systems.	K2
CO2	Understand the basics of sensors, actuators and its interaction with automotive parameters	K2
CO3	Understand the basics of electronic engine management system for SI and CI Engine Management System	K2
CO4	Identify the use of multiplex networking for automotive applications	K2
CO5	Identify the applications of automotive mechatronics in different sub-domains of automobiles	K2

UNIT I: Fundamentals of Automotive Mechatronics & Control System L-6 T-6

Fundamentals of Mechatronics, Electronics Components, Microprocessor, Ports, Memory, Buses, Microcontroller, Fetch-Execute sequence, Programming, Electronic Control Unit, Testing of Microcontroller Systems. Control System: Open and closed loop control strategies, PID control, Look up tables, Modern control strategies: Fuzzy logic and adaptive control.

List of Demonstrations:

1. Demonstration on Testing of Microcontroller Systems
2. Open and closed loop control strategies

UNIT II: Sensors & Actuators L-6 T-6

Hall Effect, hot wire, thermistor, piezo electric, piezoresistive, based sensors. Introduction, basic sensor arrangement, types of sensors, oxygen concentration sensor, lambda sensor, crankshaft angular position sensor, cam position sensor, Mass air flow (MAF) rate, Manifold absolute pressure (MAP), Throttle plate angular position, engine oil pressure sensor, vehicle speed sensor, detonation sensor, emission sensors, Actuators: solenoid actuator, stepper motors, relays, electrohydraulic actuators.

List of Demonstrations:

1. Measurement of mass flow of air in intake manifold
2. Demonstration on working of stepper motors.

UNIT III: Electronic Engine Management System L-6 T-6

Electronic Fuel Injection, Types of EFI, TBI, MPFI & GDI, Ignition System, Electronic Ignition System and its advantages, Fuel control maps, CI Engine Management. Fuel injection system, parameters affecting combustion, noise and emissions in CI engines. Pilot, main, advanced, post injection and retarded post injection. Electronically controlled Unit Injection system. Exhaust emission control systems, 2 and 3-way catalytic converter.

UNIT IV: Automotive Tools, Diagnosis & Networking L-6 T-6

Wiring Harness, Limitations of Wiring Harness, Multiplex data bus, Basic principle of Networking, Classification of automotive multiplex bus, Controller Area Network, Local Interconnect Network, FlexRay, Most, Automotive Ethernet, Connected Cars. Diagnosis: tools and equipment, Oscilloscope, onboard diagnosis system, Electromagnetic compatibility & tests for EMC.

List of Demonstrations:

1. Demonstration of Wiring Harness
2. Demonstration of onboard diagnosis system

UNIT V: Applications for different domains and current trends L-6 T-6

Lighting systems: LED, adaptive front lighting system, Comfort systems: Cruise control, adaptive cruise control, central locking, Electric mirrors, windows, multimedia systems, Safety & security systems: Airbag, Chassis Systems: ABS, TC, ESP, TPMS, Active Suspension, Active Steering system, Automatic Transmission, Use of Machine learning and data analytics for the automotive applications (ADAS, vehicle Autonomy, prognostics, health monitoring).

List of Demonstrations:

1. Demonstration of Cruise control
2. Demonstration of Automatic Transmission system

Total Periods =60

REFERENCE BOOKS:

1. Automotive Mechatronics: Automotive Networking- Driving Stability Systems- Electronics (Bosch Professional Automotive Information)- by KonradReif- Springer Fachmedien Wiesbaden- 2014.
2. Automobile Electrical & Electronic Equipments - Young- Griffitns - Butterworths- London.
3. Understanding Automotive Electronics- Wiliam B. Ribbens- 5th Edition- Newnes- Butterworth–Heinemann.
4. Diesel Engine Management by Robert Bosch- SAE Publications- 3rd Edition- 2004
5. Gasoline Engine Management by Robert Bosch- SAE Publications- 2nd Edition- 2004
6. Understanding Automotive Electronics – Bechfold SAE 1998
7. Automobile Electronics by Eric Chowanietz SAE.
8. Automotive Computer & Control System – Tomwather J. R.- Cland Hunter- Prentice Inc. NJ
9. Automotive Computers & Digital Instrumentation – Robert N. Brandy- Prentice Hall Eaglewood- Cliffs- NJ
10. Automobile Electrical & Electronic Systems – Tom Denton- Allied Publishers Pvt. Ltd.
11. James D. Halderman- Advanced Automotive Electricity and Electronics- Pearson- 2013.
12. Tom Denton- Advanced Automotive Fault Diagnosis- Routledge- 2006.

2161AU202	ELECTRIC AND HYBRID VEHICLES	L	T	P	C
		3	0	2	4

Course Category: Program core

Self-Learning Content: Basic working principles of Motors.

Course Outcomes

Upon the successful completion of the course- students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe about working principle of electric vehicles.	K2
CO2	Explain the construction and working principle of various motors used in electric vehicles.	K2
CO3	Understand about working principle of electronics and sensor less control in electric vehicles.	K2
CO4	Describe the different types and working principle of hybrid vehicles.	K2
CO5	Illustrate the various types and working principle of fuel cells.	K2

UNIT I Introduction to Electric Vehicles L - 9 P-6

Electric Vehicle – Need - Types – Cost and Emissions – End of life-Electric Vehicle Technology – layouts- cables- components- Controls. Batteries – overview and its types. Battery plug-in and life. Ultra-capacitor- Charging – Methods and Standards. Alternate charging sources – Wireless & Solar- Introduction of electric vehicles Safety Consideration- Manufacturing and Services.

List of Experiments

1. Study of various components of electric car.

List of Demonstrations

1. Demonstration of wiring layout of electric vehicle.

UNIT II Electric Vehicle Motors L - 9 P-6

Motors (DC- Induction- BLDC) – Types- Principle- Construction- Control. Electric Drive Trains (EDT) – Series HEDT (Electrical Coupling) – Power Rating Design- Peak Power Source (PPS); Parallel HEDT (Mechanical Coupling) – Torque Coupling and Speed Coupling. Switched Reluctance Motors (SRM) Drives – Basic structure- Drive Convertor- Design. Testing of Motors/Generators – Selection of Motors under variable parameters.

List of Experiments

1. V/f control of three-phase induction motor.
2. Speed control of BLDC motor in two wheeler.
3. Speed control of SRM motor in three wheeler.
4. Simulation of Four quadrant operation of three-phase induction motor.

List of Demonstrations

1. Application of DC series motor in an electric vehicle.

UNIT III Electronics and Sensor-less control in EV L - 9 P-6

Basic Electronics Devices – Diodes- Thyristors- BJTs- MOSFETs- IGBTs- Convertors- Inverters. Safety – Risks and Guidance- Precautions- High Voltage safety- Hazard management. Sensors - Autonomous EV cars- Self-Drive Cars- Hacking; Sensor less – Control methods- Phase Flux Linkage-Based Method- Phase Inductance- Mutually Induced Voltage-Matching of Battery and Engine-Motor and Wheels- Synchronizing of Conventional and Electric Control System-Testing of entire system/motor and Dynamometer to test various Hybrid vehicle Engines.

List of Experiments

1. Current/Voltage Control of an Electric vehicle.
2. Sensor & Actuators in an Electric Vehicle.
3. Control Circuit of induction motor.

List of Demonstrations

1. Demonstration of charging circuit in an electric vehicle.

UNIT IV Hybrid Vehicles **L - 9 P-6**

Hybrid Electric vehicles – Classification-layout- operation modes and Architecture-Propulsion systems and components. Regenerative Braking- Economy- Vibration and Noise reduction. Hybrid Electric Vehicles System – Analysis and its Types- Controls-

List of Demonstrations

1. Demonstration of electric hybrid vehicle using breadboard/pcb kits.

UNIT V Fuel Cells for Electric vehicles **L - 9 P-6**

Fuel cell – Introduction- Technologies & Types- Obstacles. Operation principles- Potential and I-V curve- Fuel and Oxidation Consumption- Fuel cell Characteristics – Efficiency- Durability- Specific power- Factors affecting- Power design of fuel Cell Vehicle and freeze capacity. Lifetime cost of Fuel cell Vehicle – System- Components- maintenance- Testing of Fuel cells.

1. A Case Study on "storage of hydrogen in designing the Fuel Cell"

Total Periods =45 + 30

REFERENCE BOOKS

1. Hybrid Electric Vehicle System Modeling and Control -Wei Liu- General Motors- USA- John Wiley & Sons- Inc.- 2017.
2. Hybrid Electric Vehicles – Teresa Donateo- Published by ExLi4EvA- 2017
3. Electric and Hybrid Vehicles Power Sources- Models- Sustainability- Infrastructure and the Market Gianfranco Pistoia Consultant- Rome- Italy- Elsevier Publications- 2017.
4. Modern Electric- Hybrid Electric- and Fuel Cell Vehicles- MehrdadEhsaniYiminGao Stefano Longo Kambiz M. Ebrahimi- Taylor & Francis Group- LLC- 2018.
5. Hybrid- Electric & Fuel-Cell Vehicles Jack Erjavec- Delmar- Cengage Learning.
6. Electric and Hybrid Vehicles-Tom Denton- Taylor & Francis- 2018.

Sample Questions:

UNIT-1	**Theory:**
	1. Explain in detail about layout of Electric vehicle. 2. Discuss about use of ultra capacitors in an electric vehicle.
	Practical:
	5. Dismantling- Assembling and study of electric scooter. 6. Construction and working of lead acid Battery.

	7. Demonstration of wiring layout of electric vehicle.
UNIT-2	**Theory:**
	1. Explain the working principle of BLDC motor. 2. Describe about working principle SRM motors.
	Practical:
	3. V/f control of three-phase induction motor. 4. Speed control of BLDC motor. 5. Speed control of SRM motor. 6. Simulation of Four quadrant operation of three-phase induction motor.
UNIT-3	**Theory:**
	1. Explain in detail about V-I characteristics of IGBT and MOSFET. 2. Explain in detail about phase linkage control method.
	Practical:
	3. MOSFET based step up and step down chopper. 4. VI Characteristics of SCR- IGBT &MOSFET. 5. Three phase IGBT based PWM inverter control of induction motor.
UNIT-4	**Theory:**
	1. Describe in detail about Regenerartive braking system. 2. Explain in detail about Series hybrid.
UNIT-5	**Theory:**
	3. Explain in detail about PEM fuel cell. 4. Explain in detail about solid oxide fuel cell.

2161AU112	TWO AND THREE-WHEELER TECHNOLOGY	L	T	P	C
		3	0	0	3

Course Category: Program core

Self-Learning Content: Working principle of I C Engine-Transmission system- Fuel System-Ignition systems.

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Discuss about the two-wheeler types- frames and transmission system.	K2
CO2	Describe about the three wheeler types- frames and design aspects.	K2
CO3	Explain about steering systems- suspension system and brake systems.	K2
CO4	Discuss about cooling systems- lubrication systems- wheels and tires.	K2
CO5	Explain about the Power transmission Electric two and three wheelers.	K2

UNIT I: INTRODUCTION OF TWO WHEELER L – 9

Classifications of Two Wheelers – Power Transmission Layout of Two Wheelers - Mopeds-Scooters and Motorcycles - Basic Systems - Technical Specifications. Types of Two Wheeler Frames - Kick Starter System- Self-Start System. Two wheeler dynamics-Linear and angular motions-Handling characteristics-Road holding-Vehicle stability-Aerodynamics-Squat and dive-Performance Measurements

List of Demonstration:

1. Demonstration on performance of a two wheeler using chassis dynamometer.

UNIT II: INTRODUCTION OF THREE-WHEELER L – 9

Three Wheeler Vehicles - Auto Rickshaws- Pickup Van- Delivery Van- Three Wheeler Frames-Boy construction- Technical Specifications- Types of loads acting on frames-Challenges in Cooling System.

List of Demonstrations:

1. Demonstration on measurement of given three wheeler vehicle dimensions.

UNIT III: STEERING- SUSPENSION AND BRAKE L - 9

Steering System - Front end Geometry – Electric automatic transmission system- Steering Gearbox-Types-Recirculating Ball - Rack and Pinion - Power Steering. Suspension - Front and Rear Forks - Springs for Suspension - Telescopic Suspension - Mono Suspension - Hydraulic Shock Absorber-Gas Filled Shock Absorber - Dampers. Design Consideration – Brake - Drum Brakes - Disc Brakes – ABS-its types/Channels.

List of Demonstrations:

1. Demonstration on measurement of front end geometry of vehicle-camber- caster- kingpin inclination- toe-in and toe-out.
2. Demonstration on compression and rebounce force of shock absorber.
3. Demonstration on two wheeler suspension system.
4. Demonstration on construction and working of steering systemin three-wheeler vehicle.

UNIT IV: COOLING AND LUBRICATION SYSTEMS- WHEELS AND TYRES L – 9

Types of Cooling System - Air Cooling System - Liquid Cooling System - Forced Circulation System - Pressure Cooling System. Lubrication System - Properties of Lubricating Oil - Types of Lubrication system - Petroil Lubrication - Splash Lubrication - Pressure Lubrication - Constructional details of Wheels and Tyres of Two and Three Wheelers.

List of Demonstrations:

1. Demonstration on removal and fitting of given Tyre.
2. Determination on the properties of given lubrication oil.

UNIT V: ELECTRIC VEHICLE L –9

Power Transmission Layout of Electric Two Wheelers - Motor- Hub Motors - Controller- Alternator- Battery systems- Microcontroller-Performance of Electric two wheelers- Data Acquisation of two wheelers- Strain Gauging- Three Wheeler NVH- Modern testing methods in electric vehicle NVH.

List of Demonstration:

1. Demonstration on the components of electric scooter.

Total Periods =45

REFERENCE BOOKS:

1. K. Newton- W. Steeds and T. K. Garrett- 'Motor Vehicle' Butterworth- Heinemann- 13th Edition- 2000.
2. P E Irving- 'Motorcycle Engineering'' Veloce Enterprises- Inc- 2017.
3. Dr.Kirpal Singh- 'Automobile Engineering'' Vol. I and II- Standard Publishers- New Delhi- 2011.
4. V. Ganesan- 'Internal Combustion Engines'' Tata McGraw Hill Book Co- Eighth Reprint- 2010.
5. Tom Denton- 'Automotive Electrical and Electronic Systems'' Routledge-Taylor and Francis Group- 5th Edition- 2017.
6. Dhruv U. Panchal- 'Two and Three Wheeler Technology'' PHI Learning- 2015.

Sample Assessment Questions:

UNIT-1	1. Explain the different components of motor cycle with their functions. 2. List out the troubles in scooters- their causes and remedies. 3. Considering the Indian Models of two wheelers- discuss the merits and demerits of any two high performance vehicles.
UNIT-2	1. Explain in detail about the technical specifications and features of Indian models of auto rickshaw. 2. Discuss about the servicing and maintenance of three wheeler. 3. Draw the layout of three wheeler and name the different components with their functions.

UNIT-3	1. With the aid of neat sketches describe the working of power steering system. Discuss the advantages and disadvantages of the power steering system over rack and pinion type steering system. 2. Explain about disc brake with neat sketch. Write the advantages and disadvantages. 3. Describe the front and rear suspension systems for the three wheelers.
UNIT-4	1. Explain with neat sketch about forced circulation cooling system. 2. Describe about the different types of wheels used in two wheelers with neat sketch. 3. State the requirement of lubrication system and brief about properties of lubricants.
UNIT-5	1. Draw the power transmission layout of electric two wheelers. Compare the conventional two wheeler and electric two wheeler. 2. Describe about the different types of motors used in electric two wheeler and their use. 3. Explain in detail about the construction and working of Lead acid battery.

2161AU113	AUTOMOBILE CHASSIS AND BODY ENGINEERING	L	T	P	C
		3	0	0	3

Course Category: Program core

Self-Learning Content: Sheet Metal Work-Introduction-Equipment-Tools and Accessories-Various Processes- Classification of Materials-Engineering properties of materials-Beams-Types-Supports and Loads-Shear force and Bending Moment-Springs-Helical and leaf springs-Cams-Types of Cams and Followers-Cam profile-Power Transmission-Gears-Terminology- Spur-Helical and Bevel Gears- Gear Trains-Belt drives (types)-Chain drives.

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Enumerate and Identify different car body and body materials.	K2
CO2	Describe the various commercial vehicle body- driver seat design and body repair tools.	K2
CO3	Outline the design features offrame- front axle and steering system	K3
CO4	Understand the types of suspension system- wheels and tyres	K2
CO5	Illustrate the concepts- types- construction and operation of different braking system used in automobiles.	K2

UNIT I: CAR BODY- BODY MATERIALS AND TRIM MECHANISMS L- 9

Classification of Car Body: Saloon-Convertibles-Limousine-Estate Car-Racing and Sports Car-Car Body Construction- Electric Car Body Construction-Steel Sheet-Timber-Plastic-GRP-Properties of Materials-Corrosion-Anticorrosion Methods-Selection of Paint and Painting Process-Body Trim Items- Body Mechanisms- Types of Crumble Zones and accident zones- Effect of crashes with dummy models.

List of Demonstration:

1. Demonstration on Construction and Types of Car Body.

UNIT II: COMMERCIAL VEHICLE BODY AND BODY REPAIR L- 9

Types of Bus Body: Based on Capacity-Distance Travelled and Construction-Layout for Various Types of Bus Body-Types of Metal Sections Used-Regulations-Constructional Details: Conventional and Integral-Driver Seat Design-Dimensions of Driver's Seat in Relation to Controls-Types of Commercial Vehicle Bodies-LCV-HCV- Electric Bus Body Construction-Panel Repair-Hand Tools-Power Tools-Repairing Sheet Metal and Repairing Plastics Body-Vehicle Noise- Failure of drives-Passenger comfort in Premium/Medium/Low segment vehicle.

