ANNA UNIVERSITY, CHENNAI

UNDERGRADUATE CURRICULUM (UNIVERSITY DEPARTMENTS)

Campus: MIT

Department: AUTOMOBILE ENGINEERING

Programme: B.E AUTOMOBILE ENGINEERING

Regulations: 2023 (Revised 2024), with effect from the AY 2024 – 25 to all the students of UG Programme.

OVERVIEW OF CREDITS

Sem	PCC	PEC	ESC	HSMC	ETC	OEC	SDC	UC	SLC	Total
I	0	0	4	11	0	0	4	1	0	**23**
II	0	0	4	14	0	0	3	1	0	**22**
III	4	0	12	4	0	0	2	2	0	**24**
IV	22	0	0	0	0	0	2	0	0	**24**
V	16	0	0	0	0	3	3	4	0	**26**
VI	0	18	0	0	3	3	1	0	1	**26**
VII	16	0	0	0	3	0	1	3	0	**23**
VIII	0	0	0	0	0	0	8	0	0	**8**
Total	**58**	**18**	**23**	**29**	**6**	**6**	**24**	**11**	**1**	**176**
% of Category	**32.95**	**10.23**	**13.07**	**16.48**	**3.4**	**3.4**	**13.64**	**6.25**	**0.58**	**100**

CATEGORY OF COURSES

PCC – Professional Core Course

PEC – Professional Elective Course

ETC – Emerging Technology Course

OEC – Open Elective Course

SLC – Self Learning Course

ESC – Engineering Science Course

HSMC – Humanities Science and Management Course

SDC – Skill Development Course

UC – University Course

For Honours & Minor Degree, please refer the Regulations 2023 (Revised 2024).

Semester – I							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	EN23C01	Foundation English	LIT	2-0-2	4	3	HSMC
2	MA23C01	Matrices and Calculus	T	3-1-0	4	4	HSMC
3	PH23C01	Engineering Physics	LIT	3-0-2	5	4	HSMC
4	ME23C01	Engineering Drawing and 3D Modelling	LIT	2-0-4	6	4	SDC
5	EE23C03	Basics of Electrical and Electronics Engineering	LIT	2-0-2	4	3	ESC
6	CS23C02	Computer Programming in Python	LIT	3-0-2	5	4	ESC
7	UC23H01	தமிழர் மரபு / Heritage of Tamils	T	1-0-0	1	1	UC
8		NCC / NSS / NSO / YRC	L	0-0-2	2	0	UC
					Total Credits	**23**	

*** TCP –** Total Contact Period(s)

#**TYPE OF COURSE**

LIT – Laboratory Integrated Theory

T – Theory

L – Laboratory Course

IPW – Internship cum Project Work

PW – Project Work

CDP – Capstone Design Project

Semester – II							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	EN23C02	Professional Communication	LIT	2-0-2	4	3	HSMC
2	MA23C02	Ordinary Differential Equations and Transform Techniques	T	3-1-0	4	4	HSMC
3	PH23C04	Fundamentals of Materials Science and Engineering	T	3-0-0	3	3	HSMC
4	CY23C01	Engineering Chemistry	LIT	3-0-2	5	4	HSMC
5	ME23C04	Makerspace	LIT	1-0-4	5	3	SDC
6	ME23C03	Engineering Mechanics	T	3-1-0	4	4	ESC
7	UC23H02	தமிழரும் தொழில் நுட்பமும் / Tamils and Technology	T	1-0-0	1	1	UC
8	-	Audit Course–I	-	-	-	-	UC
					Total Credits	**22**	

SEMESTER – III							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1	MA23C06	Partial Differential Equations and Complex Functions	T	3-1-0	4	4	HSMC
2	AU23301	Manufacturing Processes and Machine Tools	LIT	3-0-2	5	4	ESC
3	AU23C01	Applied Thermodynamics	LIT	3-0-2	5	4	ESC
4	AU23C02	Mechanics of Solids	LIT	3-0-2	5	4	ESC
5	AU23302	Automotive Engines	LIT	3-0-2	5	4	PCC
6		Skill Development Course Level –II	T	2-0-0	2	2	SDC
8	UC23U01	Universal Human Values	LIT	1-0-2	3	2	UC
TOTAL CREDITS						**24**	

SEMESTER – IV							
S. NO.	**COURSE CODE**	**COURSE NAME**	**COURSE TYPE#**	**PERIODS / WEEK**		**CREDITS**	**CATEGORY**
				L-T-P	**TCP***		
1	AU23401	Automotive Chassis	LIT	3-0-2	5	4	PCC
2	AU23402	Vehicle Body Engineering and Ergonomics.	T	3-0-0	3	3	PCC
3	AU23403	Fluid Mechanics for Automotive Applications	LIT	3-0-2	5	4	PCC
4	AU23404	Kinematics and Dynamics for Automotive Applications	T	3-0-0	3	3	PCC
5	AU23405	Fuels, Lubricants and Coolants	LIT	3-0-2	5	4	PCC
6	AU23406	Automotive Pollution and Control	LIT	3-0-2	5	4	PCC
7		Skill Development Course – Level II	T	2-0-0	2	2	SDC
8		Audit Course–II	-	-	-	-	UC
TOTAL CREDITS						**24**	

Semester – V							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	AU23501	Engineering Design	LIT	3-0-2	5	4	PCC
2	AU23502	Automotive Transmission	LIT	3-0-2	5	4	PCC
3	AU23503	Automotive Electrical and Electronics Systems	LIT	3-0-2	5	4	PCC
4	AU23504	Vehicle Maintenance and Testing	LIT	3-0-2	5	4	PCC
5		Open Elective – I*	T	3-0-0	3	3	OEC
6		Industry Oriented Course – I	-	-		1	SDC
7	UC23E01	Engineering Entrepreneurship Development	LIT	2-0-2	4	3	UC
8	AU23U01	Standards - Automobile Engineering	T	1-0-0	1	1	UC
9	AU23505	Summer internship	IPW	0-0-4	4	2	SDC
					Total Credits	**26**	
Courses for Honours Degree							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1.	AU23D01	Capstone Design Project-Level I	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – I	T	3-0-0	3	3	SDC
2.		Honours Elective – II	T	3-0-0	3	3	SDC
Courses for Minor Degree							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1.		Minor Elective – I	T	3-0-0	3	3	SDC
2.		Minor Elective – II	T	3-0-0	3	3	SDC

Semester – VI (Preference for Foreign Exchange)							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1		Professional Elective – I	T	3-0-0	3	3	PEC
2		Professional Elective – II	T	3-0-0	3	3	PEC
3		Professional Elective – III	T	3-0-0	3	3	PEC
4		Professional Elective – IV	T	3-0-0	3	3	PEC
5		Professional Elective – V	T	3-0-0	3	3	PEC
6		Professional Elective – VI	T	3-0-0	3	3	PEC
7		Open Elective – II*	T	3-0-0	3	3	OEC

Semester – VI (Preference for Foreign Exchange)							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
8	AU23E01	Emerging Technology Course – I	T	3-0-0	3	3	ETC
9		Industry Oriented Course –II	-	-	-	1	SDC
10	AU23L01	Self-Learning Course*	T	1-0-0	1	1	SLC
					Total Credits	**26**	
Courses for Honours Degree							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1.	AU23D02	Capstone Design Project-Level II	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – III	T	3-0-0	3	3	SDC
2.		Honours Elective – IV	T	3-0-0	3	3	SDC
Courses for Minor Degree							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1.		Minor Elective – III	T	3-0-0	3	3	SDC
2.		Minor Elective – IV	T	3-0-0	3	3	SDC
Semester – VII							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	AU23701	Design of Vehicle Components	LIT	3-0-2	5	4	PCC
2	AU23702	Electric and Hybrid Vehicles	LIT	3-0-2	5	4	PCC
3	AU23703	Vehicle Dynamics	LIT	3-0-2	5	4	PCC
4	AU23704	IC Engine Process Modeling	LIT	3-0-2	5	4	PCC
5	AU23E01	Emerging Technology Course – II	T	3-0-0	3	3	ETC
6		Industry Oriented Course –III/ Industrial case study	T	1-0-0	1	1	SDC
7	AU23U02	Perspectives of Sustainable Development in Automobile	LIT	2-0-2	4	3	UC
					Total Credits	**23**	
Courses for Honours Degree							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1.	AU23D03	Capstone Design Project – Level III	CDP	0-0-12	12	6	SDC
(OR)							
1.		Honours Elective – V	T	3-0-0	3	3	SDC
2.		Honours Elective – VI	T	3-0-0	3	3	SDC

Semester – VI (Preference for Foreign Exchange)							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
Courses for Minor Degree							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1.		Minor Elective – V	T	3-0-0	3	3	SDC
2.		Minor Elective – VI	T	3-0-0	3	3	SDC

Semester – VIII							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1.	AU23801	Project Work / Internship cum Project Work	PW/IPW	0-0-16	16	8	SDC
Total Credits						**8**	

PROFESSIONAL ELECTIVE COURSES(PEC) – VERTICALS

Sl. No.	Vertical 1 Advanced Vehicle Technology	Vertical 2 Advanced Engine Technology	Vertical 3 Vehicle Design	Vertical 4 Electric Vehicle Technology	Vertical 5 Advance Technologies	Vertical 6 Diversified Technologies
1.	Special Purpose Vehicles	Engine Management Systems	Vehicle Design data Characteristics	Batteries and Management system	Nanoscience Technology	Principles of Control Systems
2.	Two and Three-Wheeler Technology	Alternative and Advanced Fuels for IC engines.	Geometric Dimension and tolerances	Traction Motors	Manufacturing of Automotive Components	Noise, Vibration and Harshness for Automobiles
3.	Road Vehicle Aerodynamics	Advanced Theory of IC Engines	Metrology and Measurement System	Power Electronics for Electric Vehicle Application	IoT for Electric Vehicles	Vehicle air Conditioning
4.	Vehicle Control Systems	Combustion Thermodynamics and Heat Transfer	New Product Development	Autonomous and Connected Vehicles	Homologation and Certification	Hydraulic and Pneumatic Systems
5.	Advance Automotive Materials	Engine Computational Fluid Dynamics	Reverse Engineering for automobiles	Artificial Intelligence for Vehicles	Additive Manufacturing	Transport Management
6.	Automotive Safety	Supercharging and scavenging	Finite Element Techniques	Electric and Fuel cell Vehicles	Renewable Sources of Energy	Motorsport Technology

VERTICAL 1: ADVANCED VEHICLE TECHNOLOGY							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	AU23C03	Special Purpose Vehicles	T	3-0-0	3	3	PEC
2	AU23001	Two and Three-Wheeler Technology	T	3-0-0	3	3	PEC
3	AU23002	Road Vehicle Aerodynamics	T	3-0-0	3	3	PEC
4	AU23003	Vehicle Control Systems	T	3-0-0	3	3	PEC
5	AU23004	Advance Automotive Materials	T	3-0-0	3	3	PEC
6	AU23005	Automotive Safety	T	3-0-0	3	3	PEC

VERTICAL 2: ADVANCED ENGINE TECHNOLOGY							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	AU23006	Engine Management Systems	T	3-0-0	3	3	PEC
2	AU23007	Alternative and Advanced Fuels for IC engines.	T	3-0-0	3	3	PEC
3	AU23008	Advanced Theory of IC Engines	T	3-0-0	3	3	PEC
4	AU23009	Combustion Thermodynamics and Heat Transfer	T	3-0-0	3	3	PEC
5	AU23010	Engine Computational Fluid Dynamics	T	3-0-0	3	3	PEC
6	AU23011	Supercharging and scavenging	T	3-0-0	3	3	PEC

VERTICAL 3: VEHICLE DESIGN							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	AU23012	Vehicle Design data Characteristics	T	3-0-0	3	3	PEC
2	AU23013	Geometric Dimension and tolerances	T	3-0-0	3	3	PEC
3	AU23014	Metrology and Measurement	T	3-0-0	3	3	PEC
4	AU23015	New Product Development	T	3-0-0	3	3	PEC
5	AU23016	Reverse Engineering for automobiles	LIT	2-0-2	3	3	PEC
6	AU23017	Finite Element Techniques	T	3-0-0	3	3	PEC

VERTICAL 4: ELECTRIC VEHICLE TECHNOLOGY							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	AU23018	Batteries and Management system	T	3-0-0	3	3	PEC
2	AU23019	Traction Motors	T	3-0-0	3	3	PEC
3	AU23020	Power Electronics for Electric Vehicle Application	T	3-0-0	3	3	PEC
4	AU23021	Autonomous and Connected Vehicles	T	3-0-0	3	3	PEC
5	AU23022	Artificial Intelligence for Vehicles	T	3-0-0	3	3	PEC
6	AU23023	Electric and Fuel cell Vehicles	T	3-0-0	3	3	PEC

VERTICAL 5: ADVANCE TECHNOLOGIES							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	AU23024	Nanoscience Technology	T	3-0-0	3	3	PEC
2	AU23025	Manufacturing of Automotive Components	T	3-0-0	3	3	PEC
3	AU23026	IoT for Electric Vehicles	T	3-0-0	3	3	PEC
4	AU23027	Homologation and Certification	T	3-0-0	3	3	PEC
5	MF23C01	Additive Manufacturing	T	3-0-0	3	3	PEC
6	AU23028	Renewable Sources of Energy	T	3-0-0	3	3	PEC

VERTICAL 6: DIVERSIFIED TECHNOLOGIES							
S. No.	Course Code	Course Name	Course Type#	Periods / Week		Credits	Category
				L-T-P	TCP*		
1	AU23029	Principles of Control Systems	T	3-0-0	3	3	PEC
2	AU23030	Noise, Vibration and Harshness for Automobiles	T	3-0-0	3	3	PEC
3	AU23031	Vehicle air Conditioning	T	3-0-0	3	3	PEC
4	AU23032	Hydraulic and Pneumatic Systems	T	3-0-0	3	3	PEC
5	AU23033	Transport Management	T	3-0-0	3	3	PEC
6	AU23034	Motorsport Technology	T	3-0-0	3	3	PEC

HONOURS DEGREE COURSES							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	AU23035	Automotive Instrumentation and Testing	T	3-0-0	3	3	SDC
2	AU23036	Cost Management of Engineering Projects	T	3-0-0	3	3	SDC
3	AU23037	Entrepreneurship Development	T	3-0-0	3	3	SDC
4	AU23038	Ergonomics in Automotive Design	T	3-0-0	3	3	SDC
5	AU23039	Industrial Safety	T	3-0-0	3	3	SDC
6	AU23040	Introduction to Operations Research	T	3-0-0	3	3	SDC
7	AU23041	Total Quality Management	T	3-0-0	3	3	SDC
8	AU23042	Waste to Energy	T	3-0-0	3	3	SDC

MINOR DEGREE COURSES IN AUTOMOTIVE TECHNOLOGY							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	AU23043	Introduction to Automobile Engineering	T	3-0-0	3	3	SDC
2	AU23044	Basics of Automotive Engines	T	3-0-0	3	3	SDC
3	AU23045	Vehicle Chassis	T	3-0-0	3	3	SDC
4	AU23046	Vehicle Driveline Systems	T	3-0-0	3	3	SDC
5	AU23047	Fundamentals of Vehicle Bodywork	T	3-0-0	3	3	SDC
6	AU23048	Introduction to Electric and Hybrid Vehicles	T	3-0-0	3	3	SDC

EMERGING TECHNOLOGY COURSES							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	AU23E01	Fundamentals of Data Science	T	3-0-0	3	3	ETC
2	AU23E02	Fundamentals of Deep Learning	T	3-0-0	3	3	ETC
3	AU23E03	Introduction to Artificial Intelligence	T	3-0-0	3	3	ETC
4	AU23E04	Introduction to Machine Learning	T	3-0-0	3	3	ETC

OPEN ELECTIVE COURSES (OEC) (TO BE OFFERED TO OTHER DEPARTMENT)							
S. No.	**Course Code**	**Course Name**	**Course Type#**	**Periods / Week**		**Credits**	**Category**
				L-T-P	**TCP***		
1	AU23901	Vehicle Technology	T	3-0-0	3	3	OEC
2	AU23902	Automotive Powertrain System	T	3-0-0	3	3	OEC
3	AU23903	Vehicle Safety Systems	T	3-0-0	3	3	OEC
4	AU23904	Two–Wheeler Technology	T	3-0-0	3	3	OEC

EN23C01 **FOUNDATION ENGLISH** **L T P C**
2 0 2 3

COURSE OBJECTIVES:

- To develop students' foundational skills in reading, writing, grammar and vocabulary to enable them to understand and produce various forms of communication.
- To enhance students' proficiency in reading comprehension, narrative and comparative writing.
- To comprehend and analyse descriptive texts and visual images
- To articulate similarities and differences in oral and written forms.
- To improve students' proficiency in reading and writing formal letters and emails.

UNIT I BASICS OF COMMUNICATION 6

Reading - Telephone message, bio-note; Writing – Personal profile; Grammar – Simple present tense, Present continuous tense, wh-questions, indirect questions; Vocabulary – Word formation (Prefix and Suffix).

LAB ACTIVITY: 6

Listening – Telephone conversation; Speaking Self-introduction; Telephone conversation – Video conferencing etiquette

UNIT II NARRATION 6

Reading – Comprehension strategies - Newspaper Report, An excerpt from an autobiography; Writing – Narrative Paragraph writing (Event, personal experience etc.); Grammar – Subject-verb agreement, Simple past, Past continuous Tenses; Vocabulary – One-word substitution

LAB ACTIVITY: 6

Listening – Travel podcast; Speaking – Narrating and sharing personal experiences through a podcast

UNIT III DESCRIPTION 6

Reading – A tourist brochure, Travel blogs, descriptive article/excerpt from literature, visual images; Writing –Descriptive Paragraph writing, Grammar – Future tense, Perfect tenses, Preposition; Vocabulary – Descriptive vocabulary

LAB ACTIVITY: 6

Listening – Railway / Airport Announcements, Travel Vlogs; Speaking – Describing a place or picture description

UNIT IV COMPARE AND CONTRAST 6

Reading – Reading and comparing different product specifications - Writing – Compare and Contrast Essay, Coherence and cohesion; Grammar – Degrees of Comparison; Vocabulary – Transition words (relevant to compare and contrast)

LAB ACTIVITY: **6**

Listening – Product reviews, Speaking – Product comparison based on product reviews - similarities and differences

UNIT V EXPRESSION OF VIEWS **6**

Reading – Formal letters, Letters to Editor ; Writing – Letter writing/ Email writing (Enquiry / Permission, Letter to Editor); Grammar – Compound nouns, Vocabulary – Synonyms, Antonyms

LAB ACTIVITY: **6**

Listening – Short speeches; Speaking – Making short presentations (JAM)

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab assessment
- Listening
- Speaking

External Assessment
- End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- Use appropriate grammar and vocabulary to read different types of text and converse appropriately.
- Write coherent and engaging descriptive and comparative essay writing.
- Comprehend and interpret different kinds of texts and audio visual materials
- Critically evaluate reviews and articulate similarities and differences
- Write formal letters and emails using appropriate language structure and format

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume I by Orient Blackswan, 2022
2. “English for Science & Technology - I” by Cambridge University Press, 2023

REFERENCES

1. “Interchange” by Jack C.Richards, Fifth Edition, Cambridge University Press, 2017.
2. “English for Academic Correspondence and Socializing” by Adrian Wallwork, Springer, 2011.
3. “The Study Skills Handbook” by Stella Cortrell, Red Globe Press, 2019
4. www.uefap.com

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		
CO3										√		√
CO4										√		
CO5										√		√

MA23C01	MATRICES AND CALCULUS	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To develop the use of matrix algebra techniques in solving practical problems.
- To familiarize the student with functions of several variables.
- To solve integrals by using Beta and Gamma functions.
- To acquaint the student with mathematical tools needed in evaluating multiple integrals.
- To acquaint the students with the concepts of vector calculus which naturally arise in many engineering problems.

UNIT I MATRICES 9+3

Eigenvalues and Eigenvectors of a real matrix – Properties of Eigenvalues and Eigenvectors- Cayley-Hamilton theorem (excluding proof) – Diagonalization of matrices - Reduction of Quadratic form to canonical form by using orthogonal transformation - Nature of a Quadratic form.

UNIT II FUNCTIONS OF SEVERAL VARIABLES 9+3

Limit, continuity, partial derivatives – Homogeneous functions and Euler's theorem - Total derivative – Differentiation of implicit functions – Jacobians -Taylor's formula for two variables - Errors and approximations – Maxima and Minima of functions of two variables – Lagrange's method of undermined multipliers.

UNIT III INTEGRAL CALCULUS 9+3

Improper integrals of the first and second kind and their convergence – Differentiation under integrals - Evaluation of integrals involving a parameter by Leibnitz rule – Beta and Gamma functions-Properties – Evaluation of single integrals by using Beta and Gamma functions..

UNIT IV MULTIPLE INTEGRALS 9+3

Double integrals – Change of order of integration – Double integrals in polar coordinates – Area enclosed by plane curves – Triple integrals – Volume of Solids – Change of variables in double and triple integrals-

Evaluation of double and triple integrals by using Beta and Gamma functions.

UNIT V VECTOR CALCULUS 9+3

Gradient of a scalar field, directional derivative – Divergence and Curl – Solenoidal and Irrotational vector fields - Line integrals over a plane curve - Surface integrals – Area of a curved surface – Volume Integral - Green's theorem, Stoke's and Gauss divergence theorems (without proofs)– Verification and applications in evaluating line, surface and volume integrals.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students wherever applicable from the content of the course.

General engineering applications / branch specific applications from the content of each units wherever possible will be introduced to students.

Suggested Laboratory based exercises / assignments / assessments :

Matrices

1. Finding eigenvalues and eigenvectors
2. Verification of Cayley-Hamilton theorem
3. Eigenvalues and Eigenvectors of similar matrices
4. Eigenvalues and Eigenvectors of a symmetric matrix
5. Finding the powers of a matrix
6. Quadratic forms

Functions of Several Variables

1. Plotting of curves and surfaces
2. Symbolic computation of partial and total derivatives of functions

Integral Calculus

1. Evaluation of beta and gamma functions
2. Computation of error function and its complement

Multiple Integrals

1. Plotting of 3D surfaces in Cartesian and Polar forms

Vector Calculus

1. Computation of Directional derivatives
2. Computation of normal and tangent to the given surface

OUTCOMES:

CO 1 :Use the matrix algebra methods for solving practical problems.

CO 2 :Use differential calculus ideas on several variable functions.

CO 3 :Apply different methods of integration in solving practical problems by using Beta and Gamma functions.

CO 4 :Apply multiple integral ideas in solving areas and volumes problems.

CO 5 :Apply the concept of vectors in solving practical problems.

TEXT BOOKS:

1. Joel Hass, Christopher Heil, Maurice D.Weir "'Thomas' Calculus", Pearson Education., New Delhi, 2018.
2. Grewal B.S., "Higher Engineering Mathematics", Khanna Publishers, 45th Edition, New Delhi, 2020.
3. James Stewart, Daniel K Clegg & Saleem Watson "Calculus with Early Transcendental Functions", Cengage Learning, 6th Edition, New Delhi,2023.

REFERENCES:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", 10th Edition, Wiley India Pvt Ltd., New Delhi, 2018.
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5th Edition, New Delhi, 2017.
4. Narayanan S. and Manicavachagom Pillai T. K., “Calculus" Volume I and II, S. Viswanathan Publishers Pvt. Ltd., Chennai, 2009.
5. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
6. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

PH23C01 **ENGINEERING PHYSICS** **L T P C**

(Common to all branches of B.E/B.Tech Programmes) **3 0 2 4**

COURSE OBJECTIVES

- To familiarize with crystal structure, bonding and crystal growth.
- To impart knowledge on Mechanics of Materials.
- To impart knowledge of oscillations, sound and Thermal Physics
- To facilitate understanding of optics and its applications, different types of Lasers and fiber optics.
- To introduce the basics of Quantum Mechanics and its importance.

UNIT I CRYSTAL PHYSICS **9+6**

Crystal Bonding – Ionic – covalent – metallic and van der Walls's/ molecular bonding. Crystal systems - unit cell, Bravais lattices, Miller indices - Crystal structures - atomic packing density of BCC, FCC and HCP structures. NaCl, Diamond, Graphite, Graphene, Zincblende and Wurtzite structures - crystal imperfections- point defects - edge and screw dislocations – grain boundaries. Crystal Growth – Czocharalski method – vapor phase epitaxy – Molecular beam epitaxy- Introduction to X-Ray Diffractometer.

1. Determination of Lattice parameters for crystal systems.
2. Crystal Growth – Slow Evaporation method
3. Crystal Growth Sol – Gel Method

UNIT II MECHANICS OF MATERIALS **9+6**

Rigid Body – Centre of mass – Rotational Energy - Moment of inertia (M.I)- Moment of Inertia for uniform objects with various geometrical shapes. Elasticity –Hooke's law - Poisson's ratio - stress-strain diagram for ductile and brittle materials – uses- Bending of beams – Cantilever - Simply supported beams - uniform and non-uniform bending - Young's modulus determination - I shaped girders –Twisting couple – Shafts. Viscosity – Viscous drag – Surface Tension.

1. Non-uniform bending -Determination of Young's modulus of the material of the beam.
2. Uniform bending -Determination of Young's modulus of the material of the beam
3. Viscosity – Determination of Viscosity of liquids.

UNIT III OSCILLATIONS, SOUND AND THERMAL PHYSICS **9+6**

Simple harmonic motion - Torsional pendulum –- Damped oscillations –Shock Absorber -Forced oscillations and Resonance –Applications of resonance.- Waves and Energy Transport –Sound waves – Intensity level – Standing Waves - Doppler effect and its applications - Speed of blood flow. Ultrasound – applications - Echolocation and Medical Imaging. Thermal Expansion – Expansion joints – Bimetallic strip – Seebeck effect – thermocouple -Heat Transfer Rate – Conduction – Convection and Radiation.

1. Torsional pendulum-Determination of rigidity modulus of wire and moment of inertia of the disc
2. Melde's string experiment - Standing waves.
3. Ultrasonic interferometer – determination of sound velocity and liquids compressibility

UNIT IV OPTICS AND LASERS 9+6

Interference - Thin film interference - Air wedge- Applications -Interferometers–Michelson Interferometer -– Diffraction - CD as diffraction grating – Diffraction by crystals -Polarization - polarizers -– Laser – characteristics – Spontaneous and Stimulated emission- population – inversion - Metastable states - optical feedback - Nd-YAG laser, CO_2 laser, Semiconductor laser - Industrial and medical applications - Optical Fibers – Total internal reflection – Numerical aperture and acceptance angle – Fiber optic communication – Fiber sensors – Fiber lasers.

1. Laser - Determination of the width of the groove of the compact disc using laser.
   Laser Parameters
   Determination of the wavelength of the laser using grating
2. Air wedge -Determination of the thickness of a thin sheet/wire
3. Optical fibre - Determination of Numerical Aperture and acceptance angle
   -Determination of bending loss of fibre.
4. Michelson Interferometer (Demonstration)

UNIT V QUANTUM MECHANICS 9+6

Black body radiation (Qualitative) – Planck's hypothesis – Einstein's theory of Radiation - Matter waves–de Broglie hypothesis - Electron microscope – Uncertainty Principle – The Schrodinger Wave equation (time-independent and time-dependent) – Meaning and Physical significance of wave function - Normalization - Particle in an infinite potential well-particle in a three-dimensional box - Degenerate energy states - Barrier penetration and quantum tunneling - Tunneling microscope.

1. Photoelectric effect – Determination of Planck's constant.
2. Black Body Radiation (Demonstration)
3. Electron Microscope (Demonstration)

TOTAL: 75 PERIODS

COURSE OUTCOMES:

After completion of the course, the students will be able to

CO1: Understand the significance of crystal structure and bonding. Learn to grow crystals.

CO2: Obtain knowledge on important mechanical and thermal properties of materials and determine them through experiments.

CO3: Conceptualize and visualize the oscillations and sound.

CO4: Grasp optical phenomenon and their applications in real life.

CO5: Appreciate and evaluate the quantum phenomenon.

CO6 Develop skill set to solve engineering problems and design experiments.

TEXT BOOKS:

1. Raymond A. Serway, John W. Jewett, Physics for Scientists and Engineers, Thomson Brooks/Cole, 2013.
2. D. Halliday, R. Resnick and J. Walker, Principles of Physics. John Wiley & Sons, 10th Edition, 2015.
3. N. Garcia, A. Damask and S. Schwarz, Physics for Computer Science Students, Springer-Verlag, 2012.
4. Alan Giambattista, Betty McCarthy Richardson and Robert C. Richardson, College Physics, McGraw-Hill Higher Education, 2012.

REFERENCES:

1. R. Wolfson, Essential University Physics. Volume 1 & 2. Pearson, 2016.
2. D. Kleppner and R. Kolenkow. An Introduction to Mechanics, McGraw Hill Education, 2017.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	1		1							
CO2	3	2	1	1								
CO3	3	2	1	1								
CO4	3	2	1	1	1							
CO5	3	2	1	1	1							
CO6	3	2	1	2								

ME23C01	ENGINEERING DRAWING AND 3D MODELING	L	T	P	C
		2	0	4	4

INTRODUCTION

Manual drawing tools (Mini Drafter, Set Squares, Protractor, Compass, and different grades of pencil). **'**BIS' specifications and rules of Engineering Drawing – Arrows (2H thin line body, HB Filled head and L:W = 3:1 ratio), lettering (Digital fonts, font sizes pertaining to usage and representation), types of line and their syntax (Drawing based – Continuous thin & thick, dashed, dashed dotted and Application based – extension, dimensioning, construction, projection, reference, axis, section, hatching, and break lines), scaling (up, down and equal), and dimensioning. Placing and positioning the 'A3' size drawing sheet over the drawing table. Principal planes and projection, Division of line and circle in to equal parts, and construction of polygons

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UNIT 1: ENGINEERING CURVES, PROJECTION OF POINTS AND LINES

Construction of conic curves with their tangent and normal – ellipse, parabola, and hyperbola by eccentricity method

Construction of special curves with their tangent and normal – cycloid, epicycloid, and involute

Projection of points and I angle projection of lines inclined to both principal planes by rotating line method and trapezoidal rule – marking their traces.

Lab exercises: Study exercise – Introduction to Sketching (or) Drawing, and modification tools in CAD software (AutoCAD, CREO, CATIA, Solid Works, Inventor, Fusion 360)

(6+12 = 18 Hours)

Activities based learning: Identification of the curves used in the application given in the flash card, demonstration of the instantaneous centre of rotation of governors with respect to angle of inclination of the arms of the governors

UNIT 2: PROJECTION OF SURFACES & SOLIDS, AND 2D MODELING

Projection of surfaces inclined to both the principal planes – polygonal, trapezoidal, rhomboidal and circular

Projection of solids – prisms, pyramids, and axisymmetric solids when the axis inclined to both the principal planes – freely hanging – contour resting condition on either of the planes by rotating object method

Lab exercises: Construction of basic sketches – lines, circle, polygon, spline curves, coils, along with dimensioning. Familiarizing with geometric constraints and their types

(6+12 = 18 Hours)

Activities based learning: Making the solids using cardboards, shadow mapping and contour drawing at different orientation of the solids using torches

UNIT 3: 3D PROJECTION OF SOLIDS AND 3D MODELING OF SIMPLE PARTS

Free hand sketching – I & III angle projections of engineering parts and components

Isometric projection of combination of solids – prisms, pyramids, axisymmetric solids, frustum

Perspective projection of prisms, pyramids and axisymmetric solids by visual ray method

Lab exercises: 3D Modeling and 2D drafting of machine parts

(6+12 = 18 Hours)

Activities based learning: Flipped classroom for Free hand sketching, Jig saw activity for Isometric projection, arts and crafts for perspective view

UNIT 4: SECTION OF SOLIDS AND SECTIONED DRAFTING OF ASSEMBLED COMPONENTS

Section of simple and hollow solids – prisms, pyramids and axisymmetric solids, solids with holes/ slots when the section plane perpendicular to one principal plane and inclined to other principal plane ('On the axis' and 'from the axis' conditions)

Application based – section of beams (I, T, L, and C), section of pipe bracket, wood joints, composite walls, shells, flange of a coupling and other similar applications

Lab exercises: Assembly of parts with respect to engineering constraints, and sectioned drafting of assembled components

(6+12 = 18 Hours)

Activities based learning: Making of mitered joint in wood, sectioning the beams in different angles of orientation and identifying the true shape

UNIT 5: LATERAL SURFACE DEVELOPMENT AND SHEET METAL DESIGN

Lateral surface development of sectioned solids when the section plane perpendicular to VP and inclined to HP.

Application based – construction of funnel, chimney, dish antenna, door latch, trays, AC vents, lamp shade, commercial packaging boxes with respect to sectioning conditions and other similar applications

Lab exercises: Sheet metal design and drafting, drafting of coils, springs and screw threads

(6+12 = 18 Hours)

Activities based learning: Fabrication of funnels, chimney, lamp shade, boxes using card boards, ply woods, acrylics

Total: 90 Hours

Note: Activities based learning should not be covered in the regular class hours. It should be given as assignments to the group of maximum 3 members

COURSE OBJECTIVES

After successful completion of this course, the students will be able to:

1. Understand and use the engineering curves in engineering applications and projection techniques to construct conic curves, points and lines.
2. Develop skills in projecting surfaces and solids and create 2D models using CAD software.
3. Develop skills in 3D projection and 3D modeling of simple parts manually as well as using CAD software.
4. Understand and apply sectioning techniques to solids and assemble components.
5. Develop skills in lateral surface development and sheet metal design.

COURSE OUTCOMES

After successful completion of the course, the students will be able to:

CO1: Construct and identify different types of conic curves and special curves, and project the points and lines pertaining to engineering applications

CO2: Project and visualize surfaces and solids in different orientations and utilize the CAD tools for designing.

CO3: Create and draft accurate 3D models and 2D drawings of machine parts manually as well as using CAD software

CO4: Determine the true shape of a sectioned solid and draft the assembled parts accordingly

CO5: Develop lateral surfaces of sectioned solids and design sheet metal components

Text book

1. “Engineering Drawing” by N S Parthasarathy and Vela Murali, Oxford University Press; UK ed. Edition, 2015.
2. “Engineering Drawing + Auto CAD” by Venugopal K, V. Prabhu Raja, New Age International Publishers, Sixth edition (1 January 2022).

References

1. "Basic Engineering Drawing: Mechanical Semester Pattern" by Mehta and Gupta, Charotar Publishing House, 2nd edition, 2018.
2. "Engineering Drawing" by Basant Agrawal and C M Agrawal, Vikas Publishing House, 3rd edition, 2020.
3. "Engineering Drawing With Auto CAD" by B V R Gupta, McGraw Hill Education, 4th edition, 2019.
4. "Engineering Drawing" by P S Gill, Tata McGraw Hill Education, 5th edition, 2018.
5. "Engineering Drawing with an Introduction to AutoCAD" by Dhananjay Jolhe, Cengage Learning, 2nd edition, 2020.
6. "Engineering Drawing" by M B Shah, Charotar Publishing House, 3rd edition, 2019
7. "Fundamentals of Engineering Drawing" by Imtiaz Hashmi, Pearson Education, 2nd edition, 2018.
8. "Computer Aided Engineering Drawing" by S Trymbaka Murthy, Scitech Publications, 3rd edition, 2020.
9. "CAED: Computer Aided Engineering Drawing for I/II Semester BE/Btech Courses" by Reddy K B, CBS Publishers & Distributors, 2nd, 2019.
10. "Computer-Aided Engineering Drawing" by Subrata Pal, Oxford University Press, 2nd, 2020.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2		1				3	1		3	3	3	2
2	3	3	2		2				3	2		3	3	3	2
3	3	3	3	1	2				3	3		3	3	3	2
4	3	3	3	1	3				3	3		3	3	3	2
5	3	3	3	1	3				3	3		3	3	3	2

EE23C03	BASICS OF ELECTRICAL AND ELECTRONICS ENGINEERING	L	T	P	C
		2	0	2	3

UNIT-I BASIC ELECTRICAL CIRCUITS 6

Basic Elements: R,L,C- DC Circuits: Ohm's Law - Kirchhoff's Laws –Mesh and Nodal Analysis(Only Independent Sources). AC Circuits: Average Value, RMS Value, Impedance Instantaneous Power, Real Power, Reactive Power and Apparent Power, Power Factor-Steady state Analysis of RL,RC and RLC circuits.

UNIT II AC AND DC MACHINES 6

Magnetic Circuit Fundamentals -DC Machines - Construction and Working Principle, Types and Application of DC generator and Motor, EMF and Torque Equation.

AC Machines: Principle, Construction, Working and Applications of Transformer -Three phase Alternator - Three Phase Induction Motor.

UNIT III ANALOG AND DIGITAL ELECTRONICS 6

Operation and Characteristics of electronic devices: PN Junction Diodes, Zener Diode and BJT Applications: Diode Bridge Rectifier and Shunt Regulator.

Introduction to Digital Electronics: Basics Logic Gates-Flip Flops.

UNIT IV SENSORS AND TRANSDUCERS 6

Solenoids, electro-pneumatic systems, proximity sensors, limit switches, Strain gauge, LVDT, Piezo electric transducer, optical and digital transducers, Smart sensors, Thermal Imagers.

UNIT V MEASUREMENTS AND INSTRUMENTATION 6

Functional Elements of an Instrument, Operating Principle of Moving Coil and Moving Iron Instruments, Power Measurement, Energy Meter, Instrument Transformers - CT and PT, Multimeter- DSO - Block Diagram Approach.

TOTAL:30 PERIODS

LAB COMPONENET:

1. Verification of ohms and Kirchhoff's Laws.
2. Load test on DC Shunt Motor.
3. Load test on Single Phase Transformer.
4. Load test on 3 Phase Induction Motor.
5. Uncontrolled diode bridge Rectifiers.
6. Application of Zener diode as shunt regulator.
7. Verification of truth table of logic gates and flip flops.
8. Characteristics of LVDT.
9. Three phase power measurement using two wattmeter method.
10. Study of DSO.

COURSE OUTCOMES:

Students will be able to

CO1 Compute the electric circuit parameters for simple circuits.

CO2 Understand the working principles and characteristics of electrical machines.

CO3 Understand the basic electronic devices.

CO4 Understand the basic operating principles of sensors and transducer.
CO5 Understand the operating principles measuring devices

TEXT BOOKS:

1. Kotharai DP and Nagarath IJ, “Basic Electrical and Electronics Enigneering”, McGraw Hill Education, Second Edition, 2020.
2. Bhattacharya SK, “Basic Electrical and Electronics Engineering”, Pearson Education, Second Edition, 2017.

REFERENCES:

1. Mehta V.K. & Mehta Rohit, “Principles of Electrical Engineering and Electronics”, McGraw Hill Education, Second Edition, 2020.
2. Mehta V.K. & Mehta Rohit, “Principles of Electrical Machines”, S. Chand Publishing, second edition 2006.
3. Albert Malvino & David Bates, “Electronic principles”, McGraw Hill Education, Seventh Edition, 2017.

Mapping COs and POs:

COs	Pos												PSOs			
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	2	1														
CO2	2	1														
CO3	2	1														
CO4	2	1														
CO5	2	1														
Avg	2	1														

ME23C04	MAKERSPACE	L	T	P	C
		1	0	4	3

COURSE OBJECTIVES:

1. To practice the usage of various tools towards assembly and dis-assembly of different items / equipment.
2. To make simple part / component using welding processes.
3. To train on the basic wiring practices of boards, machines, etc.
4. To provide a hands-on experience on the use of electronic components, equipment, sensors and actuators.
5. To expose to modern computer tools and advanced manufacturing / fabrication processes.

LIST OF ACTIVITIES **1L,4P**

(A). Dis-assembly & Assembly Practices

i. Tools and its handling techniques.

ii. Dis-assembly and assembly of home appliances – Grinder Mixer Grinder, Ceiling Fan, Table Fan & Washing Machine.

iii. Dis-assembly and assembly of Air-Conditioners & Refrigerators.

iv. Dis-assembly and assembly of a Bicycle.

(B). Welding Practices

i. Welding Procedure, Selection & Safety Measures.

ii. Power source of Arc Welding – Gas Metal Arc Welding & Gas Tungsten Arc Welding processes.

iii. Hands-on session of preparing base material & Joint groove for welding.

iv. Hands-on session of MAW, GMAW, GTAW, on Carbon Steel & Stainless Stell plates / pipes, for fabrication of a simple part.

(C). Electrical Wiring Practices

i. Electrical Installation tools, equipment & safety measures.

ii. Hands-on session of basic electrical connections for Fuses, Miniature Circuit Breakers and Distribution Box,

iii. Hands-on session of electrical connections for Lightings, Fans, Calling Bells.

iv. Hands-on session of electrical connections for Motors & Uninterruptible Power Supply.

(D). Electronics Components / Equipment Practices

i. Electronic components, equipment & safety measures.

ii. Dis-assembly and assembly of Computers.

iii. Hands-on session of Soldering Practices in a Printed Circuit Breaker.

iv. Hands-on session of Bridge Rectifier, Op-Amp and Transimpedance amplifier.

v. Hands-on session of integration of sensors and actuators with a Microcontroller.

vi. Demonstration of Programmable Logic Control Circuit.

(E). Contemporary Systems

i. Demonstration of Solid Modelling of components.

ii. Demonstration of Assembly Modelling of components.

iii. Fabrication of simple components / parts using 3D Printers.

iv. Demonstration of cutting of wood / metal in different complex shapes using Laser Cutting Machine.

TOTAL: 75 Periods (15 Lecture + 60 Practical)

COURSE OUTCOMES:

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

CO1: Assemble and dis-assemble various items / equipment.
CO2: Make simple parts using suitable welding processes.
CO3: Setup wiring of distribution boards, machines, etc.
CO4: Utilise the electronic components to fabricate a simple equipment, aided with sensors and actuators.
CO5: Take advantage of modern manufacturing practices.

REFERENCES:

1. Stephen Christena, Learn to Weld: Beginning MIG Welding and Metal Fabrication Basics, Crestline Books, 2014.
2. H. Lipson, Fabricated - The New World of 3D Printing, Wiley, 1st edition, 2013.
3. Code of Practice for Electrical Wiring Installations (IS 732:2019)
4. A.S. Sedra and K.C. Smith, Microelectronic Circuits, Oxford University Press, 7th ed. (Indian edition), 2017.
5. Mazidi, Naimi, Naimi, AVR Microcontroller and Embedded Systems: Using Assembly and C, Pearson India, 1st edition 2013.
6. Visualization, Modeling, and Graphics for Engineering Design, D.K. Lieu, S.A. Sorby, Cengage Learning; 2nd edition.

UC23H01 **தமிழர் மரபு** **L T P C**
1 0 0 1

அலகு I **மொழி மற்றும் இலக்கியம்**: **3**

இந்திய மொழிக் குடும்பங்கள் – திராவிட மொழிகள் – தமிழ் ஒரு செம்மொழி – தமிழ் செவ்விலக்கியங்கள் - சங்க இலக்கியத்தின் சமயச் சார்பற்ற தன்மை – சங்க இலக்கியத்தில் பகிர்தல் அறம் – திருக்குறளில் மேலாண்மைக் கருத்துக்கள் – தமிழ்க் காப்பியங்கள், தமிழகத்தில் சமண பௌத்த சமயங்களின் தாக்கம் - பக்தி இலக்கியம், ஆழ்வார்கள் மற்றும் நாயன்மார்கள் – சிற்றிலக்கியங்கள் – தமிழில் நவீன இலக்கியத்தின் வளர்ச்சி – தமிழ் இலக்கிய வளர்ச்சியில் பாரதியார் மற்றும் பாரதிதாசன் ஆகியோரின் பங்களிப்பு.

அலகு II **மரபு – பாறை ஓவியங்கள் முதல் நவீன ஓவியங்கள் வரை – சிற்பக் கலை**: **3**

நடுகல் முதல் நவீன சிற்பங்கள் வரை – ஐம்பொன் சிலைகள்– பழங்குடியினர் மற்றும் அவர்கள் தயாரிக்கும் கைவினைப் பொருட்கள், பொம்மைகள் – தேர் செய்யும் கலை – சுடுமண் சிற்பங்கள் – நாட்டுப்புறத் தெய்வங்கள் – குமரிமுனையில் திருவள்ளுவர் சிலை – இசைக் கருவிகள் – மிருதங்கம், பறை, வீணை, யாழ், நாதஸ்வரம் – தமிழர்களின் சமூக பொருளாதார வாழ்வில் கோவில்களின் பங்கு.

அலகு III **நாட்டுப்புறக் கலைகள் மற்றும் வீர விளையாட்டுகள்**: **3**

தெருக்கூத்து, கரகாட்டம், வில்லுப்பாட்டு, கணியான் கூத்து, ஒயிலாட்டம், தோல்பாவைக் கூத்து, சிலம்பாட்டம், வளரி, புலியாட்டம், தமிழர்களின் விளையாட்டுகள்.

அலகு IV **தமிழர்களின் திணைக் கோட்பாடுகள்**: **3**

தமிழகத்தின் தாவரங்களும், விலங்குகளும் – தொல்காப்பியம் மற்றும் சங்க இலக்கியத்தில் அகம் மற்றும் புறக் கோட்பாடுகள் – தமிழர்கள் போற்றிய அறக்கோட்பாடு – சங்ககாலத்தில் தமிழகத்தில் எழுத்தறிவும், கல்வியும் – சங்ககால நகரங்களும் துறை முகங்களும் – சங்ககாலத்தில் ஏற்றுமதி மற்றும் இறக்குமதி – கடல்கடந்த நாடுகளில் சோழர்களின் வெற்றி.