List of Demonstrations

1. Demonstration on Construction and Types of Commercial Vehicle Body.

UNIT III: LAYOUT- FRAME- FRONT AXLE AND STEERING SYSTEM L- 9

Basic Construction of Chassis- Types of Chassis Layout with Reference to Power Plant Location and Drive-Various Types of Frames-Loads Acting on Vehicle Frame-Materials for Frames-Types

of Front Axles and Stub Axles-Front Wheel Geometry-Castor-Camber-King Pin Inclination and Toe In-Toe Out-Condition for True Rolling Motion-Ackerman's and Davis Steering Mechanisms-Reversible and Irreversible Steering-Over Steer and Under Steer- Different Types of Steering Gear Boxes- Power Assisted Steering.

List of Demonstrations:

1. Study of Heavy and Light Duty Vehicle Chassis.
2. Demonstration of Front Axle.
3. Demonstration on Construction and operation of steering system.

UNIT IV: SUSPENSION SYSTEM- WHEELS AND TYRES L- 9

Requirements of Suspension System-Types of Suspension-Constructional Details and Characteristics of Single Leaf-Multi–Leaf Spring-Coil Spring and Torsion Bar-Rubber-Pneumatic and Hydro Elastic Suspension-Independent Suspension System-Shock Absorbers-Types of Wheels-Wheel Rims-Construction of Tyres and Tyre Specifications.

List of Demonstrations

1. Demonstration on Construction and operation of various suspension systems.

UNIT V: BRAKING SYSTEM L- 9

Need for Brake System-Stopping Distance-Leading and Trailing Shoes-Braking Torque-Types and Constructional Details-Drum Brakes and Disc Brakes-Hydraulic Braking System-Mechanical Braking System-Pneumatic Braking System-Power Assisted Braking System-Anti Lock Braking System.

List of Demonstrations

1. Demonstration on Construction and operation of various braking systems.

Total Periods =45

REFERENCE BOOKS:

1. Donald E. Malen- 'Fundamentals of Automobile Body Structure Design'SAE International- 2011.
2. Geoff Davies- 'Materials for Automobile Bodies'' Butterworth-Heinemann- 2012.
3. Powloski J- 'Vehicle Body Engineering'' Business Books Ltd.- 1998.
4. James E Duffy- 'Body Repair Technology for 4-Wheelers''Cengage Learning- 2009.
5. Crouse and Anglin- 'Automotive Mechanism'' 9th Edition. Tata McGraw-Hill- 2003.
6. Jack Erjavec- 'A Systems Approach to Automotive Technology'' Cengage Learning Pub.- 2009
7. T. K. Garrett- K. Newton and W. Steeds- 'Motor Vehicle'' Butterworth- Heinemann- 13th Edition- 2000.

Sample Assessment Questions:

UNIT-1	1. Discuss the methods of improving downward- forward and rearward visibility of car with relevant sketches. 2. Explain in detail the construction of car body with neat sketches.
UNIT-2	1. (i) Explain in detail the influence of engine- entrance and exit location in bus body design with relevant sketches. (ii) Discuss the different types of metal sections used in a bus body layout

	2. (i)List out the points to be considered while designing a driver's seat. (ii)Explain the integral type of bus body construction with a neat sketch
UNIT-3	1. A vehicle of 2.875 m wheel base 1.255 m front and rear wheel track and has its pivot centre 1.155 m apart. If the inside lock angle is 40^{o}calculate (i) Outside lock angle for true rolling (ii) Turning circle radius for outer front wheel and inner rear wheel. 2. (i) With suitable diagram explain Ackerman's steering geometry. (ii) Explain the construction and working principle of rack and pinion type steering gear box.
UNIT-4	1. (i) Explain any two types of independent suspension systems in rear axle. (ii) Discuss the construction of rubber suspension system. 2. (i) Explain the pneumatically operated suspension system with neat sketch. (ii) Explain about shock absorber with reference to construction- mounting and working.
UNIT-5	1. Write short notes on the following: (i) Anti-lock braking system (ii) Effect of weight transfer during braking. 2. (i) Explain the mechanical braking system with its limitations. (ii) Discuss the servo braking system with neat diagram.

2161AU114	POWERTRAIN MANAGEMENT SYSTEM	L	T	P	C
		3	0	0	3

Course Category: Program Core

Self-Learning Content: Basic Automotive Electrical and Electronics- Engine Layout- Fuel and transmission Component.

Course Outcomes

Upon the successful completion of the course- learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the basic electronic components and its controls.	K2
CO2	Describe the operating conditions and control systems used in SI engine.	K3
CO3	Describe the ignition and injection methods used in CI engine	K3
CO4	Discuss the various emission systems and diagnostics procedure.	K3
CO5	Discuss the electronic diagnosis systems and transmission control system used in the digital dashboard unit.	K3

UNIT I: FUNDAMENTALS OF OBD SYSTEMS L-9

Components for Electronic Engine Management System- Open and Closed Loop Control Strategies- PID Control- Look Up Tables- Introduction to Modern Control Strategies Like Fuzzy Logic and Adaptive Control. Switches- Active Resistors- Transistors- Current Mirrors/Amplifiers- Voltage and Current References- Comparator- Multiplier. Amplifier- Filters- A/D and D/A Converters. Actuators and its types.

List of Demonstration:

1. Study of OBD tool kit.

UNIT II : SI ENGINE MANAGEMENT L-9

Layout and Working of SI Engine Management Systems like Bosch Motronic (K- L- LE- LU- LH- M- ME- MED) Engine Management- System Overview- System Structure. Electronic Control and Regulation-Electronic Diagnosis-Electronic Control Unit and Development. ECU Operating Conditions- Design and Data Processing.

List of Demonstration:

1. Control of Fuel Injection and Ignition System (open loop/closed loop).

UNIT III : CI ENGINE MANAGEMENT L-9

Fuel Injection System Parameters Affecting Combustion- Noise and Emissions in CI Engines. Pilot- Main- Advanced Post Injection and Retarded Post Injection. Electronically Controlled Unit Injection System- Layout of the Common Rail Fuel Injection System. Working of Components like Fuel Injector- Fuel Pump- Rail Pressure Limiter- Flow Limiter- SCR injection & Control System- Closed loop with Engine and SCR control System.

List of Demonstration:

1. Control of Fuel Injection (open loop/closed loop).

UNIT IV: DIAGNOSIS AND CONTROL SYSTEMS L-9

Electronic Control System Overview-Subsystems And Main Functions-Electronics Diagnosis-Self-Diagnosis- Engine Diagnostics - Introduction To Diagnosis- Types Of Engine Diagnostics-Need For OBD- Types Of OBD- General Requirements-Diagnosis System Management-Individual Diagnosis-Data Transfer Between Automotive Electronic System. Model Based Diagnostic Control- Various Engine Systems Diagnostic (Air System- Fuel System- and Exhaust System)

List of Demonstration:

1. Study of DTCs using OBD tool kit.

UNIT V: DIGITAL ENGINEAND VEHICLE CONTROL SYSTEMS L-9

EMS- Engine Functions and Control-General Terms and Performance – Engine Mapping- Control Strategy-Engine Control Sequence-Calibration Technique in EMS- Variable Swirl Mechanisms-Different Types of Automatic Transmission - Control System - Basics of Driveline Control-Driveline Speed And Torque Control- Gear Shift Control- Anti-Jerk Control- Driveline Diagnostic System- Advancement in Driveline Control System.

List of Demonstration:

1. Study of DCT and Torque converter**.**

Total Periods =45

REFERENCE BOOKS:

1. William- B. Ribbens- 'Understanding Automotive electronics'' Butterworth Heinemann-2017.
2. Robert Bosch- 'Diesel Engine Management '' SAE Publications- 3rd Edition- 2004
3. Robert Bosch- 'Gasoline Engine Management'' SAE Publications- 2nd Edition- 2004
4. LinoGuzzella and Christopher H. Onder- 'Introduction to Modeling and Control of Internal Combustion Engine Systems'' Springer-Verlag- 2010.
5. Lars Eriksson and Lars Nielsen- 'Modeling and Control of Engines and Drivelines'' John Wiley & Sons- 2014.
6. Rolf Isermann- 'Engine Modeling and Control - Modeling and Electronic Management of Internal Combustion Engines'' Springer Verlag- 2014.

Sample Assessment Questions:

UNIT-1	1. Draw a layout of Electronic Engine Management System with closed loop strategies. 2. Discuss Analog / digital convertors and Digital / Analog Convertors (i) Explanation iii) Commercial (ii) Types iv) Application and testing
UNIT-2	1. Draw a layout and Working of SI Engine Management Systems and compare Bosch Motronic (M- ME- MED) 2. With a neat sketch explain the diagnosis-electronic control unit and development of ECU operating conditions- design and data processing.
UNIT-3	1. Explain all factors affecting the Fuel Injection System Parameters of Combustion- Noise and Emissions in CI Engines. 2. Discuss the working of Components like Fuel Injector- Fuel Pump- Rail Pressure Limiter- Flow Limiter- and EGR Valves in C.I Engine.

UNIT-4	1. Describe the Electronic Control System- Overview & Subsystems. 2. Engine Diagnostics (i) Explanation iii)Need (ii) Types iv) Requirements & system management
UNIT-5	1. Explain the concept of engine mapping- control strategy-engine control sequence. 2. Tabulate the different types of automatic transmission based on function and its performance.

SPECIALIZATION CORE FOR POWERTRAIN ENGINEERING

2161AU203	ENGINE COMBUSTION AND SIMULATION	L	T	P	C
		3	0	2	4

Course Category: Specialization Core

Self-learning Content: Classifications- S.I and C.I engine operating cycles- Two and four stroke engines- Firing order- Port/valve timing diagram- Engine performance-Engine Components & Materials- Fuel and Ignition System-Turbo charging- supercharging- EGR

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
C01	Describe the importance of simulation tools in modelling of IC engine.	K2
C02	Discuss the stages of combustion in SI and CI engine. Determine the heating value and stoichiometric air requirements	K2
C03	Calculate the adiabatic flame temperature at constant volume and constant pressure combustion.	K3
C04	Investigate the various models for SI engine combustion and the influence of model parameters on engine performance and combustion characteristics.	K3
C05	Investigate the various models for CI engine combustion and the influence of model parameters on engine performance and combustion characteristics.	K3

UNIT I: INTRODUCTION TO SIMULATION L 9 P 6

Basic knowledge to simulation- advantages of engine simulation - Classification of engine models- Open and closed cycle models - Simulation of various cycles - Step by step approach in engine simulation- Experimental studies on engine performance- emission and combustion parameters.

List of Experiments:

1. Investigate the performance characteristics of multi cylinder diesel engine.
2. Experimental study of CI engine powered by alternative energy sources.

UNIT II: COMBUSTION AND STOICHIOMETERY L 9 P3

Combustion equation for hydrocarbon fuels- Stages of combustion in CI engine- Stages of combustion SI engine- Normal and Abnormal Combustion-Pressure and crank angle diagram- Heat release correlations - Heat of reaction -Calculation of minimum air, excess air and stoichiometric air required for combustion.

List of Experiments:

1. Measurement of higher and lower heat value of given fuel

UNIT III: ADIABATIC FLAME TEMPERATURE L 9 P 6

Theoretical flame temperature- complete combustion in C-H-N-O systems - Constant volume adiabatic combustion- constant pressure adiabatic combustion - Calculation of adiabatic flame temperature- isentropic changes of state - Deviation between actual and ideal cycle.

List of Experiments:

1. Determine the adiabatic flame temperature at constant volume combustion.
2. Determine the adiabatic flame temperature at constant pressure combustion.

UNIT IV: MODELING OF SI ENGINE L 9 P 6

Initiation of combustion- air fuel ratio- air motion- Volatility characteristics- pre-ignition-detonation and engine variables- features and design consideration of combustion chambers- Flame structure and speed- Lean burn combustion- stratified charge combustion systems- SI engine simulation with air as working medium- Fuel air cycle analysis - SI engines simulation with progressive combustion.

List of Experiments:

1. Modelling the single cylinder gasoline engine using Wavebuild
2. Simulation of multicylinder gasoline engine with exhaust gas recirculation

UNIT V: MODELING OF CI ENGINE L 9 P 9

vaporization of fuel droplets and spray formation - Zero- one and multi zone models for diesel engine combustion-Wiebe's Model- Whitehouse model- Watson model for diesel combustion - Influence of the injection system on combustion - Direct and indirect injection systems - Parametric studies on simulated engine performance.

List of Experiments:

1. Theoretical analysis of single cylinder diesel naturally aspirated engine using Wavebuild
2. Modelling of multicylinder diesel engine with turbocharger
3. Simulation of dual fuel CI engine powered by octane and cetane rating fuels

Total Periods =45 + 30

TEXT BOOKS

1. Ganesan.V. "Computer Simulation of Compression Ignition Engine Process"- Universities Press (Ind) Ltd- Hyderbad- 2013.
2. Lakshminarayan- P.A and AghavYogesh. V- "Modeling Diesel Combustion"- Springer- 2010.

REFERENCE BOOKS

1. Rolf Isermann- "Engine Modelling and Control"- Springer Heidelberg New York Dordrecht London- 2014.
2. Günter P. Merker · Christian Schwarz · Gunnar Stiesch · Frank Otto- "Simulating Combustion- Springer-Verlag Berlin Heidelberg 2006.
3. B.P. Pundir- IC Engines: Combustion and Emissions- Alpha Science International- Ltd- 2010
4. John B.Heywood- Internal Combustion Engine Fundamentals- McGraw Hill- 2006.
5. Kolchine and Demidov- "Design of Automotive Engines".

2161AU115	ENGINE DESIGN AND DEVELOPMENT	L	T	P	C
		2	2	0	3

Course Category: Specialization Core

Self-learning Content: Basic of IC Engine

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the various engine performance parameters	K2
CO2	Construct crank train for the given specifications which includes the design of piston- connecting rod- crankshaft and flywheel	K3
CO3	Calculate thermal loads and select a suitable material to design cylinder head and block	K3
CO4	Select and design suitable valve train for the given specifications.	K3
CO5	Describe the design procedure involved in Cooling- Lubrication- Intake- Exhaust and Fuel Injection Systems	K2

UNIT I: PARAMETERS L–6 T-6

Compression ratio- Pressure volume and pressure crank angle diagram- frictional mean effective pressure- engine capacity- calculation of bore and stroke length- velocity and acceleration- gas force- inertia and resultant force at various crank angles – Side thrust on cylinder walls- Optimization criteria for improving Thermal- Mechanical and Volumetric efficiency.

List of Demonstrations

1. Determination of Compression ratio
2. Determination of pressure crank angle diagram

UNIT II: DESIGN OF CRANK TRAIN L– 6 T-6

Design of Piston- piston rings- piston pin- Design of connecting rod-Material and failures related to Cylinder- piston- connecting rod- design of crankshaft for light and heavy vehicle; Crankshaft- front end- rear end- journals- crank pin- Crank web. Design of flywheel; Speed fluctuation and stress calculations- turning moment diagram- design of hub- rim and arms of the flywheel- Ring gear Material and failures related to Crankshaft and flywheel- Balancing of Crankshafts for Single and Multi Cylinder Engines.

List of Demonstrations

1. Dismantling and study of piston.
2. Dismantling and study of crankshaft and connecting rod.

UNIT III: DESIGN OF CYLINDER HEAD AND BLOCK L–6 T-6

Functional requirement- Block material like Gray Iron- Aluminum- Compacted Graphite Iron and Magnesium- Cylinder head alloys- Design layout- Basic block- Bulk head design- and Cylinder liner design approach and Thermal loads. Cylinder arrangement- number of cylinders

List of Demonstrations

1. Dismantling and study of cylinder head and cylinder liners.

UNIT IV: DESIGN OF VALVE TRAIN L– 6 T-6

Effect of valve timing on engine performance- Number of Valves- Design of valves- Valve seat- Valve guide and cotter- Time selection of valve- Cam profile construction- Design of valve spring- Design of camshaft- Single and Double Overhead camshaft design- Design of valve gear train for variable valve timing.

List of Demonstrations

1. Dismantling and study of valve train mechanism.

UNIT V: DESIGN OF COOLING- LUBRICATION- INTAKE- EXHAUST AND FUEL INJECTION SYSTEM L– 6 T-6

Design of cooling system- radiator- water pump- thermostat and fan- Computation of air cooling system Engine friction and wear- Selection of lubricant- lubricating system- pump and filters- Design of intake and exhaust system-P-Ɵ for various Intake system - Design of fuel system for CI engine- Governor Design. **.**

List of Demonstrations

1. Dismantling and study of fuel injection systems.
2. Dismantlingand study of cooling system

Total Periods =30 + 30

REFERENCE BOOKS

1. Kevin L. Hoag - ‘Vehicular Engine Design’‘SAE international-2005.
2. A.Kolchin and V.Demidov- ‘Design of Automotive Engines’‘ MIR Publishers- Moscow- 1984.
3. R.K. Jain- ‘Machine Design’‘ Khanna Publishers- New Delhi- 1997.
4. ‘Design Data Book’‘ PSG College of Technology- Coimbatore- 2000.
5. Giles J. G ‘Engine Design’ –.- Life Book Ltd. 2000
6. Crouse ‘Engine Design’ Tata McGraw Publication- Delhi 2002

2161AU116	POWERTRAIN NVH	L	T	P	C
		3	0	0	3

Course Category: Specialization Core/PE

Self-Learning Content: Basics of Noise & Vibration related issues in an automobile.

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the sources of noise in a vehicle	K2
CO2	Realize the design features to control noises in a vehicle	K2
CO3	Outline the basics of vibration and noises in a vehicle.	K2
CO4	Illustrate the measurement techniques of noise and vibration.	K2
CO5	Analyse the various parameters of powertrain noises and vibrations	K3

UNIT I INTRODUCTION TO AUTOMOTIVE NVH L-9

Automotive NVH sources Pass-by noise limits- Interior noise of vehicles- Sound quality- Ride comfort- Noise and vibration control in vehicles.

List of Demonstrations

1. Demonstration of various vibration measuring instruments.

UNIT II VEHICLE NOISE L-9

Sources of noise and vibration. Design features. Common problems. Noise quality. Target vehicles and objective targets.

List of Demonstrations

1. Demonstration of Vibration Analysis using frequency domain analysis.

UNIT III FUNDAMENTALS OF VIBRATION AND NOISE L-9

Natural vibration of Single Degree of Freedom System (SDOF) and Multi Degree of Freedom System (MDOF)- Undamped- damped and forced vibrations and Vibration of beams- plates & shells. Basics of sound propagation- Quantification of sound- Noise sources- generation and radiation- Machinery noise identification and Noise induced hearing loss.

List of Demonstrations

1. Demonstration of beating phenomenon

UNIT IV VIBRATION AND NOISE MEASUREMENT L-9

Vibration transducers and exciters- Sound pressure- intensity and power measurement- Frequency analysis and Digital signal processing.

List of Demonstrations

1. Demonstration of various noise measuring instruments.

UNIT V POWERTRAIN NVH **L-9**

Sound Pressure- Sound Intensity- Sound Intensity Ratio- Sound Intensity Level- Noise level- Sound power level- Change in Noise level- Bare Engine or Basic Engine Noise Level- Noise generation process in a Diesel engine- Combustion and Mechanical noise- Parameters affecting Combustion forces- Mechanical Impact forces.

Intake and Exhaust System NVH: Plain & three-dimensional waves in an Inviscid stationary and moving medium- Waves in ducts with compliant walls- Requirements of an engine exhaust mufflers- Acoustic considerations- Back-pressure considerations- practical considerations- Technique to measure the inlet and exhaust system NVH.

List of Demonstrations

1. Demonstration of Vibration Analysis of using Time domain analysis.

Total Periods =45

REFERENCE BOOKS:

1. Malcolm J. Crocker- "Noise and Vibration Control"- Wiley- 2007.
2. Cyril M. Harris & Allan G. Piersol- "Shock and Vibration Handbook"- McGraw Hill Inc.- 2002
3. Proceedings of the Workshop on 'Noise- Vibration & Harshness (NVH) for Automotive Engineering' 18-20 March- 2002- at ARAI- Pune- published by SAE Western India Section and ARAI
4. Prof. Munjal M.L.- "Acoustic Ducts and Mufflers"- John Wiley- 1987.
6. Nortan MP "Fundamental of Noise and Vibration"- Cambridge University Press- 1989.
7. Baxa- "Noise Control of Internal Combustion Engine"- John Wiley- 1984.
8. Lewis L- "Industrial Noise Control"- McGraw Hill Inc- 1991.
9. Prof. Munjal M.L.- "Acoustic Ducts and Mufflers"- John Wiley- 1987.
10. Fahy F.J. "Sound Intensity" Elsevier- 1989.
11. Hearn G and Metcalfe- A. "Spectral Analysis in Engineering – Concept & Cases"- Arnold- 1995.
12. Boris and Korney- "Dynamic Vibration Absorbers"- John Wiley- 1993.

2161AU204	AUTOMOBILE FUELS AND EMISSION	L	T	P	C
		3	0	2	4

Course Category: Specialization core/PTE

Course Outcomes

Upon the successful completion of the course-student will be able to

CO1	Interpret and understand the essential properties- manufacturing techniques and use of liquid fuels in petrol and diesel engines.	**K2**
CO2	Analyze the properties- characteristics and the implementation limits of gaseous fuels like LPG- CNG- and HYDROGEN in I.C engines.	**K3**
CO3	Explain the formation of pollutants in SI engine and describe the Emission control techniques.	**K2**
CO4	Describe the formation of pollutant in CI engine and describe the Emission control techniques.	**K2**
CO5	Outline the emission measurement techniques and various test procedure	**K2**

UNIT I LIQUID FUELS AND LUBRICANTS L-9 P-10

Conventional fuels- Need for alternate fuels- availability and comparative properties of alternate fuels- Biofuels- Biodiesel- Blending of methanol and ethanol-oxygenated additives- types of vegetable oils for engine application- Esterification- properties-engine modifications required- Effects of design parameters- Engine performance and emission characteristics- Lubricants- functions and types.

List of Experiments

1. Temperature dependence of viscosity of fuels by Redwood Viscometer.
2. Flash- Fire- Cloud and pour point of fuels.
3. Aniline distillation test of gasoline.
4. Calorific value of liquid fuel.
5. Reid vapor pressure test.

List of Demonstrations

1. Transesterification of various vegetable oil.

UNIT II GASEOUS FUELS L – 9 P-4

Gaseous Fuels - CNG- LPG- BIOGAS- Hydrogen- and HCNG: Availability- properties- modifications required in SI engines- storage- handling & dispensing- safety aspects -General Performance and emission characteristics- merits and demerits.

List of Experiments

1. Measurement of flow rate of various gaseous fuel.

List of Demonstrations

1. Demonstration on performance characteristics of gaseous powered vehicle

UNIT III EMISSIONS FROM SI ENGINES AND ITS CONTROL L–9P-4

Emission formation in S.I. engines- hydrocarbons- carbon monoxide- nitric oxide & lead- effects of design & operating variables on emission formation- controlling of emission formation in engines- thermal reactors- catalytic converters- charcoal canister control for evaporative emission- positive crank case ventilation system.

List of Experiments

1. Measurement and analysis of emissions from S.I engine in different load conditions.

UNIT IV EMISSIONS FROM CI ENGINES AND ITS CONTROL L – 9 P-6

Diesel combustion- stages- direct & indirect combustion- emission formation- particulate matter & smoke- effect of operating variables on emission formation- PM & NOx trade-off- controlling of emission formation in engines- Exhaust Gas Recirculation (EGR)- air injection- cetane number effect- emission after-treatment devices.

List of Experiments

1. Emission treatment using after treatment devices.
2. Diesel smoke measurement.

List of Demonstrations

1. Measurement of emission from C.I engine while using various fuel.
2. Demonstration of EGR for NOx reduction

UNIT V EMISSION MEASUREMENT AND TEST PROCEDURE L – 9 P-6

Emission scenario & norms - Fuel properties & their effects on performance & emission. Measurement & instrumentation for HC- CO- CO2- NOx & PM- smoke meters and calibration checks on emission equipment's- dilution tunnel technique for particulate measurement- emission test procedures on engine- different piston geometry.

List of Experiments

1. Measurement and analysis of formulated emissions.
    a. Fossil fuel
    b. Alternate fuels

Total Periods =45 + 30

REFERENCE BOOKS

1. Thipse.S.S.- Alternative Fuels; Concepts- Technologies and Developments- Jaico Book Distributors- 2010
2. Holt and Danniel- Fuel cell powered vehicles: Automotive technology for the future- SAE- 2001.
3. Ganesan.V.- "Internal Combustion Engineering"- Tata McGraw-Hill Publishing Co.- New Delhi- 2012.
4. Gerhard Knothe- Jon Van Gerpen- Jargon Krahl- The Biodiesel Handbook- AOCS Press Champaign- Illinois 2005.
5. John-B.- Heywood- Internal Combustion Engine Fundamentals- McGraw Hill Publishing Co.- New York- 1988.
6. B.P.Pundir- " IC Engines Combustion and Emissions" Narosa Publishers- 2010
7. Transactions of SAE on Biofuels (Alcohols- vegetable oils- CNG- LPG- Hydrogen- Biogas)
8. Science direct Journals (Biomass & Bio energy- Fuels- Energy- Energy conversion Management- Hydrogen Energy- etc.) on biofuels.

2161AU205	ENGINE TESTING AND CERTIFICATION	L	T	P	C
		3	0	2	4

Course Category: Specialization core/PTE

Course Outcomes:

Upon the successful completion of the course- students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the requirements of engine test cell facilities	K2
CO2	Explain the theory of dynamometers and other engine testing equipment	K2
CO3	Understand the engine test standards and modes of engine testing	K2
CO4	Elucidate the engine emission measurement using different emission analyzers for various driving cycles	K2
CO5	Outline the technical advancements in engine testing	K2

UNIT I TEST FACILITIES AND IN-CELL SERVICE L – 9 P-4

Introduction- Test cell Equipment layout- Test cell requirements- cell console & control room- ventilation- air conditioning &ventilation- cooling- induction air- Test cell cooling water and exhaust gas systems- lubrication/fuel supply systems- electrical design consideration- Engine testing pointer- Control Systems.

List of Demonstrations

1. Test cell preparation

Unit II DYNAMOMETER &INSTRUMENTATION L – 9 P-4

Function of dynamometers- types of dynamometers- Working of dynamometer- dynamometer panels- engine controllers- Engine testing data acquisition system- engine dynamometer coupling- fuel consumpti

on meter- air flow measurement- air fuel ratio measurement- oil pressure- oil consumption measurement- calibration.

List of Demonstrations

1. Study and selection of Dynamometers.
2. Study and use of Pressure pickups- Emission Analyzer for Engine testing.

UNIT III MEASUREMENTS L – 9 P-8

Engine test standards- full throttle & part throttle performance- ISO mapping- friction measurement- durability- Thermal Shock test- Test duration and engine life comparison- Preventive maintenance- Fault Diagnosis.

List of Experiments

1. Performance and measurement of genset Engine (5 mode)
2. Performance and measurement of Tractor Engine (8 mode)
3. Performance and measurement of C.V Engine (13 mode)
4. Determine the Frictional power on petrol engines.

List of Demonstrations

1. Study of Heat balance of an engine.

UNIT IV EMISSION MEASUREMENTS AND ANALYSIS L – 9 P-8

Exhaust gas Emission- Simple Combustion Theory- Ideal Combustion and Stoichiometry- Principles and operation of Raw- Dilute- Continuous- and Bag Sampling- Elements of sampling- Emission analyzers- emission cycles for diesel commercial vehicles- tractors & gensets- steady state and transient cycles.

List of Experiments

1. Emission measurement of genset Engine (5 mode).
2. Emission measurement of Tractor Engine (8 mode).
3. Emission measurement of C.V Engine (13 mode).

UNIT V COMBUSTION ANALYSIS AND ADVANCED ENGINE TESTING L – 9 P-6

Cylinder Pressure measurement- Combustion Analysis and Diagnostics- Types of Combustion Diagnostics- fuel injection pressure- needle lift- gas exchange process- combustion photography- swirl measurement- analysis of data.

List of Experiments

1. Fuel injector calibration.
2. Swirl measurement Test.

List of Demonstrations

1. Demonstration on Construction and Function of Differential.

Total Periods =45 + 30

REFERENCE BOOKS

1. A.J.Martyr- M.A.Plint- Engine Testing Theory and Practice- Elsevier- Third Edition- 2007.
2. Michael James Plint& Tony Martyr-“Engine Testing - Theory & Practice”- 3rd Edition - SAE International -2007.
3. Heniz Heisler- “Advanced Engine Technology”- Vol.1- SAE International 2002.
4. J.B. Heywood- ‘Internal Combustion Engine Fundamentals’‘ McGraw Hill Book Co.- 2006.

SPECIALIZATION CORE FOR ELECTRIC & HYBRID VEHICLES

2161AU117	VEHICLE MECHANICS	L	T	P	C
		3	0	0	3

Course Category: Specialization Core/EHV

Self-Learning Content: Basic concepts of Forces- Force system and Basics of Vibration terms and its types.

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Solve engineering problems using the principles of statics of particles- magnitude of forces and moments acting on rigid bodies	K2
CO2	Discuss the effects of Static and Dynamic balancing of rotating and reciprocating masses.	K2
CO3	Explain the concept of vibration and its effects.	K2
CO4	Deliberate the effective steering geometry- vehicle handling and directional control of vehicle.	K2
CO5	Explains the effect on the dynamic characteristics of the vehicle with suspension system.	K2

UNIT – I: EQUILIBRIUM OF RIGID BODIES L - 9

Introduction - Laws of Mechanics - Vectorial Representation of Forces and Couples- Resolution and Composition of Forces - Forces in Space- Equilibrium of a Particle in Space- Equivalent Systems of Forces -Principle of Transmissibility- Free body diagram- Types of Supports and their Reactions-Moments and Couples- Varignon's Theorem-Equilibrium of Rigid Bodies in Two Dimensions.

List of Demonstration:

1. Demonstration on "Deflection test on Beams".

UNIT – II: BALANCING L - 9

Static and Dynamic Balancing – Balancing of Rotating Masses – Several Masses in Single and Different Planes - Balancing of Reciprocating Masses- Concepts of Primary Balancing And Secondary Balancing - Partial Balancing of Locomotives – Balancing of Multi-Cylinder Inline Engine.

List of Demonstration:

1. Demonstration on "Balancing of Rotating masses".

UNIT III: CONCEPT OF VIBRATION L – 9

Free and Damped Vibration - Forced vibration response of Single Degree of Freedom Systems - Magnification factor – Force Transmissibility - Vibration isolation and absorption – Torsional vibration of shaft – Single and multi-rotor systems – Critical speed of shaft.

List of Demonstrations:

1. Determination of natural frequency of spring mass system.
2. Determination of critical speeds of shaft with concentrated loads.

UNIT IV: HANDLING CHARACTERISTICS OF ROAD VEHICLES L - 9

Steering Geometry - Steady State Handling Characteristics - Steady State Response to Steering Input - Testing of Handling Characteristics - Transient Response Characteristics- Directional Stability. Introduction to Aerodynamic Forces and Moments - Tire Forces and Moments.

List of Demonstration:

1. Demonstration on "Aerodynamic characteristics of a model car" using wind tunnel.
2. Demonstration on measurement of front end geometry of vehicle-camber- caster-kingpin inclination- toe-in and toe-out.

UNIT V: RIDE CHARACTERISTICS OF VEHICLES L - 9

Human Response to Vibration - Vehicle Ride Models - Active and Semi Active Suspensions- Roll Center- Roll Axis and Vehicle under Side Forces. Influence of Suspension Stiffness- Suspension Damping and Tire Stiffness- Air Suspension System and their Effectiveness.

List of Demonstration:

1. Demonstration on "Vehicle suspension stiffness effectiveness".

Total Periods =45

REFERENCE BOOKS:

1. Beer- F. P.- and Johnston- E. R.- 'Vector Mechanics for Engineers – Dynamics and Statics'' Tata McGraw-Hill- New Delhi- 2011.
2. Shigley- J.E. and Uicker- J.J.- 'Theory of Machines and Mechanisms'' McGraw-Hill- 2012.
3. Singiresu S. Rao- 'Mechanical Vibrations'' 5th Edition- Prentice Hall- 2010.
4. Thomas D. Gillespie- 'Fundamentals of Vehicle Dynamics'' Society of Automotive Engineers Inc- 1992.
5. Rajesh Rajamani- 'Vehicle Dynamics and Control'' Springer- 2005.

Web link:

1. **International Journal of Vehicle Noise and Vibration**
   https://www.inderscience.com/jhome.php?jcode=ijvnv
2. **Vehicle System Dynamics-International Journal of Vehicle Mechanics and Mobility**
   https://www.tandfonline.com/toc/nvsd20/current
3. **Journal of Sound and Vibration**
   https://www.journals.elsevier.com/journal-of-sound-and-vibration
4. **Journal of Vibration and Control**
   https://journals.sagepub.com/home/jvc
5. **NPTEL** - https://nptel.ac.in/courses/112103111/#
6. **Ride Characteristics Article** - https://rqriley.com/instructions/
7. http://vehicledynamics.com/articles/

2161AU206	POWER ELECTRONICS FOR AUTOMOBILES	L	T	P	C
		3	0	2	4

Course Category: Specialization Core/EHV

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the working principle of Semiconductor devices	K2
CO2	Describe the construction and operation of Converters.	K2
CO3	Illustrate the construction and operation of Rectifiers and Inverters.	K2
CO4	Explain the construction and working principle of various Electric motor types.	K2
CO5	Make use of power electronics components in hybrid electric vehicle and fuel cell vehicle.	K3

UNIT I: BASIC POWER ELECTRONIC DEVICES L – 9 P-6

Diodes- Thyristors- Bipolar Junction Transistors- Metal–Oxide–Semiconductor Field Effect Transistors- Insulated Gate Bipolar Transistors- Ultra capacitors.

List of Experiments

1. VI Characteristics of DIODES.
2. VI Characteristics of BJT.
3. VI Characteristics of MOSFET & IGBT.

UNIT II: DC/DC CONVERTER L – 9 P-6

Basic Principle of DC–DC Converter- Step-Down (Buck) Converter- Step-Up (Boost) Converter- Buck–Boost Converter- DC–DC Converters Applied in Hybrid Vehicle Systems- Isolated Buck DC–DC Converter- Four-Quadrant DC–DC Converter.

List of Experiments

1. Design of step up chopper.
2. Design of step down chopper.

UNIT III: RECTIFIERS AND INVERTERS L – 9 P-6

Single-phase Diode Rectifiers- Three-phase Diode Rectifiers- Poly-phase Diode Rectifiers- Filtering Systems in Rectifier Circuits- High-frequency Diode Rectifier Circuits- Single-phase Voltage Source Inverters- Three-phase Voltage Source Inverters- Current Source Inverters- Closed-loop Operation of Inverters- Regeneration in Inverters- Multistage Inverters.

List of Experiments

1. Three phase IGBT based PWM inverter control of induction motor.

2. Study of driver circuits and generation of PWM signals for three phase inverters.

List of Demonstrations

1. Design a rectifier circuit using bread board.

UNIT IV: ELECTRIC MOTOR DRIVES L – 9 P-6

DC motor operation and its types- BLDC Motor and Control- Operation of BLDC Motor- Torque and Rotating Field Production- BLDC Motor Control- BLDC Motor Torque–Speed Characteristics and Typical Technical Parameters- Sensor less BLDC Motor Control- AC Induction Motor and Control- Basic Principle of AC Induction Motor Operation- Controls of AC Induction Motor.

List of Experiments

1. Load test on D.C shunt motor.
2. Speed control of D.C shunt motor.
3. Load test on single-phase induction motor.
4. Load test on three-phase induction motor.