அலகு V **இந்திய தேசிய இயக்கம் மற்றும் இந்திய பண்பாட்டிற்குத் தமிழர்களின் பங்களிப்பு**: **3**

இந்திய விடுதலைப்போரில் தமிழர்களின் பங்கு – இந்தியாவின் பிறப்பகுதிகளில் தமிழ்ப் பண்பாட்டின் தாக்கம் – சுயமரியாதை இயக்கம் – இந்திய மருத்துவத்தில், சித்த மருத்துவத்தின் பங்கு – கல்வெட்டுகள், கையெழுத்துப்படிகள் - தமிழ்ப் புத்தகங்களின் அச்சு வரலாறு.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல்

துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City Civilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

UC23H01 HERITAGE OF TAMILS L T P C
1 0 0 1

UNIT I LANGUAGE AND LITERATURE 3

Language Families in India - Dravidian Languages – Tamil as a Classical Language - Classical Literature in Tamil – Secular Nature of Sangam Literature – Distributive Justice in Sangam Literature - Management Principles in Thirukural - Tamil Epics and Impact of Buddhism & Jainism in Tamil Land - Bakthi Literature Azhwars and Nayanmars - Forms of minor Poetry - Development of Modern literature in Tamil - Contribution of Bharathiyar and Bharathidhasan.

UNIT II HERITAGE - ROCK ART PAINTINGS TO MODERN ART – SCULPTURE 3

Hero stone to modern sculpture - Bronze icons - Tribes and their handicrafts - Art of temple car making - - Massive Terracotta sculptures, Village deities, Thiruvalluvar Statue at Kanyakumari, Making of musical instruments - Mridhangam, Parai, Veenai, Yazh and Nadhaswaram - Role of Temples in Social and Economic Life of Tamils.

UNIT III FOLK AND MARTIAL ARTS 3

Therukoothu, Karagattam, Villu Pattu, Kaniyan Koothu, Oyillattam, Leather puppetry, Silambattam, Valari, Tiger dance - Sports and Games of Tamils.

UNIT IV THINAI CONCEPT OF TAMILS 3

Flora and Fauna of Tamils & Aham and Puram Concept from Tholkappiyam and Sangam Literature - Aram Concept of Tamils - Education and Literacy during Sangam Age - Ancient Cities and Ports of Sangam Age - Export and Import during Sangam Age - Overseas Conquest of Cholas.

UNIT V CONTRIBUTION OF TAMILS TO INDIAN NATIONAL MOVEMENT AND INDIAN CULTURE 3

Contribution of Tamils to Indian Freedom Struggle - The Cultural Influence of Tamils over the other parts of India – Self-Respect Movement - Role of Siddha Medicine in Indigenous Systems of Medicine – Inscriptions & Manuscripts – Print History of Tamil Books.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும் கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils - The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi - 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department of Archaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

NCC Credit Course Level 1*

UC23P01	(ARMY WING) NCC Credit Course Level - I	L	T	P	C
		2	0	0	2

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour 'Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P02	**(NAVAL WING) NCC Credit Course Level – I**	**L**	**T**	**P**	**C**
		2	**0**	**0**	**2**

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
PD 1	Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

NCC Credit Course Level 1*

UC23P03	**(AIR FORCE WING) NCC Credit Course Level – I**	**L T P C** **2 0 0 2**

NCC GENERAL		**6**
NCC 1	Aims, Objectives & Organization of NCC	1
NCC 2	Incentives	2
NCC 3	Duties of NCC Cadet	1
NCC 4	NCC Camps: Types & Conduct	2
NATIONAL INTEGRATION AND AWARENESS		**4**
NI 1	National Integration: Importance & Necessity	1
NI 2	Factors Affecting National Integration	1
NI 3	Unity in Diversity & Role of NCC in Nation Building	1
NI 4	Threats to National Security	1
PERSONALITY DEVELOPMENT		**7**
	PD 1Self-Awareness, Empathy, Critical & Creative Thinking, Decision Making and Problem Solving	2
PD 2	Communication Skills	3
PD 3	Group Discussion: Stress & Emotions	2
LEADERSHIP		**5**
L 1	Leadership Capsule: Traits, Indicators, Motivation, Moral Values, Honour Code	3
L 2	Case Studies: Shivaji, Jhasi Ki Rani	2
SOCIAL SERVICE AND COMMUNITY DEVELOPMENT		**8**
SS 1	Basics, Rural Development Programmes, NGOs, Contribution of Youth	3
SS 4	Protection of Children and Women Safety	1
SS 5	Road / Rail Travel Safety	1
SS 6	New Initiatives	2
SS 7	Cyber and Mobile Security Awareness	1

TOTAL : 30 PERIODS

EN23C02 **PROFESSIONAL COMMUNICATION** **L T P C**

2 0 2 3

COURSE OBJECTIVES:

- To read and comprehend different forms of official texts.
- To develop students' writing skills in professional context.
- To actively listen, read and understand written and oral communication in a professional context.
- To comprehend and analyse the visual content in authentic context.
- To write professional documents with clarity and precision

UNIT I CAUSE AND EFFECT **6**

Reading – Newspaper articles on Social and Environmental issues; Writing – Instructions, Cause and effect essay; Grammar - Modal verbs; Vocabulary – Cause and effect, Idioms

LAB ACTIVITY: **6**

Listening and Speaking – Listen to news reports and summarise in oral form.

UNIT II CLASSIFICATION **6**

Reading – An article, social media posts and classifying based on the content; Writing – Definition, Note making, Note taking (Cornell notes etc.) and Summarising; Grammar – Connectives; Vocabulary – Phrasal verbs

LAB ACTIVITY: **6**

Listening and speaking: Social interaction (Conversation including small talk)

UNIT III PROBLEM AND SOLUTION **6**

Reading – Visual content (Tables/charts/graphs) for comprehension; Writing - Problem and Solution Essay; Grammar – If conditionals; Vocabulary – Sequential words.

LAB ACTIVITY: **6**

Listening – Group discussion; Speaking – Participating in a group discussion

UNIT IV REPORT **6**

Reading – Formal report on accidents (industrial/engineering); Writing – Industrial Accident report; Grammar – Active and passive voice, Direct and Indirect speech; Vocabulary – Numerical adjectives.

LAB ACTIVITY: **6**

Listening / watching – Television documentary and discussing its content, purpose etc.

UNIT V JOB APPLICATION AND INTERVIEW **6**

Reading - Job advertisement and company profile; Writing – Job application (cover letter and CV) Grammar – Mixed Tenses; Vocabulary – Collocations related to work environment

LAB ACTIVITY: **6**

Listening – Job interview; Speaking – Mock interviews

TOTAL: 60 PERIODS

TEACHING METHODOLOGY

Interactive lectures, role plays, group discussions, listening and speaking labs, technology enabled language teaching, flipped classroom.

EVALUATION PATTERN

Internal Assessment
- Written assessments
- Assignment

Lab Assessment
- Group discussion (Peer assessment)
- Listening

External Assessment
End Semester Examination

LEARNING OUTCOMES

By the end of the courses, students will be able to

- To apply appropriate language structure and vocabulary to enhance both spoken and written communication in formal contexts.
- Comprehend different forms of official documents
- Write professional documents coherently and cohesively.
- Interpret verbal and graphic content in authentic context
- Analyse and evaluate verbal and audio visual materials.

TEXT BOOKS:

1. “English for Engineers and Technologists” Volume 2 by Orient Blackswan, 2022
2. “English for Science & Technology - II” by Cambridge University Press, 2023.

REFERENCES:

1. “Communicative English for Engineers and Professionals” by Bhatnagar Nitin, Pearson India, 2010.
2. ”Take Off – Technical English for Engineering” by David Morgan, Garnet Education, 2008.
3. “Advanced Communication Skills” by Mathew Richardson, Charlie Creative Lab, 2020.
4. www.uefap.com

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										√		√
CO2										√		√
CO3										√		√
CO4										√		√
CO5										√		√

MA23C02	ORDINARY DIFFERENTIAL EQUATIONS AND TRANSFORM TECHNIQUES	L	T	P	C
		3	1	0	4

OBJECTIVES:

- To acquaint the students with Differential Equations which are significantly used in engineering problems.
- To make the students to understand the Laplace transforms techniques.
- To develop the analytic solutions for partial differential equations used in engineering by Fourier series.
- To acquaint the student with Fourier transform techniques used in wide variety of situations in which the functions used are not periodic.
- To develop Z- transform techniques in solving difference equations.

UNIT I ORDINARY DIFFERENTIAL EQUATIONS 9+3

Homogeneous linear ordinary differential equations of second order -superposition principle - general solution- Particular integral - Operator method - Solution by variation of parameters - Method of undetermined coefficients - Homogeneous equations of Euler–Cauchy and Legendre's type – System of simultaneous linear differential equations with constant coefficients.

UNIT II LAPLACE TRANSFORMS 9+3

Existence theorem - Transform of standard functions – Transform of Unit step function and Dirac delta function – Basic properties - Shifting theorems - Transforms of derivatives and integrals – Transform of periodic functions - Initial and Final value theorem - Inverse Laplace transforms- Convolution theorem (without proof) – Solving Initial value problems by using Laplace Transform techniques.

UNIT III FOURIER SERIES 9+3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half-range Sine and Cosine series – Complex form of Fourier series – Parseval's identity – Computation of harmonics.

UNIT IV FOURIER TRANSFORMS 9+3

Fourier integral theorem – Fourier transform pair - Fourier sine and cosine transforms – Properties – Transform of elementary functions – Inverse Fourier Transforms - Convolution theorem (without proof) – Parsevals's identity.

UNIT V Z – TRANSFORM AND DIFFERENCE EQUATIONS 9+3

Z-transform – Properties of Z-transform – Inverse Z-transform – Convolution theorem – Evaluation of Inverse Z transform using partial fraction method and convolution theorem - Initial and final value theorems – Formation of difference equations – Solution of difference equations using Z - transform.

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

OUTCOMES:

CO1 :Solve higher order ordinary differential equations which arise in engineering applications.
CO2 :Apply Laplace transform techniques in solving linear differential equations.
CO3 :Apply Fourier series techniques in engineering applications.
CO4 :Understand the Fourier transforms techniques in solving engineering problems.
CO5 :Understand the Z-transforms techniques in solving difference equations.

Suggested Laboratory based exercises / assignments / assessments :

Ordinary differential equations

1. Symbolic computation of linear ordinary differential equations
2. Solving System of simultaneous linear differential equations using ODE SOLVER

Laplace transforms

1. Symbolic computation of Laplace transform and Inverse Laplace transform
2. Plotting Laplace transforms

Fourier Series

1. Symbolic computation of Fourier Coefficients
2. Computation of harmonics
3. Plotting truncated Fourier Series

Fourier Transform

1. Symbolic computation of Fourier Transforms
2. Plotting truncated Fourier Transforms

Z – transform

1. Symbolic computation of Z-Transforms

TEXT BOOKS:

1. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 45th Edition, New Delhi, 2020.
2. Erwin Kreyszig, "Advanced Engineering Mathematics", 10^{th} Edition, Wiley India Pvt Ltd., New Delhi, 2018.

REFERENCES:

1. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008
2. Greenberg M.D., “Advanced Engineering Mathematics”, Pearson Education2nd Edition, 5th Reprint, Delhi, 2009.
3. Jain R.K. and Iyengar S.R.K., “Advanced Engineering Mathematics”,Narosa Publications, 5 th Edition, New Delhi, 2017.
4. Peter V.O’Neil, “Advanced Engineering Mathematics”, Cengage Learning India Pvt., Ltd, 7 th Edition, New Delhi , 2012.
5. Ramana B.V., “Higher Engineering Mathematics”, Tata McGraw Hill Co. Ltd., 11th Reprint, New Delhi, 2010.

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO 1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO 5 :	3	3	2	3	1	2	1	1	1	1	1	3

PH23C04	FUNDAMENTALS OF MATERIALS SCIENCE AND ENGINEERING	L T P C 3 0 0 3

COURSE OBJECTIVES:

- To make the students to understand the basics of phase diagrams and their applications.
- To introduce various strengthening methods of materials, and also various mechanical properties and their measurement.
- To learn about iron-carbon system, effect of alloying elements and various transformations in the Fe-C system.
- To instill the phase transformations and various heat treatment processes.
- To introduce the advanced materials preparation, properties and applications of ceramics and composites.

UNIT I PHASE DIAGRAMS 9

Solid solutions - Hume Rothery's rules - The phase rule – Gibbs Free Energy - single component system (iron) - binary phase diagrams - isomorphous systems (Cu-Ni) - determination of phase composition and phase amounts -the tie-line rule - the lever rule - eutectic phase diagram - peritectic phase diagram - other invariant reactions - binary eutectic diagram with no solid solution and limited solid solution (Pb-Sn)– microstructural change during cooling.

UNIT II MECHANICAL PROPERTIES 9

Tensile test - plastic deformation by slip – slip systems – mechanisms of strengthening in metals: strain hardening, grain size reduction, solid solution strengthening, precipitation hardening – Creep: creep curves, stress and temperature effects, mechanisms of creep, creep-resistant materials – Fracture: ductile and brittle fractures - the Griffith criterion – fracture toughness - Fatigue failure: the S-N curve – factors that affect fatigue life – Hardness: Rockwell and Brinell hardness tests, Knoop and Vicker's microhardness tests.

UNIT III FERROUS ALLOYS AND STEELS 9

The iron-carbon equilibrium diagram - phases, invariant reactions - microstructure of slowly cooled steels - eutectoid steel, hypo and hypereutectoid steels - effect of alloying elements on the Fe-C system - steels - stainless steels - cast irons - copper alloys – aluminum alloys - titanium alloys - NiTi alloy and its applications

UNIT IV HEAT TREATMENT OF MATERIALS 9

Phase transformations - T-T-T-diagram for eutectoid steel – pearlitic, bainitic and martensitic transformations - tempering of martensite - precipitation and age hardening, function of alloying elements, heat treatment of steels - annealing - normalizing - quenching and tempering - case hardening - induction- flame and laser hardening - carburizing, cyaniding - carbonitriding and nitriding.

UNIT V ADVANCED MATERIALS 9

High-temperature materials, Ceramics – types – properties and applications- Composites: classification, role of matrix and reinforcement - Fiber reinforced composites – carbon-carbon

composites, metallic glasses -types-glass forming ability of alloys, Smart materials -Shape memory alloys properties and applications – Nanocomposites – Carbon based Nanocomposites and Applications.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will

CO1: Gain knowledge of the basics of binary phase diagrams and the use of lever rule
CO2: Understand the significance of dislocations, strengthening mechanisms, and tensile, creep, hardness and fracture behavior of materials
CO3: Learn about the Fe-C phase diagram, the effect of alloying elements, TTT in the Fe-C system, and also the heat treatment of steels.
CO4: Acquire knowledge on heat treatment of materials and phase transformations
CO5: Get an adequate understanding of the preparation, properties, and applications of ceramics, composites, metallic glasses, and shape-memory alloys

TEXTBOOKS:

1. Raghavan, V. “Physical Metallurgy: Principles and Practice”, Phi Learning (2009).
2. Balasubramaniam, R. “Callister's Materials Science and Engineering”, Wiley India Pvt. Ltd. (2014).

REFERENCES:

1. Raghavan, V. “Materials Science and Engineering”, Prentice Hall of India (2007).
2. Shackelford, J.F. “Introduction to Materials Science for Engineers”. Pearson India (2006).
3. Donald Askeland. “Materials Science and Engineering”, Brooks/Cole (2010).
4. Smith, W.F., Hashemi, J. and R. Prakashh. “Materials Science and Engineering”, Tata McGraw Hill Education Private Limited (2014).

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1	1	1	1							
CO2	3	2	1	1	1							
CO3	2	2	1	1	1							
CO4	2	2	1	2	1							
CO5	2	2	2	2	1							

CY23C01	ENGINEERING CHEMISTRY	L T P C
		3 0 2 4

UNIT I WATER TECHNOLOGY

Water – sources and impurities – water quality parameters: colour, odour, pH, hardness, alkalinity, TDS, COD, BOD, and heavy metals. Boiler feed water – requirement – troubles (scale & sludge, caustic embrittlement, boiler corrosion and priming & foaming. Internal conditioning – phosphate, Calgon, and carbonate treatment. External conditioning – demineralization. Municipal water treatment (screening, sedimentation, coagulation, filtration, disinfection-ozonolysis, UV treatment, chlorination), Reverse Osmosis – desalination.

PRACTICAL:

- Estimation of HCl using Na_2CO_3 as the primary standard
- Determination of alkalinity in the water sample.
- Determination of hardness of water by EDTA method.
- Determination of DO content of water sample by Winkler's method.

UNIT II NANOCHEMISTRY

Basics-distinction between molecules, nanomaterials and bulk materials; size-dependent properties (optical, electrical, mechanical, magnetic and catalytic). Types –nanoparticle, nanocluster, nanorod, nanowire and nanotube. Preparation of nanomaterials: sol-gel, solvothermal, laser ablation, chemical vapour deposition, electrochemical deposition and electro-spinning. Characterization - Scanning Electron Microscope and Transmission Electron Microscope - Principle and instrumentation (block diagram). Applications of nanomaterials – medicine including AYUSH, automobiles, electronics, and cosmetics.

PRACTICAL:

- Preparation of nanoparticles by Sol-Gel method/sonication method.
- Preparation of nanowire by Electrospinning.
- Study of morphology of nanomaterials by scanning electron microscopy

UNIT III CORROSION SCIENCE

Introduction to corrosion – chemical and electrochemical corrosions – mechanism of electrochemical and galvanic corrosions – concentration cell corrosion-soil, pitting, inter-granular, water line, stress and microbiological corrosions-galvanic series-factors influencing corrosion- measurement of corrosion rate. Electrochemical protection – sacrificial anodic protection and impressed current cathodic protection. Protective coatings-metallic coatings (galvanizing, tinning), organic coatings (paints). Paints: Constituents and functions.

PRACTICAL:

- Corrosion experiment-weight loss method.
- Salt spray test for corrosion study.
- Corrosion prevention by electroplating.
- Estimation of corroded Iron by Potentiometry/UV-visible spectrophotometer

UNIT IV ENERGY SOURCES

Electrochemical cell, redox reaction, electrode potential – oxidation and reduction potential. Batteries – Characteristics; types of batteries; primary battery (dry cell), secondary battery (lead acid, lithium-ion battery) and their applications. Emerging energy sources – metal hydride battery, hydrogen energy, Fuel cells – H_2-O_2 fuel cell. Supercapacitors –Types and Applications, Renewable Energy: solar heating and solar cells. Recycling and disposal of batteries.

PRACTICAL:

- Study of components of Lead acid battery.
- Measurement of voltage in a photovoltaic cell.
- Working of $H_2 – O_2$ fuel cell

UNIT V POLYMER CHEMISTRY

Introduction: Functionality-degree of polymerization. Classification of polymers (Source, Structure, Synthesis and Intermolecular forces). Mechanism of free radical addition polymerization. Properties of polymers: Tg, tacticity, molecular weight-number average, weight average, viscosity average and polydispersity index (Problems). Techniques of polymerization: Bulk, emulsion, solution and suspension. Compounding and Fabrication Techniques: Injection, Extrusion, Blow and Calendaring. Polyamides, Polycarbonates and Polyurethanes – structure and applications. Recycling of polymers.

PRACTICAL:

- Determination of molecular weight of a polymer using Ostwald viscometer.
- Preparation of a polymer.
- Determination of molecular weight by Gel Permeation Chromatography.

TOTAL: 75 PERIODS

COURSE OUTCOMES:

CO1: To demonstrate knowledge of water quality in various industries and develop skills in analyzing water quality parameters for both domestic and industrial purposes.

CO2: To identify and apply fundamental concepts of nanoscience and nanotechnology for engineering and technology applications, and to develop skills in synthesizing nanomaterials and studying their morphology.

CO3: To apply fundamental knowledge of corrosion protection techniques and develop skills to conduct experiments for measuring and preventing corrosion.

CO4: To study the fundamentals of energy storage devices and develop skills in constructing and experimenting with batteries.

CO5: To recognize and apply basic knowledge of different types of polymeric materials and develop skills in preparing and determining their applications for futuristic material fabrication needs.

TEXT BOOKS:

1. Jain P. C. & Monica Jain., “Engineering Chemistry”, 17th Edition, Dhanpat Rai Publishing Company (P) Ltd, New Delhi, 2015.
2. Sivasankar B., “Engineering Chemistry”, Tata McGraw-Hill Publishing Company Ltd, New

Delhi, 2012.
3. Dara S.S., “A Textbook of Engineering Chemistry”, Chand Publications, 2004.
4. Laboratory Manual - Department of Chemistry, CEGC, Anna University (2023).

REFERENCES:

1. Schdeva M.V., “Basics of Nano Chemistry”, Anmol Publications Pvt Ltd, 2011.
2. Friedrich Emich, “Engineering Chemistry”, Medtech, 2014.
3. Gowariker V.R., Viswanathan N.V. and Jayadev Sreedhar, “Polymer Science” New AGE International Publishers, 2009.
4. Vogel’s Textbook of Quantitative Chemical Analysis (8th edition, 2014).

CO - PO Mapping

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	-	-	-	3	-	-	-	-	-
CO2	3	-	2	-	2	-	3	-	-	-	-	-
CO3	3	3	2	-	2	-	3	-	-	-	-	-
CO4	3	3	-	-	-	-	3	-	-	-	-	-
CO5	3	-	-	-	-	-	3	-	-	-	-	-
Avg	3	3	-	-	-	-	3	-	-	-	-	-

1’ = Low; ‘2’ = Medium; ‘3’ = High

CS23C02 COMPUTER PROGRAMMING IN PYTHON

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

- To understand fundamental structural programming concepts and problem-solving process.
- To solve problems using modular programming and decomposition techniques.
- To solve problems using data structures and abstraction techniques.
- To create programming solutions using libraries and packages.
- To design solutions to domain problems using programming problem-solving techniques.

UNIT I – STRUCTURED PROGRAMMING 9+6

Problem-Solving Strategies. Basic Problem-Solving Tools: Flowcharts, Pseudocode. Introduction to Programming Languages and Development Environments. Programming. Basic Concepts and Syntax: Variables, Identifiers, Data Types: Primitive Types and Strings, Statements, Operators, Expressions and its evaluation, Operator Precedence, Basic Arithmetic Operations. Principles of Structured Programming – Control Structures: Sequence, Selection, Iteration and Branching.

PRACTICALS:

- Design algorithms for simple computational problems
- Create Pseudo-code and Flow charts for simple computational problems
- Create Python programs using simple and nested selective control statements
- Create Python programs using simple and nested sequence & iterative control statements
- Create Python programs to generate series/patterns using control statements

UNIT II – MODULARITY AND DECOMPOSITION 9+6

Principles of Modular and Decomposition. Functions: Defining functions –Argument types – Function Name-spaces – Scoping: Global and Non-local. Principles of Recursion: Base case and Recursive cases – Develop and Analyze Recursive functions: Factorial, Fibonacci. Principles of First-Class and Higher-Order functions: Lambda functions – Functions as arguments.

PRACTICALS:

- Create Python programs using functions
- Create python program using recursion
- Create Python programs using lambda functions
- Create Python programs using first-class functions
- Create Python programs using higher-order functions

UNIT Ill – DATA STRUCTURES AND ABSTRACTIONS 9+6

Principles of Data Structures and Abstractions. String Methods and Manipulations,.Lists: List Operations and Methods, List comprehensions, Nested List comprehensions, Matrix operations using Lists. Tuples and sequences. Sets and Operations. Dictionaries: Dictionary operations, Dictionary comprehensions, Nested Dictionary comprehensions.

Comparing Data Structures. Search and Sort Data Structures. Principle of Functional Programming and Tools : map, filter, and reduce.

PRACTICALS:

- Create Python programs for strings manipulations.
- Design Python programs using Lists, Nested Lists and Lists comprehensions
- Create Python programs using Tuples, Nested Tuples, and Tuple comprehensions
- Create Python programs creating Sets and performing set operations
- Create Python programs using Dictionary, Nested Dictionary and comprehensions
- Create Python programs by applying functional programming concepts

UNIT IV – LIBRARIES AND MODULES 9+6

Exceptions: Syntax errors, Exceptions, Exception types, Handling exceptions, Raising exceptions. Files: File Path, Type of files, opening modes, Reading and Writing text files, Handling other format Data files. Modules: Creating Modules, import and from statements, Executing modules as scripts, Standard modules. Packages and Importing from packages

PRACTICALS:

- Design Python programs to handle errors and exceptions
- Create, import, and use pre-defined modules and packages
- Create, import, and use user-defined modules and packages
- Create Python programs to perform various operations on text files
- Create Python programs to perform various operations on other data file formats.

UNIT V – SIMPLE PROBLEM SOLVING TECHNIQUES IN PROGRAMMING 9+6

Data Structures for Problem Solving: Stack, Queue. Principles of Divide and Conquer: Binary Search. Principles of Greedy Algorithms: Minimum Coin Change Problem. Case studies on programming application of problem-solving techniques in different fields of engineering.

PRACTICALS:

- Create python programs to implement stack and queue.
- Create python programs to implement binary search.
- Create python programs to solve minimum coin change problem.
- Case study on developing python solution to a domain specific problems.

TOTAL = 45 + 30 = 75 PERIODS

COURSE OUTCOMES

1. Understand fundamental structural programming concepts and problem-solving process.
2. Solve problems using modular programming and decomposition techniques.
3. Solve problems using data structures and abstraction techniques.
4. Create programming solutions using libraries and packages.
5. Design solutions to domain problems using programming problem-solving techniques.

TEXT BOOKS

1. Reema Thareja, Python Programming using Problem Solving Approach, Oxford University Press, First Edition, 2017.

2. S. Sridhar, J. Indumathi, V. M. Hariharan, Python Programming, Pearson Education, First Edition, 2023

REFERENCE BOOKS

1. Paul Deitel, Harvey Deitel, Python for Programmers, Pearson Education, 2020.
2. John V Guttag. Introduction to Computation and Programming Using Python, With Application to Computational Modeling and Understanding Data. Third Edition, The MIT Press, 2021
3. Mark Lutz, Learning Python, 5th Edition, O'Reilly Media, Inc.
4. Python official documentation and tutorial, https://docs.python.org/3/
5. Numerical Python official documentation and tutorial, https://numpy.org/

CO's-PO's & PSO's MAPPING

CO	PO1	PO2	PO3	PO4	POS	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1	2		2		1								1	1	
2	2		2		1								1	1	
3	2	1	2		1								1	1	
4	2	1	2	1	1								1	1	
5	2	1	2	1	1								1	1	
Avg	2	1	2	1	1								1	1	

1 - low, 2 - medium, 3 - **high,** '-' - **no correlation**

ME23C03 **ENGINEERING MECHANICS** **L T P C**
3 1 0 4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:

- Determining the resultant forces acting on a particle in 2D and 3D and for applying methods of equilibrium on a particle in 2D and 3D.
- Evaluating the reaction forces for bodies under equilibrium, for determining the moment of a force, moment of a couple, for resolving force into a force-couple system and for analyzing trusses
- Assessing the centroids of 2D sections / center of gravity of volumes and for calculating area moments of inertia for the sections and mass moment of inertia of solids.
- Evaluating the frictional forces acting at the contact surfaces of various engineering systems and for applying the work-energy principles on a particle.
- Determining kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

UNIT I STATICS OF PARTICLES 9+3

Fundamental Concepts and Principles, Systems of Units, Method of Problem Solutions, Statics of Particles -Forces in a Plane, Resultant of Forces, Resolution of a Force into Components, Rectangular Components of a Force, Unit Vectors. Equilibrium of a Particle- Newton's First Law of Motion, Space and Free-Body Diagrams, Forces in Space, Equilibrium of a Particle in Space.

UNIT II EQUILIBRIUM OF RIGID BODIES AND TRUSSES 9+3

Principle of Transmissibility, Equivalent Forces, Vector Product of Two Vectors, Moment of a Force about a Point, Varignon's Theorem, Rectangular Components of the Moment of a Force, Scalar Product of Two Vectors, Mixed Triple Product of Three Vectors, Moment of a Force about an Axis, Couple - Moment of a Couple, Equivalent Couples, Addition of Couples, Resolution of a Given Force into a Force -Couple system, Further Reduction of a System of Forces, Equilibrium in Two and Three Dimensions - Reactions at Supports and Connections – Analysis of Trusses – Method of Joints and Method of Sections.

UNIT III DISTRIBUTED FORCES 9+3

Centroids of lines and areas – symmetrical and unsymmetrical shapes, Determination of Centroids by Integration, Theorems of Pappus-Guldinus, Distributed Loads on Beams, Centre of Gravity of a Three-Dimensional Body, Centroid of a Volume, Composite Bodies, Determination of Centroids of Volumes by Integration.

Moments of Inertia of Areas and Mass - Determination of the Moment of Inertia of an Area by Integration , Polar Moment of Inertia , Radius of Gyration of an Area , Parallel-Axis Theorem , Moments of Inertia of Composite Areas, Moments of Inertia of a Mass - Moments of Inertia of Thin Plates , Determination of the Moment of Inertia of a Three-Dimensional Body by Integration.

UNIT IV FRICTION AND WORK PRINCIPLES 9+3

The Laws of Dry Friction. Coefficients of Friction, Angles of Friction, Wedges, Wheel Friction. Rolling Resistance, Ladder friction. Work of a Force, Kinetic Energy of a Particle, Principle of Work and Energy,

Principle of Impulse and Momentum, Impact, Method of Virtual Work - Work of a Force, Potential Energy, Potential Energy and Equilibrium.

UNIT V DYNAMICS OF PARTICLES AND RIGID BODIES 9+3

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Momentum Methods – Kinematics of Rigid Bodies and Plane Kinetics.

TOTAL : 60 Periods

COURSE OUTCOMES:

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

1. To determine the resultant forces acting on a particle in 2D and 3D and to apply methods of equilibrium on a particle in 2D and 3D.
2. Evaluate the reaction forces for bodies under equilibrium, to determine moment of a force, moment of a couple, to resolve force into a force-couple system and to analyze trusses
3. Assess the centroids of 2D sections / center of gravity of volumes and to calculate area moments of inertia for the sections and mass moment of inertia of solids.
4. Evaluate the frictional forces acting at the contact surfaces of various engineering systems and apply the work-energy principles on a particle. evaluate the kinetic and kinematic parameters of a particle.
5. Determine kinetic and kinematic parameters of the rigid bodies subjected to concurrent coplanar forces.

TEXT BOOKS:

1. Beer Ferdinand P, Russel Johnston Jr., David F Mazurek, Philip J Cornwell, Sanjeev Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, McGraw Higher Education., 12th Edition, 2019.
2. Vela Murali, "Engineering Mechanics-Statics and Dynamics", Oxford University Press, 2018.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	3									3		
2	3	3	2	3									3		
3	3	3	2	3									3		
4	3	3	2	3									3		
5	3	3	2	3									3		
Avg	3	3	2	3									3		

UC23H02 தமிழரும் தொழில்நுட்பமும்/Tamils and Technology L T P C
1 0 0 1

அலகு I <u>நெசவு மற்றும் பானைத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் நெசவுத் தொழில் – பானைத் தொழில்நுட்பம் – கருப்பு சிவப்பு பாண்டங்கள் – பாண்டங்களில் கீறல் குறியீடுகள்.

அலகு II <u>வடிவமைப்பு மற்றும் கட்டிடத் தொழில்நுட்பம்</u>: 3

சங்க காலத்தில் வடிவமைப்பு மற்றும் கட்டுமானங்கள் & சங்க காலத்தில் வீட்டுப் பொருட்களில் வடிவமைப்பு- சங்க காலத்தில் கட்டுமான பொருட்களும் நடுகல்லும் – சிலப்பதிகாரத்தில் மேடை அமைப்பு பற்றிய விவரங்கள் – மாமல்லபுரச் சிற்பங்களும், கோவில்களும் – சோழர் காலத்துப் பெருங்கோயில்கள் மற்றும் பிற வழிபாட்டுத் தலங்கள் – நாயக்கர் காலக் கோயில்கள் - மாதிரி கட்டமைப்புகள் பற்றி அறிதல், மதுரை மீனாட்சி அம்மன் ஆலயம் மற்றும் திருமலை நாயக்கர் மஹால் – செட்டிநாட்டு வீடுகள் – பிரிட்டிஷ் காலத்தில் சென்னையில் இந்தோ-சாரோசெனிக் கட்டிடக் கலை.

அலகு III <u>உற்பத்தித் தொழில் நுட்பம்</u>: 3

கப்பல் கட்டும் கலை – உலோகவியல் – இரும்புத் தொழிற்சாலை – இரும்பை உருக்குதல், எஃகு – வரலாற்றுச் சான்றுகளாக செம்பு மற்றும் தங்க நாணயங்கள் – நாணயங்கள் அச்சடித்தல் – மணி உருவாக்கும் தொழிற்சாலைகள் – கல்மணிகள், கண்ணாடி மணிகள் – சுடுமண் மணிகள் – சங்கு மணிகள் – எலும்புத்துண்டுகள் – தொல்லியல் சான்றுகள் – சிலப்பதிகாரத்தில் மணிகளின் வகைகள்.

அலகு IV <u>வேளாண்மை மற்றும் நீர்ப்பாசனத் தொழில் நுட்பம்</u>: 3

அணை, ஏரி, குளங்கள், மதகு – சோழர்காலக் குமுழித் தூம்பின் முக்கியத்துவம் – கால்நடை பராமரிப்பு – கால்நடைகளுக்காக வடிவமைக்கப்பட்ட கிணறுகள் – வேளாண்மை மற்றும் வேளாண்மைச் சார்ந்த செயல்பாடுகள் – கடல்சார் அறிவு – மீன்வளம் – முத்து மற்றும் முத்துக்குளித்தல் – பெருங்கடல் குறித்த பண்டைய அறிவு – அறிவுசார் சமூகம்.

அலகு V <u>அறிவியல் தமிழ் மற்றும் கணித்தமிழ்</u>: 3

அறிவியல் தமிழின் வளர்ச்சி –கணித்தமிழ் வளர்ச்சி – தமிழ் நூல்களை மின்பதிப்பு செய்தல் – தமிழ் மென்பொருட்கள் உருவாக்கம் – தமிழ் இணையக் கல்விக்கழகம் – தமிழ் மின் நூலகம் – இணையத்தில் தமிழ் அகராதிகள் – சொற்குவைத் திட்டம்.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCE BOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும்
கல்வியியல் பணிகள் கழகம்).

2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

TAMILS AND TECHNOLOGY

L T P C

1 0 0 1

UNIT I WEAVING AND CERAMIC TECHNOLOGY 3

Weaving Industry during Sangam Age – Ceramic technology – Black and Red Ware Potteries (BRW) – Graffiti on Potteries.

UNIT II DESIGN AND CONSTRUCTION TECHNOLOGY 3

Designing and Structural construction House & Designs in household materials during Sangam Age -Building materials and Hero stones of Sangam age – Details of Stage Constructions in Silappathikaram - Sculptures and Temples of Mamallapuram - Great Temples of Cholas and other worship places - Temples of Nayaka Period -Type study (Madurai Meenakshi Temple)- Thirumalai NayakarMahal -ChettiNadu Houses, Indo-Saracenic architecture at Madras during British Period.

UNIT III MANUFACTURING TECHNOLOGY 3

Art of Ship Building - Metallurgical studies -Iron industry - Iron smelting, steel -Copper and gold-Coins as source of history - Minting of Coins – Beads making-industries Stonebeads -Glass beads - Terracotta beads -Shell beads/ bone beats - Archeological evidences - Gem stone types described in Silappathikaram.

UNIT IV AGRICULTURE ANDIRRIGATION TECHNOLOGY 3

Dam, Tank, ponds, Sluice, Significance of KumizhiThoompuof Chola Period,Animal Husbandry - Wells designed for cattle use - Agriculture and Agro Processing -KnowledgeofSea -Fisheries – Pearl - Conche diving - Ancient Knowledge ofOcean -KnowledgeSpecificSociety.

UNIT V SCIENTIFIC TAMIL & TAMIL COMPUTING 3

Development of Scientific Tamil - Tamil computing – Digitalization of Tamil Books – Development of Tamil Software – Tamil Virtual Academy – Tamil Digital Library – Online Tamil Dictionaries – Sorkuvai Project.

TOTAL : 15 PERIODS

TEXT-CUM-REFERENCEBOOKS

1. தமிழக வரலாறு – மக்களும் பண்பாடும் – கே.கே. பிள்ளை (வெளியீடு: தமிழ்நாடு பாடநூல் மற்றும்
   கல்வியியல் பணிகள் கழகம்).
2. கணினித் தமிழ் – முனைவர் இல. சுந்தரம். (விகடன் பிரசுரம்).
3. கீழடி – வைகை நதிக்கரையில் சங்ககால நகர நாகரிகம் (தொல்லியல் துறை வெளியீடு)
4. பொருநை – ஆற்றங்கரை நாகரிகம். (தொல்லியல் துறை வெளியீடு)
5. Social Life of Tamils (Dr.K.K.Pillay) A joint publication of TNTB & ESC and RMRL – (in print)
6. Social Life of the Tamils – The Classical Period (Dr.S.Singaravelu) (Published by: International Institute of Tamil Studies.
7. Historical Heritage of the Tamils (Dr.S.V.Subatamanian, Dr.K.D. Thirunavukkarasu) (Published by: International Institute of Tamil Studies).
8. The Contributions of the Tamils to Indian Culture (Dr.M.Valarmathi) (Published by: International Institute of Tamil Studies.)
9. Keeladi – 'Sangam City C ivilization on the banks of river Vaigai' (Jointly Published by: Department ofArchaeology & Tamil Nadu Text Book and Educational Services Corporation, Tamil Nadu)
10. Studies in the History of India with Special Reference to Tamil Nadu (Dr.K.K.Pillay) (Publishedby: The Author)
11. Porunai Civilization (Jointly Published by: Department of Archaeology & Tamil Nadu Text Bookand Educational Services Corporation, Tamil Nadu)
12. Journey of Civilization Indus to Vaigai (R.Balakrishnan) (Published by: RMRL) – Reference Book.

MA23C06 PARTIAL DIFFERENTIAL EQUATIONS AND COMPLEX FUNCTIONS

L	T	P	C
3	1	0	4

OBJECTIVES:

- To familiarize the students to solve of partial differential equations.
- To familiarize the students in solving boundary value problems.
- To understand the concepts of Complex functions.
- To familiarize complex mappings and its property.
- To familiarize the students with integration of complex functions.

UNIT I PARTIAL DIFFERENTIAL EQUATIONS 9+3

Formation – Solutions of first order equations – Standard types and Equations reducible to standard types – Lagrange's Linear equation – Solution of linear equations of higher order with constant coefficients – Linear non-homogeneous partial differential equations.

UNIT II APPLICATIONS OF FOURIER SERIES TO PARTIAL DIFFERENTIAL EQUATION 9+3

Classification of partial differential equations- Method of separation of variables – Solutions of one dimensional wave equation and one-dimensional heat equation – Steady state solution of two dimensional heat equation – Fourier series solutions in Cartesian coordinates.

UNIT III ANALYTIC FUNCTIONS 9+3

Limit, Continuity and Differentiation of Complex functions - Analytic functions – Necessary and sufficient conditions for analyticity - Properties of analytic functions – Harmonic conjugates – Construction of analytic function – elementary analytic functions (exponential, trigonometric, logarithm) and their properties.

UNIT IV CONFORMAL MAPPING 9+3

Introduction to complex mapping - Conformal mapping – Condition for conformality – Standard mappings: a+z, az, az+b, $\frac{1}{z}, z^2, e^z$ - Bilinear transformations – Physical applications: Fluid flow and heat flow problems.

UNIT V INTEGRATION OF COMPLEX FUNCTIONS 9+3

Line integral - Cauchy's integral theorem – Cauchy's integral formula – Taylor's and Laurent's series – Singularities – Residues – Cauchy's Residue theorem – Application of residue theorem for evaluation of real integrals – Use of circular contour and semicircular contours (excluding poles on real lines).

TOTAL: 60 PERIODS

Laboratory based exercises / assignments / assessments will be given to students from the content of the course wherever applicable.

Branch specific / General Engineering applications based on the content of each units will be introduced to students wherever possible.

Suggested Laboratory based exercises / assignments / assessments :

1. Symbolic computation of solution to PDE using PDE Solver
2. Conformal mapping can be done by plotting the curves and surfaces

OUTCOMES:

CO1 :Understand the concepts of partial differential equations in practical situations.
CO2 :Obtain the solutions of the partial differential equations using Fourier series.
CO3 :Understand the Concepts of complex functions in practical situations.
CO4 :Understand the conformal mapping and its applications.
CO5 :Apply the complex integrations in engineering problems.

TEXT BOOKS:

1. Erwin Kreyszig "Advanced Engineering Mathematics", John Wiley & Sons., New Delhi, 2015.
2. Wylie C. R. and Barrett L. C "Advanced Engineering Mathematics", Tata McGraw-Hill., New Delhi, 2019.
3. Grewal B.S., “Higher Engineering Mathematics”, Khanna Publishers, 44th Edition, New Delhi, 2017.

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1. Mathews J. H. and Howell R. W "Complex Analysis for Mathematics and Engineering", Narosa Publishing House. New Delhi, 2012.
2. Peter V.O Neil "Advanced Engineering Mathematics", Cengage., New Delhi, 2016.
3. Dennis G Zill "Advanced Engineering Mathematics", Jones & Bartlett India P Ltd., New Delhi, 2017.
4. Dean G Duffy "Advanced Engineering Mathematics with MATLAB", CRC., USA, 2010.
5. Spiegel, M.R., Theory and Problems of Complex Variables and its Application (Schaum’s Outline Series), McGraw Hill Book Co., Singapore (1981).

CO – PO Mapping:

Course Outcomes	PROGRAMME OUTCOMES											
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**P10**	**P11**	**P12**
CO1 :	3	3	2	3	1	2	1	1	1	1	1	3
CO2 :	3	3	2	3	1	2	1	1	1	1	1	3
CO3 :	3	3	2	3	1	2	1	1	1	1	1	3
CO4 :	3	3	2	3	1	2	1	1	1	1	1	3
CO5 :	3	3	2	3	1	2	1	1	1	1	1	3

AU23301 MANUFACTURING PROCESSES AND MACHINE TOOLS

L	T	P	C
3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

- Applying the working principles of various metal casting processes.
- Applying the working principles of various metal joining processes.
- Analyzing the working principles of forming of metals.
- Applying the working principles of plastics moulding.
- Applying the working principles of machine tools

UNIT – I METAL CASTING PROCESSES 9L, 6P

Sand Casting – Sand Mould – Type of patterns - Pattern Materials – Pattern allowances – Moulding sand Properties and testing – Cores –Types and applications– Moulding machines – Types and applications– Melting furnaces – Principle of special casting processes- Shell, investment – Ceramic mould – Pressure die casting – Centrifugal Casting - CO casting - Defects in Sand casting process– Stir casting - Defects in Sand casting.

PRACTICALS: Preparing green sand moulds with cast patterns.

UNIT – II METAL JOINING PROCESSES 9L, 6P

Fusion welding processes – Type of Gas welding – Flame characteristics – Filler and Flux materials– Arc welding, Electrodes, Coating and specifications – Principles and types of Resistance welding– Gas metal arc welding – Submerged arc welding – Electro slag welding – Gas Tungsten arcwelding – Principle and application of special welding processes – Plasma arc welding – Thermit Welding – Electron beam welding – Friction welding – Friction stir welding – Diffusion welding –Weld defects – Brazing and soldering – methods and process capabilities – Adhesive bonding, Types and application.

PRACTICALS: Fabricating simple structural shapes using Welding.

UNIT – III FORMING PROCESSES 9L, 6P

Hot working and cold working of metals – Forging processes – Open, impression and closed die forging – Characteristics of the processes – Typical forging operations – rolling of metals – Types of Rolling – Flat strip rolling – shape rolling operations – Defects in rolled parts – Principle of rod and wire drawing – Tube drawing – Principles of Extrusion – Types – Hot and Cold extrusion. Sheet metal characteristics – Typical shearing, bending and drawing operations – Stretch forming operations – Formability of sheet metal – Test methods.

PRACTICALS: Rolling of sheet metal.

UNIT – IV MANUFACTURE OF PLASTIC COMPONENTS 9L, 6P

Types and characteristics of plastics – Moulding of thermoplastics – working principles and typical applications – injection moulding – Plunger and screw machines – Compression moulding, Transfer Moulding – Typical industrial applications – introduction to blow moulding – Rotational moulding – Film blowing – Extrusion – Thermoforming – Bonding of Thermoplastics.

PRACTICALS: Making parts using injection moulding machine.

UNIT – V MACHINE TOOLS 9L, 6P

Introduction to machine tool- Basic elements of machine tool- machine tool drives- Lathe machine -Tool geometry, machining parameters- Lathe operations -Facing, Turning, Drilling, Boring, Taper turning by different methods- Milling Machine: types, working principle, milling parameters, operations- different types of indexing methods in milling. Drilling- Types of drilling machines, portable, bench, upright, Radial, Spot facing- Drilling process -Reaming: Types of reamers, reaming operations- Broaching-Types of broaches- tool material, teeth terminology and other details -Working principle and operation of shaping, planning and slotting.

PRACTICALS: Turning on circular parts using lathe machine, Gear cutting using milling machine.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Apply the working principles of various metal casting processes.

Apply the working principles of various metal joining processes.

Analyze the working principles of bulk deformation of metals.

Apply the working principles of sheet metal forming process.

Apply the working principles of plastics moulding.

REFERENCES:

1. Kalpakjian. S, “Manufacturing Engineering and Technology”, Pearson Education India Edition, 2006.
2. Roy. A. Lindberg, Processes and materials of manufacture, PHI / Pearson education, 2006.
3. Gowri.S, P. Hariharan, A. Suresh Babu, Manufacturing Technology I, Pearson Education,2008.
4. Hajra Chouldhary S.K. and Hajra Choudhury. A. K., Elements of Workshop Technology, Volume I and II, Media Promoters and Publishers Private Limited, Mumbai, 1997.
5. Paul Degarma E., Black J.T. and Ronald A. Kosher, Materials and Processes, in Manufacturing, Eight Edition, Prentice Hall of India, 1997.
6. Rao. P. N., Manufacturing Technology Foundry, Forming and Welding, 2ndEd.Tata McGraw Hill, 2003.
7. Sharma, P.C., A Textbook of Production Technology, S. Chand and Co. Ltd., 2004.

Mapping of CO with PO

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	1	2	2	2	1	3	3	3
2	3	3	3	3	3	2	1	2	2	2	1	3	3	3
3	3	3	3	3	3	2	1	2	2	2	1	3	3	3
4	3	3	3	3	3	2	1	2	2	2	1	3	3	3
5	3	3	3	3	3	2	1	2	2	2	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23C01 **APPLIED THERMODYNAMICS** **L T P C**

3 0 2 4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for
To impart knowledge of basic principles of thermodynamics via real world engineering examples
To analyse and evaluate cardinal air standard cycles
To analyse and evaluate cardinal Steam power cycles
Summarize the governing concepts of Refrigeration and Air conditioning
To inculcate various modes of heat transfer, related to real time scenarios of thermodynamics applied in engineering practice.

UNIT – I BASIC THERMODYNAMICS 9L, 6P

Systems, closed, open and isolated. Property, state, path and process, quasi-static process, Zeroth low, First law. Steady flow energy equation. Engineering Applications of Steady flow energy equation Heat and work transfer in flow and non-flow processes. Second law, Kelvin-Planck statement – Clausius statement - Concept of Entropy, Clausius inequality, Entropy changes in non- flow processes. Available and Unavailable Energy.

PRACTICALS: Determination of Specific heat of a solid.

UNIT – II AIR STANDARD CYCLES AND COMPRESSORS 9L, 6P

Cycle, Carnot cycle, Otto, Diesel, Dual combustion and Brayton cycles. Air standard efficiency. Mean effective pressure. Comparison of cycles based on same compression ratio and same heat input.

PRACTICALS: Performance test on 4 stroke engines.

UNIT – III STEAM AND JET PROPULSION 9L, 6P

Formation of steam and its thermodynamic properties, p-v, p-T, T-v, T-s, h-s diagram. p-v-T surface Properties of steam, Dryness fraction, Quality of steam-by-steam tables and Mollier chart –Rankine cycle, Work done, Steam rate.

PRACTICALS: Free and forced convective heat transfer from a flat plate,

UNIT – IV REFRIGERATION 9L, 6P

Principles of refrigeration, Vapour compression – Types of VCR system with respect to condition of vapour, Problems, Vapour absorption types, comparison - Co-efficient of performance (COP), Properties of refrigerants.

PRACTICALS: COP test on vapor compression refrigeration test rig**.**

UNIT – V HEAT AND MASS TRANSFER 9L, 6P

Modes of heat transfer, Heat conduction in parallel, radial and composite wall – Heat conduction through hollow and composite cylinders, spheres. Basics of Convective heat transfer. Fundamentals of Radiative heat transfer – Flow through heat- exchangers. -Determination for LMTD for parallel flow and AMTD for counter flow heat exchanger

PRACTICALS: Determination of effectiveness of counter flow heat exchanger, Determination of effectiveness of parallel flow heat exchanger.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

Upon completion of the course, the students

1. Will demonstrate understanding of the nature of the thermodynamic processes for pure substances of ideal gases

Will interpret First Law of Thermodynamics and its application to systems and control volumes

Will solve any flow specific problem in an engineering approach based on basic concepts and logic sequences.

Will compare and contrast between various types of refrigeration cycles

Will get exposed to the basics and modes of heat transfer

REFERENCES:

1. Chattopadhyay. P Engineering Thermodynamics", oxford University Press, New Delhi, 2010.
2. Nag.P.K., "Engineering Thermodynamics", Tata McGraw-Hill, New Delhi, 2007.
3. Rathakrishnan E., "Fundamentals of Engineering Thermodynamics" Prentice-Hall India, 2005.
4. Ganesan.V, "Thermodynamics: Basics and Applied" McGraw Hill Education (India) Private Limited, 2018.
5. Arora C.P, "Thermodynamics", Tata McGraw-Hill, New Delhi, 2003.
6. Holman.J.P., "Thermodynamics", 3rd Ed. McGraw-Hill, 2007.
7. Mathur & Sharma Steam Tables, Jain Publishers, New Delhi.
8. Merala C, Pother, Craig W, Somerton, "Thermodynamics for Engineers", Schaum Outline Series, Tata McGraw-Hill, New Delhi, 2004.
9. Ramalingam K.K. "Thermodynamics", Sci-Tech Publications, 2006

Mapping of CO with PO

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	1	1	-	2	2	-	3	3	3
2	3	3	3	3	3	1	1	-	2	2	-	3	3	3
3	3	3	3	3	3	1	1	-	2	2	-	3	3	3
4	3	3	3	3	3	1	1	-	2	2	-	3	3	3
5	3	3	3	3	3	1	1	-	2	2	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**-**	**2**	**2**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23C02 **MECHANICS OF SOLIDS** **L T P C**

3 0 2 4

COURSE OBJECTIVES:

The objectives of this course are

1. To know about how a solid (materials, structures) behaves when it is exposed to forces and deformations.
2. To apply the fundamental concepts of principle of superposition, equilibrium, compatibility, force deformation, and stress-strain relationships to the solid and structural mechanics problems.
3. To analyze determinate and indeterminate bars, beams, to determine axial forces, torques, shear forces, and bending moments
4. To have physical insight into distribution of stresses and strains in structural members
5. To identify the biaxial stresses in acting in a body or an element.

UNIT – I STRESS - STRAIN, AXIAL LOADING 9L, 6P

Stress and strain, elastic limit, Hooke's law, factor of safety, shear stress, shear strain, relationship between elastic constants. Stresses in stepped bars, uniformly varying sections, composite bars due to axial force. Lateral strain, Poisson's ratio, volumetric strain, changes in dimensions and volume. Thermal stresses and impact loading.

PRACTICALS: Tension Test.

UNIT – II STRESSES IN BEAMS 9L, 6P

Beam – Definition, types of end-supports, types of beams, types of loading. Shear force diagram and bending moment diagram for cantilever, simply supported and overhanging beams under point load, UDL, UVL and moments. Euler beam theory - Bending equation, section modulus, Bending stress in beams – Shear stress in beams. Unsymmetric bending.

PRACTICALS: Torsion Test.

UNIT – III DEFLECTION OF BEAMS AND COLUMNS 9L, 6P

Governing differential equation - Problems on Double integration method - Macaulay’s Method – Moment area method. Concepts of Conjugate Beam method and Method of superposition. Castiglianos1st and 2ndtheorems. Columns – different end conditions – buckling load – Euler’s theory – Rankine’s formula.

PRACTICALS: Deflection of Beams

UNIT – IV TORSION AND SPRINGS 9L, 6P

Theory of torsion and assumptions - torsion equation, polar modulus, stresses in solid and hollow circular shafts, power transmitted by a shaft, shafts in series and parallel, deflection in shafts fixed at the both ends. Springs – types, Deflection expression for closed coiled helical spring – Stress in springs.

PRACTICALS: Testing of Springs

UNIT – V BI-AXIAL STRESS 9L, 6P

Principal stresses, normal and tangential stresses, maximum shear stress - analytical and

graphical method. Stresses in combined loading. Thin-walled cylinder under internal pressure – changes in dimensions – volume. spherical shells subjected to internal pressure – deformation in spherical shells – Lame's theory. Strain energy.

PRACTICALS: Impact test, Hardness Test

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

At the end of the course, students will

1. Know about how a solid (materials, structures) behaves when it is exposed to forces and deformations.
2. Apply the fundamental concepts of principle of superposition, equilibrium, compatibility, force-deformation, and stress-strain relationships to the solid and structural mechanics problems
3. Analyze determinate and indeterminate bars, beams, to determine axial forces, torques, shear forces, and bending moments.
4. Have physical insight into distribution of stresses and strains in structural members.
5. Identify the biaxial stresses in acting in a body or an element.

REFERENCES:

1. James M Gere, Barry J Goodno, "Mechanics of Materials, SI Edition", Ninth Edition, Cengage Learning India Pvt. Ltd., 2022
2. Russell C. Hibbeler, "Mechanics of Materials", Tenth Edition, Pearson education, 2022
3. Stephen Timoshenko, 'Strength of Materials', Vol I & II, CBS Publishers and Distributors, 3rd edition, 2021.
4. Roy R Craig, "Mechanics of Materials", Third Edition, John Wiley & Sons, 2011
5. R.K. Rajput, 'Strength of Materials', S Chand; 6th Edition, 2015.
6. Timothy A. Philpot, "Mechanics of Materials: An Integrated Learning System," 4thEdition, Wiley, 2017.
7. William A. Nash, Merle C. Potter, "Schaum's Outline of Strength of Materials", 7thEdition, McGraw Hill Education, 2019
8. Ramamrutham S, "Strength of Materials", Dhanpat Rai Publishing Company, 16th Edition, 2011
9. Clive L. Dym, Irving H. Shames, "Solid Mechanics: A Variational Approach, Augmented Edition", Springer publishers, 2013
10. Saad, M. H., "Elasticity: Theory, Applications and Numerics", Academic Press; 3rdedition, 2014
11. Timoshenko, S. P., J. N. Goodier, "Theory of Elasticity", McGraw Hill Education; 3rdedition, 2017
12. Srinath, L. S, "Advanced Mechanics of Solids", McGraw Hill Education, 3rdedition, 2017
13. Crandal, S, Lardner, T, Dahl, N and Sivakumar, M. S., An Introduction to Mechanics of Solids", McGraw-Hill Education; 2nd edition, 1978

Mapping of CO with PO

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	1	1	-	2	2	-	3	3	3
2	3	3	3	3	3	1	1	-	2	2	-	3	3	3
3	3	3	3	3	3	1	1	-	2	2	-	3	3	3
4	3	3	3	3	3	1	1	-	2	2	-	3	3	3
5	3	3	3	3	3	1	1	-	2	2	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**1**	**1**	**-**	**2**	**2**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23302	AUTOMOTIVE ENGINES	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is

1. To impart knowledge on basics of automotive SI and CI engines construction and working.
2. To understand the engine induction and ignition systems and its functional requirements.
3. To learn the properties of gasoline and diesel fuel and combustion process involved in diesel engines.
4. To impart the knowledge on engine cooling and lubrication requirements also to understand the requirements of supercharger and turbocharger.
5. To analyze the performance characteristics of SI and CI engine and learn modern developments in IC engine.

UNIT – I ENGINE FUNDAMENTALS 9L, 6P

Introduction - classifications – Terminology - Engine components, functional requirements & materials- Working principle - valve and port timing diagram - Four stroke and two stroke cycle- Engine Cycles- Air Standard cycles – Otto Cycle-Fuel–air and actual cycle analysis–Engine operating parameters -Engine emissions –Two stroke engines – types–Merits and Demerits – Problems on cycles.

PRACTICALS: Draw the Valve and port timing diagrams.

UNIT – II INDUCTION AND IGNITION SYSTEM 9L, 6P

Carburettors - requirements - working principles, types, different circuits – compensation and maximum power devices – Fuel air ratio calculation - Requirements and objective of diesel fuel injection system – types of injection - Jerk and distributor type pumps, Unit injector, common rail direct injection -. Electronic fuel injection, Effect of Injection timing - Injection lags. Types of injection nozzle, Split and Multiple injections. Mechanical and pneumatic governors. Problems on fuel injection. Ignition system- function and types- Ignition control mechanism – Electronic ignition system. Laser ignition.

PRACTICALS: Dismantle, study, and assembly of multi cylinder petrol engine. Dismantle, study, and assembly of multi cylinder diesel engine.

UNIT – III FUEL PROPERTIES AND COMBUSTION OF FUELS 9L, 6P

Introduction on Hydrocarbon fuels- Gasoline and Diesel fuel properties. Octane and cetane number – Laboratory tests for diesel fuel. Combustion stoichiometry -Combustion in SI engine – stages - Abnormal combustion- combustion chambers - Burned and Unburned mixture states – Flame structure and Speed - Cyclic variations in combustion -P-Theta and HRR curve for SI engine and CI Engine – Importance of air motion–Swirl, Squish andTumble.SI and CI engine stages of combustion. Delay period – factors affecting delay period. Knock formation in CI engines. Comparison of knock in CI & SI engines. Direct and indirect injection combustion chambers for diesel combustion. Chambers for Si and CI engine combustion.

PRACTICALS: Dismantle, study, and assembly of MPFI engine.

UNIT – IV ENGINE COOLING, LUBRICATING SYSTEMS AND SUPERCHARGING, TURBOCHARGING **9L, 6P**

Cooling system – Function - types – Heat transfer analysis and calculation -Properties of coolants - Lubrication system- Function- types - Lubricant Properties. Supercharging – Introduction and its requirements - Thermodynamic cycle analysis for super charged engine. Types of superchargers - Modification of an engine for supercharging. Effect of supercharging on engine performance. Turbocharger – construction and working – Matching of turbocharger. - E-Turbocharger. Problems.

PRACTICALS: Dismantle, study, and assembly of CRDI engine.

UNIT – V ENGINE HEAT TRANSFER, TESTING AND RECENT DEVELOPMENTS **9L, 6P**

Importance of heat transfer- Modes of heat transfer- heat transfer and engine energy balance - Indicated and brake MEP, operating variables that affects SI engine performance –Automotive and stationary diesel engine testing and standards – Engine power and efficiencies – Variables affecting engine performance – Methods to improve engine performance - Introduction to Stratified charge engine, LHR engines, HCCI and RCCI engines. Variable valve timing.

PRACTICALS: Performance test on a 4-stroke engine.

TOTAL: 45L + 30P = 75 PERIODS

COURSE OUTCOMES:

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

1. Understand and remember engine glossaries, identify various components of SI and CI engines and its principle of working.
2. Define and interpret the knowledge on fuel induction system.
3. Illustrate and correlate the knowledge on engine combustion and its various effects.
4. Explain and apply their knowledge in analyzing the requirement of engine sub systems.
5. Analyze and Evaluate engine performance and exposed to gain knowledge on recent developments of prime sources.

REFERENCES:

1. V. Ganesan, Internal Combustion Engines, Tata-McGraw Hill Publishing Co., New Delhi,
2. John B. Heywood, “Internal Combustion Engines”, McGraw-Hill Book Company, ISBN No: 0-07-100499-8
3. M.L. Mathur and R.P. Sharma, Internal Combustion Engine, Dhanpath Rai Publications (P) Ltd, New Delhi-110002.
4. Heinz Heisler, Advanced engine technology. Butterworth Heinemann publications
5. Heldt, P.M., High Speed Combustion Engines, Oxford IBH Publishing Co., Calcutta,
6. K.K. Ramalingam, internal Combustion Engines, Sci Tech Publications, Chennai,2003.
7. Maleev, V.M, Diesel Engine Operation and Maintenance, McGraw-Hill, 1974.
8. Obert, E.F, Internal Combustion Engine analysis and Practice, International Text Book Co., Scranton, Pennsylvania,1988.

Mapping of CO with PO

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	1	2	2	1	2	2	-	3	3	3
2	3	3	3	3	1	2	2	1	2	2	-	3	3	3
3	3	3	3	3	1	2	2	1	2	2	-	3	3	3
4	3	3	3	3	1	2	2	1	2	2	-	3	3	3
5	3	3	3	3	1	2	2	1	2	2	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**1**	**2**	**2**	**1**	**2**	**2**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

UC23U01 **UNIVERSAL HUMAN VALUES** **L T P C**
1 0 2 2

COURSE OBJECTIVE:

The objective of the course is four-fold:

1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
3. Strengthening of self-reflection.
4. Development of commitment and courage to act.

MODULE I: INTRODUCTION (3L,6P)

Purpose and motivation for the course, recapitulation from Universal Human Values-I, Self-Exploration– Its content and process; 'Natural acceptance' and Experiential Validation- as the process for self-exploration Continuous Happiness and Prosperity- A look at basic Human Aspirations Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario, Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Practical Session: *Include sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking*

MODULE II: HARMONY IN THE HUMAN BEING (3L,6P)

Understanding human being as a co-existence of the sentient 'I' and the material 'Body', Understanding the needs of Self ('I') and 'Body' - happiness and physical facility, Understanding the Body as an instrument of 'I' (I being the doer, seer and enjoyer), Understanding the characteristics and activities of 'I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail, Programs to ensure Sanyam and Health.

Practical Session: *Include sessions to discuss the role others have played in making material goods available to me. Identifying from one's own life. Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.*

MODULE III: HARMONY IN THE FAMILY AND SOCIETY (3L,6P)

Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship, Understanding the meaning of Trust; Difference between intention and competence, Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship, Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence as comprehensive Human Goals, Visualizing a universal harmonious order in society- Undivided Society, Universal Order- from family to world family.

Practical Session*: Include sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students' lives*

MODULE IV: HARMONY IN THE NATURE AND EXISTENCE (3L,6P)

Understanding the harmony in the Nature, Interconnectedness and mutual fulfilment among the four orders of nature- recyclability and self regulation in nature, Understanding Existence as Co-existence of mutually interacting units in all- pervasive space, Holistic perception of harmony at all levels of existence.

Practical Session: *Include sessions to discuss human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion of resources and role of technology etc.*

MODULE V: IMPLICATIONS OF HARMONY ON PROFESSIONAL ETHICS (3L,6P)

Natural acceptance of human values, Definitiveness of Ethical Human Conduct, Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order, Competence in professional ethics: a. Ability to utilize the professional competence for augmenting universal human order b. Ability to identify the scope and characteristics of people friendly and eco-friendly production systems, c. Ability to identify and develop appropriate technologies and management patterns for above production systems. Case studies of typical holistic technologies, management models and production systems, Strategy for transition from the present state to Universal Human Order: a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers b. At the level of society: as mutually enriching institutions and organizations, Sum up.

Practical Session: *Include Exercises and Case Studies will be taken up in Sessions E.g. To discuss the conduct as an engineer or scientist etc.*

TOTAL: 45 (15 Lectures + 30 Practicals) PERIODS

COURSE OUTCOME:

By the end of the course, the students will be able to:

1. Become more aware of themselves, and their surroundings (family, society, nature);
2. Have more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.
3. Have better critical ability.
4. Become sensitive to their commitment towards what they have understood (human values, human relationship and human society).
5. Apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

REFERENCES:

1. Human Values and Professional Ethics by R R Gaur, R Sangal, G P Bagaria, Excel Books, New Delhi, 3rd revised edition, 2023.
2. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan Vidya Prakashan, Amarkantak, 1999.
3. Human Values, A.N. Tripathi, New Age Intl. Publishers, New Delhi, 2004.

4. The Story of Stuff (Book).
5. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
6. Small is Beautiful - E. F Schumacher.
7. Slow is Beautiful - Cecile Andrews.
8. Economy of Permanence - J C Kumarappa
9. Bharat Mein Angreji Raj - PanditSunderlal
10. Rediscovering India - by Dharampal
11. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
12. India Wins Freedom - Maulana Abdul Kalam Azad
13. Vivekananda - Romain Rolland (English)
14. Gandhi - Romain Rolland (English)

Web URLs:

1. Class preparations: https://fdp-si.aicte-india.org/UHV-II%20Class%20Note.php
2. Lecture presentations: https://fdp-si.aicte-india.org/UHV-II_Lectures_PPTs.php
3. Practice and Tutorial Sessions: https://fdp-si.aicte-india.org/UHV-II%20Practice%20Sessions.php

Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1						1	1	1	3			3
CO2						1	1	1	3			3
CO3						3	3	2	3		1	3
CO4						3	3	2	3		1	3
CO5						3	3	3	3		2	3

AU23401	AUTOMOTIVE CHASSIS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is

1. To understand the basic knowledge about various vehicle frames, front axles, steering systems and understand the conditions for true rolling motion of wheels during steering.
2. To recognize the construction and working principle of drive line, final drive and differential systems
3. To review the knowledge about the constructional feature of rear axle, wheels and tyres.
4. To evaluate the working principles of both conventional and independent suspension system.
5. To demonstrate working principle of braking system used in automobile.

UNIT - I INTRODUCTION, FRAME, STEERING SYSTEM 9+6

Types of Chassis layout, with reference to Power Plant location and drive, various types of frames, Loads acting on vehicle frame, Constructional details and materials for frames, Testing of frames, Types of Front Axles and Stub Axles, Front Wheel Geometry, Condition for True Rolling Motion of Wheels during Steering, Ackerman's and Davis Steering Mechanisms, Steering Error Curve, Steering Linkages, Different Types of Steering Gears, Slip Angle, Over–Steer and Under–Steer, Reversible and Irreversible Steering, EPAS.

Practicals: Study different chassis layouts, Study on power assisted steering system.

UNIT - II PROPELLER SHAFT AND FINAL DRIVE 9+6

Effect of Driving Thrust, torque reactions and side thrust, Hotchkiss drive, torque tube drive, radius rods and stabilizers, Propeller Shaft, Universal Joints, Constant Velocity Universal Joints, Front Wheel drive, Final drive, different types, Double reduction and twin speed final drives, Differential principle and types, limited speed differential. **Practical:** Dismantle, study, and assembly of Front axle- Constant Velocity Joint.

UNIT - III AXLES AND TYRES 9+6

Construction and Design of Drive Axles, Types of Loads acting on drive axles, Full – Floating, Three–Quarter Floating and Semi–Floating Axles, Axle Housings and Types, Types and Constructional Details of Different Types of Wheels and Rims, Different Types of Tyres and their constructional details. **Practical:** Dismantle, study, and assembly of Rear Axle-Differential.

UNIT - IV SUSPENSION SYSTEM 9+6

Need for Suspension System, Types of Suspension Springs, Constructional details and characteristics of Single Leaf, Multi–Leaf, Coil, Torsion bar, Rubber, Pneumatic and Hydro – elastic Suspension Spring Systems, Independent Suspension System, Telescopic Shock Absorbers.

Practical: Study on conventional and modern Suspension systems.

UNIT - V BRAKING SYSTEM 9+6

Theory of Automobile Braking, Stopping Distance Time and Braking Efficiency, Effect of Weight Transfer during Braking, Theory of Drum Brakes, Leading and Trailing Shoes, Braking Torque, Constructional Details of Drum Brake and its Activators, Disc Brake Theory, Types and Construction, Hydraulic Braking System, Mechanical Braking System, Pneumatic Braking System, Power–Assisted Braking System, Anti–Lock Braking System.

Practical: Study on conventional and modern braking systems.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon completion of the course, students will be able to

CO1	Identify the different types of chassis layout, frames used in Automotive.
CO2	Appraise different types of drive line systems and steering system drives used in Automotive.
CO3	Acquire knowledge about different types of front axle and rear axles, wheel and tyre used in motor vehicles.
CO4	Expose to the working principle of conventional and independent suspension systems.
CO5	Analyze working principles of brake and its subsystems.

TEXT BOOKS:

1. Kirpal Singh, Automobile Engineering, Standard Publisher, New Delhi, 2017
2. K.K. Ramalingam, “Automobile Engineering”, Scitech publication (India), 2011.
3. R.K. Rajput, A Text–Book of Automobile Engineering, Laxmi Publications Private Limited, 2015

REFERENCES:

1. Heinz Hazler, Modern Vehicle Technology, Butterworth, London, 2005.
2. Heldt P.M., Automotive Chassis, Chilton Co., New York, 1990
3. Newton Steeds and Garret, Motor Vehicles, 13th Edition, Butterworth, London, 2005.
4. N.K. Giri, Automotive Mechanics, Kanna Publishers, 2007
5. William. H. Crows – Work shop Manuel – 2005

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	1	1	2	2	-	3	3	3
2	3	3	3	3	3	2	1	1	2	2	-	3	3	3
3	3	3	3	3	3	2	1	1	2	2	-	3	3	3
4	3	3	3	3	3	2	1	1	2	2	-	3	3	3
5	3	3	3	3	3	2	1	1	2	2	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**2**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23402	VEHICLE BODY ENGINEERING AND ERGONOMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is

1. To design and analyze Car body
2. To design and analyze of Bus body
3. To design and compare different Commercial vehicles
4. To analyze the Vehicle Aerodynamics
5. To improve the vehicle Ergonomics

UNIT - I CAR BODY DETAILS **9**

Types of Car body - Saloon, convertibles, Limousine, Estate Van, Racing and Sports car – car body terminology - Visibility- regulations, driver's visibility, improvement in visibility and tests for visibility. Driver seat design -Car Body Construction - Various panels in car bodies – body materials. Safety: Safety design, safety equipment for cars – body correction – modern painting process.

UNIT - II BUS BODY DETAILS **9**

Types of bus body: based on capacity, distance travelled and based on construction. – Bus body lay out, floor height, engine location, entrance and exit location. Types of metal sections used – Regulations – Constructional details: Conventional and integral.

UNIT - III COMMERCIAL VEHICLE DETAILS **9**

Types of commercial vehicle bodies - Light commercial vehicle body. Construction details of Flat platform body, Tipper body and Tanker body – Dimensions of driver's seat in relation to controls – Driver's cab design.

UNIT - IV VEHICLE AERODYNAMICS **9**

Objectives, Vehicle drag and types. Various types of forces and moments. Effects of forces and moments. Side wind effects on forces and moments. Various body optimization techniques for minimum drag. Wind tunnels – Principle of operation, Types. Wind tunnel testing such as: Flow visualization techniques, Airflow management test – measurement of various forces and moments by using wind tunnel balance.

UNIT - V VEHICLE ERGONOMICS **9**

Introduction to Automotive Ergonomics, Ergonomics in Vehicle Design, Anthropometry in Designing Vehicles, Occupant Package, Controls and Displays Interface - Introduction to Field of View - styling in automotive design.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students will be able to

CO1	Analyze different aspects of car body.
CO2	Analyze different types bus body.
CO3	Compare and analyze different types of commercial vehicles.
CO4	Analyze the role of various aerodynamic forces and moments, measuring instruments in vehicle body design.
CO5	Create new Ergonomic designs.

TEXT BOOKS:

1. Dieler Anselm., “The passenger car body”, SAE International, 2000
2. James E Duffy, “Body Repair Technology for 4-Wheelers”, Cengage Learning,2009.
3. Powloski, J., “Vehicle Body Engineering”, Business Books Ltd., 1998.

REFERENCES:

1. Braithwaite, J.B., “Vehicle Body building and drawing”, Heinemann Educational Books Ltd., London, 1997.
2. Giles, G.J., “Body construction and design”, Illiffe Books Butterworth & Co., 1991.
3. John Fenton, “Vehicle Body layout and analysis”, Mechanical Engg. Publication Ltd., London,1992.
4. Vivek D. Bhise,” Ergonomics in The Automotive Design Process”, CRS Press,2016William. H. Crows – Work shop Manuel – 2005

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	1	2	1	1	1	1	1	1	2	3	3
2	3	3	3	1	2	1	1	1	1	1	1	2	3	3
3	3	3	3	1	2	1	1	1	1	1	1	2	3	3
4	3	3	3	1	2	1	1	1	1	1	1	2	3	3
5	3	3	3	1	2	1	1	1	1	1	1	2	3	3
Avg	**3**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23403	FLUID MECHANICS FOR AUTOMOTIVE APPLICATIONS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is

1. Understand the basics of fluid mechanics
2. Appraise the equations of fluid motion and dimensional analysis
3. Analyze different types of fluid flows.
4. Analyze different types of models for fluid flows.
5. Evaluate flow measurement in pipes, hydraulic machinery

UNIT - I BASIC CONCEPTS 9+6

Classification of fluids and their properties. Measurement of pressure and viscosity. Hydrostatic forces on surfaces. Buoyancy and floatation. **Practicals:** Determine the coefficient of discharge using Flow through Venturi meter.

UNIT - II EQUATIONS OF FLUID FLOW 9+6

Kinematics. Motion of a fluid particle. Fluid deformation. Navier Stokes equation and Euler's equation. Basic laws of fluid motion in integral form and differential form. Linear momentum equation. **Practicals**: Conduct the performance test for Reciprocating pump.

UNIT - III INCOMPRESSIBLE INVISCID AND VISCOUS FLOWS 9+6

Bernoulli's equations and its applications. Flow measurement – Orifice plate, Venturi meter. Fully developed laminar flow between parallel plates. Laminar and turbulent flow through pipes. Velocity profiles, energy considerations in pipe flow. Calculation of head loss in pipe flow problems. Hydraulic and energy grade lines. **Practicals:** Determination of Flow through pipe losses (Major and Minor Losses).

UNIT - IV DIMENSIONAL ANALYSIS AND MODEL STUDIES 9+6

Dimensional analysis. Dimensional Homogeneity, Rayleighs method, The Buckingham-Pi theorem. Significant dimensionless groups. Dimensionless numbers, Similitude, Flow similarity and model studies. **Practicals:** Conduct the performance test for Centrifugal pump.

UNIT - V HYDRAULIC MACHINERY FOR VEHICLE APPLICATIONS 9+6

Impact of jets. Euler's equation. Turbines – classification, heads, efficiencies, velocity triangles. Turbochargers – selection, working principle. Pumps – classification and working principle. Fuel pumps – selection and working principle. **Practicals:** Conduct the performance test for Gear pump, Conduct the performance characteristics of Francis turbine.

TOTAL: 75 PERIODS

COURSE OUTCOMES

Upon completion of the course, students will be able to

CO1 Recognize the basics of fluid statics and dynamics
CO2 Appraise the equations of fluid motion
CO3 Evaluate flow measurement in pipes
CO4 Analyze dimensional analysis and model studies

CO5 Investigate hydraulic machinery used in vehicles

TEXT BOOKS:

1. R.K. Bansal, “A textbook of fluid mechanics and hydraulic machines”, Laxmi Publications (P) Ltd, Revised Ninth Edition.

REFERENCES:

1. E. Rathakrishnan, “Fluid Mechanics: An Introduction”, Prentice Hall of India (II Ed.), 2007.
2. Robert L. Mott, Joseph A. Untener, “Applied Fluid Mechanics”, Pearson Publications (2014), Seventh edition.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	3	1	2	1	1	3	3	3
2	3	3	3	3	3	2	3	1	2	1	1	3	3	3
3	3	3	3	3	3	2	3	1	2	1	1	3	3	3
4	3	3	3	3	3	2	3	1	2	1	1	3	3	3
5	3	3	3	3	3	2	3	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23404	KINEMATICS AND DYNAMICS FOR AUTOMOTIVE APPLICATIONS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is

1. To impart knowledge on various types of mechanisms and synthesis.
2. To impart skills and analyze the position, velocity and acceleration of mechanisms.
3. To understand the effects of friction in motion of transmission and machine components.
4. To familiarize higher pairs like cams and gears.
5. To study the undesirable effects of unbalances resulting from prescribed motions in mechanisms.

UNIT - I MECHANISMS 9

Definition – Machine and Structure – Kinematic link, pair and chain – classification of Kinematic pairs – Constraint and motion – Degrees of freedom –Four Bar Chain – Single Slider crank –double – Crank rocker mechanisms – Inversions, applications – Introduction to Kinematic analysis – Determination of velocity and acceleration of simple mechanisms

UNIT - II FRICTION 9

Types of friction – friction in screw and nut – screw jack – pivot, collar and thrust bearings– belt (Flat and V) and rope drives – creep in belts – open and crossed belt drives – Ratio of tensions – Effect of centrifugal and initial tensions – condition for maximum power transmission.

UNIT - III GEAR TRAINS & CAMS 9

Gear trains – simple, compound and reverted gear trains – determination of speed and torque in epicyclic gear trains. Cam – Types of cams and followers – Cam design for different follower motions.

UNIT - IV VIBRATION 9

Free, forced and damped vibrations of single degree of freedom systems – force transmitted to supports – vibration Isolation – vibration absorption – torsional vibration of shafts – single and multi-rotor systems – geared shafts – critical speed of shafts.

UNIT - V BALANCING OF COMPONENTS 9

Static and dynamic balancing – single and several masses in different planes – primary and secondary balancing of reciprocating masses – Balancing of single and multi-cylinder engines – Governors and Gyroscopic effects.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to:

CO1	Apply the kinematics and dynamics of machinery in design and analysis of engineering problems.
CO2	Demonstrate the ability to synthesize and analysis mechanisms
CO3	Select the gears and cam for their applications.
CO4	Examine the concept of free, forced and damped vibrations
CO5	Design rotating members according to balancing point of view.

TEXT BOOKS:

1. Rattan S.S., “Theory of machines”, 5th edition 2019. Tata McGraw Hill publishing Co., New Delhi,
2. Bansal R.K., Brar J.S “A Text book of Theory of Machines”, 6th edition 2023. Laxmi Publications Pvt Ltd., New Delhi.

REFERENCES:

1. Shigley J.E. and Uicker J.J., “Theory of Machines and Mechanisms”, Oxford University Press, 2017.
2. Ambekar A.G., “Mechanism and Machine Theory”, PHI India Pvt Ltd, 2021
3. Gosh A and Mallick A.K., “Theory of Machines and Mechanisms”, Affiliated East West press, 2009.
4. Rao J.S. and Dukkipati R.V., “Mechanism and Machine Theory”, Second Edition, Wiley Eastern Limited, 2014.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	1	2	2	2	1	3	3	3
2	3	3	3	3	3	2	1	2	2	2	1	3	3	3
3	3	3	3	3	3	2	1	2	2	2	1	3	3	3
4	3	3	3	3	3	2	1	2	2	2	1	3	3	3
5	3	3	3	3	3	2	1	2	2	2	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23405	FUELS, LUBRICANTS AND COOLANTS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The objectives of this course are

1. To import knowledge on the basic of refinery of fuels and lubricants
2. To analyze different theories of lubrication
3. To analyze Properties of fuels and lubricants for the design and operation of the I.C engines.
4. To obtain knowledge in testing of fuel properties
5. To analyze effect of additives

UNIT - I REFINERY OF FUELS AND LUBRICANTS 9+6

Introduction to Structure of petroleum, refining Process-Distillation, cracking processes, Catalytic reforming, alkylation, isomerisation and polymerization, finishing process-blending, products of refining process. Manufacture of lubricating oil base stocks, manufacture of finished automotive lubricants. **Practicals:** Draw a curve by performing ASME distillation test of fuels (gasoline / diesel).

UNIT - II THEORY OF LUBRICATION 9+6

Engine friction: introduction, total engine friction, effect of engine variables on friction, hydrodynamic lubrication, elasto hydrodynamic lubrication, boundary lubrication, bearing lubrication, functions of the lubrication system, introduction to design of a lubricating system.

Practicals: Find out the consistency of grease using Penetration test.

UNIT - III LUBRICANTS AND COOLANTS 9+6

Classification of lubricating oils, Specific requirements for automotive lubricants, oxidation deterioration and degradation of lubricants, tests on lubricants. Grease, classification, properties, test used in grease. Rerefining of used oils. Coolants – Types and Properties.

Practicals: Find out the density and viscosity of oil.

UNIT - IV PROPERTIES AND TESTING OF FUELS 9+6

Properties and testing of fuels- density, calorific value, flash point, fire point, distillation, vapour pressure, spontaneous ignition temperature, viscosity, pour point, flammability, ignitability, diesel index, API gravity, aniline point, carbon residue, Biofuel-properties and testing.

Practicals: Find out the flash and fire point.

UNIT - V FUEL AND LUBRICANT ADDITIVES 9+6

Fuel and lubricant Additives - mechanism, requirements of an additive, Specifications of fuels and lubricants. ASTM and SAE standards.

Practicals: Determine the Carbon residue on given sample of fuel.

TOTAL: 75 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1 Analyze Various refinery processes.

CO2 Compare different Theory of Lubrication.

CO3 Test different properties of lubricants.

CO4 Test and analyze different properties fuels.

CO5 Analyze different types of additives for Fuels and lubricants.

TEXT BOOKS:

1. Ganesan.V, “Internal Combustion Engines”, Tata McGraw-Hill Publishing Co., New Delhi,2017
2. George E. Totten, Editor, “Fuels and Lubricants Handbook: Technology, Properties, Performance, and Testing”, ASTM International.

REFERENCES:

1. Paul Richards “Automotive fuels reference book” SAE International, Third edition 2014
2. Roger Frederick Haycock, John Hillier, Arthur J. Caines “Automotive lubricants Reference book”, SAE International, Second edition 2004
3. Wilfrid Francis., “Fuels and Fuel Technology, Vol. I & II, Elsevier Ltd

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	1	2	1	1	1	1	1	1	2	3	3
2	3	3	3	1	2	1	1	1	1	1	1	2	3	3
3	3	3	3	1	2	1	1	1	1	1	1	2	3	3
4	3	3	1	1	2	1	1	1	1	1	1	2	3	3
5	3	3	3	1	2	1	1	1	1	1	1	2	3	3
Avg	**3**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23406	AUTOMOTIVE POLLUTION AND CONTROL	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To discuss the harmful effects of major pollutants on living beings and the environment
2. To analyze the formation of major pollutants like UBHC, CO, NOx, particulate matter and smoke
3. To design various control techniques to reduce pollutants due to combustion
4. To determine the various after treatment process to minimize emissions
5. To demonstrate the various devices used to measure pollutants and discuss the Emission standards followed in various nations

UNIT - I EMISSION FROM VEHICLES 9+6

Sources of Pollution, Various emissions from Automobiles — Formation — Effects of pollutants on environment and human health – Evaluation of emission standards. Lubricants handling and harmful discharges. Carbon capturing, Introduction to Electro Magnetic Emissions, and Functional Safety of emission control devices.

Practicals: Study of FTIR technique for emission measurement

UNIT - II EMISSIONS FROM SPARK IGNITION ENGINE 9+6

Gasoline standards - Effects of gasoline Properties on emissions -Emission formation in SI Engines- Carbon monoxide- Unburned hydrocarbon, NOx, Smoke — Effects of design and operating variables on emission formation – Variable valve timing and lift-Gaseous emissions from GDI engines

Practicals: Study of FID, NDIR, CLD, Measurement of HC, CO, CO2, O2, and NOx using exhaust gas analyzer.

UNIT - III EMISSION FROM COMPRESSION IGNITION ENGINE 9+6

Diesel Fuel standards– Effects of Diesel Properties on emissions -Formation of White, Blue, and Black Smokes, NOx, soot, formation mechanism Sulphur particulate and Intermediate Compounds – Physical and Chemical delay — Significance Effect of Operating variables on Emission formation —- Fuel injection variables

Practicals: Measurement of PM and PN emission from given engine

UNIT - IV CONTROL STRATEGIES 9+6

SI Engine control strategies - Catalytic converters — Charcoal Canister — Positive Crank case ventilation system, Secondary air injection, Thermal reactor, Laser Assisted Combustion- CI engine control strategies, EGR, HCCI, DOC, Particulate Traps, Re-generation methods, SCR, LNT-, Cetane number Effect.

Practicals: Measurement of smoke emissions using smoke meter

UNIT - V TEST PROCEDURES AND EMISSION MEASUREMENTS 9+6

Constant Volume Sampling 1 and 3 (CVS1 &CVS3) Systems- Sampling Procedures — Chassis dyno - WHSC.WHTC, NRTC, NRSC – Eight mode and thirteen mode cycles for Emission Sampling — Sampling problems — Emission analyzers —NDIR, FID, Chemiluminescent, Smoke meters, Dilution Tunnel, SHED Test, Sound level meters. EMC/EMI testing of Electric electronic devices. Condensation Particulate counter, On-board pollution measurement equipment's (PEMS). Emission regulations for off-road vehicles. MIDC, WLTC.

Practicals: To classify the given vehicle for Homologation standards

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

CO1 Differentiate the various emissions formed in IC engines

CO2 Analyze the effects of pollution on human health and environment

CO3 Design the control techniques for minimizing emissions

CO4 Categorize the emission norms

CO5 Identify suitable methods to reduce the noise emissions.

TEXT BOOKS:

1. B.P Pundir, Engine Emissions, Narosa publications 2nd edition 2017
2. D.J. Patterson and N.A. Henin, 'Emission from Combustion Engine and their control', Anna Arbor Science Publication,1985.
3. G.P. Springer and D.J. Patterson, Engine Emissions, Pollutant formation, Plenum Press, New York, 1986.

REFERENCES:

1. G. Amba Prasad Rao and T. Karthikeya Sharma, 'Engine Emission Control Technologies: Design Modifications and Pollution Mitigation Techniques', Apple Academic Press, 2020.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23501	ENGINEERING DESIGN	L	T	P	C
		3	0	2	4

(Use of Design Data Book is permitted)

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To understand the principals involved in evaluating the shape and dimensions of a component.
2. To satisfy functional and strength requirements.
3. To discriminate the basis on which the components have to be designed.
4. To learn the use of standard practices in design.
5. To understand the techniques used for fastening the machine parts

UNIT - I FUNDAMENTAL CONCEPTS IN DESIGN 9+6

Introduction to the design process-factors influencing machine design, selection of materials based on mechanical properties – Machine part: Simple stresses –Torsional and bending stress–variable stresses– Preferred numbers, Fits and Tolerances–Fatigue failure.

Practicals: Drawing, Dimensioning, and Detailing of Simple Machine parts.

UNIT - II DESIGN OF SHAFTS AND SPRINGS 9+6

Design of solid and hollow shafts based on strength, rigidity and critical speed – Design of Keys, keyways. Spring material –Types –Design of closed coiled helical springs and leaf springs. Design of lever.

Practicals: Drawing, Dimensioning, and Detailing of Springs.

UNIT - III DESIGN OF TEMPORARY AND PERMANENT JOINTS 9+6

Threaded fasteners - Bolted joints – Simple and eccentrically loaded bolted joints – Cotter and knuckle joint– Design of Cotter Joint- Knuckle Joint – Riveted joint –Types and uses– Design of riveted joints. Welded joint –Types and uses–Design of Welded joints.

Practicals: Drawing, Dimensioning, and Detailing of Couplings – Flange.

UNIT - IV DESIGN OF FLYWHEEL AND BEARINGS 9+6

Introduction – Coefficient of Fluctuation of Speed – Fluctuation of Energy-Coefficient of Fluctuation of Energy. Design of Flywheel Rim, Flywheel Arms. Design of Hub –Key Sliding contact bearings – Rolling contact bearings – types – materials. Bearing life –lubrication–. Design of journal bearings – Ball and Roller bearing.

Practicals: Drawing, Dimensioning, and Detailing of Bearings and Flywheel.

UNIT - V DESIGN OF GEARS 9+6

Types of gears - Terminology of gears- Design considerations – strength of gear teeth – Lewis equation– Design of spur gears – Design of helical gears – Design of bevel gears and worm gears.

Practicals: Drawing, Dimensioning, and Detailing of Spur & Helical gear.

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

CO1	Demonstrate knowledge on designing machine elements to withstand the loads and deformations.
CO2	Approach a design problem successfully, and take decisions whenever needed.
CO3	Demonstrate their skill in developing modern joining techniques for future electric vehicles
CO4	Interpret the design of bearings and create new bearings for the given load.
CO5	Interpret, design and select gears for varied applications.

TEXT BOOKS:

1. Bhandari V, “Design of Machine Elements”, 5thEdition, McGraw Hill, New Delhi, 2020.
2. Jain, R.K., “Machine Design”, 9th Edition Khanna Publishers, 1992.
3. Joseph Shigley, Charles Mischke, Richard Budynas and Keith Nisbett, "Mechanical Engineering Design",11th Edition McGraw Hill, New Delhi, 2020

REFERENCES:

1. Ansel Ugural, “Mechanical Design – An Integral Approach”, 1st Edition, Tata McGraw-Hill Book Co, 2003.
2. “Design Data Hand Book”, PSG College of Technology, 2013- Coimbatore.
3. M F. Spotts, Terry E. Shoup and Lee E. Hornberger, “Design of Machine Elements” 8th Edition, Printice Hall, 2003.
4. Orthwein W, “Machine Component Design”, Jaico Publishing Co, 2006.
5. Robert C. Juvinall and Kurt M. Marshek, “Fundamentals of Machine component Design”,7th Edition, Wiley, 2019

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	1	2	2	2	1	3	3	3
2	3	3	3	3	3	2	1	2	2	2	1	3	3	3
3	3	3	3	3	3	2	1	2	2	2	1	3	3	3
4	3	3	3	3	3	2	1	2	2	2	1	3	3	3
5	3	3	3	3	3	2	1	2	2	2	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23502	AUTOMOTIVE TRANSMISSION	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The objective of this course is to prepare the students to gain knowledge in the

1. Construction and principle of mechanical transmission components clutch and gear box
2. Hydrodynamic devices hydrostatic devices
3. Automatic transmission system, Electric drive used in road vehicles.

UNIT - I CLUTCH 9+6

Requirement of transmission system, Types of transmission system, Requirement of Clutches – Functions-Types of clutches, construction and operation of Single plate, multi plate and Diaphragm Spring clutches. Centrifugal clutch, DCT, Electronic clutch.