UNIT V: Power Electronics and Control for Hybrid and Fuel Cell Vehicles L – 9 P- 6

Series Hybrid Vehicle Propulsion System- Parallel Hybrid Vehicle Propulsion System- Fuel Cell Vehicles- Power Electronics Requirements- Propulsion Motor Control Strategies- APU Control System in Series Hybrid Vehicles- Fuel Cell for APU Applications.

List of Experiments

1. Study of Series hybrid electric vehicle layout.
2. Study of Parallel hybrid electric vehicle layout.

Total Periods =45 + 30

REFERENCE BOOKS:

1. Rashid M.H.- "Power Electronics Circuits- Devices and Applications"- Prentice Hall India- Third Edition- New Delhi- 2011.
2. Ali Emadi- “Handbook of Automotive Power Electronics and Drives”-Taylor & Francis Group- First Edition- USA- 2005.
3. Bimal K Bose- "Modern Power Electronics and AC Drives"- Pearson Education- second Edition- 2003.
4. Dubey. G.K.- "Thyristorised power controllers"- new age International- New Delhi- 2002.
5. Bhimbhra P.S.- "Power Electronics"- Khanna Publishers- New Delhi- 2005.
6. P.C. Sen- “Modern Power Electronics”- Wheeler Publishing Co- Third edition- New Delhi- 2008.

2161AU207	MODELLING AND SIMULATION OF EHV	L	T	P	C
		3	0	2	4

Course Category: Specialization Core/EHV

Self-Learning Content: Basic of modeling and simulation- Matlab/Simulink.

Course Outcomes

Upon the successful completion of the course- learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the modeling of vehicle performance parameters.	K2
CO2	Model battery electric vehicles.	K4
CO3	Describe the drivetrain characteristics.	K2
CO4	Apply the concepts of energy management system.	K3
CO5	Explain the vehicle dynamic control systems.	K2

UNIT-I MODELLING IN PERFORMANCE PARAMETER L – 9 P-12

Modelling Vehicle Acceleration - Acceleration performance parameters- modelling the acceleration of an electric scooter- modelling the acceleration of a small car

List of Experiments:

1. Develop a simulation model for different driving cycles and analyze these driving cycles.
2. Develop a simulation model to analyze the effect of Rolling Resistance on vehicle range and performance
3. Develop a simulation model to analyze the effect of vehicle mass on vehicle range and performance
4. Develop a simulation model to analyze the effect of Aerodynamic drag on vehicle range and performance
5. Develop a simulation model to analyze the effect of Hill Climbing force on vehicle range and performance.

UNIT-II MODELLING OF BATTERY ELECTRIC VEHICLES L – 9 P-6

Electric Vehicle Modelling - Tractive Effort- Rolling resistance force- Aerodynamic drag- Hill climbing force- Acceleration force- Total tractive effort- Modelling Electric Vehicle Range - Driving cycles- Range modelling of battery electric vehicles- Constant velocity range modelling- Range modelling of fuel cell vehicles- Range modelling of hybrid electric vehicles

List of Experiments:

1. Develop a simulation model for Series HEV to analyze the effect of changing of parameters on vehicle range and performance.
2. Develop a simulation model for Parallel HEV to analyze the effect of changing of parameters on vehicle range and performance.

UNIT-III DRIVETRAIN CHARACTERISTICS L – 9 P-6

Modelling and Characteristics of EV/HEV Powertrains Components- ICE Performance Characteristics- Electric Motor Performance Characteristics - Battery Performance

Characteristics-Transmission and Drivetrain Characteristics-Regenerative Braking Characteristics-Driving Cycles Modelling and Analysis of Electric and Hybrid Electric Vehicles Propulsion and Braking - Longitudinal Dynamics Equation of Motion - Vehicle Propulsion Modelling and Analysis - Vehicle Braking Modelling and Analysis

List of Experiments:

1. Develop a simulation model to analyze Electric Motor Performance Characteristics
2. Develop a simulation model to analyze Electric Motor Regenerative Braking Characteristics for different Driving Cycles.

UNIT-IV ENERGY MANAGEMENT L – 9 P-6

Handling Analysis of Electric and Hybrid Electric Vehicles - Simplified Handling Models Energy/Power Allocation and Management - Power/Energy Management Controllers - Rule-Based Control Strategies - Optimization-Based Control Strategies

List of Experiments:

1. Develop a Control strategy for Parallel HEV for developed simulation model and analyze it.
2. Develop a Control strategy for Series HEV for developed simulation model of Parallel HEV and analyze it.

UNIT-V VEHICLE DYNAMIC CONTROL L - 9

Control of Electric and Hybrid Electric Vehicle Dynamics - Fundamentals of Vehicle Dynamic Control (VDC) Systems- VDC Implementation on Electric and Hybrid Vehicles – Case Studies- Rechargeable Battery vehicles- Hybrid Vehicles- Fuel Cell Powered Bus

Simulation Tools: Matlab/Simulink- ADVISOR and AVL Cruise.

Total Periods =45 + 30

REFERENCE BOOKS:

1. James Larminie- John Lowry- “Electric Vehicle Technology Explained”- John Wiley & Sons Ltd- 2003.
2. Amir Khajepour- Saber Fallah and AvestaGoodarzi- “Electric and Hybrid Vehicles- Technologies- Modelling and Control: A Mechatronic Approach”- John Wiley & Sons Ltd- 2014.
3. AntoniSzumanowski- “Hybrid Electric Power Train Engineering and Technology: Modelling- Control- and Simulation”- IGI Global- 2013.
4. MehrdadEhsani- YiminGao- Ali Emadi- “Modern Electric- Hybrid Electric- and Fuel Cell Vehicles_ Fundamentals- Theory- and Design- Second Edition”- CRC Press- 2010.

2161AU208	ENERGY STORAGE AND MANAGEMENT SYSTEM	L	T	P	C
		3	0	2	4

Course Category: Specialization Core/EHV

Self-Learning Content: Basic working principle of Battery- battery charging Systems and Electrical and electronic circuits.

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Discuss about the different types of energy storage system.	K2
CO2	Describe about the battery characteristic & parameters	K2
CO3	Model different types of batteries	K3
CO4	Apply the concepts of battery management system and design the battery pack.	K3
CO5	Explain about the battery testing- disposal and recycling.	K2

Unit I: ENERGY STORAGE SYSTEM **L - 9 P-6**

Batteries: Lead Acid Battery- Nickel based batteries- Sodium based batteries- Lithium based batteries – Li-ion & Li-poly- Metal Air Battery- Zinc Chloride battery; Ultra capacitors; Flywheel Energy Storage System; Hydraulic Energy Storage System; Comparison of different Energy Storage System

List of Demonstration:

1. Study of different types of batteries.

Unit II: BATTERY CHARACTERISTICS & PARAMETERS **L - 9 P-6**

Cells and Batteries- conversion of chemical energy to electrical energy- Battery Specifications: Variables to characterize battery operating conditions and Specifications to characterize battery nominal and maximum characteristics; Efficiency of batteries; Electrical parameters- Heat generation- Battery design- Performance criteria for Electric vehicles batteries- Vehicle propulsion factors- Power and energy requirements of batteries

List of Demonstration:

1. Study of different types of batteries with their characteristics & detailed specifications.

UNIT-III BATTERY MODELLING **L - 9 P-6**

General approach to modelling batteries-simulation model of a rechargeable Li-ion battery-simulation model of a rechargeable NiCd battery- Parameterization of the NiCd battery model-Simulation examples.

List of Demonstration:

1. Develop a simulation model for Lead-acid and Li-ion Batteries.

Unit IV: BATTERY PACK AND BATTERY MANAGEMENT SYSTEM L - 9 P-6

Selection of battery for EVs & HEVs- Traction Battery Pack design- Requirement of Battery Monitoring- Battery State of Charge Estimation methods- Battery Cell equalization problem- thermal control- protection interface- SOC Estimation- Energy & Power estimation- Battery thermal management system- Battery Management System: Definition- Parts: Power Module- Battery- DC/DC Converter- load- communication channel- Battery Pack Safety.

List of Experiments:

1. SOC Estimation by Open Source voltage for Lead-Acid battery- Ni-MH battery and Li-ion battery.
2. SOC Estimation by specific gravity for Lead-Acid battery.
3. SOC Estimation by Coulomb counting method for Lead-Acid battery and Li-ion battery.
4. Design a circuit for Battery monitoring System for Lead acid battery.
5. Design a circuit for passive cell balancing for Li-Ion battery.

Unit V: BATTERY TESTING- DISPOSAL & RECYCLING L - 9 P-6

Chemical & structure material properties for cell safety and battery design- battery testing- limitations for transport and storage of cells and batteries- Recycling- disposal and second use of batteries. Battery Leakage: gas generation in batteries- leakage path- leakage rates. Ruptures: Mechanical stress and pressure tolerance of cells- safety vents- Explosions: Causes of battery explosions- explosive process- Thermal Runway: High discharge rates- Short circuits- charging and discharging. Environment and Human Health impact assessments of batteries- General recycling issues and drivers- methods of recycling of EV batteries.

List of Experiments:

1. Vibration Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
2. Shock Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
3. Short Circuit Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
4. Overcharge Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.
5. Roll-Over Test for traction batteries (Lead-Acid/Li-ion) as per AIS 048 standard.

Total Periods =45 + 30

REFERENCE BOOKS

1. G. Pistoia- J.P. Wiaux- S.P. Wolsky- "Used Battery Collection and Recycling"- Elsevier- 2001. (ISBN: 0-444-50562-8)"
2. Guangjin Zhao- "Reuse and Recycling of Lithium-Ion Power Batteries"- John Wiley & Sons. 2017. (ISBN: 978-1-1193-2185-9)
3. T R Crompton- "Battery Reference Book-3rd Edition"- Newnes- Reed Educational and Professional Publishing Ltd.- 2000.
4. Ibrahim Dinçer- Halil S. Hamut and Nader Javani- "Thermal Management of Electric Vehicle Battery Systems"- JohnWiley& Sons Ltd.- 2016.
5. Chris Mi- AbulMasrur& David WenzhongGao- "Hybrid electric Vehicle- Principles & Applications with Practical Properties"- Wiley- 2011.
6. MehrdadEhsani- YiminGao- Ali Emadi- "Modern Electric Hybrid Electric and Fuel Cell Vehicles"-Taylor& Francis Group- 2010.
7. James Larminie- John Lowry- "Electric Vehicle Technology Explained"- John Wiley & Sons Ltd- 2003.

2161AU209	COMPUTER AIDED ENGINEERING	L	T	P	C
		3	0	2	4

Course Category: Specialization Core

Self-Learning Content: Engineering Graphics- AutoCAD- Ansys- NC Coding's- Two- and Three-Dimensional Graphics concepts- Graphics Aids- Part Programming and manufacturing- Computer Aided Quality control.

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the basic fundamentals of Computer Aided Engineering	K2
CO2	Design and validate technological solutions to defined problems and communicate clearly and effectively for the practical application of their work.	K3
CO3	Understand the general steps of finite element methods.	K2
CO4	Formulate and solve basic problems in heat transfer- solid mechanics and fluid mechanics.	K3
CO5	Create Numerical Modelling and its Role in the Field of Fluid Flow and Heat Transfer	K3

UNIT I INTRODUCTION L - 9 P-6

Introduction: – Industrial look at CAE- Methods to solve engineering problems – analytical- numerical- experimental and their merits and comparison - importance of meshing- boundary conditions- Product design and development – collaborative design

List of Experiments:

1. Determination of Thermal Efficiency of the Engine in experimentally.
2. Identify the problems in various real time products.
3. Design any model by using modelling software's. (Demo only)

UNIT II COMPUTER AIDED DESIGN AND MODELING L – 9 P-6

Introduction to geometric modeling technology and associated computational geometry- Geometric Transformations- Group technology- CAPMS- DFMA- A study of data exchange issues and utilizing available data exchange mechanisms.

List of Experiments:

1. Design the Isometric views of a Shaft Bracket
2. Design a wireframe model of Various shapes using CATIA.
3. Manufacturing the model by using 3D Printer. (Demo only)

UNIT III BOUNDARY CONDITIONS AND MESH GENERATION L – 9 P-6

Basic concept of finite element method- Discrete and Continuous model- Loads and Constraints- Mesh Generation- mesh refinement- assign material properties- Initial and Boundary value

problems- Variational approach- Practical applications of FEA in new design- optimization / cost- Errors in FEA

List of Experiments:

1. Compute the shear force and bending moment diagrams for the beam and find the maximum deflection.
2. Check the qualities of mesh in various aspects.
3. Determine the Static structural analysis of a model using ANSYS (Demo only)
4. Verify the results through experimentally (Demo only)

UNIT IV DISCRETE- CONTINUUM AND ISOPARAMETRIC ELEMENTS L - 9 P-6

Bar- Frame- beam elements – Application to static- dynamic and stability analysis- Various types of 2-D-elements – Application to plane stress- plane strain and axis symmetric Analysis- Iso parametric Elements – Applications to field problems like heat transfer and fluid flow.

List of Experiments:

1. Determine the nodal deflections- reactions forces- and stress for the truss system
2. Determine the Stress of a plate with circular hole in its center

UNIT V GOVERNING EQUATIONS OF VISCOUS FLUID FLOWS L - 9 P-6

Basics of Computational Fluid Dynamics – Governing Equations of Fluid Dynamics – Continuity- Momentum and Energy Equations – Chemical Species Transport – Physical Boundary Conditions – Time-Averaged Equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical Behavior of PDEs on CFD – Elliptic- Parabolic and Hyperbolic Equations.

List of Experiments:

1. Computational analysis of Fluid through pipe.
2. Analysis of Cooling for Fin.

Total Periods =45 + 30

REFERENCE BOOKS:

1. Ibrahim Zeid "CAD/CAM Theory & Practice"- TMH- 2006
2. Belagundu&Chandrupatla- "Finite Element Method"- New Age Int. Pub- 2010
3. GokhleNitin; et al; Practical Finite Element Analysis; Finite to Infinite- 88 BudhwarPeth- Pune.
4. Logan DL; A First Course in Finite Element Method; Cegage
5. Krishnamoorthy; Finite Element Analysis; Theory and Programming; MH
6. Belagundu&Chandrupatla- "Finite Element Method"- New Age Int. Pub- 2010
7. Reddy JN; An Introduction to finite element method; TMH
8. Rao- S.S./ The Finite element method in engineering; Peragamon press- Oxford

SPECIALISATION ELECTIVES FOR POWERTRAIN ENGINEERING

2162AU111	AUTOMOTIVE HVAC	L	T	P	C
		3	0	0	3

Course Category: Specialization Elective

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the types of refrigeration systems and its applications and refrigerants properties.	K3
CO2	Apply the concept of psychometry to estimating the heating and cooling load for automobiles.	K3
CO3	Design and implement refrigeration and air conditioning systems using standards.	K3
CO4	Explain the air distribution system and its control	K2
CO5	Diagnose- serviceandcontrolsthe air-conditioning system.	K3

UNIT I REFRIGERATION L - 9

Introduction - Methods of refrigeration - Air Refrigeration System and its applications -Vapour compression refrigeration system - Vapor absorption refrigeration system - Applications of refrigeration & air conditioning -Automobile air conditioning - Air conditioning for passengers- isolated vehicles- transport vehicles-Applications related with very low temperatures. Classification- properties and selection criteria - Commonly used refrigerants - Alternative refrigerants - Eco-friendly refrigerants - Applications of refrigerants -Refrigerants used in automobile air conditioning.

UNIT II PSYCHROMETRY L – 9

Review of fundamental properties of psychometric – use of psychometric charts – psychometric processes – Grand and Room Sensible Heat Factors – by pass factor – requirements of comfort air conditioning –factors governing optimum effective temperature- recommended design conditions and ventilation standards. Psychometric properties- tables- charts - Psychometric processes - Comfort charts - Factor affecting comfort - Effective temperature - Ventilation requirements.

UNIT III AIR CONDITIONING SYSTEMSAND LOAD ANALYSIS L - 9

Classification and layouts - Central / unitary air conditioning systems - Components like compressors- evaporators- condensers- expansion devices- fan blowers- heating systems etc. 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

UNIT IV AIR DISTRIBUTION SYSTEMS L - 9

Distribution duct system- sizing- supply / return ducts - Types of grills- diffusers- ventilation- air noise level - Layout of duct systems for automobiles and their impact on load calculations. Air Routine & Temperature Control: Objectives - evaporator care air flow - Through the dash recirculating unit - Automatic temperature control - Controlling flow - Control of air handling systems

UNIT V AIR CONDITIONING SERVICE AND CONTROL L - 9

Air conditioner maintenance & service - servicing heater system - Removing & replacing components- Trouble shooting of air conditioning system -Compressor service- methods of dehydration- charging & testing. Air Conditioning Control: Common control such as thermostats- Humidistat us - Control dampers - Pressure cutouts and relays.