Practicals: Dismantling, study on components and assembly of single plate clutch

UNIT - II GEAR BOX 9+6

Purpose of gear box. Construction and working principle of sliding, constant and synchromesh gear boxes, Automatic manual transmission. Introduction to epicycle gear trains, Numerical examples on performance of automobile such as Resistance to motion, Tractive effort, Engine speed & power and acceleration. Determination of gear ratios for different vehicle applications.

Practicals: Dismantling, study on components and assembly of sliding mesh gearbox and constant mesh gear box.

UNIT - III HYDRODYNAMIC TRANSMISSION 9+6

Fluid coupling – principles - Performance characteristics – advantages – limitations – drag torque – reduction of drag torque. Torque converter - principles - Performance characteristics – advantages – limitations – multistage and polyphase torque converters.

Practicals: Dismantling, study on components and assembly of torque converter.

UNIT - IV HYDROSTATIC DRIVE 9+6

Hydrostatic drive; various types of hydrostatic systems – Principles of Hydrostatic drive system. Advantages and limitations. Comparison of hydrostatic drive with hydrodynamic drive, construction and working of typical Janny hydrostatic drive.

Practicals: Dismantling, study on components and assembly of multi plate clutch.

UNIT - V AUTOMATIC TRANSMISSION AND ELECTRIC DRIVE 9+6

Wilson gear box-Cotal electric transmission. Chevrolet “Turboglide” transmission. – Four speed longitudinally mounted automatic transmission -Hydraulic control systems of automatic transmission. Continuously Variable Transmission (CVT) — types – Operations.

Automated Manual Transmission (AMT). Electric drive-types- Principle of early and modified Ward Leonard Control System-Advantages & limitations -Modern electric drives.

Practicals: Dismantling, study on components and assembly of epicyclic gear box.

TOTAL: 75 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to:

CO1	Understand the construction and working of various types of clutches
CO2	Determine the gear ratio for different vehicle applications
CO3	Describe the types and principle of hydrodynamic transmission
CO4	Compare Hydrostatic and hydrodynamics drives
CO5	Identify the differences among various automatic transmissions and electric drive.

TEXTBOOKS:

1. Heinz Heisler, “Advanced Vehicle Technology”,2nd Edition,2002, Butterworth-Heinemann
2. T. K. Garrett K. Newton W. Steeds,” Motor Vehicle”, 13th Edition, 2000, Butterworth-Heinemann

REFERENCES:

1. Crouse, W.H., Anglin, D.L., “Automotive Transmission and Power Trains construction”, McGraw Hill, 1976.
2. Heldt, P.M., “Torque converters”, Chilton Book Co., 1962.
3. Iqbal Husain, “Electric and Hybrid Vehicles Design Fundamentals”, CRC PRESS Boca Raton London New York Washington, D.C.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	1	2	1	1	1	1	1	1	2	3	3
2	3	3	3	1	2	1	1	1	1	1	1	2	3	3
3	3	3	3	1	2	1	1	1	1	1	1	2	3	3
4	3	3	1	1	2	1	1	1	1	1	1	2	3	3
5	3	3	3	1	2	1	1	1	1	1	1	2	3	3
Avg	**3**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23503	AUTOMOTIVE ELECTRICAL AND ELECTRONICS SYSTEMS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. To understand the fundamentals of vehicle electrical systems and automotive batteries.
2. To explore the principles and functionalities of vehicle starting and charging systems, and understanding their integral roles within the vehicle's electrical system.
3. To acquire advanced knowledge of vehicle ignition, lighting, and auxiliary systems, exploring the technological developments, operational principles, and practical applications
4. To gain a comprehensive understanding of the integration and functionality of electronics, sensors, and actuators in modern vehicles
5. To familiarize with vehicle networking, emphasizing the mechanisms of data transfer, network topology, and the communication protocols essential for automotive electronics, to enhance understanding of interconnected vehicle systems.

UNIT - I INTRODUCTION AND AUTOMOTIVE BATTERIES 9+6

Introduction- Overview of vehicle electrical systems-Electrical Circuits-Electrical power supply in conventional vehicle- Dimensioning of wires- Circuit diagrams and symbols-Electromagnetic Compatibility and interference suppression. Batteries– Battery design – Method of operation – Lead acid battery construction –Battery ratings and testing-Maintenance- free batteries–Battery – Substitute, versions, special case. Battery cooling.

Practicals: Testing of Lead Acid Battery,

UNIT - II STARTING AND CHARGING SYSTEM 9+6

Alternators – Generation of electrical energy in vehicle - physical principles - Alternator and voltage regulations versions–power losses –characteristics curve- Alternator operation in the vehicle - Alternator circuitry. Starter Motors– Development and Starting requirements in the IC engines- starter motor design – Starter motor design variations– starter motor control and power circuits.

Practicals: Testing of Starter Motor – Continuity Test, Insulation Test, Testing of Alternator – Continuity Test, Insulation Test.

UNIT - III IGNITION, LIGHTING AND AUXILLARY SYSTEMS 9+6

Ignitions System- Ignition fundamentals - Electronic ignition -Programmed ignition-Distributor less ignition-Direct Ignition-Sparkplugs. Automotive lighting Technology– Technical demands– Development of lighting technology- Light sources– physical principles– Front and rear lighting system-Interior lighting system–Special purpose lamps– Adaptive Lighting system- Instrument clusters -Wiper and Washer systems- electric horns.

Practicals: Measurement of Vibration Using the Accelerometer in Induction Motor.

UNIT - IV **AUTOMOTIVE ELECTRONICS AND SENSORS AND ACTUATORS** **9+6**

Automotive Electronics- overview and demands- Basic principles of semiconductor types and technology -Electronic Components- semiconductor components- Microcontrollers- Sensor- Signal Processing- Data Processing in the vehicle- Glossary for automotive microelectronics. Automotive Sensors–Basics–Sensors: Position, speed, Acceleration / Vibrational, Force /Torque, Flow meters, Gas/ Concentration, EGO, TPS, Knock, IAT, MAF Temperature- Measured Quantities, Measuring Principles and automotive applications. Automotive Actuators- Electromechanical actuators- Fluid-mechanical actuators- Electrical machines- Direct- current machines- Three-phase machines- Single-phase alternating-current Machines-Duty-type ratings for electrical machines.

Practicals: Measurement of Displacement Using Linear variable displacement transducers.

UNIT - V **VEHICLE NETWORKING** **9+6**

Data transfer between automotive Electronics system- Basic principles of networking- Network topology- Network organization- OSI reference model- Control mechanisms- communication protocols in embedded systems-Vehicle Communication Protocols–Cross-system functions- Requirements for bus systems- Classification of bus systems- Applications in the vehicle- Coupling of networks-Examples of networked Vehicles- Bus system-CAN, LIN, FlexRay–MOST etc.

Practicals: Visualization of Engine Sensor Signals and Fault Diagnosis Using OBD Kit.

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

CO1	Identify and describe the components and operations of vehicle electrical systems and automotive batteries
CO2	Analyze and evaluate the principles, functionalities, and critical roles of starting and charging systems within the vehicle's electrical framework
CO3	Demonstrate understanding of the advanced concepts in vehicle ignition, lighting, and auxiliary systems
CO4	Develop skills to integrate and apply electronic components, sensors, and actuators in modern vehicles
CO5	Comprehend and apply the concepts of vehicle networking, including data transfer mechanisms, network topology, and communication protocols

TEXT BOOKS:

1. Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive, 5th Edition, 2007, ISBNNo:978-3-658-01783-5

REFERENCES:

1. Barry Holembeak, “Automotive Electrical and Electronics”, Delmar Publishers, Clifton Park, USA,2010
2. James D Halderman, “Automotive Electrical and Electronics”, Prentice Hall, USA, 2013
3. Tom Denton, “Automotive Electrical and Electronics Systems,” Third Edition,2004, SAE International.
4. William Ribbens, "Understanding Automotive Electronics and Engineering Perspective, 7th Edition “, Elsevier Butterworth-Heinemann Publishers, 2012.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	-	3	3	3
2	3	3	3	3	3	2	2	1	2	1	-	3	3	3
3	3	3	3	3	3	2	2	1	2	1	-	3	3	3
4	3	3	3	3	3	2	2	1	2	1	-	3	3	3
5	3	3	3	3	3	2	2	1	2	1	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23504	VEHICLE MAINTENANCE AND TESTING	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. analyze the different concepts in vehicle maintenance.
2. diagnose and rectify the faults in engine and subsystems
3. test the transmission system for any failures.
4. test the steering brake and suspension system s for proper functioning.
5. diagnose and rectify the faults in electrical and electronic systems.

UNIT - I MAINTENANCE, WORKSHOP PRACTICES, SAFETY AND TOOLS 9+6

Need for Maintenance – importance, classification of maintenance work-basic problem diagnosis. Automotive service procedures – workshop – types - operations – workshop manual -Safety – Personnel, machines and equipment, vehicles, fire safety - First aid. Basic tools – special service tools – measuring instruments –Scheduled maintenance services – service intervals –On board diagnostics.

Practicals: Engine fault diagnosis using scan tool.

UNIT - II ENGINE AND SUBSYSTEM MAINTENANCE 9+6

Engine service- Dismantling of Engine components - Engine tuning - repair- working on the underside, front, top, ancillaries- Service of basic engine parts, cooling and lubricating system, fuel system, Intake and Exhaust system, electrical system - Electronic fuel injection and engine management service - fault diagnosis- servicing emission controls.
Practicals: Testing and calibration of Fuel injection equipment.

UNIT - III TRANSMISSION AND DRIVELINE MAINTENANCE 9+6

Clutch- general checks, adjustment and service- Dismantling, identifying, checking and reassembling transmission, transaxle- road testing- Removing and replacing propeller shaft, servicing of universal joint and constant velocity joints- Rear axle service points- removing axle shaft and bearings- servicing differential assemblies- fault diagnosis.
Practicals: Performance test on chassis dynamometer.

UNIT - IV STEERING, BRAKE, SUSPENSION, WHEEL MAINTENANCE 9+6

Inspection, Maintenance and Service of Hydraulic brake, Drum brake, Disc brake. Bleeding of brakes. Inspection, Maintenance and Service of Mc person strut, coil spring, leaf spring, shock absorbers. Dismantling and assembly procedures. Wheel alignment and balance, removing and fitting of tyres, tyre wear and tyre rotation. Inspection, Maintenance and Service of steering linkage, steering column, steering gear box service- Rack and pinion, Recirculating ball and Worm type and Power steering system.

Practicals: Wheel balancing and wheel alignment in four-wheelers, Testing of suspension and steering system.

UNIT - V **AUTO ELECTRICAL, AIR CONDITIOING AND VEHICLE BODY MAINTENANCE** **9+6**

Maintenance of batteries, starting system, charging system and body electrical -Fault diagnosis using Scan tools. Maintenance of air conditioning parts like compressor, condenser, expansion valve, evaporator - Replacement of hoses- Leak detection- AC Charging- Fault Diagnosis Vehicle body repair like panel beating, tinkering, soldering, polishing, painting.

Practicals: Tinkering and painting of auto body parts.

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

CO1 apply the different concepts in vehicle maintenance.
CO2 diagnose and rectify the faults in engine and subsystems
CO3 test the transmission system for any failures.
CO4 test the steering brake and suspension systems for proper functioning.
CO5 diagnose and rectify the faults in electrical and electronic systems.

TEXT BOOKS:

1. Ed May, Automotive Mechanics Volume One, Mc Graw Hill Publications, 2014
2. Ed May, Automotive Mechanics Volume Two, Mc Graw Hill Publications, 2014

REFERENCES:

1. Bosch Automotive Handbook, Tenth Edition,2018
2. Vehicle Service Manuals from different manufactures
3. William Crouse, Donald Anglin Automotive Mechanics
4. Tom Denton, Advanced Automotive Fault Diagnosis Automotive Technology: Vehicle Maintenance and Repair, Routledge,2012

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	2	2	3	3	3	3	3	3
2	3	3	3	3	3	2	2	2	3	3	3	3	3	3
3	3	3	3	3	3	2	2	2	3	3	3	3	3	3
4	3	3	3	3	3	2	2	2	3	3	3	3	3	3
5	3	3	3	3	3	2	2	2	3	3	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23U01	STANDARDS (AUTOMOBILE ENGINEERING)	L	T	P	C
		1	0	0	1

MODULE I OVERVIEW OF STANDARDS **6**

Basic concepts of standardization; Purpose of Standardization, marking and certification of articles and processes; Importance of standards to industry, policy makers, trade, sustainability and innovation. Objectives, roles and functions of BIS, Bureau of Indian Standards Act, ISO/IEC Directives; WTO Good Practices for Standardization. Important Indian and International Standards.

MODULE II AUTOMOTIVE STANDARDS AND REGULATIONS **9**

Automotive standards-Uniform guidelines-automotive industry-list of automotive industry standards (AIS). Emissions, safety, quality and performance standards. Central motor vehicles rules 1989.Environmemtal Standards-Emission norms-India's Bharat Stage (BS) emission standards-European Emission Standards (Euro norms). The stringency of emission standards. Relationship between emissions and fuel economy. Vehicle Noise Pollution-Noise pollution standards in India. Safety standrds-AIS145.Speed alert system-over speeds-Driver and co-driver safety belt reminder-Manual override for central locking system-Driver Airbag. Child restraint system standards-India. Automobile electrical components-Reliability and durability, safety and wiring. Automotive industry standards-Industry Standards (AIS) for the automotive sector- Other requirements-The Indian Road Congress (IRC) Standard on Dimensions and Weights of Road Design Vehicles. SAE standards. World Forum for the harmonization of vehicle regulations (WP.29)

TOTAL: 15 PERIODS

COURSE OUTCOMES

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

CO1	Apply the standards followed in most of the industries
CO2	Apply the standards specific for dimension, design, safety, Emission and other areas.

REFERENCES:

1. The Automotive Industry Standards (AIS) are issued by the Ministry of Road Transport and Highways (MoRTH), Government of India.
2. The Central Motor Vehicles Rules, 1989 (CMVR) were enacted by the Ministry of Road Transport and Highways, Government of India.
3. The Indian Roads Congress (IRC) Standard on Dimensions and Weights of Road Design Vehicles (IRC-3-1983)
4. Bharat stage emission standards.
5. European emission standards.
6. SAE standards.
7. World forum for the harmonization of vehicle regulations (WP.29)

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	2	2	3	3	3	3	3	3
2	3	3	3	3	3	2	2	2	3	3	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**	**3**	**3**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23505	SUMMER INTERNSHIP	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

To provide students, training in live industries so that they can know what is happening in various departments of industries.

1. The students have to undergo practical industrial training for four weeks in recognized industrial establishments during their vacation periods.

2. At the end of the training, they have to submit a report with following information:
   a. Profile of the industry
   b. Product range
   c. Organization structure
   d. Plant layout
   e. Processes/Machines/Equipment/Devices
   f. Personnel welfare schemes
   g. Details of the training undergone
   h. Projects undertaken during the training, if any
   i. Learning points

The assessments will be based equally on the report in the prescribed format and viva-voce examination by a committee nominated by the Head of the Department.

TOTAL: 60 PERIODS

COURSE OUTCOMES

Students can able to perceive,

CO1 The student will be very familiar on the very first day or his/her entry industry so that he/she can easily settle well entry industry in industries.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

Semester–VII

AU23701	DESIGN OF VEHICLE COMPONENTS	L	T	P	C
		3	0	2	4

(Use of Design Data Book is permitted)

COURSE OBJECTIVES:

The objectives of this course are

1. To understand the various steps involved in the design of automotive components
2. To show their knowledge in designing engine components.
3. To complete design exercise and arrive at important dimensions of chassis components.
4. To learn the use of standard practices in design.
5. To determine the dimensions of front and rear axles

UNIT - I	DESIGN OF CYLINDER, PISTON AND CONNECTING ROD	9+6

Choice of material for cylinder and piston, design of cylinder, design of piston, piston pin, piston rings and piston assembly. Material for connecting rod, design of connecting rod assembly. **Practicals:** Design and modelling of piston assembly, Design and modelling of the connecting rod.

UNIT - II	DESIGN OF CRANK SHAFT AND VALVES	9+6

Material for crank shaft, design of crank shaft under bending and twisting. Design –inlet & exhaust valves, tappets. Design of cam &camshaft. Design of rocker arm. **Practicals:** Design and modelling of the crankshaft, Design and modelling of the inlet and exhaust valves.

UNIT - III	DESIGN OF CLUTCHES AND GEARS	9+6

Design of single plate clutch, multiplate clutch and cone clutch assembly. Torque capacity of clutch. Design of clutch components. Gear train calculations, layout of gearboxes. Calculation of bearing loads and selection of bearings. Design of three speed and four speed gearboxes. **Practicals:** Design and modelling of clutch.

UNIT - IV	DESIGN OF VEHICLE FRAME AND SUSPENSION	9+6

Study of loads moments and stresses on frame members. Design Of frame for passenger and commercial vehicle- Determination of steering torque, - design of linkages, steering gear box. Practicals**:** Design and modelling of frame for ATV

UNIT - V	DESIGN OF FRONT AND REAR AXLE	9+6

Design of propeller shaft. Design of final drive gearing. Design –full floating, semi-floating and three – quarter floats rear shafts and rear axle housings. Analysis of loads-moments and stresses at different sections of front axle. **Practicals:** Design and modelling of axle.

TOTAL: 75 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1	Analyze the stress and strain imparted on automotive components
CO2	Compute the design and find the dimension of the vehicle components.
CO3	Identify optimal design solutions to real-world problems in compliance with industry standards.
CO4	Demonstrate the design skill by creating new design strategy with the application of the knowledge.
CO5	Interpret the modern system in vehicle and would help in developing the system with less impact to the environment.

TEXTBOOKS:

1. Genta, Lorenzo Morello, “The Automotive Chassis Volume 1, Components Design”, Springer International Edition.2014

2. Khurmi. R.S. & Gupta. J.K., "A text book of Machine Design", Eurasia Publishing House (Pvt) Ltd, 2001.
3. Stokes, “Manual gearbox design”, Butterworth-Heinemann 1992

REFERENCES:

1. Design Data Hand Book”, PSG College of Technology,2013- Coimbatore.
2. Dean Averns, "Automobile Chassis Design", IllifeBookCo.,2001.
3. Kolchin- Demidov, “Design of Automotive Engines”-Mir Publishers (1984)
4. Lukin PG Gand Rodionov V, “Automobile Chassis Design and Calculations”, Mir Publishers, Moscow,1989.
5. Robert C. Juvinall and Kurt M. Marshek, “Fundamentals of Machine component Design”, 6thEdition, Wiley, 2017

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	1	2	2	2	1	3	3	3
2	3	3	3	3	3	2	1	2	2	2	1	3	3	3
3	3	3	3	3	3	2	1	2	2	2	1	3	3	3
4	3	3	3	3	3	2	1	2	2	2	1	3	3	3
5	3	3	3	3	3	2	1	2	2	2	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23702	ELECTRIC AND HYBRID VEHICLES	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. General aspects of Electric and Hybrid Vehicles (EHV), including architectures, modelling, sizing, sub-system design and hybrid vehicle control.
2. Understand about vehicle dynamics,
3. Design the required energy storage devices,
4. Select the suitable electric propulsion systems and
5. Understand of hybrid electric vehicles.

UNIT - I	NEED FOR ALTERNATIVE SYSTEM	9+6

Need for hybrid and electric vehicles – main components and working principles of a hybrid and electric vehicles, Different configurations of hybrid and electric vehicles. Comparative study of diesel, petrol, hybrid, fuel-cell and electric Vehicles. Advantages and Limitations of hybrid and electric Vehicles. Case study on specification of electric and hybrid vehicles. **Practicals:** Dismantling, study on components and assembly of electric Vehicle

UNIT - II	DESIGN CONSIDERATIONS FOR ELECTRIC VEHICLES	9+6

Design requirement for electric vehicles- Range, maximum velocity, acceleration, power requirement, mass of the vehicle. Various Resistance- Transmission efficiency- Electric vehicle chassis and Body Design, Electric Vehicle Recharging and Refueling Systems. **Practicals:** Calculate energy consumption and range of electric Vehicle.

UNIT - III	ENERGY STORAGE DEVICES AND SOURCES	9+6

Battery Parameters- - Different types of batteries. Battery Chemistry, Battery Modelling, Battery Management System, Thermal Management system. Ultra-capacitors. Fuel Cell Characteristics - Fuel cell types- Electrolytic reactions of fuel cell. Cell Chemistry. **Practicals:** Calculation for battery sizing.

UNIT - IV	MOTORS AND CONTROLLERS	9+6

Types of Motors, Characteristic of DC motors, AC single phase and 3-phase motor, PM motors, switched reluctance motors, BLDC motor, Motor Drives and speed controllers, Torque Vectoring, Regenerative Braking. Rectifiers, Inverters, DC/DC converters. **Practicals:** Calculation for motor selection.

UNIT - V	SUBSYTEMS OF HYBRID AND ELECTRIC VEHICLES	9+6

Power Split devices for Hybrid Vehicles - Operation modes - Control Strategies for Hybrid Vehicle- Economy of hybrid Vehicles. **Practicals:** Electric Vehicle simulation using system engineering software.

TOTAL: 75 PERIODS

COURSE OUTCOMES

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

CO1	Understand working of different configurations of hybrid and electric vehicles
CO2	Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
CO3	Choose proper energy storage systems for EV applications
CO4	Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources
CO5	Understand basic operation of power-split device and control Strategies for hybrid electric vehicle

TEXTBOOKS:

1. James Larminie and John Lowry, “Electric Vehicle Technology Explained “John Wiley & Sons,2003

2. Iqbal Husain, “Electric and Hybrid Vehicles-Design Fundamentals”, CRC Press,2003
3. Mehrdad Ehsani, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles”, CRC Press,2005

REFERENCES:

1. Ron HodKinson, John Fenton, “Light Weight Electric/ Hybrid Vehicle Design”, Butterworth Heinemann Publication,2005
2. Lino Guzzella, “Vehicle Propulsion System” Springer Publications,2005

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23703	VEHICLE DYNAMICS	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. provide fundamental knowledge of the vibration,
2. impart knowledge on tyres
3. provide basic concepts on suspension design and function, ride modes
4. evaluate the performance, longitudinal dynamics and control in an automobile
5. provide basic analysis on handling, cornering stability and control

UNIT - I	CONCEPT OF VIBRATION	9+6

Modelling and Simulation, Global and Vehicle Coordinate System. Fundamentals of vibration - Definitions, Types, Free, Forced, Undamped and Damped Vibration. Vibration analysis – Formulation of Governing equation. Response Analysis of Single DOF, Two DOF, Multi DOF. Magnification factor, Transmissibility ratio, Base excitation. Vibration absorber, Vibration measuring instruments, Torsional vibration, Critical speed.

Practicals: Simulation and analysis of Single and Multi-Degree of Freedom System.

UNIT - II	TYRES	9+6

Tyre axis system, Construction and manufacturing of tires, tyre forces and moments, tyre marking, tyre structure, hydroplaning, wheel and rim. Rolling resistance, factors affecting rolling resistance. Tire slip – Longitudinal slip and slip angle concept, Relation between tractive effort and longitudinal slip, Friction circle. Longitudinal and Lateral force at various slip angles, Tractive and cornering property of tire. Camber and camber trust. Performance of tire on wet surface. Ride property of tyres. Various test carried on a tyre. Tyre models.

Practicals: Simulation and analysis of Longitudinal and lateral forces of tires using Magic Formula Tire model.

UNIT - III	VERTICAL DYNAMICS	9+6

Human response to vibration, Sources of Vibration. Suspension requirements – types. State Space Representation. MR & ER Dampers. Design and analysis of Passive, Semiactive and Active suspension using Quarter car, Bicycle Model, Half car and full car vibrating model. Influence of suspension stiffness, suspension damping, and tire stiffness. Control law. Suspension optimization techniques. Air suspension system and their properties.

Practicals: Simulation and analysis of Passive Suspension System using Quarter / Half / Full Car model. Simulation and analysis of Active Suspension System Control Strategy (PID, Skyhook, LQR) using Quarter / Half / Full Car model.

UNIT - IV	LONGITUDINAL DYNAMICS AND CONTROL	9+6

Aerodynamic forces and moments. Forces acting on a vehicle – Resistance forces, Traction force supplied by power plant. Equation of motion. Load distribution for three-wheeler and four-wheeler. Calculation of maximum acceleration, tractive effort and reaction forces for different drive vehicles. Power limited acceleration and traction limited acceleration. Estimation of CG location. Longitudinal load transfer during acceleration and braking. Stability of vehicles resting on slope. Driveline dynamics. Braking and Driving torque. Prediction of Vehicle performance. ABS, stability control, Traction control.

Practicals: Simulation and analysis of Power requirement for a Vehicle.

UNIT - V	LATERAL DYNAMICS	9+6

Steering Geometry – Steady state handling characteristics. Steady state response to steering input – Yaw velocity gain, Lateral acceleration gain, curvature response gain. Testing of handling characteristics. Transient response characteristics. Directional stability. Stability of vehicle on banked road, during turn. Effect of suspension on cornering. Roll dynamics - Roll center, Roll axis, effect of roll on vehicle dynamics. Yaw control. Stability control.

Practicals: Simulation of double lane change maneuver, Mini-Project	
TOTAL: 75 PERIODS	
COURSE OUTCOMES By the end of this course, students will be able to	
CO1	Develop physical and mathematical models of a mechanical vibrating system.
CO2	Indicate the forces and moment acting on tyres.
CO3	Identify the suspension parameters that governs ride comfort.
CO4	Evaluate the vehicle performance in longitudinal direction.
CO5	Evaluate the lateral dynamics and control in an automobile.

TEXTBOOKS:

1. Singiresu S. Rao, "Mechanical Vibrations – SI Edition," Sixth Edition, Pearson, 2018
2. J. Y. Wong, "Theory of Ground Vehicles", Fifth Edition, Wiley-Inter science, 2022
3. Rajesh Rajamani, "Vehicle Dynamics and Control," Second edition, Springer,2012
4. Reza N. Jazar, "Vehicle Dynamics: Theory and Application", Third edition, Springer, 2017.

REFERENCES:

1. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", Revised Edition, Society of Automotive Engineers Inc, 2021
2. Dean Karnopp, "Vehicle Dynamics, Stability, and Control", Second Edition, CRC Press, 2013
3. Michael Blundell & Damian Harty, "The Multi body Systems Approach to Vehicle Dynamics", 2nd Edition, Butterworth - Heinemann,2014
4. Hans B Pacejka, "Tyre and Vehicle Dynamics," Second edition, Butterworth - Heinemann, 2006

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23704	IC ENGINE PROCESS MODELING	L	T	P	C
		3	0	2	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Acquire knowledge on simulation of IC engine components.
2. Understand the principle behind the stoichiometric ratio and adiabatic flame temperature.
3. Develop a model on simulation of SI engine models.
4. Understand the concept of gas exchange process in SI engine.
5. Acquire knowledge on simulation of CI engine

UNIT - I	INTRODUCTION TO SIMULATION	9+6

Introduction to Simulation, Advantages of computer simulation, Classification of engine models. Intake and exhaust flow models – Quasi steady flow -Filling and emptying -Gas dynamic Models. Thermodynamic based in cylinder models. Step by step approach in SI engine simulation. **Practicals:** Development of an algebraic engine model for a CI / SI engine using any computer software.

UNIT - II	STOICHIOMETRY AND ADIABATIC FLAME TEMPERATURE	9+6

Reactive processes, Heat of reaction, measurement of URP, measurement of HRP. Introduction - combustion equation for hydrocarbon fuels. Calculation of minimum air, excess air and stoichiometric air required for combustion. Introduction, 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. **Practicals:** Study on engine modelling procedure in CFD and development of a sector model of an IC engine.

UNIT - III	SI ENGINE SIMULATION	9+6

SI Engine simulation with air as working medium, deviation between actual and ideal cycle. Fuel air cycle analysis - Temperature drop due to fuel vaporization, full throttle operation, work output and efficiency calculation, part-throttle operation, engine performance at part throttle, super charged operation. SI Engines simulation with progressive combustion. Models for mass burnt fraction. **Practicals:** Modelling of In-cylinder charge flow of the given engine using sector model.

UNIT - IV	SI ENGINE SIMULATION WITH GAS EXCHANGE PROCESS	9+6

Introduction, gas exchange process, Heat transfer process, friction calculations. Actual Model Development, comparison of simulated values, validation of the computer code, engine performance calculations, pressure crank angle diagram, brake power, brake thermal efficiency, effect of speed on performance. **Practicals:** Case study using CFD modelling software-Simulation on engine combustion and flow visualization.

UNIT - V	CI ENGINE SIMULATION	9+6

Zero, one and multizone models for diesel engine combustion. Wiebe's Model, Whitehouse model and Watson model for diesel combustion. Heat release rate and heat transfer models. Engine model for Multi fuel Engines. Parametric studies on simulated engine performance. **Practicals:** CFD modelling on Combustion and emissions of SI (or) CI engine for the given input conditions.

TOTAL: 75 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able

CO1	To remember the thermodynamic processes involved in SI engine combustion.

CO2	To apply the principle behind the stoichiometric ratio, heat of reaction and adiabatic flame temperature calculations.
CO3	To develop and analyze the fuel air, progressive combustion engine cycles
CO4	To evaluate the actual engine model with gas exchange process.
CO5	To create the complete theoretical engine model for SI and CI Engines

TEXTBOOKS:

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

REFERENCES:

1. Ashley Campbel, "Thermodynamic analysis of combustion engines", John Wiley & Sons, New York, 1986.
2. Benson.R.S., Whitehouse.N.D., "Internal Combustion Engines", Pergamon Press, oxford, 1979
3. John. B. Heywood, 'Internal Combustion Engines'", Tata McGraw Hill Co., New York, 1988.
4. Ramoss. A.L., "Modelling of Internal Combustion Engines Processes", McGraw Hill Publishing Co., 1992.

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	-	2	2	-	3	3	3
2	3	3	3	3	3	2	2	-	2	2	-	3	3	3
3	3	3	3	3	3	2	2	-	2	2	-	3	3	3
4	3	3	3	3	3	2	2	-	2	2	-	3	3	3
5	3	3	3	3	3	2	2	-	2	2	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**-**	**2**	**2**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23U02	PERSPECTIVES OF SUSTAINABLE DEVELOPMENT IN AUTOMOBILE	L	T	P	C
		2	0	2	3

MODULE I	INTRODUCTION	6

Principles & Historical perspectives, Importance and need for sustainability in engineering and technology, impact and implications. United Nations Sustainability Development Goals (SDG), UN summit – Rio & outcome, Sustainability and development indicators.

MODULE II	ENVIRONMENTAL SUSTAINABILITY	6

Climate change, Biodiversity loss, Pollution and waste management, Renewable vs. non-renewable resources, Water and energy conservation, Sustainable agriculture and forestry. National and international policies, Environmental regulations and compliance, Ecological Footprint Analysis

MODULE III	SOCIAL & ECONOMIC SUSTAINABILITY	9

Equity and justice, Community development, Smart cities and sustainable infrastructure, Cultural heritage and sustainability, Ethical considerations in sustainable development.
Triple bottom line approach, Sustainable economic growth, Corporate social responsibility (CSR), Green marketing and sustainable product design, Circular economy and waste minimization, Green accounting and sustainability reporting.

MODULE IV	ENERGY EFFICIENCY AND ELECTRIC VEHCILES	9

Energy efficiency and emission reduction in vehicles. Electronically controlled and Turbocharged IC engines. Automotive Aerodynamics- Vehicle body optimization. Electric vehicles -battery, fuel cell and solar electric vehicles.

MODULE V	SUSTAINABILITY PRACTICES	30

- Heat balance analysis in internal combustion engine.
- Comparison of energy efficiency between naturally aspirated and turbocharged engine.
- Comparison of emissions between mechanical and electronically controlled engines.
- Analysis of drag coefficient on different types of vehicles.
- Performance analysis of fuel cell.

TOTAL: 75 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to

CO1	have a comprehensive understanding of sustainability principles, history, and the role of engineering in sustainable development.
CO2	identify and develop strategies for addressing major environmental issues, including renewable energy and conservation.
CO3	understand the importance of equity, justice, and ethical considerations in sustainable development, as well as concepts like the triple bottom line and CSR
CO4	practically apply sustainability principles in real-world projects, including analyzing energy systems, emissions, and vehicle design.
CO5	possess practical skills in designing sustainable infrastructure, products, and energy-efficient technologies.

REFERENCES:

1. Allen, D., & Shonnard, D. R. (2011). Sustainable engineering: Concepts, design and case studies. Prentice Hall.
2. Munier, N. (2005). Introduction to sustainability (pp. 3558-6). Amsterdam, The Netherlands: Springer.
3. Blackburn, W. R. (2012). The sustainability handbook: The complete management guide to achieving social, economic and environmental responsibility. Routledge.

4. Clini, C., Musu, I., & Gullino, M. L. (2008). Sustainable development and environmental management. Published by Springer, PO Box, 17, 3300.
5. Bennett, M., James, P., & Klinkers, L. (Eds.). (2017). Sustainable measures: Evaluation and reporting of environmental and social performance. Routledge.
6. Seliger, G. (2012). Sustainable manufacturing for global value creation (pp. 3-8). Springer Berlin Heidelberg.
7. Stark, R., Seliger, G., & Bonvoisin, J. (2017). Sustainable manufacturing: Challenges, solutions and implementation perspectives. Springer Nature.
8. Davim, J. P. (Ed.). (2013). Sustainable manufacturing. John Wiley & Sons.
9. Ganesan. V, "Internal Combustion Engines", 4th Edition, McGraw Hill Publication 2012.
10. Hucho. W.H. – "Aerodynamic of Road Vehicles – From Fluid Mechanics to Vehicle Engineering", Society of Automotive Engineers, U.S, Fourth edition, 1998.
11. James Larminie and John Lowry, "Electric Vehicle Technology Explained "John Wiley & Sons,2003

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	3	3	3	2	2	2	3	3	3
2	3	3	3	3	3	3	3	3	2	2	2	3	3	3
3	3	3	3	3	3	3	3	3	2	2	2	3	3	3
4	3	3	3	3	3	3	3	3	2	2	2	3	3	3
5	3	3	3	3	3	3	3	3	2	2	2	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

PROFESSIONAL ELECTIVE COURSES

VERTICALS-I: ADVANCED VEHICLE TECHNOLOGY

AU23C03	SPECIAL PURPOSE VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Enhance the knowledge of the students about the various equipment's used in earthmoving, applications.
2. Understand the construction and working of the vehicle for constructional application
3. Describe the working nature of farm equipment's based on their application.
4. Discriminate the various industrial vehicles based on the purpose.
5. Acquire the knowledge on the functioning of military vehicle

UNIT - I	EARTH MOVING EQUIPMENTS	9

Construction layout, capacity and applications of dumpers, articulated haulers, front-end loaders, backhoe loaders, bulldozers, scrappers, motor graders, skid-steer loaders, excavator, hydraulic shovels, bucket conveyors, surface miners– highwall Miners.

UNIT - II	CONSTRUCTIONAL EQUIPMENTS	9

Construction layout, capacity and applications of cranes–types, Articulated Trucks, Concrete Ready mixer, Trenchers, Asphalt Pavers, Road Reclaimers, Compactors–types, Draglines, Drillers, Bore well machine.

UNIT - III	FARM EQUIPMEMTS	9

Classification of tractors – Main components of tractor. Working attachment of tractors – Auxiliary equipment –-Top lifting harvesters. General description, working, specification and functions- Paddy harvesting machines, Sugarcane harvesting, Feller bunchers, Forest machines.

UNIT - IV	INDUSTRIAL VEHICLES	9

Constructional features, capacity and working of forklifts, Utility vehicles, towing vehicles, man-lift chassis, scissor lift trucks, material handlers, reclaimers, Street sweepers

UNIT - V	MILITARY AND COMBAT VEHICLES	9

Special features and constructional details of Main Battle tank, gun carriers, transport vehicles, Armored vehicle – launched bridge, Amphibious bridging vehicle, Communication vehicles.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Demonstrate their understanding about the operation of the various special purpose vehicle
CO2	Understand the construction layout of earthmoving equipment's.
CO3	Have the ability to apply the knowledge to design a new concept for construction application.
CO4	Demonstrate their skill in developing modern techniques for future farming vehicles
CO5	Distinguish the various military vehicles and infer their particular technology.

TEXTBOOKS:

1. Abrosimov. K. Branberg. A. and Katayer. K., "Road making Machinery", MIR Publishers, Moscow,1971.
2. V. Rodichev and G. Rodicheva, Tractor and Automobiles, MIR Publishers,1987.
3. Wong. J. T. "Theory of Ground vehicles ", John Wiley & Sons, New York,1987.

REFERENCES:

1. Beleman and M. Moskovin, Farm tractors, MIR, Publishers Moscow.
2. Bart H Vanderveen, Tanks and Transport vehicles, Frederic Warne and Co ltd., London.
3. Kolchin, A., and V. Demidov, Design of Automotive Engines for Tractor, MIR Publishers,1972.
4. Peurifoy R.L "Construction Planning, Equipment and Methods", Tata McGraw-Hill, New Delhi,2002.
5. Wong J "Terra mechanics and Off-Road Vehicle Engineering", Butterworth-Heinemann,2009.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2	2	2	2	2	1	2	2	2	1	3	3	2
2	3	2	2	2	2	2	1	2	2	2	1	3	3	2
3	3	2	2	2	2	2	1	2	2	2	1	3	3	2
4	3	2	2	2	2	2	1	2	2	2	1	3	3	2
5	3	2	2	2	2	2	1	2	2	2	1	3	3	2
Avg	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23001	TWO AND THREE-WHEELER TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. Impart the knowledge on two-wheeler design and stability aspects
2. Understand the construction and working of power unit in two and three-wheeler & expose knowledge on different ignition systems and electrical systems.
3. Gain knowledge on clutch and transmission system of two wheelers
4. Recognize various frames used in two wheelers and to gain knowledge on two-wheeler suspension & brake systems.
5. Interpret various three wheelers and its applications

UNIT - I	INTRODUCTION	9

Classifications of different two wheelers based on usage - design considerations weight and dimension limitations – design requirements, gyroscopic effect- pendulum effect of two and three wheelers, stability problems.

UNIT - II	POWER UNITS, IGNITION SYSTEMS AND OTHER ELECTRICAL SYSTEMS	9

Two stroke and four stroke engines. Conventional IC engines for 2 & 3 wheelers, PFI, MPFI and GDI engines. Battery coil ignition, magneto ignition and electronic ignition. Lighting and other electrical systems.

UNIT - III	CLUTCHES AND TRANSMISSION	9

Gearbox and final drive – Type of Gear Boxes. Types of clutches & design. Gear change mechanism. CVT. Belt, chain and shaft drive. Freewheeling devices, starting systems.

UNIT - IV	FRAMES, SUSPENSION, WHEELS, TYRES AND BRAKES	9

Types of frames. Design of frames for fatigue strength, torsional stiffness and lateral stability. Front and rear forks. Springs for suspension, Dampers, constructional details of wheel and tyres. Braking systems.

UNIT - V	THREE WHEELERS	9

Auto rickshaws, different types, Pick-Ups and delivery type vehicle, frames and transmission, wheel types, wheel mountings attachment, tyre types. Brake systems.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Understand and demonstrate the designing of two-wheeler stability
CO2	Distinguish various two-wheeler power unit functions and Ignition systems
CO3	Demonstrate various design aspects of clutch and transmission system for two and three wheelers
CO4	Distinguish the different two-wheelers frames and its sub systems for different applications
CO5	Explain and distinguish the different three wheelers and its sub systems based on applications

TEXTBOOKS:

1. Edward Abdo, Modern motor cycle technology by 3rd Edition, 2015
2. Irving, P.E., Motor cycle Engineering, Temple Press Book, London, 1992.

REFERENCES:

1. K. K. Ramalingam, Two Wheelers, Scitech publications, Chennai
2. Dhruv U. Panchal. 'Two and Three-wheeler technology" PHI Pvt. Learning Limited, Delhi 2015.
3. Motorcycle Basics Tech book by Haynes 2nd Edition, 2015
4. Motorcycle mechanics, By George Lear,1977

5. The Essential Guide to Motorcycle Maintenance by Mark Zimmerman2016
CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2	2	2	2	2	1	2	2	2	1	3	3	2
2	3	2	2	2	2	2	1	2	2	2	1	3	3	2
3	3	2	2	2	2	2	1	2	2	2	1	3	3	2
4	3	2	2	2	2	2	1	2	2	2	1	3	3	2
5	3	2	2	2	2	2	1	2	2	2	1	3	3	2
Avg	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23002	ROAD VEHICLE AERODYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students to

1. understand the forces & moments influencing drag
2. assess the techniques of detail and shape optimizations for cars
3. assess the techniques of detail and shape optimizations for commercial vehicles
4. assess the techniques of detail and shape optimizations for motorcycles
5. expose to experimental testing and instrumentation

UNIT - I	SCOPE OF VEHICLE AERODYNAMICS	9

Scope of vehicle aerodynamics. Properties of incompressible fluids. External and internal flow phenomena related to vehicles. Causes and effects of aerodynamic forces and moments. Impact of road load on vehicle motion. Performance potential, Fuel Consumption and fuel economy calculations. Strategies for low fuel consumption.

UNIT - II	AERODYNAMIC DRAG OF PASSENGER CARS	9

Bluff body. Drag fractions and their local origins – forebody, windshield and A and C pillars, roof, rear end, plan view and side panels, underbody, wheels and wheel housings, front spoiler, rear spoiler. Strategies for aerodynamic development – Detail optimization, Shape optimization, Facelift, Adaptation of add-on devices.

UNIT - III	AERODYNAMIC DRAG OF COMMERCIAL VEHICLES	9

Relation between tractive resistance, drag and fuel consumption. Aerodynamic drag coefficients of commercial vehicles. Drag reduction on delivery vans, trucks, and buses. Add-on devices for drag reduction. Vehicle soiling types, causes, effects and control measures.

UNIT - IV	MOTORCYCLE AERODYNAMICS	9

Development of motorcycle aerodynamics. Riding dynamics and its relationship with aerodynamics. Methods of measurement in road tests. Rider influences - rider and pillion passenger. Clothing and helmets. Case studies on racing models.

UNIT - V	EXPERIMENTAL TESTING AND INSTRUMENTATION	9

Wind tunnel – Types and Principle. Limitations with reduced scale models. Measuring Equipment and Transducers – Wind tunnel balance, Hotwire anemometry, Pitot tube and transducers. Flow visualization techniques – Smoke, wool tuft, Particle image velocimetry. Introduction to computational fluid dynamics.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	comprehend the forces & moments influencing drag.
CO2	appraise the techniques of detail and shape optimizations for cars.
CO3	interpret the strategies of drag reduction in commercial vehicles.
CO4	investigate the factors influencing drag on motorcycles.
CO5	expose to experimental testing and instrumentation.

TEXTBOOKS:

1. Alan Pope, Jewel B. Barlow, William H. Rae “Low-speed wind tunnel testing”, John Wiley & Sons, Third edition, 1999
2. Hucho. W.H. – “Aerodynamic of Road Vehicles – From Fluid Mechanics to Vehicle Engineering”, Society of Automotive Engineers, U.S, Fourth edition, 1998.

REFERENCES:

1. R.H. Barnard - “Road vehicle aerodynamic design, An Introduction”, Mechaero publications, Third edition, 2010
2. T. Yomi Obidi - “Theory and Applications of Aerodynamics for Ground Vehicles”, SAE International, 2014.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23003	VEHICLE CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Comprehensively understand the basics of control systems used in automobiles
2. Give exposure to modeling and control of SI and CI engine systems
3. Introduction to drive line components and detailed knowledge on modeling and control of driveline systems
4. Overview on cruise control design, headway and their related stability control using different technologies
5. Illustrate the need for fault diagnosis, human factors and automated transport systems.

UNIT - I	INTRODUCTION TO VEHICLE CONTROL SYSTEM & CONTROL SCHEMES	9

Model based system design: - Trends, overview-Selection of controlled, manipulated, measured disturbance variables- Degree of freedom for vehicle control- classification of the variables in various automotive systems like engines, suspension, braking, air conditioning etc. – Sensors, actuators and controller modules-Vehicle communication Network-System Engineering V-diagram- Algorithm Development - Steps in vehicle control system design- Transfer function & State Space Modeling- Vehicle controller configurations- Feedback, Inferential, Feed-Forward, Cascade control, Nonlinear control- Adaptive control- PID tuning methods etc.

UNIT - II	MODELING AND CONTROL OF POWERTRAIN SYSTEMS	9

Mean value engine modeling-Basic control of SI engines-Fuel management and Lambda control, Ignition control, idle speed control- Turbo control- Basic control of CI engine-Overview, Torque control, Fuel control, control of gas flow, EGR &VGT control, Variable valve actuation, variable compression, Signal interpretation and Feedback control- Transmission control - Case Study: EGR and VGT Control and Tuning.

UNIT - III	MODELING AND CONTROL OF DRIVERLINE SYSTEMS	9

Driveline- Motivation, behavior without appropriate control- Rigid driveline model-Driveline surge and other additional driveline dynamics- clutch influence and backlash-Modeling of neutral gear and open clutch, clutch modeling -Torque Converter-Characteristics of Driveline control- Basic control of Driveline – Driveline speed control-Control of Drive torque- Transmission torque control- Drive shaft torsion control.