Total Periods =45

REFERENCE BOOKS:

1. Refrigeration and Air-Conditioning - W.F. Stoecker and J.W. Jones- Tata McGraw Hill Pub.
2. Paul Lung- "Automotive Air Conditioning"- C.B.S. Publisher & Distributor- Delhi
3. Modern Air-Conditioning Practice - Norman C. Harris- Principles of Refrigeration -R.J. Dcssat- Wiley Eastern Pub.
4. Refrigeration and Air-Conditioning - C.P. Arora- Tata McGraw Hill Pub
5. Refrigeration and Air-Conditioning – S.S.Thipse- Jaico
6. Automotive air conditioning by Crouse
7. Harris- "Modern Air Conditioning"
8. Khurmi R.S.- and Gupta- J. K.- A text book of Refrigeration and Air Conditioning- Eurasia Publishing housing (P) Ltd- New Delhi- 2002
6. Manohar Prasad- Refrigeration and Air conditioning- New Age International (P) Ltd- New Delhi-
9. 1999.
7. Ashrae Hand Book'' 4 Vol.- Current Ed.- Carrier Air Conditioning Co.- 'Hand Book of Air
10. Conditioning'' Prentice Hall of India- 1974

2162AU112	HYDROGEN AND FUEL CELL	L	T	P	C
		3	0	0	3

Course Category: Specialization Elective/PTE

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describethe different properties- productionand storage methods of hydrogen.	K2
CO2	Explain the concept- methods and various features related to usage of hydrogen in SI Engines.	K2
CO3	Explain the concept- methods and various features related to usage of hydrogen in CI Engines.	K2
CO4	Illustrate the technical features of fuel cells for automotive applications.	K2
CO5	Outline the design concepts of hydrogen fuel cell systems for road vehicles.	K2

UNIT I: HYDROGEN AS FUTURE ENERGY CARRIER L - 9

Hydrogen Production : Thermal Processes - Electrolytic Processes - Photolytic Processes - Hydrogen Distribution - Hydrogen Storage - Hydrogen Storage in High Compressed Gas Form - Hydrogen Storage in Liquid Cryogenic Form - Hydrogen Storage in Solid Materials - Need- Properties- Pollution- Emission standards- World and Indian Scenario.

UNIT II: HYDROGEN IN S.I. ENGINE SYSTEM L – 9

Engine Modifications- Combustion Characteristics – Dual Fueling- Direct Injection of Gaseous and Liquefied Hydrogen.

UNIT III: HYDROGEN IN C.I. ENGINE SYSTEM L - 9

Engine Modification & Combustion Characteristics - Direct Injection – Gaseous and Liquified Hydrogen- Dual Fuel Mode- and Hydrogen Enrichment.

UNIT – IV: FUEL CELLS FOR AUTOMOTIVE APPLICATIONS L - 9

Basic Concepts of Electrochemistry - Proton Exchange Membrane Fuel Cells: Membrane- Electrocatalysts- GDL- Bipolar Plates - Sensitivity of PEM Stacks to Operating Conditions: Polarization Curve- Effect of Operative Parameters on the Polarization Curve - Durability of PEM Fuel Cells

UNIT – V: DESIGN OF HYDROGEN FUEL CELL SYSTEMS L - 9

Hydrogen Fuel Cell Systems: Preliminary Remarks - Hydrogen Feeling System - Air Feeding System - Thermal Management System - Water/Humidification Management System - Integrated Fuel Cell System: Efficiency- Dynamics- Costs.

Total Periods =45

REFERENCE BOOKS:

1. Johannes Topler and Jochen Lehmann- Hydrogen and Fuel Cell Technologies and Market Perspectives- Springer- 2016
2. Pasquale Corbo-FortunatoMigliardini andOttorinoVeneri- Hydrogen Fuel Cells for Road Vehicles (Green Energy and Technology)- Spinger- 2011.
1. Alternative Fuels (A decade of success and Promise) edited by RedaMoh.Bata- SAE PT-48- ISBN 1-56091 – 593 – 5.
2. Osamu Hirao and Richard K. Pefley- Present and future Automotive Fuels- John Wiley and Sons- 1988.
3. Keith Owen and Trevor Eoley- Automotive Fuels Handbook- SAE Publications- 1990.
4. Richard L. Bechtold- Automotive Fuels Guide Book- SAE Publications- 1997.
5. Hydrogen Fuel Cells forRoad Vehicles- April 2010- Springer.

2162AU113	SUPERCHARGING AND TURBOCHARGING	L	T	P	C
		3	0	0	3

Course Category: Specialization Elective/PTE

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the principles of superchargingwith supercharging units.	K2
CO2	Understand thethermodynamics of supercharging.	K2
CO3	Describe the construction and operation of exhaust gas turbocharging.	K2
CO4	Illustrate the new technicaldevelopments inturbocharging system	K2
CO5	Outline theconcept ofmatching the turbocharger and charge air cooling	K2

UNIT I SUPERCHARGING L - 9

Basic Principles and Objectives of Supercharging-Interrelationship Between Charge Mass Flow and Engine Power Output-Influence of Charge Air Cooling-Definitions and Survey of Supercharging Methods-Supercharging with Supercharging Units-Charger Pressure–Volume Flow Map-Displacement Compressor.

UNIT II THERMODYNAMICS OF SUPERCHARGING L - 9

Energy Balance of the Supercharged Engines Work Process - Engine High-Pressure Process- Gas Exchange Cycle Low-Pressure Processes- Utilization of Exhaust Gas Energy- Efficiency Increase by Supercharging - Characteristic Values for the Description of the Gas Exchange and Engine Efficiencies - Influencing the Engine's Total Efficiency Value via Supercharging.

UNIT III TURBOCHARGING L - 9

Objectives and Applications for Exhaust Gas Turbocharging - Turbocharging Requirements - Principles of Operation of Turbo Machines - Basic Fluid Mechanics of Turbocharger Components - Energy Transfer in Turbo Machines- Compressors- Turbines- Energy Balance of the Charging System.

UNIT IV TURBOCHARGING SYSTEM DEVELOPMENTS L – 9

Exhaust Waste Gate - Variable Geometry Systems - Turbo Compounding - Variable Geometry and Compound Systems - Exhaust Gas Recirculation - Electric Drive Turbocharger -Two-Stage or Series Turbo Charging - Sequential Turbo Charging - Complex- Hyper Bar Systems.

UNIT V MATCHING OF THE TURBOCHARGERAND CHARGE AIR COOLING L - 9

Matching of the Turbocharger - Possibilities for the Use of Exhaust Energy and the Resulting Exhaust System Design - Turbine Design and Control - Compressor Design and Control - Charge Air Coolers and Charge Air Cooling Systems: Basics and Characteristics -Charge Air Cooling Systems - Design Variants of Charge Air Coolers - Water-Cooled Charge Air Coolers- Air-to-Air Charge Air Coolers.

Total Periods =45

REFERENCE BOOKS:

1. K. Kollmann and H. P. Lenz- ‘Charging the Internal Combustion Engine’‘ Springer Wien NewYork- 2007.
2. N. Watson and M. S. Janota’‘Turbochargingthe Internal CombustionEngine’‘The Macmillan Press LtdLondon- 1982.
3. Obert E.F- ‘Internal Combustion Engines and Air Pollution’‘ Intext Educational New York- 1980.
4. Richard Stone- ‘Internal Combustion Engines’‘ SAE- 1992.

2162AU114	EXPERIMENTAL METHODS AND OPTIMIZATION TECHNIQUES	L	T	P	C
		3	0	0	3

Course Category: ProgramElective

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Apply the experimental design and analysis of variance for solving design problems using one-way- two-way and three-way classifications with the statistical methods CRD- RBD and LSD	K3
CO2	Understand the experimental design problems for two-factor experiments and also learn Taguchi approach for robust design	K2
CO3	Apply the classical optimization techniques for single variable and multi-variable optimization problems using Calculus	K3
CO4	Apply the numerical optimization techniques for unconstrained optimization problems for single-variable and multi-variable optimization problems	K3
CO5	Understandthe constrained nonlinear programming problems with equality and inequality constraints using numerical optimization methods	K2

UNIT I ANALYSIS OF VARIANCE L - 9

Analysis of Variance (ANOVA) – one-way classification– two-way classification – basic principles of design of experiments – replication- randomization and local control – Completely Randomized Design (CRD) – Randomized Block Design (RBD) – Latin Square Design (LSD).

UNIT II DESIGN OF EXPERIMENTS L - 9

Factorial experiments and their need – $2^2 - 2^3$and 3^2 Factorial Experimental Designs without confounding (Theory and Problem only- no derivation expected) – Applications of $2^2 - 2^3$and 3^2 Factorial Experimental Designs– Taguchi Approach – Parameter Design – Robust Design

UNIT IIICLASSICAL OPTIMIZATION TECHNIQUES L - 9

Optimal problem formulation - Single-variable optimization – First Derivative Test – Second Derivative Test – Multi-variable optimization – Gradient Test – Hessian Matrix – Constrained Optimization Problems using Equality Constraints – Direct Method

UNIT IV NUMERICAL OPTIMIZATION TECHNIQUES L - 9

Single-variable optimization – Bracketing methods – Fibonacci search method – Golden section search method – Newton-Raphson method – Multi-variable optimization – Gradient methods – Newton's method –Cauchy's steepest descent method – Powell's conjugate direction method

UNIT V NONLINEAR PROGRAMMING **L - 9**

Constrained optimization – Equality and inequality constraints - Lagrange multiplier method for nonlinear programming – Kuhn-Trucker conditions – Penalty function method – Frank-Wolfe method – Generalized projection method.

Total Periods =45

REFERENCE BOOKS:

1. R. Panneerselvam- 'Design and Analysis of Experiments'' PHI Learning Private Limited- New Delhi- 2012.
2. K. Deb- 'Optimization for Engineering Design'' PHI Learning Private Limited- New Delhi- 2012.
3. D.C. Montgomery- `Design and Analysis of Experiments'' Wiley- New Jersey- 1984.
4. S.S. Rao- `Optimization Theory and Applications'' Wiley- New Jersey- 1984.
5. M.S. Phadke- `Quality Engineering using Robust Design'' Prentice Hall- New Jersey- 1989.

2162AU115	VEHICLE DYNAMICS	L	T	P	C
		3	0	0	3

Course Category: Specialization Elective / PTE

Self-learning Content:
Basic of vibrations- tires and chassis Components….

Course Outcomes

Upon the successful completion of the course- learners will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Classify the tyre dynamics with respect to force- friction & moments.	K2
CO2	Predict the various vehicle stability in all drives.	K3
CO3	Demonstrate the aerodynamic forces- moments and its performance.	K3
CO4	Analyze the effect on the steering dynamic and stability of the vehicle.	K3
CO5	Compute the effective suspension and parameters and its properties.	K3

UNIT I MECHANICS OF PNEUMATIC TIRE L - 9

Tyre forces and moments- rolling resistance of tyres- coefficient of friction in different road conditions- Tractive effort and longitudinal slip- cornering properties of tyres- performance of tyres on wet surfaces- Ride properties of tyres- Estimation of tire road friction. Test on various road surfaces. Tire vibration.

UNIT II STABILITY OF VEHICLES L-9

Load distribution for three wheeler and four wheeler. Stability of vehicle running on slope- banked road and during turn- calculation of Tractive effort- maximum acceleration and reaction forces for different drives.

UNIT III PERFORMANCE CHARACTERISTICS OF ROAD VEHICLES L - 9

Equation of motion and maximum tractive effort- Aerodynamic forces and moments- vehicle power plant and transmission characteristics- prediction of vehicle performance- operating fuel economy- engine and transmission matching- braking performance.

UNIT IV HANDLING CHARACTERISTICS OF ROAD VEHICLES L - 9

Steering geometry- Steady state handling characteristics- Steady state response to steering input. Testing of handling characteristics. Transient response characteristics- Directional stability.

UNIT V RIDE CHARACTERISTICS OF VEHICLES L - 9

Human response to vibration- vehicle ride models- introduction to random vibration- active and semi active suspensions- Roll center- Roll axis and Vehicle under side forces. Influence of

suspension stiffness- suspension damping- and tire stiffness. Air suspension system and their properties.

Total Periods =45

REFERENCE BOOKS:

1. N.K Giri-Automobile mechanics- khanna publishers- 2010.
2. Wong. J. Y.- "Theory of Ground Vehicles"- 3rd Edition- Wiley-Interscience- 2001
3. Singiresu S. Rao- "Mechanical Vibrations"- 5 th Edition- Prentice Hall- 2010
4. Rajesh Rajamani- "Vehicle Dynamics and Control"- 1st edition- Springer- 2005
5. Thomas D. Gillespie- "Fundamentals of Vehicle Dynamics"- Society of Automotive Engineers Inc- 1992.

2162AU116	ENGINE MATERIALS AND MANUFACTURING	L	T	P	C
		3	0	0	3

Course Category: Specialization Elective/PTE

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Select a suitable material- manufacturing process and surface modification required for producing cylinder block and cylinder liner.	K2
CO2	Describe the different piston materials- manufacturing process and its heat treatment methods.	K2
CO3	Acquaint knowledge on functions- materials- manufacturing process for piston ring and connecting rod.	K2
CO4	Learn the different materials- manufacturing process and surface hardening required for producing crankshaft and camshaft.	K2
CO5	Describe the different valve and valve spring materials- manufacturing process and its heat treatment methods.	K2

UNIT-1 CYLINDER BLOCK AND CYLINDER LINER L - 9

Structure and functions- Monolithic block - Cast iron and Compact graphite iron- Aluminium block- Cast in composite- Manufacturing process- High pressure and low pressure die casting process- Gravity die casting and Squeeze die casting process. Cylinder liner- Cast iron and Aluminium- Surface Modification-Chromium plating- Ni-SiC composite plating- Honing operation.

UNIT-2 PISTON L - 9

Structure and function- Aluminium Alloy- Influence of silicon on thermal expansion of piston- Manufacturing process- Permanent mold casting- Modification of distribution of silicon crystal- Heat treatment- Age hardening and age softening- High strength piston- Light weight forged piston- Cast iron and Friction welded steel piston.

UNIT-3 PISTON RING AND CONNECTING ROD L - 9

Piston ring- Cast iron piston ring- spherical graphite cast iron- Light weight steel ring and its manufacturing process- Surface Modification-Physical vapor deposition. Function- Monolithic and assembled connecting rod- needle roller bearing- secondary refining after steel making- High carbon steel.

UNIT-4 CRANKSHAFT AND CAMSHAFT L - 9

Function and types of crankshaft- Cast Iron- Forged steel and Micro alloyed steel- Forging -Hot forging and semi hot forging- cold forging process- Surface hardening methods-carburizing and nitrocarburizing- carbonitriding- Induction hardening- Camshaft- Chilled cast iron- Cam lobe- sintered steel- High carbon steel- Powder metallurgical process.

UNIT-5 VALVE AND VALVE SPRING L - 9

Functions- Heat resistant steels-Martensitic and Austenitic steels- Bonded valve using friction welding process- Stellite coating on valve- Nickel based superalloy valve- Lighter valves- Ceramic and Titanium alloys- Production process of silicon nitride ceramic valve- Valve spring-Steel wire and manufacturing process of valve spring- short peening.

Total Periods =45

Text Book

1. Hiroshi Yamagata- The science and technology of materials in automotive engines- Woodhead Publishing Limited- 2005.

2.William D. Callister- Jr. David G. Rethwisch- Materials Science and Engineering an Introduction-John Wiley & Sons-Ninth Edition- 2014.

Sample Questions

UNIT-1	1. Compare high pressure die casting and low pressure die casting process. (K2)
	2. Suggest the coating process used for cylinder block that will resist scuffing. (K3)
UNIT-2	1. Describe about permanent molding process used for manufacturing piston. (K2)
	2. Explain about the influence of silicon on thermal expansion of Aluminium piston. (K2)
UNIT-3	1. Describe about the characteristics of cast iron piston ring.(K2)
	2. Explain about monolithic crankshaft with neat sketch. (K2)
UNIT-4	1. Compare hot forging and cold forging process. (K2)
	2. Explain about nitrocarburizing process and its effect on material properties. (K2)
UNIT-5	1. Discuss about the production process of silicon nitride ceramic valve. (K2)
	2. Explain about bonded valve using friction welding process and its advantages. (K2)

2162AU117	TRIBOLOGY	L	T	P	C
		3	0	0	3

Course Category: Specialization Elective/PTE

Course Outcomes:

Upon the successful completion of the course- students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the importance of surface treatment and wear mechanisms	K2
CO2	Describe the theory of lubrication of different phases	K2
CO3	Comprehend the necessity of contact surface and load transfer	K2
CO4	Identify and able to measure the surface wear using the instruments	K2
CO5	Assess the technical knowledge for designing engine components	K2

UNIT I SURFACES- FRICTION AND WEAR L - 9

Topography Of The Surfaces - Surface Features Of Metal And Composites - Surface Interaction - Theories Of Friction - Sliding And Rolling Friction- Friction Properties Of Metallic And Non-Metallic Materials - Friction In Extreme Conditions – Wear- Types Of Wear - Mechanism Of Wear - Wear Resistance Materials - Surface Treatment - Surface Modifications – Surface Coatings- Failure Analysis- New Trends In Friction And Wears.

List of Demonstration:

1. Scratch Test
2. Wore down parts of long run machines

UNIT II LUBRICATION THEORY L - 9

Lubricants And Their Physical Properties Lubricants Standards - Lubrication Regimes Hydrodynamic Lubrication - Reynolds Equation- Thermal- Inertia-And Turbulent Effects - Elasto Hydrodynamic And Plasto Hydrodynamic And Magneto Hydrodynamic Lubrication - Hydro Static Lubrication - Gas Lubrication. – Stir Back Diagram- design And Performance Analysis of thrust and Journal Bearings – Slide Bearing - Full- Partial- Fixed and Pivoted Journal Bearings Design - Lubricant Flow And Delivery - Power Loss- Heat And Temperature Rotating Loads And Dynamic Loads In Journal Bearings - Special Bearings - Hydrostatic Bearing Design.

List of Demonstration:

1. Types of Lubricants
2. Effect of Lubricants on Machinery

UNIT III ROLLING ELEMENT BEARINGS L - 9

Geometry And Kinematics - Materials And Manufacturing Processes - Contact Stresses - Hertzian Stress Equation - Load Divisions - Stresses And Deflection - Axial Loads And Rotational Effects- Bearing Life Capacity And Variable Loads - Iso Standards - Oil Films And Their Effects - Rolling Bearings Failures- Needle bearing.