UNIT - IV	CRUISE, HEADWAY AND STABLITY CONTROL	9

PI,PID, Adaptive PI & PID design, Anti-locking braking system (ABS) – Cruise controller Adaptive cruise control overview, requirements, dynamics of braked wheel, ABS control loops, typical control cycles-Traction control system (TCS)- tasks, functions, structure, typical control situation- Electronic Stability program(ESP)- requirements, task and methods of operation, ESP control loop- Linear and non-linear vehicle model- VSC Design Principles – Four-wheel steering – Goals of 4WS Algorithms – Active steering.

UNIT - V	FAULT DIAGNOSIS, HUMAN FACTORS AND INTELLIGENT TRANSPORT SYSTEM	9

Dependability-Reasons, basic definition and concepts-Fault diagnosis- Sensor faults, actuator fault, triple sensor redundancy- Engineering of diagnosis system – Catalyst and lambda sensors, Throttle supervision, Evaporative system monitoring, misfire and air intake- Human factors in vehicle automation- cross over model principle- Risk-Homeostatic Theory- Driving simulators- percentage of road departure. OBD-II.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Understand the basics of control systems used in automobiles

CO2	Ability to explain and apply modeling and different control schemes for powertrain system
CO3	Understand the drive line components needs and apply different modeling and control approaches in driveline systems design
CO4	Apply the cruise control design, headway and their related stability control to different vehicle systems
CO5	Illustrate the need for fault diagnosis, human factors and automated transport systems

TEXTBOOKS:

1. Galip Ulsoy, Automotive Control System, Cambridge University Press, 2012
2. Lars Eriksson And Lars Nielsen, Modeling and Control of Engines and Drivelines, Wiley, 2014.

REFERENCES:

1. Uwe Kiencke and Lars Nielson, Automotive Control System, SAE Publications, 2006
2. Automotive Mechatronics- Automotive Networking, Driving Stability Systems, Electronics
3. Bosch Automotive Handbook, Sixth Edition, 2004
4. Benjamin C. Kuo and Farid Golnaraghi, Automatic Control System, John Wiley & Sons, Eight edition, 2003.
5. Katsuhiko Ogata, System Dynamics, Prentice Hall International, Inc. Third Edition,1998
6. Richard C. Dorf and Robert H. Bishop, Modern Control Systems, Pearson Prentice Hall,2008

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	-	3	3	3
2	3	3	3	3	3	2	2	1	2	1	-	3	3	3
3	3	3	3	3	3	2	2	1	2	1	-	3	3	3
4	3	3	3	3	3	2	2	1	2	1	-	3	3	3
5	3	3	3	3	3	2	2	1	2	1	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23004	ADVANCE AUTOMOTIVE MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Knowledge on properties of engineering materials for automobile.
2. Select suitable material selection process for automobile Structural design.
3. Select Materials for engine components and transmission systems.
4. Select materials used for automotive structures.
5. Select electronic materials for automotive applications.

UNIT - I	ENGINEERING MATERIALS AND THEIR PROPERTIES	9

Classes of engineering materials - the evolution of engineering materials, Definition of materials properties, displaying material properties using materials selection charts, Forces for change in materials selection and design, Materials and the environment- selection of materials for automotive, aerospace, marine and defense applications.

UNIT - II	BASIS OF MATERIAL SELECTION	9

Selection strategy, Attribute limits and Material indices, structural index Selection procedure: Design process - types of design, design requirements, Function, Material attributes, Shape and Manufacturing processes - Materials processing and design processes and their influence on design, Process attributes, Systematic process selection, Process selection diagrams, Process cost, Energy consumption for production, Material costs, Availability, Recyclability, Environmental consideration. Computer aided selection.

UNIT - III	MATERIALS FOR ENGINES AND TRANSMISSION SYSTEMS	9

Materials selection for IC engines: Piston, piston rings, cylinder, Engine block, connecting rod, Crank shaft, Fly wheels, Gear box, Gears, Splines, Clutches.

UNIT - IV	MATERIALS FOR AUTOMOTIVE STRUCTURES	9

Materials selection for bearings, leaf springs, chassis & frames, Bumper, shock absorbers, wind screens, panels, brake shoes, Disc, wheels, differentials, damping and antifriction fluids, Tyres and tubes.

UNIT - V	ELECTRONIC MATERIALS FOR AUTOMOTIVE APPLICATIONS	9

Materials for electronic devices meant for engine control, ABS, Steering, Suspension, Sensors, anti-collision, Anti-fog, Head lamps.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Summarize properties of engineering materials for automobile.
CO2	Choose suitable material selection process for design of automotive components.
CO3	Select Materials for IC engine components and transmission systems.
CO4	Recommend the materials used for automotive structures.
CO5	Decide suitable electronic materials for automotive electrical and electronics applications.

REFERENCES:

1. Ahmed Elmarakbi," Advanced Composite Materials for Automotive Applications- Structural Integrity and Crash worthiness", John Wiley&SonsLtd,2014.
2. Brian Cantor, Patrick Grant, Colin Johnston, "Automotive Engineering: Lightweight, Functional, and Novel Materials", CRC Press, Taylor& FrancisGroup,2010.
3. Geoffrey Davies, "Materials for Automobile Bodies", Butterworth-Heinemann,2012
4. Hiroshi Yamagata, "The Science and Technology of Materials in Automotive Engines", Woodhead Publishing, 2005
5. Smallman R. E, Bishop R. J," Modern Physical Metallurgy and Materials Engineering Science, process, applications", Sixth Edition, Butterworth-

Heinemann, 1999.
CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	2	-	1	1	1	2	1	-	3	3	3
2	3	3	2	2	-	1	1	1	2	1	-	3	3	3
3	3	3	2	2	2	1	1	1	2	1	-	3	3	3
4	3	3	2	2	-	1	1	1	2	1	-	3	3	3
5	3	3	2	2	-	1	1	1	2	1	-	3	3	3
Avg	**3**	**3**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**1**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23005	AUTOMOTIVE SAFETY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is

1. To introduce vehicle structural crashworthiness and crash testing
2. To introduce pedestrian safety
3. To get the knowledge in sensors provided in the vehicle to avoid the crash and to detect the obstacles around the vehicle.
4. To understand the fundamentals of sensor data fusion as it relates to ADAS.
5. To Understand the concept of the connected vehicle and its role in ADAS and automated vehicles.

UNIT - I	CONCEPTS OF AUTOMOTIVE SAFETY	9

Automotive safety: Introduction and Types. Active safety: driving safety, conditional safety, Perceptibility safety, operating safety. Passive safety: Design of body for safety. Concept of crumble zone, Safety Cage. Optimum crash pulse, deceleration on impact with stationary and movable obstacles. Design for Crashworthiness. NCAP.

UNIT - II	PASSIVE SAFETY EQUIPMENTS AND CONVENIENCE SYSTEM	9

Seat belt, Seat belt tightener system and importance, collapsible steering column. Air bags and its activation. Designing aspects of automotive bumpers and materials for bumpers. Steering and mirror adjustment, central locking system, Tire pressure control system, rain sensor system, Automated wiper system.

UNIT - III	ACTIVE SAFETY	9

Antilock braking system, Stability Control. Adaptive cruise control, Lane Keep Assist System, Collision warning, avoidance system, Blind Spot Detection system, Driver alertness detection System. ADAS.

UNIT - IV	VEHICLE INTEGRATION AND NAVIGATION SYSTEM	9

Looking out sensors and looking in sensors, Intelligent vision system, Vehicle Integration system. Global Positioning System. Vehicle Navigation System. Road Network.V2V, V2X.

UNIT - V	AUTONOMOUS VEHICLE	9

SAE Levels of Driving Automation, Level 0 – No Driving Automation, Level 1 – Driver Assistance, Level 2 – Partial Driving Automation, Level 3 – Conditional Driving Automation, Level 4 – High Driving Automation, Level 5 – Full Driving Automation.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Know about the concept of crumble zone and vehicle structural crashworthiness and crash testing
CO2	Know the various types of Occupant safety system
CO3	Know about Active Safety in the vehicle and avoid crash and function of ADAS.
CO4	Understand the fundamentals of sensor and to detect the obstacles around the vehicle and the concept of the connected vehicle.
CO5	Understand SAE Levels of Driving Automation.

TEXTBOOKS:

1. Ljubo Vlacic, Michel Parent, Fumio Harashima – “Intelligent Vehicle Technologies Theory and Applications” -Butterworth-Heinemann, 2001
2. J. Marek, H.-P. Trah, Y. Suzuki, I. Yokomori - “Sensors for Automotive Applications “-WILEY-VCH Verlag GmbH & Co. 2003
3. Robert Bosch GmbH - “Safety, Comfort and Convenience Systems”- Wiley; 3rd edition,2007

REFERENCES:

1. Bosch, “Automotive Hand Book”, 6th edition, SAE, 2004.
2. J. Powloski - “Vehicle Body Engineering” - Business books limited, London - 1969.

3. Ronald. K. Jurgen - “Automotive Electronics Handbook” - Second edition- McGraw-Hill Inc., - 1999.
4. ARAI Safety standards

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	-	3	3	3
2	3	3	3	3	3	2	2	1	2	1	-	3	3	3
3	3	3	3	3	3	2	2	1	2	1	-	3	3	3
4	3	3	3	3	3	2	2	1	2	1	-	3	3	3
5	3	3	3	3	3	2	2	1	2	1	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

VERTICALS-II: ADVANCED ENGINE TECHNOLOGY

AU23006	ENGINE MANAGEMENT SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Analyze the need and role of components used in an engine management system.
2. Apply the function of various sensors and actuators in an engine.
3. Categorize the different available ignition system.
4. Design of injection system for SI and CI engines.
5. Distinguish various engine control algorithm used during engine operation.

UNIT - I	FUNDAMENTALS OF AUTOMOTIVE ELECTRONICS	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.

UNIT - II	SENSOR AND ACTUATORS	9

Working principles, construction and location of sensors to measure speed, load, air flow, temperature, pressure, lambda, throttle position, knock, etc. Working principles, construction and location of actuators viz. Solenoid, relay, stepper motor etc. Design constraints.

UNIT - III	SI ENGINE MANAGEMENT	9

Layout, types and working of SI engine management systems (K, KE, Mono Jetronic, L, LH, Motronic. GDI. Development of ignition system – Transistor assisted, Contactless, Distributor less, CDI, Ignition Map, Knock control. Flowcharts for combined fuel injection and ignition control. Introduction to LASER Ignition system.

UNIT - IV	SI ENGINE MANAGEMENT	9

Fuel injection system parameters affecting combustion, noise and emissions in CI engines. Electronically controlled Unit Injection system. Common rail fuel injection system. Working of components like fuel injector, fuel pump, rail pressure limiter, flow limiter.

UNIT - V	DIGITAL ENGINE CONTROL SYSTEM	9

Control algorithm for different operating modes of engine. Pollution control devices. Integrated engine control system, Electromagnetic compatibility – EMI Suppression techniques – Electronic dash board instruments – On-board diagnosis system.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Differentiate between the mechanical and electronic engine management working.
CO2	Apply the function, construction and operation of various sensors and actuators.
CO3	Categorize different ignition and injection systems.
CO4	Design different injection systems.
CO5	Apply various engine control algorithm used during engine operation.

TEXTBOOKS:

1. Bosch, "Automotive Sensors", Robert Bosch GmbH, 2001.
2. William Ribbens, “Understanding Automotive Electronics - An Engineering Perspective," 7th Edition, Elsevier Butterworth-Heinemann Publishers, 2012.

REFERENCES:

1. Allan W. M. Bonnick, "Automotive Computer Controlled Systems", Butterworth-Heinemann, 2001.
2. Eric Chowanietz, “Automobile Electronics,” SAE, 1995.
3. Diesel Engine Management by Robert Bosch, SAE Publications, 3rd Edition, 2004.
4. Tom Denton, “Advanced Automotive Fault Diagnosis,” Second edition, 2006

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23007	ALTERNATIVE AND ADVANCED FUELS FOR IC ENGINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To acquire complete knowledge on availability of possible biofuels and their properties to use as fuel in CI and SI engines.
2. To apply the knowledge on the possible way of using alcohols as a fuel IN IC engines.
3. To analyses the challenges and difficulties in using vegetable oil as an alternative fuel in internal combustion engines.
4. To evaluate the uses of hydrogen as fuel in IC engines as an alternative to fossil fuels.
5. To create new and novel methods to use alternative fuels in internal combustion engines.

UNIT - I	ALTERNATIVE FUELS, PROPERTIES AND TESTING METHODS OF FUEL	9

Need for alternative fuels. World and Indian energy scenario on alternative fuels. Production technologies for biofuels for internal combustion engines- Pyrolysis, gasification, digestion.

UNIT - II	ALCOHOLS AS FUELS	9

Alcohols as fuels. Production methods of alcohols. Properties of alcohols as fuels. Methods of using alcohols in CI and SI engines. Blending, dual fuel operation, surface ignition and oxygenated additives. Performance emission and combustion characteristics in CI and SI engines. Recent Trends in Alcohol engine technologies.

UNIT - III	VEGETABLE OILS AS FUELS	9

Various vegetable oils and their important properties. Different methods of using vegetable oils in engines – Blending, preheating Transesterification and emulsification of Vegetable Oils-Performance in engines – Performance, Emission and Combustion Characteristics in diesel engines. Role of Nano fluids, additives and cetane improvers for performance improvement of vegetable oils as fuel.

UNIT - IV	HYDROGEN AS ENGINE FUEL	9

Production methods of hydrogen. Combustive properties of hydrogen. Problems associated with hydrogen as fuel and solutions. Different methods of using hydrogen in SI and CI engines. Performance, emission and combustion analysis in engines. Hydrogen storage - safety aspects of hydrogen. Recent trends in Hydrogen engines.

UNIT - V	BIOGAS, LPG AND NATURAL GAS AS FUELS	9

Production methods of Biogas, Natural gas and LPG. Properties studies. CO_2 and H_2S scrubbing in Biogas., Modification required to use in SI and CI Engines- Performance and emission characteristics of Biogas, NG and LPG in SI and CI engines.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Acquire complete knowledge on availability of possible alternate fuels and their properties to use as fuel in CI and SI engines.
CO2	Apply the knowledge on the possible way of using alcohols as a fuel in IC engines.
CO3	Analyze the challenges and difficulties in using vegetable oil as an alternative fuel in internal combustion engines.
CO4	Evaluate the uses of hydrogen as fuel in IC engines as an alternative to fossil fuels.
CO5	Create new and novel technologies to use alternative fuels in internal combustion engines.

TEXTBOOKS:

1. Donald Klass, Biomass for Renewable Energy, Fuels, and Chemicals, 1998, Academic Press, ISBN: 978-0-12-410950-6.
2. Richard L Bechtold P.E., Alternative Fuels Guide book, Society of Automotive Engineers, 1997 ISBN 0-76-80-0052-1.

REFERENCES:

1. Ayhan Demirbas, 'Biodiesel A Realistic Fuel Alternative for Diesel Engines', Springer- Verlag London Limited 2008, ISBN-13: 9781846289941
2. Gerhard Knothe, Jon Van Gerpen, Jargon Krahl, The Biodiesel Handbook, AOCS Press Champaign, Illinois 2005.
3. Science direct Journals (Biomass & Bio energy, Fuels, Energy, Energy conversion Management, Hydrogen Energy, etc.) on biofuels.
4. Technical papers.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	3	2	-	2	-	3	2	2	3	1	2
2	3	3	2	3	2	-	2	-	3	2	2	3	1	2
3	3	3	2	3	2	-	2	-	3	2	2	3	1	2
4	3	3	2	3	2	-	2	-	3	2	2	3	1	2
5	3	3	2	3	2	-	2	-	3	2	2	3	1	2
Avg	**3**	**3**	**2**	**3**	**2**	**-**	**2**	**-**	**3**	**2**	**2**	**3**	**1**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23008	ADVANCED THEORY OF ICENGINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The objective of this course is to make the students

1. To impart knowledge over entire combustion theory of internal combustion engines.
2. To describe and summarize the cycles of an internal combustion engine
3. To acquire complete knowledge in engine modelling and combustion analysis
4. of internal combustion engines.
5. To expose knowledge in non- conventional engines and their operation in de

UNIT - I	COMBUSTION OF FUELS	9

Chemical composition and molecular structure of hydrocarbon fuels. Combustion Stoichiometry of hydrocarbon fuels – Chemical energy and heat of reaction calculations – Chemical equilibrium and adiabatic flame temperature calculation. Theory of SI and CI engine combustion–Flame velocity and area of flame front. Fuel spray characteristics – droplet size, depth of penetration and atomization – Problems on chemical equilibrium and reactions.

UNIT - II	ENGINE CYCLE ANALYSIS	9

Ideal air, fuel air cycle and actual cycle analysis. Progressive combustion analysis in SI engines. Parametric studies on work output, efficiency and other engine performance – Problems on engine cycle.

UNIT - III	ADVANCED CONCEPTS IN IC ENGINES	9

Concept of Low Temperature Combustion. Homogeneous Charge Compression Ignition Engine. Reactivity Controlled Compression Ignition Engine. Premixed Charge Compression Ignition Engine. Recent Developments – Hydrogen applications in IC engines.

UNIT - IV	NON-CONVENTIONAL IC ENGINES	9

Concept of L.H.R. engine and its recent developments. Variable compression ratio engine and its use in engine research. Wankel rotary combustion engine. Dual fuel engine concept for multi fuel usage in CI engines -performance studies on dual fuel engine. Free piston engine. Stratified charge and lean burn engines. Locomotive and marine engines. RCCI engines

UNIT - V	COMBUSTION ANALYSIS IN IC ENGINES	9

Photographic studies of combustion processes – Analysis of Pressure crank angle diagrams in SI and CI engines. Knock study for Pressure crank angle histories. Apparent heat release rate and Wiebe's law analysis for combustion. Calculation of Ignition delay and combustion duration. – Hotwire and laser Doppler anemometry and velocimetry for flow and combustion analysis in IC engines. Study on air flow characteristics

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Illustrate the knowledge over the theory of IC engine combustion.
CO2	Analyze and interpret the knowledge over the cycles and combustion of an IC Engine.
CO3	Demonstrate engine modelling and combustion analysis of internal combustion engines.
CO4	Understand and compose the non-conventional engines and their operation.
CO5	Apply and distinguish the processes involved in IC engine combustion.

TEXTBOOKS:

1. John, B., Heywood, Internal Combustion Engine Fundamentals, Mc Graw Hill Publishing Co., New York,2011.
2. Ganesan., Internal combustion engines, Tata McGraw Hill Publishing Co.,2015.

3. Ramalingam. K. K., Internal combustion engines, Scitech publications, Chennai,2003.

REFERENCES:

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

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2	1	2	1	3	3	2	1	1	-	2	3	3
2	3	2	1	2	1	3	3	2	1	1	-	2	3	3
3	3	2	1	2	1	3	3	2	1	1	-	2	3	3
4	3	2	1	2	1	3	3	2	1	1	-	2	3	3
5	3	2	1	2	1	3	3	2	1	1	-	2	3	3
Avg	**3**	**2**	**1**	**2**	**1**	**3**	**3**	**2**	**1**	**1**	**-**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23009	COMBUSTION THERMODYNAMICS AND HEAT TRANSFER	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To remember the principle of combustion in thermodynamics.
2. To identify the kinetics behind the chemical reaction of combustion of fuels.
3. To analyse the behaviour of the flames inside a combustion chamber.
4. To analyse the behaviour of conduction, convection and radiation heat transfer in IC engines.
5. To evaluate the in-cylinder pressure of the engine.

UNIT - I	THERMODYNAMICS OF COMBUSTION	9

Premixed and diffusion combustion process in IC engines. First and Second Law of Thermodynamics applied to combustion- combustion Stoichiometry- chemical equilibrium, spray formation and droplet combustion.

UNIT - II	CHEMICAL KINETICS OF COMBUSTION	9

Fundamentals of combustion kinetics, rate of reaction, equation of Arrhenius, activation energy. Chemical thermodynamic model for Normal Combustion.

UNIT - III	FLAMES	9

Laminar premixed – flame speed correlations- quenching, flammability, and ignition, flame stabilization, laminar diffusion flames, turbulent premixed flames - Reynolds and Damkohler numbers and their significance.

UNIT - IV	HEAT TRANSFER IN IC ENGINES	9

Engine Heat transfer and heat Balance. Measurement of Instantaneous heat transfer rate. Heat transfer modelling. Heat transfer coefficients, radiative heat transfer.

UNIT - V	EXPERIMENTS IN IC ENGINES	9

Cylinder pressure measurement. Rate of heat release calculation – hot wire and laser Doppler anemometry and velocimetry for flow and combustion analysis in IC engines.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Remember the principle of combustion in thermodynamics.
CO2	Identify the kinetics behind the chemical reaction of combustion of fuels.
CO3	Analyse the behavior of the flames inside a combustion chamber.
CO4	Analyse the behavior of conduction, convection and radiation heat transfer in IC engines.
CO5	Evaluate the in-cylinder pressure of the engine.

TEXTBOOKS:

1. John. B. Heywood, 'Internal Combustion Engines'", Tata McGraw Hill Co., New York, 1988.

REFERENCES:

1. Ashley Campbel, "Thermodynamic analysis of combustion engine", John book company, New York, 1979.
2. Spalding. D. B., "Some fundamental of Combustion", Butterworth Science Publications, London, 1985.
3. Taylor.E.F."The Internal Combustion Engines ", International Text Book Co., Pennsylvania, 1982.
4. V. Ganesan, 'Internal combustion Engines', Tata McGraw Hill Book Co, Eighth Reprint, 2005.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	3	2	-	2	-	3	2	2	3	1	2
2	3	3	2	3	2	-	2	-	3	2	2	3	1	2
3	3	3	2	3	2	-	2	-	3	2	2	3	1	2
4	3	3	2	3	2	-	2	-	3	2	2	3	1	2
5	3	3	2	3	2	-	2	-	3	2	2	3	1	2
Avg	**3**	**3**	**2**	**3**	**2**	**-**	**2**	**-**	**3**	**2**	**2**	**3**	**1**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23010	ENGINE COMPUTATIONAL FLUID DYNAMICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

This course aims to introduce the numerical modelling in the field of IC engine

1. To Introduce the importance of computational fluid dynamics in engine process.
2. To understand the need of gas exchange process in IC Engine.
3. To develop computational model in air fuel mixture preparation.
4. To acquire knowledge on combustion thermochemistry.
5. To create different emission models for IC engines.

UNIT - I	INTRODUCTION TO CFD	9

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer –Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretisation techniques using finite difference methods – Taylor's Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

UNIT - II	DIFFUSION PROCESSES: FINITE VOLUME METHOD	9

Steady one-dimensional diffusion, Two- and three-dimensional steady state diffusion problems, Discretisation of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson's schemes, Stability of schemes.

UNIT - III	FLOW MODELLING	9

Introduction of flow in S.I. Engines and C.I. engines simulation with air as working medium, gas exchange processes, Wave Propagation in Compressible Medium, Shock Waves, Nozzles and Diffusers, wall interaction theory, Air motion.

UNIT - IV	COMBUSTION AND FUEL	9

Droplet evaporation and burning -Simple model for droplet evaporation, Simple model of droplet burning, Chemical Kinetics- Elementary reaction rates, Important chemical mechanisms, Flame types, Conservation Equations for reacting flows, Laminar flames - premixed flames, diffusion flames. Turbulent flames -Structure of turbulent premixed flames, Turbulent non premixed flames; Burning of solids, Simulations using different combustion models.

UNIT - V	EMISSION MODELLING	9

Calculation of equilibrium composition. Enthalpy and Energy, Coefficients for reactions and adiabatic flame temperature, Modelling of CO, HC, NO reactions in SI and CI Engines – Soot Modelling -Hiroyasu soot model, Zeldovich NOx model, Modelling of After Treatment Device

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of this course the students will be able to

CO1	Understand the governing equations and boundary conditions in Computational fluid dynamics
CO2	Apply different gas exchange processes in modeling.
CO3	Optimize the air- fuel mixture process in IC engine.
CO4	Develop the combustion chemistry models in Engine modeling.
CO5	Create and analyse different emission models for IC engines.

REFERENCES:

1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics the Finite volume Method," Pearson Education, Ltd., 2008.
2. A.F. Williams, combustion in flames, Oxford Press, Second Edition, 2019.
3. John. B. Heywood, "Internal Combustion engine fundamentals" McGraw – Hill, 2018.
4. V. Ganesan, Computer Simulation of C.I. Engine Processes, Universities Press,2000.

5. V.Ganesan, Computer Simulation of Spark Ignition Engine Processes, Universities Press, 2000
CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	3	2	-	2	-	3	2	2	3	1	2
2	3	3	2	3	2	-	2	-	3	2	2	3	1	2
3	3	3	2	3	2	-	2	-	3	2	2	3	1	2
4	3	3	2	3	2	-	2	-	3	2	2	3	1	2
5	3	3	2	3	2	-	2	-	3	2	2	3	1	2
Avg	**3**	**3**	**2**	**3**	**2**	**-**	**2**	**-**	**3**	**2**	**2**	**3**	**1**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23011	SUPERCHARGING AND SCAVENGING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To design supercharger.
2. To design turbocharger.
3. To analyze I.C engine performance and emissions.
4. To analyze scavenging of two stroke engines.
5. To design muffler and port.

UNIT - I	SUPERCHARGING	9

Engine modifications required. Effects on Engine performance – Thermodynamics of Mechanical Supercharging. Types of compressors – Positive displacement blowers – Centrifugal compressors – Performance characteristic curves – Surging and Choking - Suitability for engine application – Matching of supercharger compressor and Engine.

UNIT - II	TURBOCHARGING	9

Turbocharging methods - Thermodynamics – Engine exhaust manifolds arrangements. – Waste gate, Variable nozzle turbochargers, Variable Geometry Turbocharging –- Matching of compressor, Turbine and Engine.

UNIT - III	SCAVENGING OF TWO STROKE ENGINES	9

Features of two stroke cycle engines – Classification of scavenging systems – Charging Processes in two stroke cycle engine – Terminologies – Sankey diagram – Relation between scavenging terms – scavenging modelling – Perfect displacement, Perfect mixing. Mixture control through Reed valve induction.

UNIT -IV	PORTS AND MUFFLER DESIGN	9

Porting – Port flow characteristics-Design considerations – Design of Intake and Exhaust Systems – Tuning- Kadenacy system.

UNIT - V	EXPERIMENTAL METHODS AND RECENT TRENDS IN TWO STROKE ENGINES	9

Experimental techniques for evaluating scavenging – Firing engine tests – Non firing engine tests – Development in two stroke engines for improving scavenging. Direct injection two stroke concepts.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

On successful completion of this course the student will be able to

CO1	design superchargers
CO2	design match turbochargers with engines
CO3	design two stroke cycle engines.
CO4	design intake and exhaust systems
CO5	apply recent trends

REFERENCES:

1. G P Blair, Two stroke Cycle Engines Design and Simulation, SAE Publications, 1997.
2. Heinz Heisler, Advanced Engine Technology, Butterworth Heinmann Publishers, 2002.
3. John B. Heywood, Two Stroke Cycle Engine, SAE Publications, 1999.
4. Obert, E.F., Internal Combustion Engines and Air Pollution, Intext Educational Publishers, 1980.Richard Stone, Internal Combustion Engines, SAE, 2012.
5. Schweitzer, P.H., Scavenging of Two Stroke Cycle Diesel Engine, MacMillan Co., 1949.
6. Watson, N. and Janota, M.S., Turbocharging the I.C. Engine, MacMillan Co., 1982.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

VERTICALS-III: VEHICLE DESIGN

AU23012	VEHICLE DESIGN DATA CHARACTERISTICS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the various steps involved in the design of automotive components
2. To determine the various vehicle performance parameters
3. To determine the various design parameters and to draw curves using these data.
4. To learn the engine design parameters and its importance.
5. To understand the importance of gear ratio

UNIT - I	INTRODUCTION	9

Study and selection of vehicle specifications - Choice of Cycle, fuel, speed, cylinder arrangement, number of cylinders, method of cooling, material, design variables and operating variables affecting performance and emission.

UNIT - II	PERFORMANCE CURVES	9

Resistance, Power and torque curve, driving force against vehicle speed – Acceleration and gradeability in different gears for a typical car or truck plotted from specifications.

UNIT - III	RESISTENCE TO VEHICLE MOTION	9

Calculation and plotting the curves of air, rolling and gradient resistances, driving force – Engine power, speed, rear axle ratio, Torque and mechanical efficiency at different vehicle speeds.

UNIT - IV	ENGINE DESIGN	9

Pressure volume 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.

UNIT - V	GEAR RATIOS	9

Determination of Gear Ratios, Acceleration and gradeability - typical problems.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Analyse the design variables and operating variables affecting the performance and emission.
CO2	Compute the vehicle performance parameters.
CO3	Calculate and plot the curves of all the resistances at different speed.
CO4	Interpret the modern system in engine and would help in developing the system with less impact to the environment.
CO5	Demonstrate the design skill by determining the gear ratio

TEXTBOOKS:

1. Giri. N. K., “Automotive Mechanics”, Khanna Publishers, New Delhi, 2005 2
2. Heldt, P.M., High Speed Combustion Engine, Oxford & IBH Publishing Co.,

REFERENCES:

1. “Design Data Handbook”, PSG College of Technology,2013- Coimbatore.
2. Dean Averns, “Automobile Chassis Design”, IllifeBookCo.,2001.
3. Kolchin-Demidov, “Design of Automotive Engines”-Mir Publishers (1984)
4. Hardcover P. Lukin, G. Gasparyants, V. Rodionov, “Automobile Chassis: Design and Calculations”, Mir Publishers, Moscow,1989.
5. Robert C. Juvinall and KurtM. Marshek, “Fundamentals of Machine component Design”,6th Edition, Wiley, 2017

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23013	GEOMETRIC DIMENSIONING AND TOLERANCING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the various aspects of geometric tolerances
2. To understand the datum system
3. To analyse the aspects of tolerance
4. To learn the selective assembly
5. To understand the importance of various design aspects

UNIT - I	INTRODUCTION TO GD&T	9

ASME Y 14.5 standard. Examples for application of geometric tolerances - Feature control frame - Rule 1 and Rule 2 of GD&T - Modifiers - Form tolerances - Orientation tolerances - Location tolerances - Profile tolerances. True Position Theory - virtual size concept - floating and fixed fasteners – projected tolerance zone - zero true position tolerance - functional gauges - paper layout gauging - compound assembly - examples.

UNIT - II	DATUM SYSTEMS	9

Degrees of freedom - grouped datum systems-different types - two and three mutually perpendicular grouped datum planes - grouped datum system with spigot and recess - pin and hole - grouped datum system with spigot and recess pair and tongue-slot pair - computation of translational and rotational accuracy - geometric analysis and applications.

UNIT - III	TOLERANCE ANALYSIS	9

DFM approach - DFM guidelines - standardisation - comparison of materials on cost basis – design for assembly - DFA index - Poka - Yoke principle; six sigma concepts. Cumulative effect of tolerances - sure fit law - normal law and truncated normal law - obtainable tolerances in axial dimensions for various machining operations - Process capability – process capability metrics - Cp - Cpk - cost aspects - feature tolerances - surface finish - review of relationship between attainable tolerance grades and different machining process. Introduction to Tolerance chart.

UNIT - IV	SELECTIVE ASSEMBLY	9

Interchangeable and selective assembly - deciding the number of groups-model-I: group tolerances of mating parts equal; model-II: total and group tolerances of shaft - model-III-control of axial play - introducing secondary machining operations - laminated shims – examples.

UNIT - V	DESIGN FOR MACHINING, FORM DESIGN OF CASTINGS AND WELDMENTS	9

Design features to facilitate machining -component design, machining considerations - redesign for manufacture - examples. Redesign of castings based on parting line considerations - minimising core requirements - redesigning cast members using weldments - use of welding symbols - design of weldments.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	understand the various aspects of geometric tolerances
CO2	understand the datum system
CO3	analyse the aspects of tolerance
CO4	learn the selective assembly
CO5	understand the importance of various design aspects

TEXTBOOKS:

1. Bryan R Fischer, "Mechanical Tolerance Stackup and Analysis", CRC Press, New York, 2011.
2. Paul J Drake, "Dimensioning and Tolerancing Handbook", McGraw Hill, New York, 1999.

REFERENCES:

1. Creveling C M, "Tolerance Design - A Hand Book for Developing Optimal Specifications", Addison Wesley Longman, New York,1997.
2. Harry Peck, "Designing for Manufacture", Pitman Publications, London, 1983.
3. Spotts M F, "Dimensioning and Tolerance for Quantity Production", Prentice Hall Inc., New Jersey, 1983.
4. Oliver R Wade, "Tolerance Control in Design and Manufacturing", Industrial Press Inc., New York, 1967.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23014	METROLOGY AND MEASUREMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To understand the different degree of accuracy obtained from different types of instruments
2. To understand the process of reducing uncertainties in measurements
3. To identify the various instruments used for linear and angular measurements
4. To interpret the working of pressure force and torque measurement devices
5. To brief the measurement of flow and temperature using various instruments.

UNIT - I	SCIENCE OF MEASUREMENT	9

Mechanical measurement – direct comparison and indirect comparison – the generalized measurement system – types of input quantities – measurement standards – calibration – uncertainty –errors– classifications of errors– zero, Sensors – transducers. Resistive, Capacitive and Inductive Sensors – Static characteristics– Dynamic characteristics of instruments.

UNIT - II	LINEAR AND ANGULAR MEASUREMENT	9

Linear measuring instruments: Vernier, micrometer, interval measurement, Slip gauges and classification, interferometer, optical flats, limit gauges – Comparators: Mechanical, pneumatic and electrical types, applications. Angular measurements: -Sine bar, optical bevel protractor, angle Decker–Taper measurements, coordinate measuring machine (CMM), Blue Line Scanner.

UNIT - III	FORM MEASUREMENT	9

Measurement of screw threads – Thread gauges, floating carriage micrometer – measurement of gears –tooth thickness-constant chord and base tangent method – Gleason gear testing machine radius measurements – surface finish, straightness, flatness and roundness measurements.

UNIT -IV	PRESSURE, FORCE AND TORQUE MEASUREMENT	9

Bourdon tube, diaphragm, bellows and pressure capsules: Transducers used in pressure measurement – potentiometer, strain gauges, LVDT, piezo electric and piezo resistive transducers. Low pressure measurement – Mc leod gauge, Pirani gauge, thermal conductivity type pressure measurement. Force measuring devices – Balances, platform scales, weigh bridges, load cells, proving ring. Torque measurement – prony brake, rope brake and fan type brakes. Dynamometers – types.

UNIT - V	MEASUREMENT OF TEMPERATURE AND FLOW	9

Measurement of temperature – liquid in glass thermometer –partial and total immersion thermometers – resistance thermometers – thermistor –thermocouples – pyrometers. Measurement of flow – orifice plate, Venturi meter, flow nozzles, pitot static tube, rotameter – theory and constructional details – magnetic flow meters – hotwire anemometers-turbine flow meter - ultrasonic flow meter.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Demonstrate their knowledge about different measurement method and devices used in industries.
CO2	Design measuring equipment's for the measurement of pressure force, temperature and flow.
CO3	Generate new ideas in designing measuring instruments for automotive application.
CO4	Demonstrate their learned skill to develop new system that would help in keeping the environment sustainable.
CO5	Have the ability to handle and interpret measurement data, to estimate measurement uncertainties

TEXTBOOKS:

1. Ernest O Doeblin, “Measurement systems”, McGraw Hill Publishers, 2011.
2. R. K. Jain, “Engineering Metrology”, Khanna Publishers, New Delhi, 2012.

REFERENCES:

1. Beckwith Thomas G, “Mechanical Measurements”, 6rd Edition Pearson Education,2008.
2. I.C Gupta, “Engineering Metrology”, Danpat Rai Publications, 2005.
3. N.V. Raghavendra & L. Krishnamurthy, “Engineering Metrology and Measurements”, Oxford University press, 2013
4. S K Singh “Industrial Instrumentation & Control”, McGrawHill, 2009

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23015	NEW PRODUCT DEVELOPMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To introduce the importance of product design
2. To understand the needs of a customer towards a product
3. To initiate the idea of creativeness on product
4. To understand the decision-making concepts.
5. To design a product based on cost frame and need of the customer.

UNIT - I	INTRODUCTION	9

Need for developing products – the importance of engineering design – types of design – the design process – relevance of product lifecycle issues in design –designing to codes and standards- societal considerations in engineering design –generic product development process – various phases of product development-planning for products –establishing markets- market segments- relevance of market research.

UNIT - II	CUSTOMER NEEDS	9

Identifying customer needs –voice of customer –customer populations- hierarchy of human needs gathering methods – affinity diagrams – needs importance- establishing engineering. characteristics-competitive benchmarking- quality function deployment- house of quality product design specification-case studies.

UNIT - III	CREATIVE THINKING	9

Creative thinking –creativity and problem solving- creative thinking methods- generating design concepts-systematic methods for designing –functional decomposition – physical decomposition – functional representation –morphological methods-TRIZ- axiomatic design.

UNIT -IV	DECISION MAKING AND PRODUCT ARCHITECTURE	9

Decision making –decision theory –utility theory –decision trees –concept evaluation methods – Pugh concept selection method- weighted decision matrix –analytic hierarchy process –introduction to embodiment design –product architecture – types of modular architecture – steps in developing product architecture.

UNIT - V	DESIGN AND COST ANALYSIS	9

Industrial design – human factors design –user friendly design – design for serviceability – design for environment – prototyping and testing – cost evaluation –categories of cost – overhead costs – activity-based costing –methods of developing cost estimates – manufacturing cost –value analysis in costing.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Introduce the importance of product design.
CO2	Understand the needs of a customer towards a product.
CO3	Initiate the idea of creativeness on product.
CO4	Understand the decision-making concepts.
CO5	Design a product based on cost frame and need of the customer

TEXTBOOKS:

1. Anita Goyal, Karl T Ulrich, Steven D Eppinger, “Product Design and Development, 4th Edition, 2009, Tata McGraw-Hill Education, ISBN-10-007-14679-9
2. Kevin Otto, Kristin Wood, “Product Design”, Indian Reprint 2015, Pearson Education, ISBN 9788177588217

REFERENCES:

1. Clive L. Dym, Patrick Little, “Engineering Design: A Project-based Introduction”, 3rd Edition, John Wiley & Sons, 2009, ISBN 978-0-470-22596-7.
2. George E. Dieter, Linda C. Schmidt, “Engineering Design”, McGraw-Hill International Edition, 4th Edition, 2009, ISBN 978-007-127189-9.
3. Yousef Haik, T. M. M. Shahin, “Engineering Design Process”, 2nd Edition Reprint, Cengage Learning, 2010, ISBN 0495668141.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23016	REVERSE ENGINEERING FOR AUTOMOBILES	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. fundamental concepts and principles of reverse engineering in product design and development.
2. concept and principles material characteristics, part durability and life limitation in reverse engineering of product design and development.
3. the concept and principles of material identification and process verification in reverse engineering of product design and development. the concept and principles of data processing, part performance and system compatibility in reverse engineering of product design and development.
4. Analyzing the various legal aspect and applications of reverse engineering in product design and development.

UNIT - I	INTRODUCTION TO REVERSE ENGINEERING	6+3

Definition – Uses – The Generic Process – Phases – Computer Aided Reverse Engineering - Surface and Solid Model Reconstruction – Dimensional Measurement – Prototyping. **Practical**: Prepare a function and product structure of an automotive component.

UNIT - II	MATERIAL CHARACTERISTICS, PART DURABILITY AND LIFE LIMITATION	6+3

Alloy Structure Equivalency – Phase Formation and Identification – Mechanical Strength – Hardness –Part Failure Analysis – Fatigue – Creep and Stress Rupture – Environmentally Induced Failure. **Practical**: Freehand sketch of assembly and parts

UNIT - III	MATERIAL IDENTIFICATION AND PROCESS VERIFICATION	6+3

Material Specification - Composition Determination - Microstructure Analysis – Manufacturing Process Verification. **Practical**: Prepare part interface matrix

UNIT - IV	DATA PROCESSING, PART PERFORMANCE AND SYSTEM COMPATIBILITY	6+3

Statistical Analysis – Data Analysis – Reliability and the Theory of Interference – Weibull Analysis – Data Conformity and Acceptance – Data Report – Performance Criteria – Methodology of Performance Evaluation – System Compatibility. **Practical**: Prepare manufacturing drawing for assembly and parts

UNIT - V	ACCEPTANCE AND LEGALITY OF RE	6+3

Legality of Reverse Engineering – Patent – Copyrights –Trade Secret – Third-Party Materials. **Practical**: Prepare a prototype using 3D Printing / machining

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Apply the fundamental concepts and principles of reverse engineering in product design and development.
CO2	Apply the concept and principles material characteristics, part durability and life limitation in reverse engineering of product design and development.
CO3	Apply the concept and principles of material identification and process verification in reverse engineering of product design and development.
CO4	Apply the concept and principles of data processing, part performance and system compatibility in reverse engineering of product design and development.
CO5	Analyze the various legal aspect and applications of reverse engineering in product design and development.

TEXTBOOKS:

1. Wego Wang, “Reverse Engineering Technology of Reinvention”, CRC Press, 2011.
2. Vinesh Raj and Kiran Fernandes, “Reverse Engineering: An Industrial Perspective”, Springer-Verlag London Limited 2008.

REFERENCES:

1. Kathryn, A. Ingle, “Reverse Engineering”, McGraw-Hill, 1994.
2. Linda Wills, “Reverse Engineering”, Kluver Academic Publishers, 1996
3. Donald R. Honsa, “Co-ordinate Measurement and Reverse Engineering”, American Gear Manufacturers Association.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	2	1	3	2	1	1	3	1	2	3	3	3
2	3	3	2	1	3	2	1	1	3	1	2	2	3	3
3	3	3	2	1	3	2	1	1	3	1	2	2	3	3
4	3	3	2	1	3	2	1	1	3	1	2	2	3	3
5	3	3	2	1	3	2	1	1	3	1	2	2	3	3
Avg	**3**	**3**	**2**	**1**	**3**	**2**	**1**	**1**	**3**	**1**	**2**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23017	FINITE ELEMENT TECHNIQUES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To Understand and perform engineering analysis of structural members using FEM.
2. To evaluate and interpret FEA analysis results for design and evaluation purposes
3. To understand the computer codes for FEM Elements.
4. To derive the characteristics equation of Iso parametric elements.
5. To Imply knowledge towards Modal analysis in a vibrating element analytically.

UNIT - I	INTRODUCTION	9

Engineering design analysis. Basic concepts of FEM. Steps in FEM. Advantages and limitations of FEM. Handling of simultaneous equations – Gaussian elimination method – Gaussian Jordan method. Numerical integration. Commercial FEM packages.

UNIT - II	DISCRETE ELEMENTS	9

Spring Element. Bar elements, uniform section, mechanical and thermal loading, varying section, truss analysis. Beam element - problems for various loadings and boundary conditions – Use of local and natural coordinates. Computer codes for discrete elements.

UNIT - III	CONTINUUM ELEMENTS	9

Plane stress, Plane strain and axisymmetric problems, constant and linear strain, triangular elements, stiffness matrix, axisymmetric load vector. Computer codes for CST and LST elements.

UNIT -IV	ISOPARAMETRIC ELEMENTS	9

Definitions, Shape function for 4, 8 and 9 nodal quadrilateral elements, Stiffness matrix and consistent load vector.

UNIT - V	MODAL ANALYSIS	9

Equations of motion for vibration problems. Consistent and lumped mass matrices. Formulation of element mass matrices. Free vibration problem formulation. Case study – FEM in structural analysis, heat transfer and fluid flow problems with respect to Automotive industries.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Understand and perform engineering analysis of structural members using FEM.
CO2	Demonstrate the ability to evaluate and interpret FEA analysis results for design and evaluation purposes
CO3	Develop computer codes for FEM Elements.
CO4	Derive the characteristics equation of Iso parametric elements.
CO5	Apply knowledge towards Modal analysis in a vibrating element analytically

TEXTBOOKS:

1. Daryl L Logan, "A First Course in the Finite Element Method", 5th Edition, CL Engineering, 2010
2. David V Hutton, "Fundamentals of finite element analysis", McGraw Hill India, 2017
3. Singiresu S. Rao, "The Finite Element Method in Engineering", Sixth Edition, Butterworth Heinemann, 2017.

REFERENCES:

1. Bathe, K.J. and Wilson, E.L., Numerical Methods in Finite Elements Analysis, Prentice Hall of India, 1985.
2. Krishnamurthy, C.S., Finite Element Analysis, Tata McGraw Hill, 2000.
3. Reddy J.N., “An Introduction to Finite Element Method”, Third edition, McGraw Hill, 2000.

4. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, "Concepts and Applications of Finite Element Analysis", 4th Edition, John Wiley and Sons, Inc., 2001.
5. Tirupathi.R. Chandrapatha and Ashok D. Belegundu – Introduction to Finite Elements in Engineering – Printice Hall India, Third Edition, 2003.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	1	3	2	1	1	3	1	2	3	3	3
2	3	3	2	1	3	2	1	1	3	1	2	2	3	3
3	3	3	2	1	3	2	1	1	3	1	2	2	3	3
4	3	3	2	1	3	2	1	1	3	1	2	2	3	3
5	3	3	2	1	3	2	1	1	3	1	2	2	3	3
Avg	**3**	**3**	**2**	**1**	**3**	**2**	**1**	**1**	**3**	**1**	**2**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

VERTICALS-IV: ELECTRIC VEHICLE TECHNOLOGY

AU23018	BATTERIES AND MANAGEMENT SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Acquire knowledge of electric vehicle batteries.
2. Design a Battery Pack.
3. Battery Model or Simulation.
4. Estimate State-of-Charges in a Battery Pack.
5. Approach different BMS architectures during real world usage.