List of Demonstration:

1. Bearing Elements (Ball/Roller/Cones)
2. Identification and Selection of bearings based on application

UNIT IV TRIBO MEASUREMENT IN INSTRUMENTATION L - 9

Wear Measurement Principle - Surface Topography Measurements – Surface Texture Measurement and Assessment Statically Methods -Scanning Electron Microscope & Friction and Wear Measurements - Laser Method - Instrumentation - International Standards - Bearings Performance Measurements - Bearing Vibration Measurement- Lubricate Monitoring Soap-Ferographyand other Rapid Testing Methods for Lubrication Catenation

List of Demonstration:

1. Lubricity Measurement
2. Friction & Wear Measurement
3. Fatigue Testing

UNIT V APPLICATION OF TRIBOLOGY IN ENGINE COMPONENTS AND VISCOSITY L - 9

Components Like Piston- Bearings- Piston Rings- Value Train- Drive Train- Reciprocating Components- Engine Friction- Spytter Coated Bearing etc Basic Definition for Viscosity-Convention- Dynamic Viscosity- Measurement- Variation With Temperature- ASTM Charts-Grade Of Oil.

List of Demonstration:

1. Identification of Stress Locations
2. Identification of Failure Locations
3. Importance of Bearing & Lubrication in Engine

Total Periods =45

REFERENCE BOOKS:

1. Bowden- F.P. & Tabor- D.- “Friction And Lubrication Of Solids”- Oxford University Press 1986.
2. Ernest Rabinowiez z- “Friction And Wear Of Materials” Inter science Publishers- 1995.
3. Neale- M.J.- Tribology – Hand Book- Butterworth- 1995.
4. Fuller D.D.- Theory And Practice Of Lubrication Of Engineers: John Wiley Sons- 1984
5. Cameron- A. "Basic Lubrication Theory"- Ellis Herward Ltd. Uk- 1981.
6. Hulling- J. (Editor) --"Principles Of Tribology"- Macmillan- 1984.
7. Williams J.A. "Engineering Tribology"- Oxford Univ. Press- 1994.
8. Neale M.J- "Tribology Hand Book "- Butterworth Heinemann- 1995.
9. Bhushan. B. “Modern Tribology Handbook”- Volumes 1 & 2. - Boca Raton A.O.: Crc Press- 2000. – 1760 P.

2162AU118	MATERIALS FOR AUTOMOBILES	L	T	P	C
		3	0	0	3

Course Category: Specialization Elective

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Select and examine the engineering alloys suitable for light weight and high-performance automotive application.	K3
CO2	Acquaint knowledge on classification- mechanical properties- processing of ceramics and its automotive application.	K2
CO3	Describe the different types of polymers. mechanical properties and its application.	K2
CO4	Distinguish the relevant features between fiber-reinforced and particle reinforced composites and its automotive application.	K3
CO5	Recognize the need of light weight- smart and nano materials and describe its unique characteristics in automotive application	K2

UNIT-1 ENGINEERING ALLOYS **L - 9**

Mechanical behavior of iron-carbon alloy- Effect of alloying elements on steel- Alloy steels – Maraging steel- High strength low alloy steel (HSLA Steel) and Dual Phase (DP) steel-Super Alloys- Manufacturing process-casting- forming- forging- Non-Ferrous Alloys-Aluminium and its alloys- Magnesium and its alloys- Titanium and its alloys.
Application: Nano structured steel for Automotive body structures- High pressure die cast Aluminium (AlSi- AlMg) alloys.

List of Demonstration

1. Demonstrate the process of sand molding.
2. Demonstrate the process of sand casting.

UNIT-2 POLYMER **L - 9**

Polymer structure- Thermoplastic and Thermosetting Polymer- Mechanical behaviour of Polymer- Stress Strain behaviour- Fracture of polymers- Types of polymer- Advanced polymeric materials- Ultra high molecular weight polyethylene- Liquid crystal polymers- Polymer additives- Bio based thermoplastics and thermosets polymer.
Application: Shrink wrap polymer films- Polymers for interior and exterior structure of vehicle.

List of Demonstration

1. Demonstrate the process of injection moulding.

UNIT-3 CERAMICS **L - 9**

Classification of ceramics- Ceramic phase diagram (Al2O3–Cr2O3- MgO–Al2O3)- Mechanical properties of ceramics-Brittle fracture of ceramics- Stress-strain behaviour- Processing- Powder Pressing and Tape casting-Engineering Ceramics-Oxide and Non-oxide ceramics- Processing-mechanical properties and application.
Application: Electro ceramic materials for sensors and actuators- Alumina for High Temperature sodium sulfur battery.

List of Demonstration

1. Demonstrate the process of powder pressing.

UNIT-4 COMPOSITES **L - 9**

Particle Reinforced composites- Fiber reinforced composites- Polymer matrix composites- Metal matrix composites- Ceramic matrix composites- Influence of Fiber length- Fiber orientation and fiber concentration- Processing of fiber reinforced composites-Pultrusion and Filament winding process. Structural composites- Laminar composites and sandwich panels. **Application:** Aluminum metal matrix composites for brake discs- Kevlar fiber ceramic matrix composites for Ballistic armor application.

List of Demonstration

1. Demonstrate the preparation of fiber reinforced composite laminate by hand layup method.
2. Demonstrate the mechanical testing of fiber reinforced composite laminate.

UNIT-5 LIGHT WEIGHT- SMART AND NANO MATERIALS **L - 9**

Thermoplastic foams and Thermosetting foams -Classification and mechanical properties-Functional need of thermoplastic and thermosetting foam in automotive application. Smart materials- Nickel Titanium Shape Memory Alloys- Nano materials-Nano carbon -Classification and mechanical properties-Nano composites and its classification- Nano fillers for Nano composites and green composites.

Application: Thermoset Foam For cushioning and Energy absorptive application- Smart material for automotive application (Noise vibration and harshness).

CASE STUDIES

Materials to resist fatigue: Connecting rod for high performance engines.
Materials Selection for a Cryogenic Tank for storing hydrogen.
Materials Selection for a High-Performance Jet Engine Turbine Blade.

Total Periods =45

REFERENCE BOOKS

1. R. E. Smallman- A. H.W. Ngan- Physical Metallurgy and Advanced Materials-Butterworth-Heinemann-Seventh edition- 2007. Cost: Rs.2958.
2. William D. Callister- Jr. David G. Rethwisch- Materials Science and Engineering an Introduction-John Wiley & Sons-Ninth Edition- 2014. Cost: Rs.4481.
3. Jason Rowe- Advanced Materials in Automotive Engineering- Woodhead Publishing Limited- Cambridge- 2012. Cost: Rs.11-525.
4. Omar Faruk- Jimi Tjong and MohiniSain- Lightweight and Sustainable Materials for Automotive Applications- CRC Press- Taylor & Francis Group- USA-2017.
5. Robert.B.Heimann- Classic and advanced ceramics from fundamentals to application- WILEY-VCH Verlag GmbH & Co. KGaA -2010

2162AU119	AUTOMOTIVE ELECTRICAL AND ELECTRONIC SYSTEMS	L	T	P	C
		3	0	0	3

Course Category: Program core

Self-Learning Content: Basic Electrical Principles- Electronic Components and Circuits- Digital Electronics- Microprocessor Systems- Measurement- Diagnostics – Electronics- Electrical Wiring- Terminals and Switching- Multiplexed Wiring Systems- Circuit Diagrams And Symbols.

Course Outcomes

Upon the successful completion of the course- students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe about working principle of sensors and actuators present in an automobile.	K2
CO2	Explain the construction- characteristics and maintenance of starting and ignition system and diagnose the ignition system fault of any vehicle.	K2
CO3	List out the principles and characteristics of charging system components and also the components involved in electronic fuel control.	K2
CO4	Describe the components and latest technologies present in a lighting systems and automotive instrumentation.	K2
CO5	Describe the components of chassis electrical system and auxiliaries.	K2

UNIT-I: SENSORS AND ACTUATORS L – 9

Introduction- Basic Sensor Arrangement- Types of Sensors- Oxygen Sensor- Cranking Sensor- Position Sensor- Engine Oil Pressure Sensor- Linear and Angle Sensor- Flow Sensor- Temperature and Humidity Sensor- Gas Sensor- Speed and Acceleration Sensor- Knock Sensor- Torque Sensor- Yaw Rate Sensors- Tire Pressure Sensor- Actuators & its types-correlation between sensors-actuators- micro controller- microprocessor.

List of Demonstration:

1. List and function of Sensors in the Automobile.

UNIT-II: STARTING SYSTEMS AND IGNITION SYSTEMS L - 9

Requirements of the Starting System- Starter Motors And Circuits- Types Of Starter Motor- Diagnosing Starting System Faults- Advanced technology in Starting System. Ignition Fundamentals- Types of Ignition System- Electronic Ignition- Programmed Ignition- Distributor Less Ignition- Direct Ignition- Spark-Plugs- Diagnosing Ignition System Faults- laser Ignition Technology.

List of Demonstrations:

1. Construction and working of Starter Motor.
2. Construction and working of Spark Plug.

UNIT-III: CHARGING SYSTEMS AND ELECTRONIC FUEL CONTROL

L - 9

Requirements of the Charging System- Charging System Principles- Alternators and Charging Circuits- Diagnosing Charging System Faults- Advanced Charging System Technology. Combustion- Engine Fuelling And Exhaust Emissions- Electronic Control of Carburetion- Fuel Injection Systems- Diesel Fuel Injection- Diagnosing Fuel Control System Faults- Advanced Fuel Control Technology.

List of Demonstrations:

1. Construction and working of Alternator.
2. Construction and working of Fuel Injection (DI/IDI).

UNIT-IV: LIGHTING SYSTEMS AND INSTRUMENTATION

L - 9

Lighting fundamentals- Lighting circuits- Gas discharge and LED lighting- Diagnosing lighting system faults- Advanced lighting technology- new developments in lighting systems. Gauges and sensors- Driver information- Visual displays- GPS- Diagnosing instrumentation system faults- advanced instrumentation technology- Driver Override Systems- Comprehensive Vehicle Tracking.

List of Demonstration:

1. Various lighting systems and components.

UNIT-V: ELECTRICAL SYSTEMS AND AUXILIARIES L - 9

Anti-Lock Brakes- Active Suspension- Traction Control- Automatic Transmission- Other Chassis Electrical Systems- Diagnosing Chassis Electrical System Faults- Advanced Chassis Systems Technology. Windscreen Washers And Wipers- Signalling Circuits- Other Auxiliary Systems- Diagnosing Auxiliary System Faults- Advanced Auxiliary Systems Technology- Vehicle to vehicle connectivity.

List of Demonstrations:

1. Working principle of ABS and TCS.
2. Working principle of Active suspension system.

Total Periods =45

REFERENCE BOOKS:

1. Tom Denton- ‘Automotive Electrical and Electronic Systems’‘ Routledge-Taylor and Francis Group- 5th Edition- 2017.
2. Young A.P. and Griffiths. L. ‘Automotive Electrical Equipment’‘ ELBS& New Press- 1999.
3. William B.Ribbens- ‘Understanding Automotive Electronics’‘ 5th edition - Butter worth Heinemann Woburn- 1998.
4. Crouse- W.H. ‘Automobile Electrical Equipment’‘ McGraw-Hill Book Co.- Inc.- New York- 3rd edition- 1986.
5. Kholi.P.L- ‘Automotive Electrical Equipment’‘ Tata McGraw-Hill Co.- Ltd.- New Delhi- 1975.
6. Robert Bosch- ‘Automotive Hand Book’‘ SAE- 5th Edition- 2000.

2162AU201	FINITE ELEMENT ANALYSIS	L	T	P	C
		3	0	2	4

Course Category: Specialization Elective/PTE

Self-Learning Content:
Numerical Methods- Mechanics of solids and Heat transfer

Course Outcomes
Upon the successful completion of the course-student will be able to

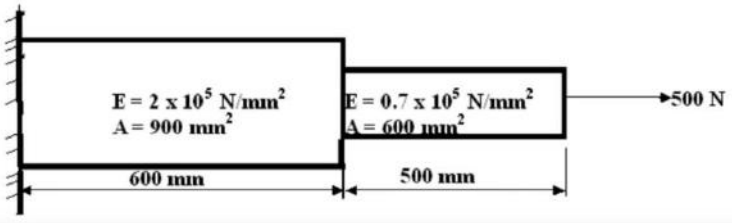
CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the numerical methods involved in Finite Element Theory	K2
CO2	Derive equations in finite element methods for 1Dproblems.	K2
CO3	Implement the formulation techniques to solve two-dimensional problemsusing triangle and quadrilateral elements.	K3
CO4	Understand the basic finite element formulation techniques.	K2
CO5	Understand the application of FEA in Thermal and heat transfer problem	K2

UNIT I INTRODUCTION **L - 9 P-6**

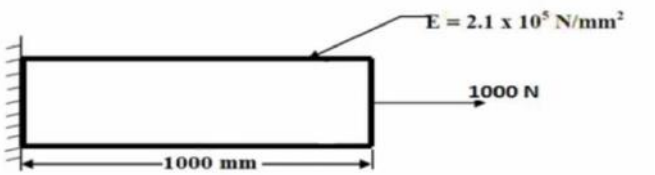
Historical Background – Mathematical modeling of field problems in Engineering – Governing Equations –Interpolation functions –Discrete and Continuous models– numerical integration – Boundary- Initial and Eigen value problems – Weighted Residual methods – Variational formulation of Boundary Value problems – Ritz Technique – Basic concepts of the finite element method.

List of Experiments:

1. For the simple stepped bar as shown in figure. Determine the displacements-stresses and reactions.



2. Consider the bar shown in fig.Youngs modulus $2.1*10^5 N/mm^2$ below. Determine the nodal displacement- stress in each element. Reaction Forces.

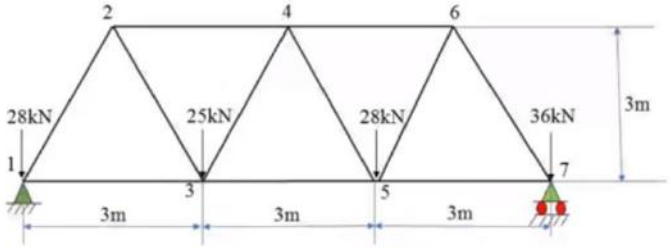


UNIT II ONE DIMENSIONAL PROBLEMS L – 9 P-6

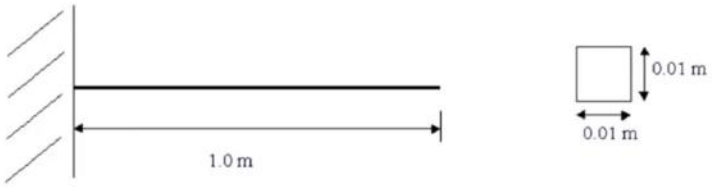
One Dimensional second order Equations - Discretization – Element types – Linear and Higher order Elements – Derivation of Shape functions and stiffness matrices and force vectors – Assembly of matrices – Longitudinal vibration frequencies and mode shapes – Transverse deflections and Natural frequencies of beams

List of Experiments:

1. Determine the nodal deflections- reactions forces- and stress for the truss system shown below E=200Gpa- A= 3250mm^2



2. Modal analysis of cantilever beam for natural frequency determination. The beam has square cross section. Modulus of elasticity = 200GPa - density = 7800 Kg/m^3



UNIT III TWO-DIMENSIONAL PROBLEMS L – 9 P-6

Second Order 2D Equations involving Scalar Variable Functions – Variational formulation – Finite element formulation – Triangular Elements- Application to Field problems – Thermal problems – Quadrilateral Elements–Higher order elements–Equations of elasticity – Plane stress-Plane strain and axis symmetric problems – Body forces and Temperature Effects – Stress calculations- Plate and Shell elements.

List of Experiments:

1. Determine the stress distribution in a plate 200mm x 100mm with a central circular hole of radius 30mm. The thickness of the plate is 10mm. Pressure of 200MPa acts at right end of the plate and the left end should be arrested by all degree of freedom.

UNIT IV ISOPARAMETRIC FORMULATION L – 9 P-6

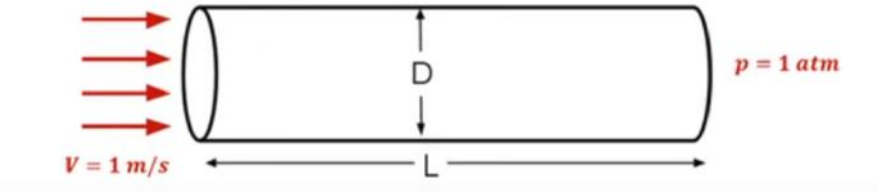
Natural co-ordinate systems – Isoparametric elements – Shape functions for iso parametric elements – serendipity elements – Matrix solution techniques – Solution techniques to Dynamic problems – Introduction to Analysis software.

1. Buckling analysis of 3D rectangular beam

UNIT V HEAT TRANSFER PROBLEMS L – 9 P-6

Nonlinear Problems – Temperature Effects – Conduction – Conduction with Surface Radiation – Convective Diffusion Equation – Free and Forced Convection – Errors in Finite Element Analysis.

1. Thermal analysis of composite wall structure
2. Thermal analysis of Heat sink.
3. Consider fluid flowing through a circular pipe of constant radius as illustrated below. The figure is not to scale. The pipe diameter D= 0.2m and length L=3 m. Consider the inlet velocity to be constant over the cross section and equal to 1m/s. The pressure at the pipe outlet is 1 atm. Take density 1 kg/m^{3}and coefficient of viscosity is 0.002kg/m-s.



Total Periods =45 + 30

REFERENCE BOOKS:

1. A first course in the finite element method" (4th edition)- by Daryl L. Logan- Cengage Learning India- 2007
2. Belagundu&Chandrupatla-"Finite Element in Engineering"- Third Edition.
3. Kenneth H.Huebner& Donald L.Dewhirst "The Finite Element method for Engineers" Wiley Edition.
4. J.N. Reddy "An Introduction Finite Element Method" Third Edition.

2162AU202	COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	2	4

Course Category: Specialization Elective/PTE

Self-learning Content:

Basics of Heat transfer- Fluid mechanics- FEM- FEA- etc.

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand basic mathematical equations for flow phenomena	K2
CO2	Apply mathematical and computational methods for heat transfer and Fluid flow simulations.	K3
CO3	Solve computational problems related to conduction and convection process.	K3
CO4	Identify the grid sensitivity and the accuracy of a numerical solution.	K2
CO5	Solve flow and heat transfer problems in engine using suitable software.	K3

UNIT I FUNDAMENTALS OF FLUID FLOW & DISCRETISATION METHOD L-9 P-6

Basic conservation equations for fluid flow and heat transfer- classification of the partial differential equations- Initial and Boundary conditions – Initial and Boundary Value problems – Common methods of discretization: an overview of finite difference- finite element and finite volume methods. Numerical solution of parabolic partial differential equations using finite-difference and finite-volume methods: explicit and implicit schemes- consistency- stability and convergence.

PRACTICALS

List of Experiments

1. 3D modelling- static and dynamic analysis of connecting rod.
2. Simulation of flow around external vehicle

UNIT II CONDUCTION HEAT TRANSFER L-9 P-6

Conduction equation- Grid layout- discretization - Stability and convergence- nonlinear sources-nonlinear coefficients- under relaxation-boundary conditions- solution by Gauss-Seidal method-solution by Tridiagonal matrix method. Solution of discretized equations using point and line iterations- strongly implicit methods and pre-conditioned conjugate gradient methods.

PRACTICALS

List of Experiments

1. 3D design and analysis of heat conduction and flux in piston.

UNIT III CONVECTION-CONDUCTION PROBLEMS L– 9 P-5

Convection-conduction problems: Central difference- upwind- exponential- hybrid and power-law schemes- comparison of exact solution- false conductivity- total variation diminishing scheme - Stability of the unsteady conduction-convection equation.

Note: Tutorials/One –dimensional code should be written by the student & submit

PRACTICALS

List of Experiments

1. 3D design and analysis of convection process in engine cylinder wall.
2. 3D design and analysis of conduction in exhaust valve.

UNIT IV NAVIER-STOKES EQUATIONS L-9 P-5

Numerical solution of the Navier-Stokes system for incompressible flows: stream-function-vorticity and artificial compressibility methods- requirement of a staggered grid. MAC- SIMPLE-SIMPLEC and SIMPLER algorithms.

PRACTICALS

List of Experiments

2. 1D flow of compressible gas in exhaust pipe

UNIT V ANALYSIS USING SOFTWARE L-9 P-8

Flow through manifolds; air motion in engines; turbulence and its modeling; phase-change problems- interface/free-surface tracking methods; engine processes with and without chemical reactions.

PRACTICALS

List of Experiments

2. Modelling and Simulation of exhaust gas flow pattern in exhaust manifold.
3. Computational analysis of gasoline engine exhaust pipe
4. Computational analysis of catalytic converter
5. Analysis of gasoline engine exhaust pipe

Total Periods =45 + 30

TEXT BOOKS:

1. Anderson J.D.: Computational fluid dynamics: The basics with applications-McGraw hill Publication-1995.
2. Wesseling.P: Principles of Computational fluid dynamics -Springer- 2004
3. 3.Patankar S V : Numerical heat transfer and Fluid flow- Hemisphere publishing corporation- New york-USA-2000.

REFERENCE BOOKS:

1. Chung- T. J.: Computational Fluid Dynamics- Cambridge University Press- 2002.
2. Date- A. W.: Introduction to Computational Fluid Dynamics- Cambridge University Press- 2005.
3. Ferziger- J. H. and M. Peric: Computational methods for Fluid Dynamics- Second Edition Springer- 1999.
4. Fletcher- C. A. J.: Computational Techniques for Fluid Dynamics- Vol. 1- Second Edition- Springer- 1991.
5. Muralidhar- K.- Sundarajan- T.: Computational Fluid Flow and Heat Transfer- Narosa Publishing House- New Delhi- 1997.

SPECIALIZATION ELECTIVES FOR ELECTRIC & HYBRID VEHICLES

2162AU120	AUTOMOTIVE EMBEDDED SYSTEM	L	T	P	C
		3	0	0	3

Course Category: Specialization Elective/EHV

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the various embedded systems to control all the subsystems in an automobile.	K2
CO2	Describe the working principles of embedded hardware.	K2
CO3	Explain the working of the sensors associated with automotive embedded systems.	K2
CO4	Illustrate the softwares associated with automotive embedded systems.	K2
CO5	Describe the various tests and validation carried out in automotive embedded systems.	K2

UNIT I: AUTOMOTIVE EMBEDDED SYSTEM OVERVIEW L - 9

Automotive Embedded System Technology- Overview of Embedded System Categories- Various Embedded Sub Systems like Chassis- Body- Driveline- Engine- Fuel- Emission- Brakes- Suspension- Emission- Brakes- Suspension- Doors- Safety & Security- Comfort & Multimedia- Communication & Lighting and Future Trends in Automotive Embedded Systems: X by Wire technologies.

UNIT II: AUTOMOTIVE HARDWARE MODULE L - 9

Concept to Market: Understanding Automotive Product Design Cycle- Microcontroller- architecture- Memory map- I/O map- Building Blocks of Automotive Electronic Product: Actuators- Sensors- Semiconductor Components- Devices- Integrated Circuits (ICs)- Relay- Stepper motor- PCBs etc.

UNIT III: AUTOMOTIVE SENSORS L - 9

Automotive Sensors and Transducers: Temperature- Force- Oxygen Sensor- LAMBDA Sensor- Proximity Distance Sensors- Speed- Engine Knock Sensor- Resistive Potentiometer & Flow. Typical Sensors Specifications & Microcontroller Interfacing- Signal Processing circuit- Sensor Calibration.

UNIT IV: AUTOMOTIVE SOFTWARE L - 9

Structure of embedded program- infinite loop- and compiling- linking and locating- downloading and debugging- Intra processor Communication Protocols: I2C & I2S- SPI & USB- LIN and CAN. Coding Standards and Guidelines: MISHRA C & Automotive Operating System: OSEK/VDX- AUTOSAR.

UNIT V: VERIFICATION & VALIDATION L - 9

The Validation and Verification Process- Introduction to NI Lab VIEW for Automotive- Test Categories like Functional Test- Black Box Test- Boundary level Test & Test Case Development- Reliability and Certifications Tests: EMI / EMC Tests as per AIS 004 standard- Environmental Test- Vibration Tests- Protection against Dust- Water Ingress and IP Standards Vehicle Diagnostic Interface like OBD- OBD - II.

Total Periods =45

REFERENCE BOOKS:

1. MiroslawStaron- "Automotive Software Architectures: An Introduction"- Springer- 2017. (ISBN: 978-3-319-58609-0)
2. Automotive Computer Controlled Systems-Diagnostic tools and techniques-Allan W. M. Bonnick- Butterworth-Heinemann-2001. (ISBN 0 7506 5089 3).
3. Nicolas Navet and Francoise Simonot-Lion- "Automotive Embedded Systems Handbook"- CRC Press- 2009. (ISBN: 978-0-8493-8026-6)
4. Ronald K. Jurgen- "Distributed Automotive Embedded Systems"- SAE International- 2007. (ISBN: 978-0-7680-1966-7)
5. Ronald K. Jurgen- "Automotive Software"- SAE International- 2006. (ISBN: 978-0-7680-1714-4).

2162AU121	AUTOMOTIVE THERMAL SYSTEM	L	T	P	C
		3	0	0	3

Course Category: Program Elective/EHV

Fundamental Concept of Thermodynamics- Path and Point Functions- Reversible and Irreversible Processes- Concept of Temperature and Thermal Equilibrium- First Law and Second Law of Thermodynamics- Refrigeration- Steady and Unsteady Heat Conduction.

Course Outcomes

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
C01	Understand the fundamental concept of thermodynamics and solve the problem of closed and open systems and steady flow processes	K2
C02	Calculate the change entropy at Closed and open system and understand the Available and Unavailable Energy.	K3
C03	Apply the general thermodynamic property relations and standards to solve problems	K3
C04	Explain the different gas power cycles and application in internal combustion engine and air conditioning	K2
C05	Describe the different heat transfer principles of different automotive applications.	K2

UNIT I BASIC CONCEPTS AND FIRST LAW L- 9

Basic concepts - Concept of continuum- comparison of microscopic and macroscopic approach- Intensive and extensive properties- thermodynamics System and their types- Quasi-static- Heat and work transfer- displacement work and other modes of work- Zeroth law of thermodynamics – - application to closed and open systems and steady flow processes.

UNIT II SECOND LAW- ENTROPY AND AVAILABILITY L- 9

Heat Reservoir- source and sink- Heat Engine- Refrigerator and Heat pump- Statements of second law and its corollaries- Carnot cycle- reversed Carnot cycle- Performance- Clausius inequality- Concept of entropy- T-s diagram- Tds Equations- Entropy Changes for a Closed and open system- Third Law of Thermodynamics- principle of increase in entropy- Available and Unavailable Energy.

UNIT III IDEAL- REAL GASES AND THERMODYNAMIC RELATIONS L- 9

Properties of Ideal gas- Ideal and real gas comparison- Equations of state for ideal and real gases- Reduced properties- Mole and Mass fraction- Dalton's and Amagat's Law- Properties of gas mixture – Molar mass- gas constant- density- change in internal energy -Maxwell relations- Tds Equations- Difference and ratio of heat capacities- Joule-Thomson Coefficient- ClausiusClapeyron equation.

UNIT IV REFRIGERATION AND AIR CONDITIONING L- 9

Refrigerants- classification of refrigerants - Elements of refrigeration systems- Vapour compression refrigeration cycle- factors affecting the performance of a vapour compression system - Vapour absorption system and working principle- comparison between vapour compression and vapour absorption systems - Air conditioning system- types and working principles.

List of Demonstration:

- Determination of COP of a refrigeration system
- Demonstration on Psychrometric processes

UNIT V CONDUCTION- CONVECTION AND RADIATION L- 9

General Differential equation of heat conduction– Cartesian and Polar Coordinates – One dimensional steady state heat conduction — plane and Composite Systems-Free and Forced Convection-Heat Exchanger Types - Overall Heat Transfer Coefficient-Black Body Radiation – Grey body radiation - Shape Factor-Radiation Shields.

List of Demonstration:

- Demonstration on Natural convection-vertical cylinder
- Explain the forced convection inside tube

Total Periods =45

REFERENCE BOOKS:

1. Y.A. Cengel- Heat Transfer – A practical Approach- Tata McGraw-Hill- 2003.
2. M.N. Ozisik- Heat transfer- McGraw Hill (1985).
3. Bejan- Advanced Engineering Thermodynamics- John Wiley and Son- 1998.
4. S.R.Turns- Thermodynamics - concepts and Application- Cambridge UniversityPress- 2008.
5. Van Wylen& Sonntag - Thermodynamics- John Wiley & Sons 1991
6. J. M. Smith and H.C Van Ness. Introduction to Chemical Engineering Thermodynamics- McGraw-Hill Inc.- 1987.
7. F.P. Incropera and Dewitt D.P- Fundamentals of Heat and Mass transfer- John Willey& Sons (1996).

2162AU122	ELECTRIC DRIVES AND CONTROL	L	T	P	C
		3	0	0	3

Course Category: Program Elective/EHV

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Ability to understand suitability drive for the given application.	K2
CO2	Ability to analyze the operation of the converter/chopper fed DC drive.	K2
CO3	Ability to analyze the operation and performance of induction motor drive.	K2
CO4	Ability to understand the operation of field control DC drives.	K2
CO5	Ability to analyze the performance of direct torque control of induction motor drives.	K2

UNIT I: MOTORS FUNDAMENTALS AND MECHANICAL SYSTEMS L - 9

DC motor - Types- induced emf- speed-torque relations; Speed control – Armature and field control; Ward Leonard control – Constant torque and constant horse power operations. Review of Induction Motor operation – Equivalent circuit – Performance of the machine with variable voltage- slip power recovery – Static Kramer Drive.

UNIT II: CONVERTER AND CHOPPER CONTROL L - 9

Principle of phase control – Series and separately excited DC motor with single phase and three phase converters – waveforms- performance characteristics- Drive employing dual converter. Class A- B- C- D and E chopper controlled DC motor.

UNIT III: VSI AND CSI FED INDUCTION MOTOR CONTROL L - 9

AC voltage controller fed induction machine operation – Energy conservation issues – V/f operation theory – requirement for slip and stator voltage compensation. CSI fed induction machine – Operation and characteristics - PWM controls.

UNIT IV: FIELD ORIENTED CONTROL L - 9

Field oriented control of induction machines – Theory – DC drive analogy – Direct or Feedback vector control - Indirect or Feed forward vector control – Flux vector estimation - Space Vector Modulation control.

UNIT V: DIRECT TORQUE CONTROL L - 9

Direct torque control of Induction Machines – Torque expression with stator and rotor fluxes- DTC control strategy – optimum switching vector selection – reduction of torque ripple methods.

Total Periods =45

REFERENCE BOOKS:

1. VedamSubramanyam- "Electric Drives – Concepts and Applications"- Tata McGraw Hill- 2000.
2. R.Krishnan- "Electric Motor Drives – Modeling- Analysis and Control"- Prentice- Hall of India Pvt. Ltd.- New Delhi- 2003.
3 Austin Hughes- "Electric Motors and Drives – Fundamentals- Types and Applications"- Elsevier – a division of Reed Elsevier India private Limited- New Delhi- 2006.

2162AU123	AUTOMOTIVE DIAGNOSTICS	L	T	P	C
		3	0	0	3

Course Category: Program Elective/EHV

Course Outcomes

Upon the successful completion of the course-studentwill be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Understand the working principle of Networking protocols and ECU	K2
CO2	Illustrate the knowledge on Fault codes and Diagnostics of ECU	K2
CO3	Illustrate the knowledge on Diagnostics Tools	K2
CO4	Explain the approach techniques to resolve the issues flagged	K2
CO5	Illuminate the understanding of the OBD- its tools and techniques	K3

UNIT-I: THE COMPUTER ECM **L - 9**

Fundamental parts of a computer- practical automotive computer system- Principles of operation- Computer data- Computer interfaces- Control of output devices- Computer memories- Fault codes- Adaptive operating strategy of the ECM- Networking of computers- Vehicle network systems- Prototype network systems.

List of Demonstration:

1. Communication Protocols
2. Parts and Interfaces of the ECU

UNIT-II: SELF DIAGNOSIS AND FAULT CODES **L - 9**

Access to Diagnostic trouble codes (DTC)- Developments in self-diagnosis- Diagnostic equipment and limitations of DTCs- Diagnostic equipment and limitations of DTCs.

List of Demonstration:

1. Identify DTCs

UNIT-III: DIAGNOSTIC TOOLS AND EQUIPMENT **L - 9**

Breakout boxes- Diagnostic tools that connect to ECM- The digital multimeter- Portable flat screen oscilloscopes- Diagnostic tool and oscilloscope combined- Pressure gauges- Calibrating test instruments- Location charts and wiring diagrams- Sources of diagnostic data -Exhaust gas emissions and emission system testing.

List of Demonstration:

1. Use of Tools to read Data from the ECU

UNIT-IV: DIAGNOSTIC TECHNIQUES **L - 9**

Circuit testing- Vehicle specific details- six-steps approach- Skills required for effective diagnosis- An approach to fault finding- Emissions related testing- Ignition system tests- Diesel injection- Sensor tests on other systems- Intermittent faults.

List of Demonstration:

1. Error solving by resolving the identified DTCs

UNIT-V: ON-BOARD DIAGNOSTICS **L - 9**

On-board diagnostics – a first perspective- Petrol/gasoline on-board diagnostic monitors- On-board diagnostics – a second perspective- OBD for Engine systems- chassis systems- electrical systems- transmission systems.

List of Demonstration:

1. Read data from Vehicle using OBD and identify the causes and rectification

Total Periods =45

REFERENCE BOOKS:

1. Allan W. M. Bonnick- Automotive Computer Controlled Systems Diagnostic tools and techniques- Butterworth-Heinemann- 2011.
2. Tom Denton-Advanced Automotive Fault Diagnosis-Second Edition-2006.

2162AU124	MICRO ELECTRO MECHANICAL SYSTEMS	L	T	P	C
		3	0	0	3

Course Category: Program Elective/EHV

Aims & Objectives:
This course enables understanding the concept of MEMS and Microsystems. Helps to understand the diverse technological and functional approaches and applications and provides an insight of micro sensors- actuators and micro fluidics. Gain the knowledge about microfabrication-micromachining and micro packaging.

Course Outcomes

Upon the successful completion of the course-student will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Attain a broad range of the knowledge required to grow in the evolving field of MEMS and microsystem.	K2
CO2	Familiar with the principle and operation of microsensor and microactuator.	K2
CO3	Select and assess suitable materials for manufacturing MEMS and microsystem.	K2
CO4	Describe the different microfabrication and micromachining process.	K2
CO5	Describe the different stages of microsystems packaging and packaging materials.	K2

UNIT I: OVERVIEW OF MEMS AND MICROSYSTEMS L - 9
MEMS and Microsystems–MEMS as micro sensors and micro actuators- MEMS and Microsystem products– Evolution of Microfabrication- Microsystems and Microelectronics- Comparison of Microsystems and microelectronics-Multidisciplinary nature of Microsystems- Microsystems and miniaturization- Applications of Microsystems in various industries.

UNIT II: MICRO SENSORS AND ACTUATORS L - 9
Micro sensors-Optical sensors- Pressure sensors- Thermal sensors – thermopiles- thermistors-Tyre Pressure Sensors. Micro actuator - Micro actuation principles-Micro gripper-Micro motors-Micro valves-Micro pumps- Micro accelerometers-Micro fluidics.

UNIT III: MATERIALS FOR MEMS AND MICROSYSTEMS L - 9
Substrates and wafers – Silicon as a substrate material- ideal substrates for MEMS – single crystal Silicon and wafers crystal structure – mechanical properties of Si –Silicon compounds – Gallium arsenide- quartz – piezoelectric crystals – polymers.