UNIT - I	ADVANCED BATTERIES	9

Li-ion Batteries-different formats, chemistry, safe operating area, efficiency, aging. Characteristics- SOC, DOD, SOH. Balancing-Passive Balancing Vs Active Balancing. Other Batteries-NCM and NCA Batteries. Battery specifications.

UNIT - II	BATTERY PACK	9

Battery Pack- design, sizing, calculations, flow chart, real and simulation Model. Peak power – definition, testing methods-relationships with Power, Temperature and ohmic Internal Resistance. Cloud based Vs Local Smart charging.

UNIT - III	BATTERY MODELLING	9

Battery Modelling Methods-Equivalent Circuit Models, Electrochemical Model, Neural Network Model. ECM Comparisons- Rint model, Thevenin model, PNGV model. State space Models- Introduction. Battery Modelling software/simulation frameworks.

UNIT -IV	BATTERY STATE ESTIMATION	9

SOC Estimation- Definition, importance, single cell Vs series batteries SOC. Estimation Methods- Load voltage, Electromotive force, AC impedance, Ah counting, Neural networks, Neuro-fuzzy forecast method, Kalman filter. Estimation Algorithms.

UNIT - V	BMS ARCHITECTURE AND REAL TIME COMPONENTS	9

Battery Management System- need, operation, classification. BMS architecture ASIC. Communication Modules- CAN Open-Flex Ray- CANedge1 package. Battery Tester. BMS Development with Model- Based Design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Acquire knowledge of different Li-ion Batteries performance.
CO2	Design a Battery Pack and make related calculations.
CO3	Demonstrate a Battery Model or Simulation.
CO4	Estimate State-of-Charges in a Battery Pack.
CO5	Approach different BMS architectures during real world usage.

TEXTBOOKS:

1. Jiuchun Jiang and Caiping Zhang, “Fundamentals and applications of Lithium-Ion batteries in Electric Drive Vehicles’’, Wiley, 2015.
2. Davide Andrea, “Battery Management Systems for Large Lithium-Ion Battery Packs” ARTECH House, 2010.

REFERENCES:

1. Developing Battery Management Systems with Simulink and Model-Based Design-whitepaper

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2	3	3	2	2	1	2	2	2	1	3	3	2
2	3	2	3	3	2	2	1	2	2	2	1	3	3	2
3	3	2	3	3	2	2	1	2	2	2	1	3	3	2
4	3	2	3	3	2	2	1	2	2	2	1	3	3	2
5	3	2	3	3	2	2	1	2	2	2	1	3	3	2
Avg	**3**	**2**	**3**	**3**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23019	TRACTION MOTORS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Understand Traction systems fundamentals
2. Apply Traction mechanics principles
3. Identify the power supply equipment for traction systems
4. Analyze the characteristics of traction motors
5. Differentiate AC and DC traction drives

UNIT - I	TRACTION SYSTEMS	9

Electric drives – Advantages & disadvantages – System of track electrification – D.C., 1-Phase low frequency, 3-Phase low frequency and composite systems, Problems of 1-phase traction system – Current unbalance, Voltage unbalance, Production of harmonics, Induction effects, Booster transformer – Rail connected booster transformer. Comparison between ac. and D.C. systems.

UNIT - II	TRACTION MECHANICS	9

Types of services, Speed – time curves – Construction of quadrilateral and trapezoidal speed time curves, Average & schedule speeds. Tractive effort – Speed characteristic, Power of traction motor, specific energy consumption – Factors affecting specific energy consumption, Coefficient of adhesion, slip – Factors affecting slip, magnetically suspended trains.

UNIT - III	POWER SUPPLY ARRANGEMENTS	9

High voltage supply, Constituents of supply system – Substations, feeding post, Feeding & sectioning arrangements, Remote control centre, Design considerations of substations, Overhead equipment – principle of design of OHE, Polygonal OHE – Different types of constructions, Basic sag & tension calculations, Dropper design, Current collection gear for OHE.

UNIT -IV	TRACTION MOTORS	9

Desirable characteristics, D.C. series motors, A.C. series motors, 3-Phase induction motors, linear induction motors, D.C. motor series & parallel control – Shunt bridge transition – Drum controller, Contact type bridge transition control, Energy saving, Types of braking in A.C. and D.C drives, Conditions for regenerative braking, Stability of motors under regenerative braking.

UNIT - V	SEMI CONDUCTOR CONVERTER CONTROLLED DRIVES	9

Advantages of A.C. Traction – Control of D.C. motors – single and two stage converters, Control of ac. motors – CSl fed squirrel cage induction motor, PWM VSl induction motor drive, D.C. traction — Chopper controlled D.C. motors, composite braking, Diesel electric traction — D.C. generator fed D.C series motor, Alternator fed D.C series motor, Alternator fed squirrel cage induction motor, Locomotive and axle codes.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Understand Traction systems fundamentals.
CO2	Apply Traction mechanics.
CO3	Identify the power supply equipment for traction systems.
CO4	Analyze various types of motors used in traction.
CO5	Differentiate AC and DC traction drives.

REFERENCES:

1. Partab.H – Modern Electric Traction, Dhanpat Rai & Sons – 1998.
2. Dubey. G.K. – Fundamentals of Electrical Drives, Narosa Publishing House – 2001.
3. C. L. Wadhwa — Generation, Distribution and Utilization of Electrical Energy, New Age International – 2006.

4. J.B. Gupta – Utilization of Electrical Power and Electric Traction, S. K. Kataria & Sons publications, 9th edition 2004.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2	3	3	2	2	1	2	2	2	1	3	3	2
2	3	2	3	3	2	2	1	2	2	2	1	3	3	2
3	3	2	3	3	2	2	1	2	2	2	1	3	3	2
4	3	2	3	3	2	2	1	2	2	2	1	3	3	2
5	3	2	3	3	2	2	1	2	2	2	1	3	3	2
Avg	**3**	**2**	**3**	**3**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23020	POWER ELECTRONICS FOR ELECTRIC VEHICLE APPLICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Define and understand the power semiconductor components and its characteristics
2. Distinguish and demonstrate the different DC-DC and AC-AC converters topology
3. Interpret and relate the operation, characteristics and performance parameters of rectifiers
4. Compare and contrast the operation, switching techniques for various types of DC-AC inverters
5. Design and develop the motor drives for automotive motor control applications

UNIT - I **AUTOMOTIVE SEMICONDUCTOR DEVICES** **9**

Introduction to power semiconductor devices, Diodes: Construction, characteristics and applications– Rectification, Diodes – Freewheeling, Diodes - Clamping Devices, Transistors: BJT, Power MOSFETs, and - Low-Voltage Load Drivers, IGBTs: Construction, characteristics and applications. Operation parametrization: Turn ON and Turn OFF techniques, Series and Parallel operation Power Integrated Circuits, Power Integrated Circuits Examples, Smart Power Devices, Emerging Device Technologies - Super-Junction, Emerging Device Technologies - Sic Devices, Protection circuit, Power Losses and Thermal analysis in semiconductors, Interpretation of data sheets.

UNIT - II **CHOPPER** **9**

Chopper circuit – Construction, Operation and Types, DC chopper: Buck, Boost, and Buck-Boost Converter: Construction, Principle of Operation and Characteristics – Duty cycle, Control strategies: Variable and constant frequency- Bi-directional operation, overview, Buck, Boost, and Buck-Boost Converter Circuit overview, Buck Converter - Components, Buck Converter - circuit, Buck Converter - Analysis, Buck Converter, Boost Converter - Components, Boost Converter - Circuit, Boost Converter - Analysis, Boost Converter – Analysis, Buck-Boost Converter – Components, Buck-Boost Converter – Circuit, Buck-Boost Converter – Analysis, Push-Pull Converter: Half Bridge and Full Bridge operation , AC choppers: Construction, Working and types.

UNIT - III **CONVERTERS** **9**

Rectifiers: Characteristics and Circuit Configuration, Full Bridge Diode AC-DC Rectifier, Three-Phase Full-Bridge Diode Rectifier -Circuit Configuration, Three-Phase Full-Bridge Diode Rectifier – Analysis, Three-Phase Full-Bridge Diode Rectifier – Waveforms, Design of Dynamic Breaking Unit, Calculation of DC-Link Power, Three-Phase Full-Bridge. Thermistor AC-DC Rectifier-Circuit Configuration, Three-Phase Full-Bridge Thermistor AC-DC Rectifier-Analysis, Three-Phase Full- Bridge Thermistor AC-DC Rectifier-Waveforms, Topology and Operation Modes, 2 pulse and 6 pulse: Construction, Principle of Operation and Characteristics - Fire Angle Control Scheme, Ripple Inverters: Types of Inverters overview, Voltage Source Inverters: 120 and 180 degree mode of operation, Current Source inverters, Current Source inverters applications, Control Techniques – PWM generation and types, Harmonics , Current control techniques – Hysteresis Current Control Filter circuits, Multilevel inverters.

UNIT -IV **AUTOMOTIVE MOTOR DRIVES** **9**

Drive module architecture, DC motor drives: DC motor- Construction, Working Principle and types, Speed control techniques, converter fed operation, Introduction to brushless motor drive. DC motor drives-Types, Torque Production in Brushed DC-Motor Drives, Series operation connected DC motor drives, Induction Motor Drives: Induction motor-Construction, Working Principle and types, Speed control techniques, inverter fed operation, Introduction to permanent magnet motor drive, Induction Motor Drives., Induction motor Variable Speed Drive operating modes, Torque and speed control of Induction - Motor Drives, Fundamentals of Scalar and vector control for induction motor, Types of scalar control for induction motors, Vector control for induction motors, Types of vector control for

induction motors, Induction motor drives for Electric Vehicles, Configurations Drive module for Electric vehicles.

UNIT - V	**POWER ELECTRONICS INTERFACE FOR ELECTRIC VEHICLES**	**9**

Schematic diagram of the battery electric vehicles, Power distribution, Power Management Control Strategy, Back-to-Back power converters, Calculation of DC-Link Power, Design of heat sink, G2V and V2G operation in EV, Power Quality Improvement, Automotive standards.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	List and recognize the various power semiconductor devices suitable for motor drive applications
CO2	Identify and solve the DC-DC and AC-AC converters suitable for the desired requirements
CO3	Experiment and sketch the various AC-DC Rectifier configurations and their input and output Waveforms
CO4	Relate and use the DC - AC Inverters with various sources and control techniques
CO5	Investigate and select the various motor drives suitable for the desired applications

REFERENCES:

1. Ali_Emadi" Handbook of automotive power electronics and motor drives",3rd Edition, 2014
2. Ned Mohan, T.M. Undeland, W.P. Robbins," Power Electronics: Converters, applications and design", John Wiley and Sons, 3rd Edition, 2006.
3. Rashid M.H., "Power Electronics Circuits, Devices and Applications", Prentice Hall India, 4th Edition, New Delhi, 2013.

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2	3	3	2	2	1	2	2	2	1	3	3	2
2	3	2	3	3	2	2	1	2	2	2	1	3	3	2
3	3	2	3	3	2	2	1	2	2	2	1	3	3	2
4	3	2	3	3	2	2	1	2	2	2	1	3	3	2
5	3	2	3	3	2	2	1	2	2	2	1	3	3	2
Avg	**3**	**2**	**3**	**3**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23021	AUTONOMOUS AND CONNECTED VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Understand the requirements of connected vehicles
2. Differentiate the levels of automation
3. Design the hardware requirements in connected vehicles
4. Create software base in connected vehicles
5. Understand the effect of human factor

UNIT - I	INTRODUCTION TO AUTONOMOUS VEHICLE TECHNOLOGY	9

Introduction - SAE autonomous Level Classification-Examples-Application of Autonomous Vehicle- Advantages and Disadvantages of Autonomous Vehicles.

UNIT - II	PATH PLANNING AND DECISION MAKING	9

Approaches- Approximation- Heuristic- Graph Based-Point guidance. Verification and validation of decision making and path planning- Application examples of task allocation and path planning algorithms. Principles of decision making and path planning for autonomous vehicles-Decision making

UNIT - III	SENSORS, PERCEPTION AND VISUALISATION	9

Introduction to sensors, perception and visualisation for autonomous vehicles-Sensor integration architectures and multiple sensor fusion-AI algorithms for sensing and imaging-neural networks.

UNIT - IV	NETWORKING AND CONNECTED VEHICLES	9

Current and future vehicle networking technologies- CAN, LIN, MOST, ethernet and Flex-ray. The use of modern validation and verification methods. The role of Functional Safety and ISO26262 within the overall control system. Inter- dependency between software engineering and control system-advanced test methods for the validation of safety-critical systems. connected vehicle control (CACC). vehicle-to-vehicle [V2V], vehicle-to-infrastructure [V2I], and Vehicle to “Cloud” [V2C]. Applications such as intelligent traffic signals, collaborative adaptive cruise and vehicle platooning.

UNIT - V	HUMAN FACTORS AND ETHICAL DECISION MAKING	9

Introduction to Human Factors-Human Performance: Perception and Attention-Situation Awareness and Error-Human Reliability: Driver Workload and Fatigue-Emotion and Motivation in Design-Trust in Autonomous Vehicles and Assistive Technology-Designing ADAS Systems-Driverless Vehicles and Ethical Dilemmas: Human Factors and Decision-Making Software-Application of Human Factors in Autonomous Vehicles. International and national regulatory frameworks for CAV and their safe operation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Estimate vehicle state based on available data.
CO2	Describe various computer vision features and techniques.
CO3	Develop motion plan for the vehicle based on the environment, behaviour and interaction of objects.
CO4	Describe the applications of AI in autonomous and connected vehicles.
CO5	Analyse human factors in autonomous vehicles

TEXTBOOKS:

1. Autonomous Driving: How the Driverless Revolution will Change the World, by Andreas Herrmann, Walter Brenner, Rupert Stadler, ISBN-10 1787148343, ISBN-13 978-1787148345, Emerald Publishing Limited, 26 March 2018.

REFERENCES:

1. Autonomous Vehicles: Technologies, Regulations, and Societal Impacts, George Dimitrakopoulos, Aggelos Tsakanikas and Elias Panagiotopoulos, Paperback ISBN: 9780323901376, eBook ISBN: 9780323901383, 1st Edition - April 14, 2021, Elsevier.
2. Driverless: Intelligent Cars and the Road Ahead (MIT Press) 1St Edition, by Hod Lipson, Melba Kurman), ISBN-13: 978-0262035224, ISBN-10: 0262035227, September 23, 2016.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	1	3	2	1	1	3	1	2	3	3	3
2	3	3	2	1	3	2	1	1	3	1	2	2	3	3
3	3	3	2	1	3	2	1	1	3	1	2	2	3	3
4	3	3	2	1	3	2	1	1	3	1	2	2	3	3
5	3	3	2	1	3	2	1	1	3	1	2	2	3	3
Avg	**3**	**3**	**2**	**1**	**3**	**2**	**1**	**1**	**3**	**1**	**2**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23022	ARTIFICIAL INTELLIGENCE FOR VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Study about uninformed and Heuristic search techniques.
2. Learn techniques for reasoning under uncertainty
3. Introduce Machine Learning and supervised learning algorithms
4. Study about ensembling and unsupervised learning algorithms
5. Learn the basics of deep learning using neural networks

UNIT - I	PROBLEM SOLVING	9

Introduction to AI - AI Applications - Problem solving agents – search algorithms – uninformed search strategies – Heuristic search strategies – Local search and optimization problems – adversarial search – constraint satisfaction problems (CSP)

UNIT - II	PROBABILISTIC REASONING	9

Acting under uncertainty – Bayesian inference – naïve bayes models. Probabilistic reasoning – Bayesian networks – exact inference in BN – approximate inference in BN – causal networks.

UNIT - III	SUPERVISED LEARNING	9

Introduction to machine learning – Linear Regression Models: Least squares, single & multiple variables, Bayesian linear regression, gradient descent, Linear Classification Models: Discriminant function – Probabilistic discriminative model - Logistic regression, Probabilistic generative model – Naive Bayes, Maximum margin classifier – Support vector machine, Decision Tree, Random forests.

UNIT -IV	ENSEMBLE TECHNIQUES AND UNSUPERVISED LEARNING	9

Combining multiple learners: Model combination schemes, Voting, Ensemble Learning - bagging, boosting, stacking, Unsupervised learning: K-means, Instance Based Learning: KNN, Gaussian mixture models and Expectation maximization.

UNIT - V	NEURAL NETWORKS	9

Perceptron - Multilayer perceptron, activation functions, network training – gradient descent optimization – stochastic gradient descent, error backpropagation, from shallow networks to deep networks –Unit saturation (aka the vanishing gradient problem) – ReLU, hyperparameter tuning, batch normalization, regularization, dropout. reinforced learning.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Use appropriate search algorithms for problem solving
CO2	Apply reasoning under uncertainty
CO3	Build supervised learning models
CO4	Build ensembling and unsupervised models CO5: Build deep learning neural network models
CO5	Build deep learning neural network models

TEXTBOOKS:

1. Stuart Russell and Peter Norvig, “Artificial Intelligence – A Modern Approach”, Fourth Edition, Pearson Education, 2021.
2. Ethem Alpaydin, “Introduction to Machine Learning”, MIT Press, Fourth Edition, 2020.

REFERENCES:

1. Dan Watterson, “Introduction to Artificial Intelligence and Expert Systems”, Pearson Education,2007
2. Kevin Night, Elaine Rich, and Nair B. “Artificial Intelligence”, McGraw Hill, 2008
3. Patrick H. Winston, “Artificial Intelligence", Third Edition, Pearson Education, 2006
4. Deepak Khemani, “Artificial Intelligence”, Tata McGraw Hill Education,2013 (http://nptel.ac.in/)

5. Christopher M. Bishop, “Pattern Recognition and Machine Learning”, Springer, 2006.
6. Tom Mitchell, “Machine Learning”, McGraw Hill, 3rd Edition,1997.
7. Charu C. Aggarwal, “Data Classification Algorithms and Applications”, CRC Press, 2014
8. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, “Foundations of Machine Learning”, MIT Press, 2012.
9. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2016

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	2	1	3	2	1	1	3	1	2	3	3	3
2	3	3	2	1	3	2	1	1	3	1	2	2	3	3
3	3	3	2	1	3	2	1	1	3	1	2	2	3	3
4	3	3	2	1	3	2	1	1	3	1	2	2	3	3
5	3	3	2	1	3	2	1	1	3	1	2	2	3	3
Avg	**3**	**3**	**2**	**1**	**3**	**2**	**1**	**1**	**3**	**1**	**2**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23023	ELECTRIC AND FUEL CELL VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To describe the different types and working principle of batteries used in Electric vehicles.
2. To demonstrate the thermal and water management of the fuel cell and select suitable mechanism to store hydrogen.
3. To illustrate the structure of fuel cell and types and working principle of fuel cells.
4. To develop the power requirement for Electric and Fuel cell vehicle.
5. To select suitable design for construct the Electric and Fuel cell vehicle.

UNIT - I	ELECTRIC VEHICLES	9

Introduction - Benefits and Challenges in EV – Types of Electric Vehicles: Battery Electric Vehicles, The IC Engine/Electric Hybrid Vehicle, EVs using Supply Lines, Solar-Powered Vehicles. Battery -Battery Parameters, Lead Acid Batteries, Nickel-Based Batteries, Sodium - Based Batteries, Lithium Batteries, Metal–Air Batteries, Battery Modelling.

UNIT - II	FUEL CELLS	9

Introduction - Hydrogen Fuel Cells – Basic Principles - Fuel Cell Thermodynamics – PEM Fuel Cell - Water Management in the PEMFC - Thermal Management of the PEMFC - Practical Efficiency of Fuel Cells. Hydrogen as a Fuel - Fuel Reforming, Storage as Hydrogen gas, Liquid Hydrogen, Metal Hydride Hydrogen Stores, Carbon Nanofibers.

UNIT - III	STRUCTURE AND TYPES OF FUEL CELL	9

Basic Structure - Fuel Cell Stacking - Planar-Bipolar Stacking - Stacks with Tubular Cells - Fuel Cell Systems. Fuel Cell Types - Polymer Electrolyte Fuel Cell (PEFC), Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), Solid Oxide Fuel Cell (SOFC).

UNIT -IV	MODELLING OF ELECTRIC & FUEL CELL VEHICLE	9

Tractive Effort, Modelling Vehicle Acceleration -Electric Scooter & Passenger Car, 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 – Computer coding.

UNIT - V	DESIGN CONSIDERATION	9

Introduction - Design Consideration: Aerodynamic, Rolling Resistance, Transmission Efficiency, Vehicle Mass. Electric Vehicle Chassis and Body Design - Body/Chassis Requirements, Body/Chassis Layout, Body/Chassis Strength, Rigidity and Crash Resistance, Designing for Stability, Suspension for Electric Vehicles, Chassis used in Modern Fuel Cell Electric Vehicles, Software in the use of Electric Vehicle Design.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Describe the different types and working Principle batteries used in Electric vehicles
CO2	Demonstrate the thermal and water management of the fuel cell and select suitable mechanism to store hydrogen.
CO3	Illustrate the structure of fuel cell and types and working principle of fuel cells.
CO4	Develop the power requirement for Electric and Fuel cell vehicle
CO5	Select suitable design for construct the Electric and Fuel cell vehicle

TEXT BOOKS:

1. James Larminie, John Lowry “Electric Vehicle Technology Explained” A John Wiley & Sons, Ltd., Publication.
2. “Hybrid & Electric Vehicles” by CRC Press, Taylor & Francis.
3. Fuel Cell Handbook (Seventh Edition) By EG&G Technical Services, Inc., U.S. Department of Energy.

REFERENCES:

1. Electric and Hybrid Vehicles Power Sources, Models, Sustainability, Infrastructure
2. and the Market Gianfranco Pistoia Consultant, Rome, Italy, Elsevier Publications,2017
3. Mehrdad Ehsani, Yimin Gao, Sebastien E. Gay and Ali Emadi, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC
4. Press, 2009.
5. Jack Erjavec and Jeff Arias, “Hybrid, Electric and Fuel Cell Vehicles”, Cengage Learning, 2012
6. Jack Erjavec and Jeff Arias, “Alternative Fuel Technology – Electric, Hybrid and Fuel Cell Vehicles”, Cengage Learning Pvt. Ltd., New Delhi, 2007.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	2	-	2	2	2	1	1	-	3	3	3
2	3	3	3	2	-	2	2	2	1	1	-	3	3	3
3	3	3	3	2	-	2	2	2	1	1	-	3	3	3
4	3	3	3	2	2	2	2	2	1	1	-	3	3	3
5	3	3	3	2	2	2	2	2	1	1	-	3	3	3
Avg	**3**	**3**	**3**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

VERTICALS-V: ADVANCE TECHNOLOGIES

AU23024	NANOSCIENCE TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To familiarize about the science behind the nanomaterials and various types nano materials
2. To demonstrate various technique to prepare the nanomaterials
3. To select the Nanomaterial in the basics of Electrical, Mechanical, Thermal and Magnetic Behavior
4. To develop knowledge in the field of nanomaterial Characterization
5. To Apply the concepts of Nano materials in the field of automobile and industrial applications.

UNIT - I	INTRODUCTION TO NANOSCIENCE AND TYPES	9

Nanoscale Science and Technology - Implications for Physics, Chemistry, Biology and Engineering- Classifications of nanostructured materials- nano particles- quantum dots, nanowires-ultra-thin films- multilayered materials. Types of Nanomaterial- Nanoclusters, Solid solutions, thin film, Nanocomposites (Metal Oxide and Polymer based), Core Shell Nanostructure, Buckyballs, Carbon nano tubes and, Zeolites minerals, Dendrimers, Micelles, Liposomes, Block Copolymers, Porous Materials, Metal Nanocrystals, Semiconductor nanomaterials.

UNIT - II	METHODS OF PREPARATION	9

Bottom-up Synthesis-Top-down Approach: Co-Precipitation, Ultrasonication, Mechanical Milling, Colloidal routes, Self-assembly, Vapour phase deposition, MOCVD, Sputtering, Evaporation, Molecular Beam Epitaxy, Atomic Layer Epitaxy, MOMBE, Photolithography, Electron beam lithography.

UNIT - III	PROPERTIES OF NANO MATERIALS	9

Electrical Property - Electrical and electronic conductivity- Hall effect and its determination. Dielectric Properties: Kinds of dielectric materials, Dielectric constant and its determination – Piezoelectric, pyroelectric and ferroelectric materials. Optical Properties: Photoconductivity, Optical absorption and transmission- Optical properties of semiconductor nanoparticles, Mechanical behaviour Stress-strain, tensile strength, toughness, micro-hardness, wear resistance, corrosion resistance behaviours of nanomaterials. Thermal properties: Heat capacity, thermal conductivity and thermal expansion of nanomaterials. Magnetic properties: Fundamentals of magnetism - Different kinds of magnetic materials: dia, para, ferro, ferri and anti-ferromagnetic materials - Magnetic hysteresis – Super paramagnetism – Important properties in relation to Nanomagnetis.

UNIT -IV	CHARACTERIZATION TECHNIQUES	9

Structural characterization techniques - X-ray diffraction (XRD) technique, particle size determination using XRD, Optical and Electron Microscopy - Scanning Electron Microscopy, Transmission Electron Microscopy, Scanning Tunneling Microscopy, Spectroscopic Techniques - UV visible spectroscopy, Infrared Spectroscopy and Fourier Transform Infrared Spectroscopy, Raman Spectroscopy, Photoluminescence (PL), Photoelectron Spectroscopy (X-Ray Photoelectron Spectroscopy, Auger Electron Spectroscopy & Ultra Violet Photoelectron Spectroscopy)

UNIT - V	APPLICATIONS	9

Nano InfoTech: Information storage- nano computer, molecular switch, super chip, nanocrystal, Nano biotechnology: nanoprobes in medical diagnostics and biotechnology, Nano medicines, Targeted drug delivery, Bioimaging - Micro Electro Mechanical Systems (MEMS), Nano Electro Mechanical Systems (NEMS)- Nanosensors, nano crystalline silver for bacterial inhibition, Nanoparticles for sun barrier products - In Photostat, printing, solar cell, battery.

TOTAL: 45 PERIODS

COURSE OUTCOMES: Upon completion of the course, the students will be able to	
CO1	Familiarize about the science of nanomaterials and various types nano materials
CO2	Demonstrate various technique to prepare the nanomaterials
CO3	Select the Nanomaterial in the basics of Electrical, Mechanical, Thermal and Magnetic Behavior.
CO4	Develop knowledge in the field of nanomaterial Characterization
CO5	Apply the concepts of Nano materials in the field of automobile and industrial applications

TEXT BOOKS:

1. A.S. Edelstein and R.C. Cammearata, eds., “Nanomaterials: Synthesis, Properties and Applications”, Institute of Physics Publishing, Bristol and Philadelphia, 1996.
2. N John Dinardo, “Nanoscale Characterization of surfaces & Interfaces”, 2nd edition, Weinheim Cambridge, Wiley-VCH, 2000.
3. S.M. LINDSAY, “Introduction to Nanoscience” Arizona State University, Oxford University Press, 1stedition 2010.

REFERENCES:

1. Akhlesh Lakhtakia, “The Hand Book of Nano Technology, Nanometer Structure, Theory, Modeling and Simulations”. Prentice-Hall of India (P) Ltd, New Delhi, 2007.
2. G Timp, “Nanotechnology”, AIP press/Springer, 1999.

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	2	-	1	1	1	1	1	-	3	3	3
2	3	3	3	2	-	1	1	1	1	1	-	3	3	3
3	3	3	3	2	-	1	1	1	1	1	-	3	3	3
4	3	3	3	2	-	1	1	1	1	1	-	3	3	3
5	3	3	3	2	-	1	1	1	1	1	-	3	3	3
Avg	**3**	**3**	**3**	**2**	**-**	**1**	**1**	**1**	**1**	**1**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23025	MANUFACTURING OF AUTOMOTIVE COMPONENTS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To compare and analyse the different casting process.
2. To design various machining process according to the requirement.
3. To Analyse the suitable process related to forming.
4. To differentiate the effect of powder metallurgy on selective components.
5. To impart knowledge on recent trends of automotive components.

UNIT - I	CASTING	9

Special consideration of machining of various components such as flywheel, piston rings, bearing bushes, and liners, permanent mould casting of piston.

UNIT - II	MACHINING	9

Forging materials - process flow chart, forging of valves, connecting rod, crank shaft, cam shaft, propeller shaft, transmission gear blanks, steering column. Extrusions: Basic process steps, extrusion of transmission shaft, housing spindle, steering worm blanks, piston pin and valve tappets. Hydro forming - Process, hydro forming of manifold and comparison with conventional methods- Hydro forming of tail lamp housing – forming of wheel disc and rims. Stretch forming - Process, stretch forming of auto body panels –Super plastic alloys for auto body panels.

UNIT - III	FORGING AND EXTRUSION PROCESS	9

Forging materials - process flow chart, forging of valves, connecting rod, crank shaft, cam shaft, propeller shaft, transmission gear blanks, steering column. Extrusions: Basic process steps, extrusion of transmission shaft, housing spindle, steering worm blanks, piston pin and valve tappets. Hydro forming - Process, hydro forming of manifold and comparison with conventional methods- Hydro forming of tail lamp housing – forming of wheel disc and rims. Stretch forming - Process, stretch forming of auto body panels –Super plastic alloys for auto body panels.

UNIT -IV	POWDER METALLURGY AND PROCESSING OF PLASTICS	9

Powder metallurgy process, process variables, Manufacture of friction lining materials for clutches and brakes – plastics-raw material –automobile components – molding – injection, compression and blow – PU foam molding - Machining of plastics.

UNIT - V	RECENT TRENDS IN MANUFACTURING OF AUTO COMPONENTS	9

Powder injection moulding - Production of aluminium MMC liners for engine blocks - Plasma spray coated engine blocks and valves - Recent developments in auto body panel forming –Squeeze Casting of pistons - aluminium composite brake rotors. Sinter diffusion bonded idler sprocket – gas injection moulding of window channel – cast con process for auto parts

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Identify the methods to manufacture the vehicle components.
CO2	Analyze the requirements of each component and material.
CO3	Differentiate between the casting and forming process.
CO4	Design the process for manufacturing vehicle components.
CO5	Understand the advanced techniques used for manufacturing Automobile components.

TEXTBOOKS:

1. A Heldt. P.M., " High Speed Combustion Engines ", Oxford Publishing Co., New York, 1990.
2. Rusinoff, " Forging and Forming of metals ", D.B. Taraporevala Son & Co. Pvt Ltd., Mumbai, 1995.

REFERENCES:

1. Haslehurst.S.E., " Manufacturing Technology ", ELBS, London, 1990.
2. High Velocity "Forming of Metals ", ASTME, prentice Hall of India (P) Ltd., New Delhi, 1990 HMT handbook
3. Sabroff.A.M. & Others, "Forging Materials & Processes ", Reinhold Book Corporation, New York, 1988.
4. Upton, "Pressure Die Casting ", Pergamon Press, 1985.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	2	1	3	2	1	1	3	1	2	3	3	3
2	3	3	2	1	3	2	1	1	3	1	2	2	3	3
3	3	3	2	1	3	2	1	1	3	1	2	2	3	3
4	3	3	2	1	3	2	1	1	3	1	2	2	3	3
5	3	3	2	1	3	2	1	1	3	1	2	2	3	3
Avg	**3**	**3**	**2**	**1**	**3**	**2**	**1**	**1**	**3**	**1**	**2**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23026	IOT FOR ELECTRIC VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To design and drive the mathematical model of a BLDC motor and its characteristics
2. To learn the different control schemes for BLDC motor
3. To study the basics of fuzzy logic
4. To study the FPGA & VHDL basics
5. To implement fuzzy logic control of BLDC motor in real time

UNIT - I	MATHEMATICAL MODEL AND CHARACTERISTICS ANALYSIS OF THE BLDC MOTOR	9

Structure and Drive Modes - Basic Structure, General Design Method, Drive Modes. Mathematical Model, Differential Equations, Transfer Functions, State-Space Equations. Characteristics Analysis, Starting Characteristics, Steady-State Operation, Dynamic Characteristics, Load Matching Commutation Transients

UNIT - II	SPEED CONTROL FOR ELECTRIC DRIVES	9

Introduction -PID Control Principle, Anti windup Controller, Intelligent Controller. Vector Control. Control applied to BLDC motor used in EV.

UNIT - III	FUZZY LOGIC	9

Membership functions: features, fuzzification, methods of membership value assignments Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness -fuzzy integrals - fuzzy rule base and approximate reasoning : truth values and tables, fuzzy propositions, formation of rules decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems, overview of fuzzy expert system-fuzzy decision making.

UNIT -IV	FPGA AND VHDL BASICS	9

Introduction – FPGA Architecture-Advantages-Review of FPGA family processors- Spartan 3, Spartan 6 and Spartan 7. VHDL Basics- Fundamentals-Instruction set-data type-conditional statements- programs like arithmetic, sorting, PWM generation, Speed detection.

UNIT - V	REAL TIME IMPLEMENTATION	9

Inverter design, identifying rotor position via hall effect sensors, open loop and fuzzy logic control of48 V BLDC motor using FPGA-real-time monitoring of the health and performance of an EV's battery.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	To design the mathematical model of a BLDC motor and to discuss about its characteristics
CO2	To demonstrate the PID control, ant windup controller, Intelligent Controller and Vector Control. Control applied to BLDC motor.
CO3	To illustrate the basics of fuzzy logic system
CO4	To describe the basics of VHDL & FPGA applied to control of EVs.
CO5	To design and implement of fuzzy logic control scheme for BLDC motor using FPGA in real time.

REFERENCES:

1. Electric Powertrain Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, John G. Hayes, G. Abas Goodarzi, Wiley 1st Edition 2018.
2. VHDL Primer, A (3rd Edition), Jayaram Bhasker, Prentice Hall, 1st Edition 2015.
3. Iqbal Hussain, “Electric and Hybrid Vehicles: Design Fundamentals, Third Edition” CRC Press, Taylor & Francis Group, 2021, 1st Edition.
4. Chang-liang, Permanent Magnet Brushless DC Motor Drives and Controls, Xia Wiley 2012,1st Edition.

5. M.N. Cirstea, A. Dinu, J.G. Khor, M. McCormick, Neural and Fuzzy Logic Control of Drives and Power Systems, Newnes publications, 1st Edition, 2002.
6. Wei Liu, Hybrid Electric Vehicle System Modeling and Control, Wiley 2017, 2nd Edition
7. Electric and Plug-in Hybrid Vehicle Networks Optimization and Control, Emanuele Crisostomi • Robert Shorten, Sonja Stüdli • Fabian Wirth, CRC Press, 1st Edition. 2018.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	2	1	1	3	1	2	1	3	3	3
2	3	3	3	3	2	1	1	3	1	2	1	3	3	3
3	3	3	3	3	2	1	1	3	1	2	1	3	3	3
4	3	3	3	3	2	1	1	3	1	2	1	3	3	3
5	3	3	3	3	2	1	1	3	1	2	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**3**	**1**	**2**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23027	HOMOLOGATION AND CERTIFICATION	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. Understanding of certification practices.
2. Analyzing the of limits.
3. Understanding of Engine testing.
4. Understanding of vehicle testing.
5. Applying standards followed in automobile industry for their testing and homologation.

UNIT - I	INTRODUCTION	9

Need of vehicle testing and homologation, Vehicle testing organizations, Hierarchy of testing: Individual component approval, System level approval and Whole vehicle approval. Type Approval & Conformity of Production tests, Approval for Safety systems (Active & Passive).

UNIT - II	ENGINE, FUEL SYSTEMS AND EMISSIONS TESTING	9

Laboratory testing of basic engine parameters: Measurement of BHP, IHP, Engine testing on dynamometers, different types of dynamometers hydraulic, eddy current etc., engine analyzers- for petrol and diesel engines, FIP calibrating and testing. Emission test for CO, HC, NOx, CO2, PM, etc. using exhaust gas analyzers, Spectroscopic methods, NDIR (Non-Dispersive Infrared), FID (Flame Ionization Detector), chemiluminescent analyzers, Gas Chromatograph, Smoke meters. Emission testing on chassis dynamometers, Driving Cycles- USA, Japan, Euro and India. Test procedures – European driving cycles, Modified Indian Driving Cycle, SHED (Sealed Housing for. Evaporative Determination) Test on chassis dynamometers.

UNIT - III	NOISE VIBRATION AND HARSHNESS TESTING	9

Standard noise measurement methods, Noise inside and outside the vehicle, sources of vehicle noise - intake and exhaust noise, combustion noise, mechanical noise, noise from auxiliaries, wind noises, transmission noises, brake squeal, structure noise and noise control methods. Pass by Noise testing method.

UNIT -IV	VEHICLE PERFORMANCE TESTING	9

Methods for evaluating vehicle performance - energy consumption in conventional automobiles, performance, and emission and fuel economy, Operation of full load and part load conditions. Gradability test, Turning circle diameter test, Steering Impact test, Steering effort test. Road and track testing: Maximum speed and acceleration, brake testing, lane changing, handling and ride characteristics. Track testing on Multi Friction Braking Track, High Speed Track, Wet skid pad, Test slopes, External noise test track, Accelerated fatigue track, Water wade, Salt-water wade, and Gravel Road and off-road track, Dry handling circuit, Comfort track.

UNIT - V	AUTOMOBILE TESTING STANDARDS	9

Introduction, overview and study of testing standards like; AIS testing standards, Euro Standards, SAE standards. ISO26262 standards for functional safety of electrical and/or electronic systems in automobiles. Understanding of some AIS Standards: AIS-008 (Installation requirements of lighting and light-signalling devices for motor vehicles having more than three wheels, trailer and semi- Trailer excluding agricultural tractor and special purpose vehicles), AIS-018:2001 (Automotive Vehicles - Speed limitation Devices – Specifications), AIS-037 (Procedure for Type Approval and establishing conformity of production for safety of critical components), AIS093 (Code of practice for construction and approval of truck cabs & truck bodies), AIS-003 (Automotive Vehicles - Starting Gradeability -Method of Measurement and Requirements), AIS-038 (Battery Operated Vehicles – Requirements for Construction and Functional Safety).

TOTAL: 45 PERIODS

COURSE OUTCOMES: Upon completion of the course, the students will be able to	
CO1	Recall the need of vehicle testing and homologation.
CO2	Apply fundamental knowledge to measure the emissions and calculate the vehicle performance with reference to standard reference conditions.
CO3	Identify the testing procedures of evaluating the vehicle performance, road test and track test.
CO4	Understand standard procedures for vehicle certification and approval as per rules and regulations.
CO5	Interpret and understand various automotive testing standards.

REFERENCES:

1. Raymond M. Brach and R. Matthew Brach, "Vehicle Accident Analysis and Reconstruction
2. Methods", SAE International, 2011
3. J. G. Giles – Vehicle operation and performance, Wildlife Publications, London, 1969.
4. W. H. Crouse and L. Anglin – Motor vehicle inspection, McGraw Hill Book Co. 1978.
5. Dr. N.K. Giri- Automotive technology – Khanna publishers, 2009
6. Ulrich Seiffert and Lothar Wech, “Automotive Safety Handbook”, SAE International, 2007 ISO Standards, ICS: 43.020, 43.040, 43.100
7. Indian emission Standards.

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	2	3	2	1	2	2	2	1	3	3	3
2	3	3	2	2	3	2	1	2	2	2	1	3	3	3
3	3	3	2	2	3	2	1	2	2	2	1	3	3	3
4	3	3	2	2	3	2	1	2	2	2	1	3	3	3
5	3	3	2	2	3	2	1	2	2	2	1	3	3	3
Avg	**3**	**3**	**2**	**2**	**3**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

MF23C01	ADDITIVE MANUFACTURING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To familiarize various design considerations, software tools, processes, and techniques to create physical components using AM.
2. To enhance product customization for suitable AM techniques
3. To impart knowledge on Medical and Industrial applications of AM

UNIT - I	INTRODUCTION	9

Overview – Distinction between traditional manufacturing and AM – Evolution of Additive Manufacturing (AM) - AM Process workflow - Classification – Benefits. AM Standards - AM Considerations-Business and Societal Implications of AM -Economic aspects.

UNIT - II	DESIGN FOR ADDITIVE MANUFACTURING (DFAM)	9

AM Unique Capabilities- Need for DFAM- Design consideration in AM- Part Consolidation - Topology Optimization- Generative Design- Lightweight Structure - DFAM for Part Quality Improvement. CAD Model Preparation - File formats for AM (STL, PLY, VRML, AMF) - Part Orientation and Support Structure Generation - Model Slicing - Tool Path Generation.

UNIT - III	PHOTO POLYMERIZATION, MATERIAL EXTRUSION, AND POWDER BED FUSION PROCESSES	9

Photo polymerization: Stereolithography Apparatus (SLA) - Materials - Process - Capabilities - Applications. Digital Light Processing (DLP) - Materials – Process - Capabilities - Applications. Continuous Liquid Interface Production (CLIP) - Materials - Process - Capabilities and Applications. Extrusion Based System: Fused Deposition Modelling (FDM) - Process – Types- Materials - Applications. Powder Bed Fusion: Selective Laser Sintering (SLS): Process –Materials and Application. Multijet fusion. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Materials – Principle - Process - Capabilities and Applications.

UNIT -IV	SHEET LAMINATION, DIRECT ENERGY DEPOSITION, BINDER AND MATERIAL JETTING PROCESSES	9

Sheet Lamination Process: Laminated Object Manufacturing (LOM) - Basic Principle-Mechanism: Gluing or Adhesive Bonding – Thermal Bonding- Materials-Application and Limitation Direct Energy Deposition Process: Laser Engineered Net Shaping (LENS) and Wire Arc Additive Manufacturing (WAAM) - Process -Material Delivery - Process Parameters -Materials -Capabilities – Industrial Applications. Binder and Material Jetting: Three-Dimensional Printing - Materials - Physics of 3DP – Process- Types of printing – Material - Capabilities and Application. Hybrid Additive Manufacturing – Need - Principles - Synergy in Hybrid AM Materials - Part Quality and Process Efficiency.

UNIT - V	APPLICATION OF AM	9

Rapid tooling - Direct tooling - Indirect tooling – Soft tooling- bridge tooling. Rapid Tooling for Investment Casting, sand casting, Injection moulding. Case Studies/Application: Aerospace and automotive industries, Medical and healthcare - Architecture and construction - Food Printing -Printing Electronics - Consumer products and fashion. Health and safety requirements. Hazards and risks involved.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Gain an understanding of Additive Manufacturing and its development and identify different business opportunities associated with Additive Manufacturing.
CO2	Develop a comprehensive understanding of design considerations specific to Additive Manufacturing and familiarize oneself with a range of software tools used in the design process for Additive Manufacturing.
CO3	Elaborate the photo polymerization, material extrusion processes, powder bed fusion processes and its applications.

CO4	Acquire knowledge on process and applications of sheet lamination, direct energy deposition, Binder and Material Jetting Processes and introduce the concept of hybrid Additive Manufacturing processes that combine multiple techniques to achieve desired outcomes.
CO5	Achieve in-depth knowledge of Rapid Tooling techniques in Additive Manufacturing and explore case studies and industrial applications of AM

TEXTBOOKS:

1. Gibson, Ian, David Rosen, Brent Stucker, Mahyar Khorasani, "Design for additive manufacturing", Additive manufacturing technologies (2021), ISBN: 978-3-030-56126-0.
2. Andreas Gebhardt and Jan-Steffen Hötter “Additive Manufacturing: 3D Printing for Prototyping and Manufacturing”, Hanser publications, United States, 2016, ISBN: 978-1-56990-582-1.

REFERENCES:

1. Diegel, Olaf, Axel Nordin, and Damien Motte, “A Practical Guide to Design for Additive Manufacturing”, Springer, 2020.
2. Amit Bandyopadhyay, Susmita Bose, “Additive Manufacturing, Second Edition”, CRC Press Taylor and Francis Group, 2020, ISBN- 978-1-4822-2360-6.
3. Redwood, Ben, Filemon Schoffer, and Brian Garret, “The 3D Printing Handbook: Technologies, Design and Applications”, 3D Hubs, 2017.
4. C.P Paul, A.N Junoop, “Additive Manufacturing: Principles, Technologies and Applications”, McGraw Hill, 2021.

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2	2	1	1	1	2	1	1	1	1	3	3	3
2	3	2	2	1	1	1	2	1	1	1	1	3	3	3
3	3	2	2	1	1	1	2	1	1	1	1	3	3	3
4	3	2	2	1	1	1	2	1	1	1	1	3	3	3
5	3	2	2	1	1	1	2	1	1	1	1	3	3	3
Avg	**3**	**2**	**2**	**1**	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23028	RENEWABLE SOURCES OF ENERGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The objective of the courses is to develop in-depth knowledge for the following:

1. Various renewable energy resources available at a location and assessments of its potential, using tools and techniques.
2. Solar energy radiation, its interactions, measurement and estimation
3. Properties critical for Bio-energy resource assessment, pathway selection, biomass supply
4. Site selection for wind turbines, wind systems, measurements and instruments
5. Geothermal, wave, tidal and OTEC resources, site selection

UNIT - I	INTRODUCTION TO RENEWABLE ENERGY SOURCES	9

World energy usage -reserves for world energy resources. Principles of renewable energy – renewable energy resources and their importance. Conventional and non-conventional fuels. Review of possible renewable energy resources. Scientific principles, technical implications, and social implications.