UNIT IV: MICROFABRICATION AND MICRO MACHINING L - 9

Photolithography-Ion Implantation-Diffusion-Chemical vapour deposition (CVD)-Enhanced CVD-Physical vapours deposition (Sputtering)-Etching-chemical etching- plasma etching-Bulk Micro Machining -Surface Micro Machining -LIGA process.

UNIT V: MICROSYSTEM PACKAGING L - 9

General considerations in packaging - Levels of Microsystem packaging – die level- device level and system level – Essential packaging technologies – die preparation- surface bonding- wire bonding and sealing - Three-dimensional packaging- assembly of Microsystems – selection of packaging materials.

Total Periods =45

Text Books

1. Tai-Ran Hsu-MEMS and Microsystems Design and Manufacture- Tata McGraw Hill- New Delhi- 2017.
2. Mahalik- N. P-MEMS- Tata McGraw Hill- New Delhi- 2007.

REFERENCE BOOKS

1. Julian W. Gardner- Florin Udrea-Microsensors: Principles and Applications- Wiley- 2015.
2. Michael Kraft and Neil M. White- MEMS for automotive and aerospace applications- Woodhead Publishing Limited- 2013.
3. Chang Liu- “Foundations of MEMS”- Pearson International Edition- 2006.
4. Marc F Madou-Fundamentals of Micro Fabrication- CRC Press- 2nd Edition- 2002

2162AU125	IN-VEHICLE NETWORKING	L	T	P	C
		3	0	0	3

Course Category: Program Elective/EHV

Self-Learning Content: Basic working principles of analog and digital communication.

Course Outcomes

Upon the successful completion of the course- students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe about in –vehicle networking.	K2
CO2	Explain the different network and communication protocol.	K2
CO3	Understand the higher layer protocols.	K2
CO4	Describe the flexray protocol.	K2
CO5	Describe the latest trends in in–vehicle networking.	K2

UNIT I BASICS OF IN-VEHICLE NETWORKING L - 9

Overview of Data communication and networking –need for In-Vehicle networking –layers of OSI reference model –multiplexing and de-multiplexing concepts –vehicle buses.

List of Demonstration:

1. Different types of communication between two-microcontrollers.

UNIT II NETWORKS AND PROTOCOLS L – 9

Overview of general-purpose networks and protocols -Ethernet- TCP- UDP- IP-ARP-RARP - LIN standard overview –workflow concept-applications –LIN protocol specification –signals -Frame transfer –Frame types –Schedule tables –Task behaviour model –Network management –status management - overview of CAN –fundamentals –Message transfer –frame types-Error handling – fault confinement-Bit time requirements.

List of Demonstration:

1. CAN communication between two-microcontrollers.

UNIT III HIGHER LAYER PROTOCOL L – 9

Introduction to CAN open –TTCAN –Device net -SAE J1939 - overview of data channels –control channel-synchronous channel – asynchronous channel –Logical device model –functions-methods-properties-protocol basics- Network section-data transport –Blocks –frames –Preamble-boundary descriptor

List of Demonstration:

1. Diagnosis tool for CAN communication between two-microcontrollers.

UNIT IV FLEXRAY PROTOCOL L– 9

Introduction –network topology –ECUs and bus interfaces –controller host interface and protocol operation controls –media access control and frame and symbol processing –coding/decoding unit –FlexRay scheduling

UNIT V LATEST TRENDS **L - 9**

Car networking protocols – Networking future trends –Roadmaps –Competitive advantage

Total Periods =45

REFERENCE BOOKS:

1. J.Gabrielleen-"Automotive In-Vehicle Networks"- John Wiley & Sons- Limited- 2008
2. Robert Bosch-" Bosch Automotive Networking"- Bentley publishers- 2007
3. Society of Automotive Engineers- "In-Vehicle Networks"- 2002.
4. Ronald K Jurgen- "Automotive Electronics Handbook"- McGraw-Hill Inc. 1999.
5. IndraWidjaja- Alberto Leon-Garcia- "Communication Networks: Fundamental Concepts and Key Architectures"- McGraw-Hill College; 1st edition- 2000.
6. KonradEtschberger- "Controller Area Network- IXXAT Automation"- August 22- 2001.
7. Olaf Pfeiffer- Andrew Ayre- Christian Keydel- "Embedded Networking with CAN and CANopen"- Annabooks/Rtc Books- 2003

2162AU126	INTELLIGENT TRANSPORT SYSTEMS	L	T	P	C
		3	0	0	3

Course Category: Program Elective/EHV

Self-Learning Content: Fundamentals of sensors- navigation and wireless communication.

Course Outcomes

Upon the successful completion of the course- students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe the digital map database module.	K2
CO2	Describe the working of the positioning module.	K2
CO3	Describe the working of the direction module.	K2
CO4	Describe the working of wireless communication module.	K2
CO5	Describe the working autonomous location and navigation.	K2

UNIT I DIGITAL MAP DATABASE MODULE L - 9

Introduction to Modern Vehicle Location and Navigation - Basic Representations - Reference Coordinate Systems – Standards - Proprietary Digital Map Databases - Digital Map Compilation.

List of Demonstration:

1. By using Global Positioning System device.

UNIT II POSITIONING MODULE L– 9

Introduction-Dead Reckoning-Global Positioning System - Sensor fusion - Conventional map matching - Fuzzy logic Based Map matching - Other Map matching algorithms - Map aided Sensor calibration

List of Demonstration:

1. By using Global Positioning System device with digital map.

UNIT III DIRECTION MODULE L - 9

Shortest Path - Heuristic Search - Bidirectional Search - Hierarchical search - other algorithms - Guidance while En Route - Guidance while off Route - Guidance with dynamic information.

List of Demonstration:

1. By using directional sensors data on digital map.

UNIT IV WIRELESS COMMUNICATION MODULE L – 9

Introduction - Communication Subsystem Attributes - Existing Communication Technologies - Communication Subsystem Integration.

List of Demonstration:

1. By using Mobile communication- Bluetooth & Wi-Fi communication.

UNIT V AUTONOMOUS LOCATION AND NAVIGATION L – 9

Introduction – Vehicle Location: Standalone Technologies - Radio Technologies - Satellite Technologies - Vehicle Navigation: Coping with complex requirements - Dual use navigation and entertainment components - Centralized location and Navigation Introduction - Automatic Vehicle Location: Centralized and Distributed Approach- Dynamic Navigation :Centralized and Distributed.

Total Periods =45

REFERENCE BOOKS:

1. "Intelligent Vehicle Technologies Theory and Applications"– L Vlacic- M Parent- F Harashima- Butterworth Heinemann
2. "Vehicle location and Navigation Systems" – Yilin Zhao – Artech House Inc.
3. Sussman Joseph- "Perspectives on Intelligent Transportation Systems (ITS)"- New York- NY: Springer- 2010.
4. Mashrur A. Chowdhury- and Adel Sadek- "Fundamentals of Intelligent Transportation Systems Planning"- Artech House- Inc.- 2003.

2162AU127	AUTOMOTIVE SAFETY	L	T	P	C
		3	0	0	3

Course Category: Program Elective/EHV

Course Outcomes:

At the end of the course- students will demonstrate the ability to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Identity different safety systems and vehicle structural crashworthiness	K2
CO2	Determine injury thresholds and apply trauma for analysis of crash injuries	K2
CO3	Describe the importance of the vehicle safety systems	K3
CO4	Determine the fundamentals of light-vision and colour	K2
CO5	Analyse pedestrian safety by use of light measurement and testing	K3

UNIT I INTRODUCTION VEHICLE SAFETY, STRUCTURAL CRASHWORTHINESS AND CRASH TESTING L – 9

Automotive Safety-Active and passive safety, Driver assistance systems in automobiles, Definitions and terminology. Balance of stiffness and toughness characteristics and energy absorption characteristics of vehicle structures, Design of crash crumple zones, Modeling and simulation studies, Optimization of vehicle structures for crash worthiness, Types of impacts, and Impact with rebound, movable barrier tests, Analysis and simulation of vehicle in barrier impacts, Roll over crash tests, Behavior of specific body structures in crash testing, Photographic analysis of impact tests.

List of Demonstration:

1. Behavior of specific body structures in crash test
2. Demonstration of roll over crash tests

UNIT II ERGONOMICS AND HUMAN RESPONSE TO IMPACT L – 9

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

List of Demonstration:

1. Importance of Ergonomics in Automotive safety

UNIT III VEHICLE SAFETY SYSTEMS L – 9

Survival space requirements, Restraints systems used automobiles, Types of safety belts, Head restraints, Air bags used in automobiles, Use of energy absorbing systems in automobiles, Impact protection from steering controls, Design of seats for safety, types of seats used in automobiles. Importance of Bumpers in automobiles, Damageability criteria in bumper designs. Introduction to the types of safety glass and their requirements and rearward field of vision in automobiles, Types of rear view mirrors and their assessment. Warning devices, Hinges and latches etc. Active safety.

UNIT IV FUNDAMENTALS OF LIGHT, VISION AND COLOUR L – 9

Electromagnetic radiation and light, Propagation of light, Spectral sensitivity of light, Measures of radiation and light, standard elements for optical control. Illuminant calculations, Derivation of luminous flux from luminous intensity, flux transfer and inter reflection, luminance calculations, discomfort glare, eyes as an optical system visual processing, lighting for results, modes of appearance, Pointers for lighting devices. Nature of the color Tri-chromatic Colorimetry, Surface color, color spaces and color solids, color rendering.

UNIT V LIGHT MEASUREMENTS, TESTING EQUIPMENT, CALIBRATION AND PHOTOMETRIC PRACTICE L – 9

Basics of standards and detectors, spectral measurements and Colorimetry, illuminant meters and luminance meters, colorimeters. Fundamentals of equipment used for light measurement in Automotive field; Gonio- Photometer, Reflecto-meter, Colorimeter, Integrating sphere, types, application, coordinates system, Types of sensors and working principle, construction, characteristics etc. used in different equipment. National and international Regulations, test requirements and testing procedure.

List of Demonstration:

1. Demonstration on light measurement system

Total Periods =45

REFERENCE BOOKS:

1. JullianHappian-Smith ‘An Introduction to Modern Vehicle Design’ SAE- 2002
2. Johnson- W.- and Mamalis- A.G.- "Crashworthiness of Vehicles- MEP- London- 1995
3. Edward .A- Lamps and Lighting- Hodder & Stoughton- London- 1993.
4. Bosch –automotive -handbook -edition 5-SAE Publication-2000
5. Rollover Prevention- Crash Avoidance- Crashworthiness- Ergonomics and Human Factors”- SAE Special Publication- November 2003.

2162AU128	PLUG-IN ELECTRIC VEHICLES IN SMART GRID	L	T	P	C
		3	0	0	3

Course Category: Program Elective/EHV

Self-Learning Content: Fundamentals of power system- power grid- smart grid and battery charging.

Course Outcomes

Upon the successful completion of the course- students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe about vehicle electrification and impact of charging strategies.	K2
CO2	Describe the influence of EVs on power system.	K2
CO3	Describe the frequency control and voltage reserve from EVs.	K2
CO4	Describe the ICT solutions to support EV deployment.	K2
CO5	Describe the EV charging and facility planning.	K2

UNIT I VEHICLE ELECTRIFICATION & IMPACT OF CHARGING STRATEGIES L- 9

Introduction- Impact of charging strategies- EV charging options and infrastructure- energy-economic and environmental considerations- Impact of EV charging on power grid- effect of EV charging on generation and load profile- Smart charging technologies- Impact on investment.

List of Demonstration:

1. Demonstration of EV Charging.

UNIT II INFLUENCE OF EVS ON POWER SYSTEM L - 9

Introduction- identification of EV demand- EV penetration level for different scenarios- classification based on penetration level- EV impacts on system demand: dumb charging- multiple tariff charging- smart charging- case studies.

List of Demonstration:

1. Demonstration the influence of EVs on power system using simulation model.

UNIT III FREQUENCY CONTROL RESERVES & VOLTAGE SUPPORT FROM EVS L - 9

Introduction- power system ancillary services- electric vehicles to support wind power integration- electric vehicle as frequency control reserves and tertiary reserves- voltage support and electric vehicle integration- properties of frequency regulation reserves- control strategies for EVs to support frequency regulation.

List of Demonstration:

1. Demonstration the frequency regulation by EVs.
2. Demonstration the voltage regulation by EVs.

UNIT IV ICT SOLUTIONS TO SUPPORT EV DEPLOYMENT L - 9

Introduction- Architecture and model for smart grid & EV- ICT players in smart grid- smart metering- information & communication models- functional and logical models- technology and solution for smart grid: interoperability- communication technologies.

UNIT V EV CHARGING FACILITY PLANNING L - 9

Energy generation scheduling- different power sources- fluctuant electricity- centralized charging schemes- decentralized charging schemes- energy storage integration into Microgrid- Design of V2G Aggregator.

Total Periods =45

REFERENCE BOOKS:

1. SumedhaRajakaruna- FarhadShahnia and Arindam Ghosh- "Plug In Electric Vehicles in Smart Grids-Integration Techniques"- Springer Science + Business Media Singapore Pte Ltd.- 2015.
2. Canbing Li- Yijia Cao- YonghongKuang and Bin Zhou- "Influences of Electric Vehicles on Power System and Key Technologies of Vehicle-to-Grid"- Springer-Verlag Berlin Heidelberg- 2016.
3. Qiuwei Wu- "GRID INTEGRATION OF ELECTRIC VEHICLES IN OPEN ELECTRICITY MARKETS"- John Wiley & Sons- Ltd- 2013.

2162AU203	TESTING AND CERTIFICATION OF ELECTRIC AND HYBRID VEHICLES	L	T	P	C
		3	0	2	4

Course Category: Program Elective

Self-Learning Content: Fundamentals of automotive engineering- electric and hybrid vehicles- battery and battery charging.

Course Outcomes

Upon the successful completion of the course- students will be able to

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Describe about vehicleSpecification & Classificationand types of Homologation.	K2
CO2	Describe the static testing of Vehicle.	K2
CO3	Describe the dynamic testing of Vehicle.	K2
CO4	Describe the vehicle component testing.	K2
CO5	Describe the tests for Hybrid Electric Vehicles- retro-fitment and charging station.	K2

UNIT I: INTRODUCTION L – 9 P-8

Specification & Classification of Vehicles (including M, N and O layout), Homologation & its Types, Regulations overview (EEC, ECE, FMVSS, AIS, CMVR), Type approval Scheme, Homologation for export, Conformity of Production, various Parameters, Instruments and Types of test tracks, Hardware in The Loop (HIL) concepts for EV/HEVs.

List of Demonstration:

1. Demonstration of Instruments and Types of test tracks

List of experiments:

1. Weight Test of Vehicle
2. Gradeability Test of Vehicle

UNIT II: STATIC TESTING OF VEHICLE L – 9

Photographs, CMVR physical verification, Tyre Tread Depth Test, Vehicle Weightment, Horn installation, Rear view mirror installation, Tell Tales, External Projection, Wheel Guard, Arrangement of Foot Controls for M1 Vehicle, Angle & Dimensions Measurement of Vehicle, The Requirement of Temporary Cabin For Drive– Away – Chassis, Electric vehicle – Safety Norms, Energy consumption and Power test.

List of Demonstration:

1. Demonstration of Electric vehicle – Safety Norms
2. Demonstration on installation of horn and mirror

UNIT III: DYNAMICS TESTING OF VEHICLE L – 9 P-6

Hood Latch, Gradeability, Pass-by Noise, Interior Noise, Turning Circle Diameter & Turning Clearance Circle Diameter, Steering Effort, Constant Speed Fuel Consumption, Cooling

Performance, Speedo-meter Calibration, Range Test, Maximum Speed, Acceleration Test, Coast-down test, Brakes Performance ABS Test, Broad band / Narrow band EMI Test, Electric vehicle – Range Test.

List of experiments:

1. Turning Circle Diameter Measurement Test
2. Battery Test as per AIS048 standard

UNIT IV: VEHICLE COMPONENT TESTING L – 9 P-6

Horn Testing, Safety Glasses Test: Windscreen laminated and toughened safety glass, Rear View Mirror Test, Hydraulic Brakes Hoses Fuel Tank Test: Metallic & Plastic, Hinges and Latches Test, Tyre& Wheel Rim Test, Bumper Impact Test, Side Door Intrusion, Crash test with dummies, Demist test, Defrost Test, Interior Fittings, Steering Impact test (GVW<1500 kg), Body block test, Head form test, Driver Field Of Vision, Safety belt assemblies, Safety belt anchorages, Seat anchorages & head restraints test, Airbag Test, Accelerator Control System, Motor power, Safety Requirements of Traction Batteries, EMI-EMC (CI, BCI, RE,RI and CTE).

List of Demonstration:

1. Demonstration of Bumper Impact Test

List of experiments:

1. EMI-EMC Test
2. Maximum Power Test for Traction Motor

UNIT V: TESTS FOR HYBRID ELECTRIC VEHICLES, RETRO-FITMENT AND CHARGING STATION L – 9 P-6

Hybrid Electric Vehicles Tests (M and N category), Tests for Hybrid Electric System Intended for Retro-fitment on Vehicles of M and N Category (GVW < 3500 kg), Test for Electric Propulsion kit intended for Conversion, Test for Electric Vehicle Conductive AC Charging System, and Test for Electric vehicle conductive DC charging system.

List of Demonstration:

1. Demonstration on testing of Hybrid Electric System
2. Test for Electric Vehicle Conductive AC Charging System

List of experiments:

1. Steering Effort Measurement Test
2. Electric vehicle – Range Test

Total Periods =45+30

REFERENCE BOOKS:

1. "Vehicle Inspection Handbook"- American Association of Motor Vehicle Administrators
2. Michael Plint& Anthony Martyr- "Engine Testing & Practice"- Butterworth Heinmenn- 3rd Ed- 2007
3. Proceedings- Automotive Testing & Certification held on 20th to 24th July 2010 at ARAI PUNE
4. Bosch Automotive Handbook- Robert Bosch- 7th Edition- 2007