UNIT - II	SOLAR ENERGY	9

Solar radiation: Extraterrestrial solar radiation - Measurement and estimation of solar radiation. Solar heating devices. Systems with separate storage. Selective surfaces. Solar concentrators and other devices. Steam generation and solar thermal-electricity. Recent advancements in solar power generation. Photovoltaic Devices and Systems. Types and usage of photovoltaic systems. Grid connection; system design and RAPS (remote area power supply) applications.

UNIT - III	BIOMASS AND BIOENERGY	9

Biomass resources - Reviews the use of agricultural crops and solid biomass wastes in the production of alternative fuels. Available Technologies for biomass energy production. Incineration, pyrolysis, gasification and other thermo-chemical processes. Ethanol and biogas production technologies. Recent advancements in Biomass energy production.

UNIT -IV	WIND ENERGY	9

Basics of Wind Energy. Current and Future Technologies - Benefits and Drawbacks of Wind Energy - Wind Turbine and its components- Loads on the wind turbine. Forces acting on-wind turbines and calculation of wind turbine efficiency. Process of electricity generation and supply to the grid (wind farms). Current and Potential Uses - Issues, Challenges, and Obstacles.

UNIT - V	OTHER RENEWABLE ENERGIES	9

Introduction to Geothermal, Ocean thermal and tidal energies. Working principles of Geothermal, Ocean thermal and tidal power plants. Binary cycle power generation. Advantages and drawbacks. Current trends in geothermal, ocean thermal and tidal power technologies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Know the importance of renewable energy sources utilization and various renewable energy technologies.
CO2	Describe the use of solar energy and the various components used in the energy production with respect to applications like - heating, cooling, desalination, power generation, drying, cooking etc.
CO3	Understand the concept of Biomass energy resources and their classification, types of biogas Plants- applications
CO4	Appreciate the need of Wind Energy and the various components used in energy generation and know the classifications.
CO5	Acquire the knowledge of wave power, tidal power and geothermal principles and applications.

TEXTBOOKS:

1. G.D. Rai, “Non-Conventional Energy Sources”, Khanna Publishers, New Delhi, 2014.
2. Twidell, J.W. & Weir, A., “Renewable Energy Resources”, EFN Spon Ltd., UK, 2005.

REFERENCES:

1. B.H. Khan, “Non-Conventional Energy Resources”, The McGraw Hill companies, 2009
2. G.N. Tiwari, “Solar Energy – Fundamentals Design, Modelling and applications”, Alpha Science Intl Ltd, 2015.
3. Godfrey Boyle, “Renewable Energy, Power for a Sustainable Future”, Oxford University Press, U.K., 2012.
4. J. Dewulf and Herman Van Langenhove, ‘Renewables Based Technology: Sustainability Assessment’. 2006 John Wiley & Sons, Ltd. ISBN: 0-470-02241-8
5. Neil Schlager and Jayne Weisblatt, Alternative Energy, Thomson Gale sales ISBN 1- 4414-0507 3, 2006

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	3	1	2	1	1	3	3	3
2	3	3	3	3	3	2	3	1	2	1	1	3	3	3
3	3	3	3	3	3	2	3	1	2	1	1	3	3	3
4	3	3	3	3	3	2	3	1	2	1	1	3	3	3
5	3	3	3	3	3	2	3	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

VERTICALS-VI: DIVERSIFIED TECHNOLOGIES

AU23029	PRINCIPLES OF CONTROL SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The objective of the courses is to develop in-depth knowledge for the following:

1. To understand the methods of representation of system and their transfer function models
2. To provide adequate knowledge in the time response of systems and steady state error analysis
3. To give basic knowledge in obtaining the open loop and closed loop frequency responses of systems
4. To understand the concept of stability of control system and methods of stability analysis
5. To study the three-way of designing compensators for a control system

UNIT - I	SYSTEM AND THIER REPRESENTATION	9

Basic elements in control systems-Open loop and Closed loop system-Feedback characteristics- Effects of feedback-mathematical modelling of physical systems: - mechanical, Thermal, hydraulic and Pneumatic systems -Transfer function- AC and DC servomotor- Block diagram reduction techniques- signal flow graph- control system components – computer simulation.

UNIT - II	TIME RESPONSE ANALYSIS	9

Time response- Types of test inputs- First and second order responses- Error coefficient- Generalized error series- Steady state error- Time domain specifications- Problems related to automotive domain- Computer simulation.

UNIT - III	FREQUENCY RESPONSE ANALYSIS	9

Frequency response- Frequency domain specifications-Bode Plot-Polar plot- Determination of phase margin and gain margin- Constant M and N circles-Nichols chart- Determination of closed loop responses from open loop response- Problems related to automotive domain- Computer simulation.

UNIT -IV	STABILITY OF CONTROL SYSTEM	9

Concepts of stability- Location of roots in S-plane for stability- Routh Hurwitz criterion- Root locus techniques- Construction-Nyquist stability criterion- Problems related to automotive domain - Computer simulation.

UNIT - V	CONTROL SYSTEM DESIGN	9

PID controllers –Performance criteria- Selection of controller modes-lag, Lead, and lag-Lead networks- Compensator design for desired response using root locus and Bode diagrams- Problems related to automotive domain -Computer simulation.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	To understand the methods of representation of system and their transfer function models
CO2	To provide adequate knowledge in the time response of systems and steady state error analysis
CO3	To give basic knowledge in obtaining the open loop and closed loop frequency responses of systems
CO4	To understand the concept of stability of control system and methods of stability analysis
CO5	To study the three ways of designing compensators for a control system

TEXTBOOKS:

1. Gopal, M., “Control System, Principles and Design”, Tata McGraw-Hill Pub. Co., 2nd Edition, New Delhi, 2006.

2. Nagrath, I.J. and Gopal, M., “Control System Engineering”, New Age International(p),4th Edition, Tata McGraw Hill, 2004

REFERENCES:

1. Dorf Bishop, “Modern Control System”, Prentice Hall,2004
2. Kuo, B.C., “Automatic Control System’ Prentice Hall of India Ltd., New Delhi,2003
3. Ogata, K., “Modern Control Engineering”, Prentice Hall of India Ltd., 4th Edition, New Delhi,2006

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	2	1	2	1	-	3	3	3
2	3	3	3	3	3	2	2	1	2	1	-	3	3	3
3	3	3	3	3	3	2	2	1	2	1	-	3	3	3
4	3	3	3	3	3	2	2	1	2	1	-	3	3	3
5	3	3	3	3	3	2	2	1	2	1	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23030	NOISE, VIBRATION AND HARSHNESS FOR AUTOMOBILES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

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

UNIT - I	FUNDAMENTALS OF ACOUSTICS AND NOISE, VIBRATION	9

Theory of Sound—Predictions and Measurement, Sound Sources, Sound Propagation in the Atmosphere, Sound Radiation from Structures and Their Response to Sound, General Introduction to Vibration, Vibration of Simple Discrete and Continuous Systems, Random Vibration, Response of Systems to Shock, Passive Damping

UNIT - II	EFFECTS OF NOISE, BLAST, VIBRATION, AND SHOCK ON PEOPLE	9

General Introduction to Noise and Vibration Effects on People and Hearing Conservation, Sleep Disturbance due to Transportation Noise Exposure, Noise-Induced Annoyance, Effects of Infrasound, Low-Frequency Noise, and Ultrasound on People, Auditory Hazards of Impulse and Impact Noise, Effects of Intense Noise on People and Hearing Loss, Effects of Vibration on People, Effects of Mechanical Shock on People, Rating Measures, Descriptors, Criteria, and Procedures for Determining Human Response to Noise.

UNIT - III	ENGINE NOISE AND VIBRATION —SOURCES, PREDICTION, AND CONTROL	9

Introduction to ENGINE Noise and Vibration Sources, Internal Combustion Engine Noise Prediction and Control—Diesel, Exhaust and Intake Noise and Acoustical Design of Mufflers.

UNIT -IV	TRANSPORTATION NOISE AND VIBRATION SOURCES-PREDICTION AND CONTROL	9

Introduction to Transportation Noise and Vibration Sources, Tire/Road Noise —Generation, Aerodynamic Sound Sources in Vehicles—Prediction and Control, Transmission and Gearbox Noise and Vibration Prediction and Control, Brake Noise Prediction and Control.

UNIT - V	NOISE AND VIBRATION TRANSDUCERS, ANALYSIS, SIGNAL PROCESSING, AND MEASURING TECHNIQUES	9

General Introduction to Noise and Vibration Transducers, Measuring Equipment, Noise and Vibration Measurements, Signal Acquisition, and Processing. Sound Level Meters, Noise Dosimeters, Analyzers and Signal Generators, Equipment for Data Acquisition, Determination of Sound Power Level and Emission, Sound Intensity Measurements, Noise and Vibration Data Analysis, Calibration of Measurement Microphones, Calibration of Shock and Vibration Transducers, Metrology and Traceability of Vibration and Shock Measurements.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Classify the types of vibrations.
CO2	Understand the effect of vibrations and noises.
CO3	Identify the sources of noise in IC engines and how to control it.
CO4	Control vibration and noise with suitable techniques for Transportation.
CO5	Apply engineering techniques and tools for NVH measurements.

TEXTBOOKS:

1. McConnell K, “Vibration Testing Theory and Practice”, John Wiley, 1995.
2. Norton M P, Fundamental of Noise

3. and Vibration, Cambridge University Press,1989

REFERENCES:

1. Ilan G. Piersol, Thomas L. Paez “Harris’ shock and vibration hand book”, McGraw-Hill, New Delhi, 2010
2. Clarence W. de Silva, “Vibration Monitoring, Testing, and Instrumentation “, CRC Press,2007
3. David A. Bies and Colin H. Hansen “Engineering Noise Control: Theory and Practice “Spon Press, London. 2009
4. Colin H Hansen “Understanding Active Noise Cancellation “ , Spon Press , London .2003
5. Matthew Harrison “Vehicle Refinement: Controlling Noise and Vibration in Road Vehicles “, Elsevier Butterworth-2004

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	2	3	3	2	1	1	1	3	3	3
2	3	3	3	3	2	3	3	2	1	1	1	3	3	3
3	3	3	3	3	2	3	3	2	1	1	1	3	3	3
4	3	3	3	3	2	3	3	2	1	1	1	3	3	3
5	3	3	3	3	2	3	3	2	1	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**2**	**1**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23031	VEHICLE AIR CONDITIONING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. To solve the simple problems related to psychrometry and refrigerant.
2. To understand the operation of the individual components of the A/System, sensors, actuators and electronic control.
3. To understand the range of techniques that can be used in diagnosing
4. To identify faults which affect system performance.
5. To provide adequate knowledge in safe working practice. Understanding the correct procedures for A/C service and repair.

UNIT - I	AUTOMOTIVE AIRCONDITIONING FUNDAMENTALS	9

Purposes of Heating, Ventilation and Air Conditioning- Environmental Concerns- Ozone layer depletion- Location of air conditioning components in a car – Schematic layout of a vehicle refrigeration system. Psychrometry – Basic terminology and Psychrometric Mixtures-Psychrometric Chart- Related problems.

UNIT - II	AUTOMOTIVE COOLING AND HEATING SYSTEM	9

Vehicle Refrigeration System and related problems- Fixed thermostatic and Orifice tube system- Variable displacement thermostatic and Orifice tube system- Vehicle air conditioning operation Types of compressors- Compressor Clutches- Compressor Clutch electrical circuit- Compressor lubrication- Condensers- Evaporators- Expansion devices- Evaporator temperature and pressure controls- receiver-drier- Accumulators- refrigerant hoses, Connections and other assemblies-Heating system.

UNIT - III	AIR-CONDITIOING CONTROLS, DELIVERY SYSTEM AND REFRIGERANTS	9

Types of Control devices- Preventing Compressor damage- Preventing damage to other systems- Maintaining drive ability- Preventing Overheating Ram air ventilation- Air Delivery Components- Control devices- Vacuum Controls Containers – Handling refrigerants – Discharging, Charging & Leak detection – Refrigeration system diagnosis – Diagnostic procedure- Ambient conditions affecting system pressures.

UNIT -IV	AUTOMATIC TEMPERATURE CONTROL	9

Different types of sensors and actuators used in automatic temperature control- Fixed and variable displacement temperature control- Semi Automatic- Controller design for Fixed and variable displacement type air conditioning system.

UNIT - V	SYSTEM SERVICING AND TESTING	9

Special tools for servicing vehicle air conditioning – Diagnosing components and air conditioning systems- Diagnosing cooling system- Air delivery system- Automatic Temperature Control system diagnosis and service.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Solve the simple problems related to psychrometry and refrigerant
CO2	Understand the operation of the individual components of the A/System, sensors, actuators and electronic control
CO3	Understand the range of techniques that can be used in diagnosing
CO4	Identify faults which affect system performance
CO5	Provide adequate knowledge in safe working practice. Understanding the correct procedures for A/C service and repair

TEXTBOOKS:

1. Warren Farnell and James D. Halderman, Automotive Heating, Ventilation, and Air Conditioning systems, Classroom Manual, Pearson Prentice Hall,2004
2. William H Crouse and Donald L Anglin, Automotive Air conditioning, McGraw Hill Inc.,1990.

REFERENCES:

1. Goings, L.F., Automotive Air Conditioning, American Technical services, 1974.
2. McDonald, K.L., Automotive Air Conditioning, Theodore Audel series, 1978.
3. Mitchell Information Services, Inc., Mitchell Automatic Heating and Air Conditioning Systems, Prentice Hall Inc., 1989.
4. Paul Weisler, Automotive Air Conditioning, Reston Publishing Co. Inc., 1990.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	2	1	2	1	1	1	1	1	1	3	3	3
2	3	3	2	1	2	1	1	1	1	1	1	2	3	3
3	3	3	2	1	2	1	1	1	1	1	1	2	3	3
4	3	3	2	1	2	1	1	1	1	1	1	2	3	3
5	3	3	2	1	2	1	1	1	1	1	1	2	3	3
Avg	**3**	**3**	**2**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23032	HYDRAULIC AND PNEUMATICS SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. To understand the basics of hydraulic and pneumatic systems.
2. To examine the working of hydraulic power drives.
3. To apply knowledge on fluid power elements.
4. To design hydraulic and pneumatic systems.
5. To evaluate the concept of programming in PLC circuits.

UNIT - I	INTRODUCTION TO FLUID POWER	9

Introduction to fluid power control- Hydraulic and pneumatics- Selection criteria, application of fluid power, application of pascal's law, equation, Layout of hydraulic and pneumatic circuit Transmission and multiplication of force- Brahma Press- pressure losses- fluids, selection and properties- ISO symbols.

UNIT - II	FLUID POWER DRIVES	9

Fluid power drives- Pumps- working principle and construction details of gear, vane piston pumps, hydraulic motor, Hydrostatic transmission drives and characteristics - Linear actuators- Types of hydraulic components -Hydraulic Supply Components- Pneumatic power supply- Compressor, air distribution, air motors, FRL unit.

UNIT - III	FLUID POWER ELEMENTS	9

Control valves- pressure, flow direction- working principles and construction- Special type valves cartridge, modular, proportional and servo- Selection and actuation methods. - mounting, cushioning, pipe fittings- Fluid conditioning elements - Accumulators. Case study related to automotive application.

UNIT -IV	HYDRAULIC AND PNEUMATIC CIRCUITS DESIGN	9

Design of Hydraulic and Pneumatic circuits for automation, Selection and specification of circuit components, sequencing circuits, cascade and Karnaugh- Veitch map method- Regenerative, speed control using Meter in Meter out, High low circuit, Synchronizing circuits. Case study related to automotive application.

UNIT - V	ELECTRO PNEUMATICS AND PLC CIRCUITS	9

Use of electrical timers, switches, solenoid, relay, proximity sensors etc. Electro pneumatic sequencing Ladder diagram- PLC: – elements, function and selection- PLC programming- Logic gates using PLC-Ladder and different programming methods- Sequencing circuits. Case study related to automotive application.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Understand the basics of hydraulic and pneumatic systems.
CO2	Examine the working of hydraulic power drives.
CO3	Apply knowledge on fluid power elements.
CO4	Design hydraulic and pneumatic systems.
CO5	Evaluate the concept of programming in PLC circuits.

REFERENCES:

1. Anthony Espisito, "Fluid Power with Application", Pearson Education (Singapore) Pte.Ltd, Delhi, India, Fifth Edition, First Indian Reprint, 2003
2. Werner Deppert and Kurt Stoll, "Pneumatic Controls: An introduction to principles ", Vogel-Druck Wurzburg, Germany, 1975
3. Pippenger, J.J, "Industrial Hydraulic & Pneumatics", McGraw Hill, 2002

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	1	1	2	1	1	3	3	3
2	3	3	3	3	3	2	1	1	2	1	1	3	3	3
3	3	3	3	3	3	2	1	1	2	1	1	3	3	3
4	3	3	3	3	3	2	1	1	2	1	1	3	3	3
5	3	3	3	3	3	2	1	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23033	TRANSPORT MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. To understand transport management and fleet organization.
2. To learn about various transport systems and their advantages
3. To understand scheduling and fare structure.
4. To learn the need and requirement of documentation and certification.
5. To learn the importance of transport management.

UNIT - I	INTRODUCTION	9

Personnel management; objectives and functions of personnel management, psychology, sociology and their relevance to organization, personality problems. Selection process: job description, employment tests, interviewing, introduction to training objectives, advantages, methods of training, training procedure, psychological tests.

UNIT - II	TRANSPORT SYSTEMS	9

Introduction to various transport systems. Advantages of motor transport. Principal function of administrative, traffic, secretarial and engineering divisions. chain of responsibility, forms of ownership by state, municipality, public body and private undertakings.

UNIT - III	SCHEDULING AND FARE STRUCTURE	9

Principal features of operating costs for transport vehicles with examples of estimating the costs. Fare structure and method of drawing up of a fare table. Various types of fare collecting methods. Basic factors of bus scheduling. Problems on bus scheduling.

UNIT -IV	MOTOR VEHICLE ACT	9

Traffic signs, fitness certificate, registration requirements, permit insurance, constructional regulations, description of vehicle-tankers, tippers, delivery vans, recovery vans, Power wagons and fire fighting vehicles. Spread over, running time, test for competence to drive.

UNIT - V	MAINTENANCE	9

Preventive maintenance system in transport industry, tyre maintenance procedures. Causes for uneven tyre wear, remedies, maintenance procedure for better fuel economy, Design of bus depot layout.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Understand the functions of management, training procedure and psychological Tests followed in transport management.
CO2	Understand the transport systems, functions of administrative, traffic secretarial and engineering divisions.
CO3	Understand and apply the knowledge on scheduling and fare structure and the Collecting methods.
CO4	Understand the vehicle act, traffic signs, fitness procedure and vehicle insurance.
CO5	Apply the knowledge on preventive maintenance, causes for failure in vehicles and the remedies to solve the problems.

TEXT-BOOKS:

1. John Duke, "Fleet Management", McGraw-Hill Co, USA, 1984.
   Kitchin.L.D., "Bus Operation", III edition, Illiffee and Sons Co., London, 1992

REFERENCES:

1. Government Motor Vehicle Act, Publication on latest act to be used as on date.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	1	3	2	2	-	2	2	1	-	2	-	3	1	3
2	1	3	2	2	-	2	2	1	-	2	-	3	1	3
3	1	3	2	2	-	2	2	1	-	2	-	3	1	3
4	1	3	2	2	-	2	2	1	-	2	-	3	1	3
5	1	3	2	2	-	2	2	1	-	2	-	3	1	3
Avg	**1**	**3**	**2**	**2**	**-**	**2**	**2**	**1**	**-**	**2**	**-**	**3**	**1**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23034	MOTORSPORT TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. To understand transport management and fleet organization.
2. To learn about various transport systems and their advantages
3. To understand scheduling and fare structure.
4. To learn the need and requirement of documentation and certification.
5. To learn the importance of transport management.

UNIT - I	RACE CAR DESIGN AND DEVELOPMENT	9

Problems Imposed by Racing and Racing Objectives. Rulebook, Regulations, and Constraints. Road Car vs Race Car Comparison. Performance and Handling Specifications. Structure, Weight Distribution, and Driver Safety. Tire and Adjustable Features. Preliminary Design and Analysis. Driver-Vehicle Relationship and Desirable Characteristics. Case Studies.

UNIT - II	RACE CAR AERODYNAMICS	9

Aerodynamic Forces and Moments. Race Car Drag Components and Estimation. Ground Effects and Ground Plane Simulation. Spoilers, Wings, and Effectiveness in Cornering. Flow Control Devices and Vortex Creation. Pressure Change Creation Devices. Full Size Wind Tunnel Testing. Case Studies: Chaparral Wings, Formula Benetton's Wind Tunnel.

UNIT - III	RACE CAR CHASSIS	9

Conditions for Cornering and Chassis Tuning. Effects of High-Speed Braking, Cornering, and Combined Actions. Steady State Cornering and Acceleration. Straight Line Acceleration and Throttle Behavior. Moving CG Position and Roll Center. Anti-Pitch Geometry and Chassis Steering Axis. Chassis Ride Roll Characteristics and Track Width. Tires, Rims, and Roll Stiffness Adjustment. Case Studies: Monocoque Chassis Development, Carbon Fiber.

UNIT -IV	RACE CAR SUSPENSION SYSTEM	9

Front Suspension Design and Performance Features. Camber Effects and McPherson Struts. SLA Suspension and Rear Suspension Types.F1 Car Suspension Configurations. Suspension Springs and Installation Considerations. Damping in Racing and Ride/Handling Compromise. Steering Activity and Bump/Rebound Damping. Chassis Track Width and Ride Spring Rate. Adjusting Roll Stiffness Distribution.

UNIT - V	RACE CAR DRIVES AND BRAKING SYSTEMS	9

Front and Rear-Wheel Drive in Racing. Four-Wheel Drive and Differentials in Racing. Limited Slip Differential and Traction Control. Mechanical Components in Braking System. Limitations and Considerations of Braking in Racing. Brake Boost and Effects of "g" Force. Brake Hydraulics, Ventilation, and Distribution. ABS in Racing and Carbon-Carbon Discs. Case Study.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

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

CO1	Understand the unique challenges and objectives in racing, including rulebook compliance, performance requirements, and design considerations.
CO2	Apply principles of aerodynamics, including the use of spoilers, wings, and flow control devices, to optimize race car performance and cornering capabilities.
CO3	Analyze and optimize race car chassis design and tuning, considering factors such as weight distribution, suspension systems, and handling characteristics.
CO4	Evaluate and optimize race car suspension systems to enhance stability, traction, and overall handling performance.
CO5	Assess and optimize race car drive systems and braking systems to achieve optimal performance, control, and safety on the track.

REFERENCES:

1. Adrian Newey, "How to Build a Car: The Autobiography of the World's Greatest Formula 1 Designer," HarperCollins, 2017.
2. Simon McBeath, "Competition Car Aerodynamics: A Practical Handbook," Haynes Publishing, 2014.
3. Brian Beckman, "Vehicle Dynamics: Theory and Application," Society of Automotive Engineers (SAE) International, 2013.
4. John Dixon, "Competition Car Composites: A Practical Handbook," Haynes Publishing, 2013.
5. Michael Costin and David Phipps, "Competition Car Chassis: Design, Structures, and Materials," Haynes Publishing, 2008.
6. Allan Staniforth, "Competition Car Suspension: Design, Construction, Tuning," Haynes Publishing, 2005.
7. David E. Hoyle, "ISO 9000 Quality Systems Handbook: Automotive Industry Edition," Butterworth-Heinemann, 2005.
8. Paul Van Valkenburgh, "Race Car Engineering & Mechanics," Bentley Publishers,2001.
9. William F. Milliken and Douglas L. Milliken, "Race Car Vehicle Dynamics," SAE International, 1995.
10. Carroll Smith, "Tune to Win: The art and science of race car development and tuning," Aero Publishers, 1978.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	1	2	1	1	1	1	1	1	2	3	3
2	3	3	3	1	2	1	1	1	1	1	1	2	3	3
3	3	3	3	1	2	1	1	1	1	1	1	2	3	3
4	3	3	3	1	2	1	1	1	1	1	1	2	3	3
5	3	3	3	1	2	1	1	1	1	1	1	2	3	3
Avg	**3**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

HONOURS DEGREE COURSES

AU23035	AUTOMOTIVE INSTRUMENTATION AND TESTING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

Of this course are

1. To provide theoretical and applicative knowledge in automobile test instrumentation.
2. To identify the various instruments for measuring force, torque, pressure, temperature, fluid flow, velocity and rotational speed.
3. To enhance the knowledge of students regarding the experimental methods followed in industries.
4. To familiarize the students on standard test codes.
5. To impart skills on the testing procedure followed for evaluating brake and engine

UNIT - I	MECHANICAL MEASUREMENT	9

Introduction to measurements – Construction, principle, working of Instruments for measuring force, torque, pressure, temperature, fluid flow, velocity, rotational speed.

UNIT - II	VIBRATION AND BODY TEST	9

Vibration measurement instrument – accelerometer and signal conditioning. Dynamic simulation sled testing, methodology, vehicle acceleration measurement and documentation. Dolly roll over test, dolly role over fixture, photographic / video coverage. Vehicle roof strength test –. Door system crush test – wind tunnel tests.

UNIT - III	CRASH AND BRAKE TEST	9

Crash tests –standards – road hazard impact test for wheel and tyre assemblies, test procedures, failure and performance criteria. Bumpers - types of tests, pendulum test, fixed collision barrier test, procedure, performance criteria. Air and hydraulic brake test, air brake actuator, valves test, performance requirements.

UNIT - IV	ENGINE EXPERIMENTAL TECHNIQUES	9

I.S Code for Engine testing – Instruments for performance testing of engine, Instrumentation for measuring noise, vibration in cylinder, different types of engine tests are performed within the industry.

UNIT - V	VEHICLE EXPERIMENTAL TECHNIQUES	9

Laboratory tests- test tracks - Endurance Tests - Dynamic cornering fatigue, dynamic radial fatigue tests – procedure, bending moment and radial load calculations.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Demonstrate the understanding of engine testing procedures.
CO2	Develop a measurement strategy for temperature, pressure, mass flow, velocity.
CO3	Understand sensors and instrumentation, and to analyze and interpret test data.
CO4	Develop new system that would help in keeping the environment sustainable.
CO5	Demonstrate the understanding of brake testing procedures

TEXTBOOKS:

1. Crouse W H and Anglin D L., “Automotive Mechanics”’ Tata McGraw Hill Publishing Company, 2004.
2. J. G. Giles, Vehicle Operation & Testing. Volume 7 of Automotive technology series, Iliffe,1969
3. Richard D. Atkins, “An Introduction to Engine Testing and Development”, SAE International 2009.

REFERENCES:

1. Beckwith TG and Buck N L, “Mechanical Measurements”, Addition Wesley Publishing Company Limited, 1995.

2. Jain R K “Mechanical and Industrial Measurements”, Khanna Publishers, Delhi, 1999.
3. Stockel M W, “Auto Mechanics Fundamentals”, Good Heart-Wilcox Co., Inc., 2000.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	3	3	3	3	3	3	3	3	2
2	3	3	3	3	3	3	3	3	3	3	3	3	3	2
3	3	3	3	3	3	3	3	3	3	3	3	3	3	2
4	3	3	3	3	3	3	3	3	3	3	3	3	3	2
5	3	3	3	3	3	3	3	3	3	3	3	3	3	2
Avg	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23036	COST MANAGEMENT OF ENGINEERING PROJECTS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Summarize the costing concepts and their role in decision making
2. Infer the project management concepts and their various aspects in selection
3. Interpret costing concepts with project execution
4. Develop knowledge of costing techniques in service sector and various budgetary control techniques
5. Illustrate with quantitative techniques in cost management

UNIT - I	INTRODUCTION TO COSTING CONCEPTS	9

Introduction to measurements – Construction, principle, working of Instruments for measuring force, torque, pressure, temperature, fluid flow, velocity, rotational speed.

UNIT - II	INTRODUCTION TO PROJECT MANAGEMENT	9

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts.

UNIT - III	PROJECT EXECUTION AND COSTING CONCEPTS	9

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

UNIT - IV	COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL	9

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

UNIT - V	QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT	9

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Understand the costing concepts and their role in decision making
CO2	Understand the project management concepts and their various aspects in selection
CO3	Interpret costing concepts with project execution
CO4	Gain knowledge of costing techniques in service sector and various budgetary control techniques
CO5	Become familiar with quantitative techniques in cost management

REFERENCES:

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	-	3	2	2	1	1	-	3	3	3	2
2	3	3	3	-	3	2	2	1	1	-	3	3	3	2
3	3	3	3	-	3	2	2	1	1	-	3	3	3	2
4	3	3	3	-	3	2	2	1	1	-	3	3	3	2
5	3	3	3	-	3	2	2	1	1	-	3	3	3	2
Avg	**3**	**3**	**3**	**-**	**3**	**2**	**2**	**1**	**1**	**-**	**3**	**3**	**3**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23037	ENTREPRENEURSHIP DEVELOPMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:

1. Explaining the types, characteristics of entrepreneurship and its role in economic development.
2. Applying the theories of achievement motivation and the principles of entrepreneurship development program to enterprise.
3. Selecting the appropriate form of business ownership in setting up an enterprise.
4. Applying the fundamental concepts of finance and accounting to enterprise.
5. Identifying sickness in industry, selecting the appropriate corrective measures, and identifying the growth strategies in enterprise.

UNIT - I	ENTREPRENEURSHIP	9

Entrepreneur – Characteristics – Types of Entrepreneurs – Difference between Entrepreneur and Intrapreneur – Role of Entrepreneurship in Economic Development – Factors Affecting Entrepreneurial Growth – Economic, Non-Economic, Government Actions.

UNIT - II	MOTIVATION	9

Entrepreneurial Motivation: Theories and Factors, Achievement Motivation – Entrepreneurial Competencies – Entrepreneurship Development Programs – Need, Objectives – Business Game, Thematic Apperception Test, Self-Rating, Stress management.

UNIT - III	BUSINESS	9

Small Enterprises – Definition, Characteristics, Project Identification and selection – Project Formulation: Significance, content, formulation of project report – Project Appraisal: Concept and method – Ownership Structures: Selection & Pattern.

UNIT - IV	FINANCING AND ACCOUNTING	9

Finance: Need, Sources, Capital Structure, Term Loans – Accounting: Need, Objectives, Process, Journal, Ledger, Trial Balance, Final Accounts – Working Capital Management: Significance, Assessment, Factors, Sources, Management.

UNIT - V	SUPPORT TO ENTREPRENEURS	9

Sickness in small Business: Concept, Signals, Symptoms, Magnitude, Causes and Consequences, Corrective Measures – Government Policy for Small Scale Enterprises – Growth Strategies in Small Scale Enterprise – Institutional Support to Entrepreneurs: Need and Support – Taxation Benefits to Small Scale Industry: Need, Depreciation, Rehabilitation, Investment.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Explain the types, characteristics of entrepreneurship and its role in economic development.
CO2	Apply the theories of achievement motivation and the principles of entrepreneurship development program.
CO3	Select the appropriate form of business ownership in setting up an enterprise.
CO4	Apply the fundamental concepts of finance and accounting to enterprise.
CO5	Identify sickness in industry, select the appropriate corrective measures, and identify the growth strategies in enterprise.

TEXTBOOKS:

1. S.S. Khanka, “Entrepreneurial Development” S. Chand& Co. Ltd. Ram Nagar New Delhi,1999.
2. Kurahko & Hodgetts, “Entrepreneurship – Theory, process and practices”, Thomson learning 6th edition.

REFERENCES:

1. Charantimath, P. M., Entrepreneurship Development and Small Business Enterprises, Pearson, 2006.
2. Hisrich R D and Peters M P, “Entrepreneurship” 5th Edition Tata McGraw-Hill, 2002.
3. Mathew J Manimala,” Entrepreneurship theory at cross roads: paradigms and praxis” Dream tech, 2nd edition 2006.
4. Rabindra N. Kanungo, “Entrepreneurship and innovation”, Sage Publications, New Delhi, 1998.
5. Singh, A. K., Entrepreneurship Development and Management, University Science Press, 2009.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	-	3	2	2	1	1	-	3	3	3	2
2	3	3	3	-	3	2	2	1	1	-	3	3	3	2
3	3	3	3	-	3	2	2	1	1	-	3	3	3	2
4	3	3	3	-	3	2	2	1	1	-	3	3	3	2
5	3	3	3	-	3	2	2	1	1	-	3	3	3	2
Avg	**3**	**3**	**3**	**-**	**3**	**2**	**2**	**1**	**1**	**-**	**3**	**3**	**3**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23038	ERGONOMICS IN AUTOMOTIVE DESIGN	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The objective of this course is to educate the students regarding the

1. various ergonomic techniques.
2. Design and develop a new styling in a given vehicle model.
3. importance of ergonomics in reducing the driver fatigue.
4. role of ergonomics in look and safe operation of the vehicle.
5. mirror design and logical formation of cockpit

UNIT - I	FUNDAMENTALS OF ERGONOMICS	9

Introduction- principles – applications- Dimension determination, Anthropometry – Need, Data collection methodology, Different postural considerations -Recent developments in ergonomics and styling

UNIT - II	ERGONOMICS FOR SEATING	9

Seating dimensions- interior ergonomics- seat comfort- suspension seats- split frame seating-back pain reducers- driver & pillion seating arrangement dash board instruments-electronic displays- commercial vehicle cabin ergonomics/mechanical package layout-goods vehicle layout.

UNIT - III	ERGONOMICS FOR VISIBILITY	9

Regulations- driver's visibility- tests for visibility- methods of improving visibility and space-Dash board equipments and arrangement, mirror and cockpit design.

UNIT - IV	ERGONOMICS FOR FRAMES AND BODY	9

Types of frame, construction, loads, design consideration, materials, , ergonomics & comfort, Positioning of operational controls, Types of three wheeler bodies, layout, RTO regulations, aerodynamic, aesthetic & ergonomics considerations for body work

UNIT - V	VEHICLE ERGONOMICS	9

Passenger Compartment, Floor Pan, Vehicle interior ergonomics, ergonomics system design technical requirements, Force Analysis, Seating and position – ECE Regulations, Human Factors, Navigation systems, pedal positioning Crash tests, forces in rollover, head on impact.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, the student will be able to

CO1	Possess the knowledge of various ergonomic techniques.
CO2	Design and develop a new styling in a given vehicle model.
CO3	Understand the importance of ergonomics in reducing the driver fatigue.
CO4	Explain the role of ergonomics in look and safe operation of the vehicle.
CO5	Apply the Knowledge in mirror design and logical formation of cockpit

TEXTBOOKS:

1. Vivek D. Bhise 'Ergonomics in the Automotive Design Process" 2012 CRC Press Taylor & Francis Group
2. Gkikas, N., 2016. Automotive Ergonomics: Driver-Vehicle Interaction. CRC Press

REFERENCES:

1. Jullian Happian -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.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	2	2	2	3	3	2	-	-	-	1	3	3	3
2	3	2	2	2	3	3	2	-	-	-	1	3	3	3
3	3	2	2	2	3	3	2	-	-	-	1	3	3	3
4	3	2	2	2	3	3	2	-	-	-	1	3	3	3
5	3	2	2	2	3	3	2	-	-	-	1	3	3	3
Avg	**3**	**2**	**2**	**2**	**3**	**3**	**2**	**-**	**-**	**-**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23039	INDUSTRIAL SAFETY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Summarize basics of industrial safety
2. Describe fundamentals of maintenance engineering
3. Explain wear and corrosion
4. Illustrate fault tracing
5. Identify preventive and periodic maintenance

UNIT - I	INTRODUCTION	9

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety colour codes. Fire prevention and firefighting, equipment and methods.

UNIT - II	FUNDAMENTALS OF MAINTENANCE ENGINEERING	9

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

UNIT - III	WEAR AND CORROSION AND THEIR PREVENTION	9

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

UNIT - IV	FAULT TRACING	9

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault-finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, I. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

UNIT - V	PERIODIC AND PREVENTIVE MAINTENANCE	9

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, the student will be able to

CO1	summarize basics of industrial safety
CO2	describe fundamentals of maintenance engineering
CO3	explain wear and corrosion
CO4	illustrate fault tracing
CO5	identify preventive and periodic maintenance

REFERENCES:

1. Audels, "Pump-hydraulic Compressors", Mc grew Hill Publication, 1978.
2. Garg H P, "Maintenance Engineering ", S. Chand and Company,1987.

3. Hans F. Winterkorn, “Foundation Engineering Handbook”, Chapman & Hall London,2013.
4. Higgins & Morrow, “Maintenance Engineering Handbook”, Eighth Edition,2008

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	1	1	2	-	-	-	1	3	3	3
2	3	3	3	2	1	1	2	-	-	-	1	3	3	3
3	3	3	3	2	1	1	2	-	-	-	1	3	3	3
4	3	3	3	2	1	1	2	-	-	-	1	3	3	3
5	3	3	3	2	1	1	2	-	-	-	1	3	3	3
Avg	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**-**	**-**	**-**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23040	INTRODUCTION TO OPERATIONS RESEARCH	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To introduce the concepts in optimization of resources for manufacturing and service- based industries.
2. To introduce students to use quantities methods and techniques for effective decisions– making; model formulation and applications that are used in solving business decision problems.
3. Enlighten the students with the various optimization techniques to understand and apply in industrial operations
4. To Introduce the concepts in optimization of resources for manufacturing and service- based industries

UNIT - I	LINEAR PROGRAMMING PROBLEMS	9

OR-Definition - Phases - models, LP problems formulation – Graphical solution, GLPP, Standard and Canonical forms of LPP- simplex methods- Big M, Two phase methods, Alternate optimal solutions, Duality in LP.

UNIT - II	TRANSPORTATION	9

Transportation problems- Basic feasible solution, Optimal solution By MODI method, Balanced and Unbalanced TP, Degeneracy, Production problems. Assignment problems – Hungarian method Traveling salesman problems - Sequencing models- Johnson algorithm, n job 2 machines, n job 3 machines and n job m machines.

UNIT - III	INVENTORY CONTROL	9

Types of inventories- Inventory cost - EOQ - Deterministic inventory problems – Purchase and Production models with and without shortages-EOQ with price breaks - Stochastic inventory problems - Multi product problems - Systems of inventory control (P and Q Systems) - Determination of buffer stock and re-order levels -Selective inventory control techniques (ABC, VED, SDE, etc.)

UNIT - IV	QUEUING THEORY	9

Queuing system - Characteristics - symbols - Poisson process and exponential distribution -Single server queuing models - Multiserver queuing models, Simulation Monte Carlo technique- Inventory & Queuing problems.

UNIT - V	PROJECT MANAGEMENT AND REPLACEMENT MODELS	9

Project management: Network logic – Ford-Fulkerson's rule - AON diagram - CPM and PERT techniques, Critical path and float calculations Replacement models -types of failures – Gradual failures-replacement of items: Efficiency deteriorates with time, sudden failures-individual and group replacement policies.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Recognize the importance and value of Operations Research and mathematical modelling in solving practical problems in industry;
CO2	Formulate a managerial decision problem into a mathematical model;
CO3	Understand Operations Research models and apply them to real-life problems;
CO4	Understand and apply the operations research techniques in industrial operations.
CO5	Introduce the concepts in optimization of resources for manufacturing and service-based industries

TEXT BOOKS:

1. Hamdy Ataha, “Operations research an introduction”, 9th edition 2011, PHI/Pearson education.

2. Wayne.L. Winston, “Operations research applications and algorithms”,4th edition, 2007, Thomson learning.

REFERENCES:

1. Frederick. S. Hiller and Gerald. J. Lieberman, “Operations research concepts and cases”, 8th edition (SIE) 2008, TMH.
2. G. Srinivasan, “Operations research principles and applications”, 2nd edition EEE 2010, PHI.
3. J.K. Sharma, “Operations research theory and applications”,5Th edition 2013, Macmillan India.
4. R. Pannerselvam, “Operations research”, 2nd edition 2009, PHI
5. Ravindran, Phillips and Solberg, “Operations research principles and practice”, 2nd edition 2007, Wiley India.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	1	1	2	-	-	-	1	3	3	3
2	3	3	3	2	1	1	2	-	-	-	1	3	3	3
3	3	3	3	2	1	1	2	-	-	-	1	3	3	3
4	3	3	3	2	1	1	2	-	-	-	1	3	3	3
5	3	3	3	2	1	1	2	-	-	-	1	3	3	3
Avg	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**-**	**-**	**-**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23041	TOTAL QUALITY MANAGEMENT	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Teach the need for quality, its evolution, basic concepts, contribution of quality gurus, TQM framework, Barriers and Benefits of TQM.
2. Explain the TQM Principles for application.
3. Define the basics of Six Sigma and apply Traditional tools, new tools, Benchmarking and FMEA.
4. Describe Taguchi's Quality Loss Function, Performance Measures and apply Techniques like QFD, TPM, COQ and BPR.
5. Illustrate and apply QMS and EMS in any organization.

UNIT - I	INTRODUCTION	9

Introduction - Need for quality - Evolution of quality - Definition of quality - Dimensions of product and service quality –Definition of TQM-- Basic concepts of TQM –-Gurus of TQM (Brief introduction) -- TQM Framework- Barriers to TQM –Benefits of TQM.

UNIT - II	TQM PRINCIPLES	9

Leadership - Deming Philosophy, Quality Council, Quality statements and Strategic planning- Customer Satisfaction –Customer Perception of Quality, Feedback, Customer complaints, Service Quality, Kano Model and Customer retention – Employee involvement – Motivation, Empowerment, Team and Teamwork, Recognition & Reward and Performance Appraisal--Continuous process improvement –Juran Trilogy, PDSA cycle, 5S and Kaizen - Supplier partnership – Partnering, Supplier selection, Supplier Rating and Relationship development.

UNIT - III	TQM TOOLS & TECHNIQUES I	9

The seven traditional tools of quality - New management tools - Six-sigma Process Capability- Bench marking - Reasons to benchmark, Benchmarking process, What to Bench Mark, Understanding Current Performance, Planning, Studying Others, Learning from the data, Using the findings, Pitfalls and Criticisms of Benchmarking - FMEA - Intent , Documentation, Stages: Design FMEA and Process FMEA.

UNIT - IV	TQM TOOLS & TECHNIQUES II	9

Quality circles – Quality Function Deployment (QFD) - Taguchi quality loss function – TPM – Concepts, improvement needs – Performance measures- Cost of Quality - BPR.

UNIT - V	QUALITY MANAGEMENT SYSTEM	9

Introduction-Benefits of ISO Registration-ISO 9000 Series of Standards-Sector-Specific Standards - AS 9100, TS16949 and TL 9000-- ISO 9001 Requirements-Implementation-Documentation-Internal Audits-Registration-ENVIRONMENTAL MANAGEMENT SYSTEM: Introduction—ISO 14000 Series Standards—Concepts of ISO 14001—Requirements of ISO 14001-Benefits of EMS.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	apply TQM concepts in a selected enterprise.
CO2	apply TQM principles in a selected enterprise.
CO3	understand Six Sigma and apply Traditional tools, New tools, Benchmarking and FMEA.
CO4	understand Taguchi's Quality Loss Function, Performance Measures and apply QFD, TPM, COQ and BPR.
CO5	apply QMS and EMS in any organization.

TEXT BOOKS:

1. Dale H. Besterfield, Carol B. Michna, Glen H. Bester field, Mary B. Sacre, Hemant Urdhwareshe and Rashmi Urdhwareshe, “Total Quality Management”, Pearson Education Asia, Revised Third Edition, Indian Reprint, Sixth Impression,2013.

REFERENCES:

1. Joel. E. Ross, “Total Quality Management – Text and Cases”, Routledge.,2017.
2. Kiran.D. R, “Total Quality Management: Key concepts and case studies, Butterworth – Heinemann Ltd, 2016.
3. Oakland, J.S. “TQM – Text with Cases”, Butterworth – Heinemann Ltd., Oxford, Third Edition, 2003.
4. Suganthi, L and Anand Samuel, “Total Quality Management”, Prentice Hall (India) Pvt. Ltd., 2006.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	-	2	1	-	2	1	2	2	1	-	-	3	3	3
2	-	2	1	-	2	1	2	2	1	-	-	3	3	3
3	-	2	1	-	2	1	2	2	1	-	-	3	3	3
4	-	2	1	-	2	1	2	2	1	-	-	3	3	3
5	-	2	1	-	2	1	2	2	1	-	-	3	3	3
Avg	**-**	**2**	**1**	**-**	**2**	**1**	**2**	**2**	**1**	**-**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23042	WASTE TO ENERGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Interpret the various types of wastes from which energy can be generated
2. Develop knowledge on biomass pyrolysis process and its applications
3. Develop knowledge on various types of biomass gasifiers and their operations
4. Invent knowledge on biomass combustors and its applications on generating energy
5. Summarize the principles of bio-energy systems and their features

UNIT - I	INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE	9

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

UNIT - II	BIOMASS PYROLYSIS	9

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

UNIT - III	BIOMASS GASIFICATION	9

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

UNIT - IV	BIOMASS COMBUSTION	9

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

UNIT - V	BIO ENERGY	9

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermochemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Understand the various types of wastes from which energy can be generated
CO2	Gain knowledge on biomass pyrolysis process and its applications
CO3	Develop knowledge on various types of biomass gasifiers and their operations
CO4	Gain knowledge on biomass combustors and its applications on generating energy
CO5	Understand the principles of bio-energy systems and their features

REFERENCES:

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo -Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non-Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	1	3	1	2	1	1	1	1	3	3	3
2	3	3	3	1	3	1	2	1	1	1	1	3	3	3
3	3	3	3	1	3	1	2	1	1	1	1	3	3	3
4	3	3	3	1	3	1	2	1	1	1	1	3	3	3
5	3	3	3	1	3	1	2	1	1	1	1	3	3	3
Avg	**3**	**3**	**3**	**1**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

MINOR DEGREE COURSES IN AUTOMOTIVE TECHNOLOGY

AU23043	INTRODUCTION TO AUTOMOBILE ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Identify various Engine layout and Chassis for vehicles.
2. To recognize the construction and working principle of drive line, final drive and differential systems.
3. To review the knowledge about the constructional feature and working principle of Steering Systems, Conventional and Independent Suspension Systems.
4. To demonstrate working principle of braking system and wheels used in automobile.
5. To understand the need for electrical systems in the vehicle and working of modern vehicle

UNIT - I	VEHICLE STRUCTURE AND ENGINE	9

History of Automobiles – Types of Automobiles –Chassis– Frame -Engines- Types– Construction and Working Principle - Two and Four Stroke Engines – SI and CI Engines– MPFI, GDI and CRDI. Emission Norms, Cooling and Lubrication System.

UNIT - II	TRANSMISSION SYSTEM	9

Types of Transmission – Clutch – Types, Gear Box – Types – Working Principle and Construction, Automatic Transmission – Fluid Coupling, Torque Converter. Propeller Shaft- Slip Joint – Universal Joint, Differential, Final Drive, Rear Axle and its types

UNIT - III	STEERING AND SUSPENSION SYSTEMS	9

Steering Geometry- Ackermann and Davis Steering Principle, Steering- Hydraulic and Electronic, Suspension System- Types – Conventional and Independent suspension

UNIT - IV	BRAKE AND WHEELS	9

Types of Brakes -Construction and Working. Antilock Braking System, TCS. Types of Wheels – Construction of Wheel. Types of Tyres – Tubeless Tyres and Tubed Tyres and its Classifications.

UNIT - V	AUTOMOTIVE ELECTRICAL AND MODERN VEHICLES	9

Batteries- Lead Acid, Lithium Ion Battery. Starting System. Ignition System-types, Laser Ignition. Vehicle Lighting- Head Lamp. Automotive Sensors and its types. Need For Hybrid and Electric Vehicle–Types- Fuel Cell Technology.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After completing the course, the student will able to

CO1	Assess and critically evaluate various Engine concepts, determine their characteristics, advantages and limitations
CO2	Interpret different types of drive lines and drives used in Automotive.
CO3	Examine the working principle of steering systems, conventional and independent suspension systems.
CO4	Apply knowledge on working principles of brake and its subsystems.
CO5	Demonstrate understanding of Hybrid and Electric vehicle architectures and their technologies.

TEXT BOOK:

1. Kirpal Singh, Automobile Engineering, Standard Publisher, New Delhi, 2017
2. K.K. Ramalingam, “Automobile Engineering”, Scitech publication (India), 2011.
3. R.K. Rajput, A Text–Book of Automobile Engineering, Laxmi Publications Private Limited, 2015
4. Jack Erjavec, Automotive Technology,3rd Edition.

REFERENCES:

1. Heinz Hazler, Modern Vehicle Technology, Butterworth, London, 2005.
2. Heldt P.M., Automotive Chassis, Chilton Co., New York, 1990.

3. Newton Steeds and Garret, Motor Vehicles, 13th Edition, Butterworth, London, 2005.
4. N.K. Giri, Automotive Mechanics, Kanna Publishers, 2007.
5. William H Crouse, “Automotive Mechanics”, The McGraw-Hill companies,2007.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	3	1	2	1	2	2	1	3	3	3
2	3	3	3	2	3	1	2	1	2	2	1	3	3	3
3	3	3	3	2	3	1	2	1	2	2	1	3	3	3
4	3	3	3	2	3	1	2	1	2	2	1	3	3	3
5	3	3	3	2	3	1	2	1	2	2	1	3	3	3
Avg	**3**	**3**	**3**	**2**	**3**	**1**	**2**	**1**	**2**	**2**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23044	BASICS OF AUTOMOTIVE ENGINES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is

1. To impart knowledge on basics of automotive SI and CI engines construction and working.
2. To understand the engine induction and ignition systems and its functional requirements.
3. To learn the properties of gasoline and diesel fuel and combustion process involved in diesel engines.
4. To impart the knowledge on engine cooling and lubrication requirements also to understand the requirements of supercharger and turbocharger.
5. To analyze the performance characteristics of SI and CI engine and learn modern developments in IC engine.

UNIT - I	ENGINE FUNDAMENTALS	9

Introduction - classifications – Terminology - Engine components, functional requirements & materials- Working principle - valve and port timing diagram - Four stroke and two stroke cycle- Engine Cycles- Air Standard cycles – Otto Cycle-Fuel–air and actual cycle analysis– Engine operating parameters -Engine emissions –Two stroke engines – types–Merits and Demerits – Problems on cycles.

UNIT - II	INDUCTION AND IGNITION SYSTEM	9

Carburettors - requirements - working principles, types, different circuits – compensation and maximum power devices – Fuel air ratio calculation - Requirements and objective of diesel fuel injection system – types of injection - Jerk and distributor type pumps, Unit injector, common rail direct injection -. Electronic fuel injection, Effect of Injection timing - Injection lags. Types of injection nozzle, Split and Multiple injections. Mechanical and pneumatic governors. Problems on fuel injection. Ignition system- function and types- Ignition control mechanism – Electronic ignition system. Laser ignition.

UNIT - III	FUEL PROPERTIES AND COMBUSTION OF FUELS	9

Introduction on Hydrocarbon fuels- Gasoline and Diesel fuel properties. Octane and cetane number – Laboratory tests for diesel fuel. Combustion stoichiometry -Combustion in SI engine – stages - Abnormal combustion- combustion chambers - Burned and Unburned mixture states – Flame structure and Speed - Cyclic variations in combustion -P-Theta and HRR curve for SI engine and CI Engine – Importance of air motion–Swirl, Squish andTumble.SI and CI engine stages of combustion. Delay period – factors affecting delay period. Knock formation in CI engines. Comparison of knock in CI & SI engines. Direct and indirect injection combustion chambers for diesel combustion. Chambers for Si and CI engine combustion.

UNIT - IV	ENGINE COOLING, LUBRICATING SYSTEMS AND SUPERCHARGING, TURBOCHARGING	9

Cooling system – Function - types – Heat transfer analysis and calculation -Properties of coolants - Lubrication system- Function- types - Lubricant Properties. Supercharging – Introduction and its requirements - Thermodynamic cycle analysis for super charged engine. Types of superchargers - Modification of an engine for supercharging. Effect of supercharging on engine performance. Turbocharger – construction and working – Matching of turbocharger. - E-Turbocharger. Problems.

UNIT - V	ENGINE HEAT TRANSFER, TESTING AND RECENT DEVELOPMENTS	9

Importance of heat transfer- Modes of heat transfer- heat transfer and engine energy balance -Indicated and brake MEP, operating variables that affects SI engine performance –Automotive and stationary diesel engine testing and standards – Engine power and efficiencies – Variables affecting engine performance – Methods to improve engine

performance - Introduction to Stratified charge engine, LHR engines, HCCI and RCCI engines. Variable valve timing.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students will be able to

CO1	Understand and remember engine glossaries, identify various components of SI and CI engines and its principle of working.
CO2	Define and interpret the knowledge on fuel induction system.
CO3	Illustrate and correlate the knowledge on engine combustion and its various effects.
CO4	Explain and apply their knowledge in analyzing the requirement of engine sub systems.
CO5	Analyze and Evaluate engine performance and exposed to gain knowledge on recent developments of prime sources.

TEXT BOOKS:

1. V. Ganesan, Internal Combustion Engines, Tata-McGraw Hill Publishing Co., New Delhi,
2. John B. Heywood, “Internal Combustion Engines”, McGraw-Hill Book Company, ISBN No: 0-07-100499-8
3. M.L. Mathur and R.P. Sharma, Internal Combustion Engine, Dhanpath Rai Publications (P) Ltd, New Delhi-110002.

REFERENCES:

1. Heinz Heisler, Advanced engine technology. Butterworth Heinemann publications
2. Heldt, P.M., High Speed Combustion Engines, Oxford IBH Publishing Co., Calcutta,
3. K.K. Ramalingam, internal Combustion Engines, Sci Tech Publications, Chennai,2003.
4. Maleev, V.M, Diesel Engine Operation and Maintenance, McGraw-Hill, 1974.
5. Obert, E.F, Internal Combustion Engine analysis and Practice, International Text Book Co., Scranton, Pennsylvania,1988.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	1	2	2	1	2	2	-	3	3	3
2	3	3	3	3	1	2	2	1	2	2	-	3	3	3
3	3	3	3	3	1	2	2	1	2	2	-	3	3	3
4	3	3	3	3	1	2	2	1	2	2	-	3	3	3
5	3	3	3	3	1	2	2	1	2	2	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**1**	**2**	**2**	**1**	**2**	**2**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23045	VEHICLE CHASSIS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is

1. To understand the basic knowledge about various vehicle frames, front axles, steering systems and understand the conditions for true rolling motion of wheels during steering.
2. To recognize the construction and working principle of drive line, final drive and differential systems
3. To review the knowledge about the constructional feature of rear axle, wheels and tyres.
4. To evaluate the working principles of both conventional and independent suspension system.
5. To demonstrate working principle of braking system used in automobile.

UNIT - I	INTRODUCTION, FRAME, STEERING SYSTEM	9

Types of Chassis layout with reference to Power Plant location and drive, various types of frames, Loads acting on vehicle frame, Constructional details and materials for frames, testing of frames, Types of Front Axles and Stub Axles, Front Wheel Geometry, Condition for True Rolling Motion of Wheels during Steering, Ackerman's and Davis Steering Mechanisms, Steering Linkages, Different Types of Steering Gears, Slip Angle, Over–Steer and Under–Steer, Reversible and Irreversible Steering, EPAS.

UNIT - II	PROPELLER SHAFT AND FINAL DRIVE	9

Effect of Driving Thrust, torque reactions and side thrust, Hotchkiss drive, torque tube drive, radius rods and stabilizers, Propeller Shaft, Universal Joints, Constant Velocity Joints, Final drive types, Double reduction and twin speed final drives, Differential principle and types, limited speed differential.

UNIT - III	AXLES, WHEELS AND TYRES	9

Construction and Design of Drive Axles, Types of Loads acting on Rear axles, Full – Floating, Three–Quarter Floating and Semi–Floating Axles, Axle Housings and Types, Types and Constructional Details of Different Types of Wheels and Rims, Different Types of Tyres and their constructional details.

UNIT - IV	SUSPENSION SYSTEM	9

Need for Suspension System, Types of Suspension Springs, Constructional details and characteristics of Single Leaf, Multi–Leaf, Coil, Torsion bar, Rubber, Pneumatic and Hydro – elastic Suspension Spring Systems, Independent Suspension System, Telescopic Shock Absorbers.

UNIT - V	BRAKING SYSTEM	9

Theory of Automobile Braking, Stopping Distance Time and Braking Efficiency, Effect of Weight Transfer during Braking, Theory of Drum Brakes, Leading and Trailing Shoes, Braking Torque, Constructional Details of Drum Brake and its Activators, Disc Brake Theory, Types and Construction, Hydraulic Braking System, Mechanical Braking System, Pneumatic Braking System, Anti–Lock Braking System.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students will be able to

CO1	Identify the different types of chassis layout, frames used in Automotive.
CO2	Appraise different types of drive line systems and steering system drives used in Automotive.
CO3	Acquire knowledge about different types of front axle and rear axles, wheel and tyre used in motor vehicles.
CO4	Expose to the working principle of conventional and independent suspension systems.

CO5	Analyze working principles of brake and its subsystems.

TEXTBOOKS:

1. Kirpal Singh, Automobile Engineering, Standard Publisher, New Delhi, 2017
2. K.K. Ramalingam, “Automobile Engineering”, Scitech publication (India), 2011.
3. R.K. Rajput, A Text–Book of Automobile Engineering, Laxmi Publications Private Limited, 2015

REFERENCES:

1. Heinz Hazler, Modern Vehicle Technology, Butterworth, London, 2005.
2. Heldt P.M., Automotive Chassis, Chilton Co., New York, 1990
3. Newton Steeds and Garret, Motor Vehicles, 13th Edition, Butterworth, London, 2005.
4. N.K. Giri, Automotive Mechanics, Kanna Publishers, 2007
5. William. H. Crows – Work shop Manuel – 2005

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	1	1	2	2	-	3	3	3
2	3	3	3	3	3	2	1	1	2	2	-	3	3	3
3	3	3	3	3	3	2	1	1	2	2	-	3	3	3
4	3	3	3	3	3	2	1	1	2	2	-	3	3	3
5	3	3	3	3	3	2	1	1	2	2	-	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**1**	**1**	**2**	**2**	**-**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23046	VEHICLE DRIVELINE SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The objective of this course is to prepare the students to gain knowledge in the

1. Construction and principle of mechanical transmission components clutch and gear box
2. Hydrodynamic devices hydrostatic devices
3. Automatic transmission system, Electric drive used in road vehicles.

UNIT - I	CLUTCH	9

Requirement of transmission system, Types of transmission system, Requirement of Clutches – Functions-Types of clutches, construction and operation of Single plate, multi plate and Diaphragm Spring clutches. Centrifugal clutch, Electromagnetic clutch.

UNIT - II	GEAR BOX	9

Purpose of gear box. Construction and working principle of sliding, constant and synchromesh gear boxes, Automatic manual transmission. Introduction to epicycle gear trains, Numerical examples on performance of automobile such as Resistance to motion, Tractive effort, Engine speed & power and acceleration. Determination of gear ratios for different vehicle applications.

UNIT - III	HYDRODYNAMIC TRANSMISSION	9

Fluid coupling – principles - Performance characteristics – advantages – limitations – drag torque – reduction of drag torque. Torque converter - principles - Performance characteristics – advantages – limitations – multistage and polyphase torque converters.

UNIT - IV	HYDROSTATIC DRIVE	9

Hydrostatic drive; various types of hydrostatic systems – Principles of Hydrostatic drive system. Advantages and limitations. Comparison of hydrostatic drive with hydrodynamic drive, construction and working of typical Janny hydrostatic drive.

UNIT - V	AUTOMATIC TRANSMISSION AND ELECTRIC DRIVE	9

Wilson gear box-Cotal electric transmission. Chevrolet “Turboglide” transmission. – Four speed longitudinally mounted automatic transmission -Hydraulic control systems of automatic transmission. Continuously Variable Transmission (CVT) — types – Operations. DCT, Electric drive-types- Principle of early and modified Ward Leonard Control System- Advantages & limitations -Modern electric drives.

TOTAL: 45 PERIODS

COURSE OUTCOMES

At the end of the course, students will be able to:

CO1	Understand the construction and working of various types of clutches
CO2	Determine the gear ratio for different vehicle applications
CO3	Describe the types and principle of hydrodynamic transmission
CO4	Compare Hydrostatic and hydrodynamics drives
CO5	Identify the differences among various automatic transmissions and electric drive.

TEXTBOOKS:

1. Heinz Heisler, “Advanced Vehicle Technology”,2nd Edition,2002, Butterworth-Heinemann
2. T. K. Garrett K. Newton W. Steeds,” Motor Vehicle”, 13th Edition, 2000, Butterworth-Heinemann

REFERENCES:

1. Crouse, W.H., Anglin, D.L., “Automotive Transmission and Power Trains construction”, McGraw Hill, 1976.
2. Heldt, P.M., “Torque converters”, Chilton Book Co., 1962.

3. Iqbal Husain, “Electric and Hybrid Vehicles Design Fundamentals”, CRC PRESS Boca Raton London New York Washington, D.C.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	1	2	1	1	1	1	1	1	2	3	3
2	3	3	3	1	2	1	1	1	1	1	1	2	3	3
3	3	3	3	1	2	1	1	1	1	1	1	2	3	3
4	3	3	1	1	2	1	1	1	1	1	1	2	3	3
5	3	3	3	1	2	1	1	1	1	1	1	2	3	3
Avg	**3**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23047	FUNDAMENTALS OF VEHICLE BODYWORK	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is

1. To design and analyze Car body
2. To design and analyze of Bus body
3. To design and compare different Commercial vehicles
4. To analyze the Vehicle Aerodynamics
5. To improve Ergonomics

UNIT - I	CAR BODY DETAILS	9

Types of Car body - Saloon, convertibles, Limousine, Estate Van, Racing and Sports car – car body terminology - Visibility- regulations, driver's visibility, improvement in visibility and tests for visibility. Driver seat design -Car Body Construction - Various panels in car bodies – body materials. Safety: Safety design, safety equipment for cars

UNIT - II	BUS BODY DETAILS	9

Types of bus body: based on capacity, distance travelled and based on construction. – Bus body lay out, floor height, engine location, entrance and exit location. Types of metal sections used – Regulations – Constructional details: Conventional and integral.

UNIT - III	COMMERCIAL VEHICLE DETAILS	9

Types of commercial vehicle bodies - Light commercial vehicle body. Construction details of Flat platform body, Tipper body and Tanker body – Dimensions of driver's seat in relation to controls – Driver's cab design.

UNIT - IV	VEHICLE AERODYNAMICS	9

Objectives, Vehicle drag and types. Various types of forces and moments. Effects of forces and moments. Various body optimization techniques for minimum drag. Wind tunnels – Principle of operation, Types. Wind tunnel testing such as: Flow visualization techniques, Airflow management test – measurement of various forces and moments by using wind tunnel balance.

UNIT - V	VEHICLE ERGONOMICS	9

Introduction to Automotive Ergonomics, Ergonomics in Vehicle Design, Anthropometry in Designing Vehicles, Occupant Package, Controls and Displays Interface - Introduction to Field of View - styling in automotive design.

TOTAL: 45 PERIODS

COURSE OUTCOMES

Upon completion of the course, students will be able to

CO1	Analyze different aspects of car body.
CO2	Analyze different types bus body.
CO3	Compare and analyze different types of commercial vehicles.
CO4	Analyze the role of various aerodynamic forces and moments, measuring instruments in vehicle body design.
CO5	Create new Ergonomic designs.

TEXTBOOKS:

1. Dieler Anselm., "The passenger car body", SAE International, 2000
2. James E Duffy, "Body Repair Technology for 4-Wheelers", Cengage Learning,2009.
3. Powloski, J., "Vehicle Body Engineering", Business Books Ltd., 1968.

REFERENCES:

1. Braithwaite, J.B., "Vehicle Body building and drawing", Heinemann Educational Books Ltd., London, 1997.
2. Giles, G.J., "Body construction and design", Illiffe Books Butterworth & Co., 1991.
3. John Fenton, "Vehicle Body layout and analysis", Mechanical Engg. Publication Ltd. London,1992.

4. Vivek D. Bhise," Ergonomics in The Automotive Design Process", CRS Press,2016William. H. Crows – Work shop Manuel – 2005
CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	1	2	1	1	1	1	1	1	2	3	3
2	3	3	3	1	2	1	1	1	1	1	1	2	3	3
3	3	3	3	1	2	1	1	1	1	1	1	2	3	3
4	3	3	3	1	2	1	1	1	1	1	1	2	3	3
5	3	3	3	1	2	1	1	1	1	1	1	2	3	3
Avg	**3**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23048	INTRODUCTION TO ELECTRIC AND HYBRID VEHICLES	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. General aspects of Electric and Hybrid Vehicles (EHV), including architectures, modelling, sizing, sub-system design and hybrid vehicle control.
2. Understand about vehicle dynamics,
3. Design the required energy storage devices,
4. Select the suitable electric propulsion systems and
5. Understand of hybrid electric vehicles.

UNIT - I	NEED FOR ALTERNATIVE SYSTEM	9

Need for hybrid and electric vehicles – main components and working principles of a hybrid and electric vehicles, Different configurations of hybrid and electric vehicles. Comparative study of diesel, petrol, hybrid, fuel-cell and electric Vehicles. Advantages and Limitations of hybrid and electric Vehicles. Case study on specification of electric and hybrid vehicles.

UNIT - II	DESIGN CONSIDERATIONS FOR ELECTRIC VEHICLES	9

Design requirement for electric vehicles- Range, maximum velocity, acceleration, power requirement, mass of the vehicle. Various Resistance- Transmission efficiency- Electric vehicle chassis and Body Design, Electric Vehicle Recharging and Refueling Systems.

UNIT - III	ENERGY STORAGE DEVICES AND SOURCES	9

Battery Parameters- - Different types of batteries. Battery Chemistry, Battery Modelling, Battery Management System, Thermal Management system. Ultra-capacitors. Fuel Cell Characteristics - Fuel cell types- Electrolytic reactions of fuel cell. Cell Chemistry.

UNIT - IV	MOTORS AND CONTROLLERS	9

Types of Motors, Characteristic of DC motors, AC single phase and 3-phase motor, PM motors, switched reluctance motors, BLDC motor, Motor Drives and speed controllers, Torque Vectoring, Regenerative Braking. Rectifiers, Inverters, DC/DC converters.

UNIT - V	SUBSYTEMS OF HYBRID AND ELECTRIC VEHICLES	9

Power Split devices for Hybrid Vehicles - Operation modes - Control Strategies for Hybrid Vehicle- Economy of hybrid Vehicles.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Understand working of different configurations of hybrid and electric vehicles
CO2	Design and develop basic schemes of electric vehicles and hybrid electric vehicles.
CO3	Choose proper energy storage systems for EV applications
CO4	Choose a suitable drive scheme for developing an electric hybrid vehicle depending on resources
CO5	Understand basic operation of power-split device and control Strategies for hybrid electric vehicle

TEXTBOOKS:

1. James Larminie and John Lowry, “Electric Vehicle Technology Explained “John Wiley & Sons,2003
2. Iqbal Husain, “Electric and Hybrid Vehicles-Design Fundamentals”, CRC Press,2003
3. Mehrdad Ehsani, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles”, CRC Press,2005

REFERENCES:

1. Ron HodKinson, John Fenton, “Light Weight Electric/ Hybrid Vehicle Design”, Butterworth Heinemann Publication,2005
2. Lino Guzzella, “Vehicle Propulsion System” Springer Publications,2005

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

EMERGING TECHNOLOGY COURSE

AU23E01	FUNDAMENTALS OF DATA SCIENCE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for

1. Clearly demonstrate the data collection methods.
2. Collect, investigate, clean, munge, and alter data.
3. Use Data Visualization techniques to explore data.
4. Use regression and classification models and evaluate it
5. implement suitable data science application

UNIT - I	INTRODUCTION	9

Introduction to Data Science - Overview of Data - Sources of Data - Types of Data – Small Data and Big Data - Data collection methods - Surveys - Interviews - Log and Diary data - User studies in Lab and Field - Web Scraping - Public datasets - Data cleaning - Tools for Data Science.

UNIT - II	DESCRIPTIVE DATA ANALYSIS	9

Dataset Construction - Sampling of data - Stem and Leaf Plots - Frequency table - Time Series data - Central Tendency Measures of the location of data - Dispersion measures – Correlation analysis - Data reduction techniques - Principal Component analysis – Independent component analysis – Hypothesis testing – Statistical Tests

UNIT - III	DATA VISUALIZATION	9

Overview of python libraries matplotlib and seaborn - Histogram - Kernel density estimate plots - Box and violin plots - Regression plots - Heatmaps - Clustered matrices – Three-Dimensional plot - Surface and Contour plot - Geographic data visualization

UNIT - IV	PREDICTIVE ANALYTICS AND EVALUATION	9

Overview of Machine learning concepts – Model construction using regression and Classification models - Linear regression and multiple regression models – KNN classification models - Comparison models - Training Data construction - Normalization - Cross-validation techniques - Accuracy metrics for evaluation of models – Contingency table, ROC curve, Precision-recall curves - A/B testing

UNIT - V	DATA SCIENCE APPLICATIONS	9

Fraud Detection, Stock Market; Personalized Recommendation System, Content Development using Data Analytics, Analytics for Campaigns - Targeted marketing through Customer Segmentation, Medical Image Analysis and Diagnosis, Drug Discovery, Patient data management, Customer Sentiment Analysis, Natural Language Processing for Review Analysis – Chabot.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Clearly demonstrate the data collection methods.
CO2	Collect, investigate, clean, munge, and alter data.
CO3	Use Data Visualization techniques to explore data.
CO4	Use regression and classification models and evaluate it
CO5	implement suitable data science application

REFERENCES:

1. Chirag Shah, A Hands-on Introduction to Data Science, Cambridge University Press, UK, 2020
2. Grus, Joel, Data science from scratch: first principles with python. O'Reilly Media,2019.

3. Aragues, A. Visualizing Streaming Data: Interactive Analysis beyond Static Limits. O'Reilly Media, Inc, 2018.
4. Géron, A. Hands-On Machine Learning with Scikit-Learn and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems O'Reilly Media, 2017.
5. Wes McKinney, Python for Data Analysis, 3rd Edition, O' Reilly, 2022
6. T.V. Geetha and S. Sendhil kumar, Machine Learning: Concepts, Techniques and Applications, 1st Edition, CRC Press, Taylor and Franics, 2022.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	2	1	2	1	2	3	3	3	2	2
2	3	3	3	3	2	1	2	1	2	3	3	3	2	2
3	3	3	3	3	2	1	2	1	2	3	3	3	2	2
4	3	3	3	3	2	1	2	1	2	3	3	3	2	2
5	3	3	3	3	2	1	2	1	2	3	3	3	2	2
Avg	**3**	**3**	**3**	**3**	**2**	**1**	**2**	**1**	**2**	**3**	**3**	**3**	**2**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23E02	FUNDAMENTALS OF DEEP LEARNING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To Understand the role of Deep Learning in Machine Learning Applications.
2. To get familiar with using Tensor Flow / Keras in Deep Learning Applications
3. To design and implement Deep Learning Applications.
4. To Analyze Different Deep Learning Models in Image–Related Projects.
5. To design and implement Convolutional Neural Networks

UNIT - I	BASICS OF NEURAL NETWORKS	9

Basic concept of Neurons–Perceptron Algorithm–Feed Forward and Back Propagation Networks

UNIT - II	CONVOLUTIONAL NEURAL NETWORKS	9

CNN Architectures – Convolution – Pooling Layers – Transfer Learning – Image Classification using Transfer Learning.

UNIT - III	ADVANCED DEEP LEARNING ARCHITECTURES	9

LSTM, GRU, Encoder/Decoder Architectures – Autoencoders – Standard- Sparse – Denoising – Contractive- Variational Autoencoders – Adversarial Generative Networks – Autoencoder and DBM,

UNIT - IV	DEEP REINFORCEMENT LEARNING	9

Introduction to Reinforcement Learning – Deep Q Networks – Naïve REINFORCE Algorithm - Actor–Critic Method – Introduction to Deep Belief Networks

UNIT - V	APPLICATIONS OF DEEP LEARNING	9

Image Segmentation – Object Detection – Automatic Image Captioning – Image Generation with Generative Adversarial Networks – Video to Text with LSTM Models – Attention Models for Computer Vision –Analysis using Recursive Neural Networks – Dialogue Generation with LSTMs – Transformers like BERT

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Understand the role of Deep Learning in Machine Learning Applications.
CO2	get familiar with using Tensor Flow / Keras in Deep Learning Applications
CO3	design and implement Deep Learning Applications.
CO4	Critically Analyze Different Deep Learning Models in Image–Related Projects.
CO5	design and implement Convolutional Neural Networks

REFERENCES:

1. Ian Good Fellow, Yoshua Bengio, Aaron Courville, “Deep Learning,” MIT Press, 2017
2. Francois Chollet, “Deep Learning with Python,” Manning Publications,2018.
3. PhilKim, “Matlab Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence,” Apress, 2017
4. Jon Krohn,” Deep Learning Illustrated: A Visual, Interactive Guide to Artificial Intelligence,” Addison-Wesley, 2020.
5. Andrew Glassner, “Deep Learning – A visual Approach,” No Starch Press, 2021

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	2	2	1	3	2	1	2	1	2	1	3	3	2	2
2	2	2	1	3	2	1	2	1	2	1	3	3	2	2
3	2	2	1	3	2	1	2	1	2	1	3	3	2	2
4	2	2	1	3	2	1	2	1	2	1	3	3	2	2
5	2	2	1	3	2	1	2	1	2	1	3	3	2	2
Avg	**2**	**2**	**1**	**3**	**2**	**1**	**2**	**1**	**2**	**1**	**3**	**3**	**2**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23E03	INTRODUCTION TO ARTIFICIAL INTELLIGENCE	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To relate the type of agents and environments in the real-world scenarios
2. To analyze different search techniques with computational complexity
3. To understand the working of Bayesian techniques to solve AI problems
4. To use the decision-making process to solve simple and complex problems
5. To understand the different learning techniques

UNIT - I	INTELLIGENT AGENTS AND SEARCH TECHNIQUES	9

Agents and Environments – Good Behavior: The concepts of Rationality – The Nature of Environments – The Structure of Agents, Problem solving - Solving problems by searching - Search in Complex Environments - Adversarial Search and games - Constraint Satisfaction Problem

UNIT - II	KNOWLEDGE AND REASONING	9

Logical Agents - Propositional Logic - Theorem proving, First Order Logic: Syntax and Semantics - Knowledge Engineering in First Order Logic, Inference in First Order Logic: Forward Chaining -Backward Chaining - Resolution, Knowledge Representation: - Ontological Engineering - Categories and Objects - Events - Mental Objects and Modal Logic - Reasoning System for Categories - Reasoning with Default Information

UNIT - III	BAYESIAN NETWORKS	9

Directed Graphical Models – Bayesian Networks – Exploiting Independence Properties – From Distributions to Graphs – Inference in Graphical Models - Bayes model - Generative and Discriminative model - Maximum-likelihood parameter learning: Continuous models – Bayesian parameter learning - Bayesian linear regression

UNIT - IV	DECISION MAKING/ DECISION PROCESS	9

Decision Process formulation, utility theory, utility functions, decision networks, value of information, Making Complex Decisions: Sequential Decision Problems - Algorithms for MDPs - Bandit Problems - partially observable MDPs - Algorithms for Solving POMDPs – Reinforcement learning

UNIT - V	AI APPLICATIONS	9

Learning AI model deployment - Containers - Dockers - Discussion of AI Applications – Natural Language Processing - Chatbots - Dialog Flow - Image Classification - Robotics – Model deployment with containers such as Docker

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Relate the type of agents and environments in the real-world scenarios
CO2	Analyze different search techniques with computational complexity
CO3	Understand the working of Bayesian techniques to solve AI problems
CO4	Use the decision-making process to solve simple and complex problems
CO5	Understand the different learning techniques

REFERENCES:

1. Stuart J. Russell, Peter Norvig, Artificial Intelligence – A Modern Approach, Pearson Education, 4th Edition, 2021
2. Elaine Rich, Kevin Knight, Shivashankar B. Nair, Artificial Intelligence, Third Edition, Tata McGraw-Hill, 2008.
3. Dheepak Khemani, “A First Course in Artificial Intelligence”, McGraw-Hill, 2013

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	1	3	2	1	2	3	2	3	3	3	2	2
2	3	3	1	3	2	1	2	3	2	3	3	3	2	2
3	3	3	1	3	2	1	2	3	2	3	3	3	2	2
4	3	3	1	3	2	1	2	3	2	3	3	3	2	2
5	3	3	1	3	2	1	2	3	2	3	3	3	2	2
Avg	**3**	**3**	**1**	**3**	**2**	**1**	**2**	**3**	**2**	**3**	**3**	**3**	**2**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23E04	INTRODUCTION TO MACHINE LEARNING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students

1. To disseminate the key elements of machine learning and the basics of learning theory.
2. To apply regression analysis and decision tree models for regression and classification problems.
3. To implement SVM or Neural Network model for an appropriate application and improve the performance using ensemble models.
4. To design and implement an BBN, HMM for a sequence model type of application and implement a PGM for any real time application using an open-source tool
5. To identify suitable learning tasks to which Reinforcement learning techniques can be applied.

UNIT - I	INTRODUCTION	9

Machine Learning – Basic Concepts in Machine Learning – Types of Machine Learning – Applications of Machine Learning - Basics of Learning Theory – Concept Learning – Hypothesis Space - Find-S algorithm - Version spaces - Bias-Variance Tradeoffs - Modelling in Machine learning- Model Selection and Model Evaluation - Model Performance - Resampling Methods

UNIT - II	DATA PREPARATION	9

Understanding of data – Data preprocessing - Linear Regression – Multiple variable regression – Logistic regression – Regularization techniques - LASSO, Ridge and Elastic Net Regression.

UNIT - III	SUPERVISED LEARNING I	9

Decision Tree Learning – ID3 - Univariate Analysis – Bivariate and multivariate analysis – PCA and feature reduction – Data Visualization. - Support Vector Machines – Support Vector Regression - Neural Networks – Perceptron - Feed-Forward Networks for binary and multi-class classification- Multi Layer Perceptron - Back Propagation - Ensemble Methods – Bagging – Random Forest - Boosting – AdaBoost

UNIT - IV	PROBABILISTIC GRAPHICAL MODELS	9

Introduction to Graphs – Inference in Graphical Models – Bayesian Belief Networks – Markov Chain – Markov Model - Hidden Markov Models – Inference – Learning - Generalization – Undirected Graphical Models – Markov Random Fields – Conditional Independence Properties – Conditional Random Fields.

UNIT - V	UNSUPERVISED LEARNING AND REINFORCEMENT LEARNING	9

Clustering– K-means Clustering– Hierarchical Clustering – Expectation Maximization algorithm – Gaussian Mixture Model- Cluster Evaluation Methods. Overview of Reinforcement Learning - Components of Reinforcement Learning - Model Based Learning - Model Free Learning - Q Learning – Evolutionary techniques – Genetic algorithms in neural networks.

TOTAL: 45 PERIODS

COURSE OUTCOMES

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

CO1	Disseminate the key elements of machine learning and the basics of learning theory.
CO2	Apply regression analysis and decision tree models for regression and classification problems.
CO3	Implement SVM or Neural Network model for an appropriate application and improve the performance using ensemble models.

CO4	Design and implement an BBN, HMM for a sequence model type of application and implement a PGM for any real time application using an open-source tool
CO5	Identify suitable learning tasks to which Reinforcement learning techniques can be applied.

REFERENCES:

1. Sridhar S, Vijayalakshmi M, “Machine Learning”, First Edition, Oxford University Press, 2021.
2. Christopher Bishop, “Pattern Recognition and Machine Learning”, First Edition, Springer, 2006.
3. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
4. Ethem Alpaydin, “Introduction to Machine Learning”, Third Edition, Prentice Hall of India, 2005.
5. Tom Mitchell, “Machine Learning”, McGraw-Hill, 1997.
6. T. Hastie, R. Tibshirani, J. Friedman, “The Elements of Statistical Learning”, Second Edition, Springer, 2008.
7. Stephen Marsland, “Machine Learning – An Algorithmic Perspective”, CRC Press, 2009.
8. T.V. Geetha and S. Sendhil kumar, Machine Learning: Concepts, Techniques and Applications, 1st Edition, CRC Press, Taylor and Franics, 2022.

CO-PO Mapping

COs	**POs**												**PSOs**	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	2	3	2	2	2	3	2	3	3	3	2	2
2	3	3	2	3	2	2	2	3	2	3	3	3	2	2
3	3	3	2	3	2	2	2	3	2	3	3	3	2	2
4	3	3	2	3	2	2	2	3	2	3	3	3	2	2
5	3	3	2	3	2	2	2	3	2	3	3	3	2	2
Avg	**3**	**3**	**2**	**3**	**2**	**2**	**2**	**3**	**2**	**3**	**3**	**3**	**2**	**2**

1 – Slight, 2 – Moderate, 3 – Substantial

OPEN ELECTIVE COURSES (OEC)

AU23901	VEHICLE TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Identify various Engine layout and Chassis for vehicles.
2. To recognize the construction and working principle of drive line systems.
3. To review the knowledge about the constructional feature and working principle of Steering Systems, Conventional and Independent Suspension Systems.
4. To demonstrate working principle of braking system and wheels used in automobile.
5. To understand the need for electrical systems in the vehicle and working of modern vehicles

UNIT - I	VEHICLE STRUCTURE AND ENGINE	9

History of Automobiles – Types of Automobiles –Chassis– Frame -Engines- Types– Construction and Working Principle - Two and Four Stroke Engines – SI and CI Engines– MPFI, GDI and CRDI. Emission Norms, Cooling and Lubrication System.

UNIT - II	TRANSMISSION SYSTEM	9

Types of Transmission – Clutch – Types, Gear Box – Types – Working Principle and Construction, Automatic Transmission – Fluid Coupling, Torque Converter. Propeller Shaft- Slip Joint – Universal Joint, Differential, Final Drive, Rear Axle and its types

UNIT - III	STEERING AND SUSPENSION SYSTEMS	9

Steering Geometry- Ackermann and Davis Steering Principle, Steering- Hydraulic and Electronic, Suspension System- Types – Conventional and Independent suspension

UNIT - IV	BRAKE AND WHEELS	9

Types of Brakes -Construction and Working. Antilock Braking System, TCS. Types of Wheels – Construction of Wheel. Types of Tyres – Tubeless Tyres and Tubed Tyres and its Classifications.

UNIT - V	AUTOMOTIVE ELECTRICAL AND MODERN VEHICLES	9

Batteries- Lead Acid, Lithium Ion Battery. Starting System. Ignition System-types, Laser Ignition. Vehicle Lighting- Head Lamp. Automotive Sensors and its types. Need For Hybrid and Electric Vehicle–Types- Fuel Cell Technology.

TOTAL: 45 PERIODS

COURSE OUTCOMES

After completing the course, the student will able to

CO1	Assess and critically evaluate various Engine and Chassis layouts, determine their characteristics, advantages and limitations
CO2	Interpret different types of drive lines used in Automobile.
CO3	Examine the working principle of steering systems, conventional and independent suspension systems.
CO4	Apply knowledge on working principles of brake and its subsystems.
CO5	Demonstrate the working principles of Electrical systems and new generation Vehicles.

TEXT BOOK:

1. Kirpal Singh, Automobile Engineering, Standard Publisher, New Delhi, 2017
2. K.K. Ramalingam, “Automobile Engineering”, Scitech publication (India), 2011.
3. R.K. Rajput, A Text–Book of Automobile Engineering, Laxmi Publications Private Limited, 2015
4. Jack Erjavec, Automotive Technology,3rd Edition.

REFERENCES:

1. Heinz Hazler, Modern Vehicle Technology, Butterworth, London, 2005.
2. Heldt P.M., Automotive Chassis, Chilton Co., New York, 1990.

3. Newton Steeds and Garret, Motor Vehicles, 13th Edition, Butterworth, London, 2005.
4. N.K. Giri, Automotive Mechanics, Kanna Publishers, 2007.
5. William H Crouse, “Automotive Mechanics”, The McGraw-Hill companies,2007.

CO-PO Mapping

COs	POs												PSOs	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
1	3	3	3	2	3	1	2	1	2	2	1	3	3	3
2	3	3	3	2	3	1	2	1	2	2	1	3	3	3
3	3	3	3	2	3	1	2	1	2	2	1	3	3	3
4	3	3	3	2	3	1	2	1	2	2	1	3	3	3
5	3	3	3	2	3	1	2	1	2	2	1	3	3	3
Avg	**3**	**3**	**3**	**2**	**3**	**1**	**2**	**1**	**2**	**2**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23902	AUTOMOTIVE POWERTRAIN SYSTEM	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To introduce the various layout of vehicle chassis, engine types.
2. To expose the need, constructional details and working principle of various clutches.
3. To envisage the working of manual transmission systems.
4. To explicate the operating principle of various automatic transmission systems.
5. To relate the importance of driveline components, wheels and tyres.

UNIT - I	INTRODUCTION	9

Layout with reference to power plant. IC Engine operation - classifications and working principle. E – Vehicle layout, operation, advantages and limitations

UNIT - II	CLUTCH	9

Requirements of Transmission system. Purpose and requirement of clutch. Principle of friction clutches. Principle and operation of single plate coil spring and multiplate clutches, Centrifugal Clutch. Introduction to Electromagnetic clutch and its applications.

UNIT - III	GEAR BOX	9

Purpose and requirement of gear box. Construction and working principle of sliding mesh and constant mesh gear boxes. Construction and working principle of synchromesh gear box. Introduction to Automated Manual Transmission. Comparison between conventional and Automated Manual Transmission

UNIT - IV	AUTOMATIC TRANSMISSION	9

Construction and working principle of Fluid Coupling, advantages and limitations. Construction and working principle of Torque Converter. Multistage and Polyphase Torque converters. Principle of CVT, advantages and limitations

UNIT - V	FINAL DRIVE AND DIFFERENTIAL	9

Forces and Torque reaction on rear axle. Propeller shaft, Universal joints. Final Drive and its types. Construction and working principle of Differential. Introduction to Limited Slip Differential. Types of wheels and tyres.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course the students will be able to

CO1	Visualize the power flow of various vehicle layouts.
CO2	Understand the working principle the various positive engagement clutches.
CO3	Appraise upon the constructional details and working principle of the manual transmission systems.
CO4	Compare and contrast between various automatic transmission systems.
CO5	Summarize the significant driveline components, wheels and tyres.

TEXTBOOKS:

1. Rajput R.K., “A Textbook of Automobile Engineering”, Laxmi Publications; Second edition, 2017.
2. K. Newton, Steeds and T.K. Garret, “The Motor Vehicle”, 13th Edison, Butterworth Heinemann, India 2004.
3. William H. Crouse and Donald L. Anglin, “Automotive Mechanics”, 10th Edison, McGraw- Hill Education, 2017.

REFERENCES:

1. David A Crolla, “Automotive Engineering: Powertrain, Chassis System and Vehicle Body”, Butterworth-Heinemann, 2009.
2. Ramalingam K.K, “Automobile Engineering”, Sci-Tec Book, 2005.
3. Heinz Heisler, “Advanced Vehicle Technology”, Butterworth-Heinemann, 2002.
4. “Bosch Automotive Handbook”, 10th Edition, Robert Bosch GmbH, 2018

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	1	2	1	1	1	1	1	1	2	3	3
2	3	3	3	1	2	1	1	1	1	1	1	2	3	3
3	3	3	3	1	2	1	1	1	1	1	1	2	3	3
4	3	3	1	1	2	1	1	1	1	1	1	2	3	3
5	3	3	3	1	2	1	1	1	1	1	1	2	3	3
Avg	**3**	**3**	**3**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23903	VEHICLE SAFETY SYSTEMS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. To introduce vehicle structural crashworthiness and crash testing
2. To introduce Occupant safety system
3. To get the knowledge in Active Safety in the vehicle and function of ADAS.
4. To understand the fundamentals of sensor and to detect the obstacles around the vehicle and the concept of the connected vehicle.
5. To Understand SAE Levels of Driving Automation.

UNIT - I	CONCEPTS OF AUTOMOTIVE SAFETY	9

Automotive safety: Introduction and Types. Active safety: driving safety, conditional safety, Perceptibility safety, operating safety. Passive safety: Design of body for safety. Concept of crumble zone, Safety Cage. Optimum crash pulse, deceleration on impact with stationary and movable obstacles. Design for Crashworthiness. NCAP.

UNIT - II	PASSIVE SAFETY EQUIPMENTS AND CONVENIENCE SYSTEM	9

Seat belt, Seat belt tightener system and importance, collapsible steering column. Air bags and its activation. Designing aspects of automotive bumpers and materials for bumpers. Steering and mirror adjustment, central locking system, Tire pressure Monitoring system, rain sensor system, Automated wiper system.

UNIT - III	ACTIVE SAFETY	9

Antilock braking system, Stability Control. Adaptive cruise control, Lane Keep Assist System Collision warning, avoidance system, Blind Spot Detection system, Driver alertness detection System. ADAS.

UNIT - IV	VEHICLE INTEGRATION AND CONNECTED VEHICLE	9

Looking out sensors and looking in sensors, Intelligent vision system, Vehicle Integration system. Global Positioning System. Vehicle Navigation System. Road Network, V2V.

UNIT - V	AUTONOMOUS VEHICLE	9

SAE Levels of Driving Automation, Level 0 – No Driving Automation, Level 1 – Driver Assistance, Level 2 – Partial Driving Automation, Level 3 – Conditional Driving Automation, Level 4 – High Driving Automation, Level 5 – Full Driving Automation.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On completion of the course the students will be able to

CO1	Know about the concept of crumble zone and vehicle structural crashworthiness and crash testing
CO2	Know the various types of Occupant safety system
CO3	Know about Active Safety in the vehicle and avoid crash and function of ADAS.
CO4	Understand the fundamentals of sensor and to detect the obstacles around the vehicle and the concept of the connected vehicle.
CO5	Understand SAE Levels of Driving Automation.

TEXTBOOKS:

1. Ljubo Vlacic, Michel Parent, Fumio Harashima – “Intelligent Vehicle Technologies Theory and Applications” -Butterworth-Heinemann, 2001
2. J. Marek, H.-P. Trah, Y. Suzuki, I. Yokomori - “Sensors for Automotive Applications “ , WILEY-VCH Verlag GmbH & Co. 2003
3. Robert Bosch GmbH - “Safety, Comfort and Convenience Systems”- Wiley; 3rd edition 2007

REFERENCES:

1. Bosch, “Automotive Hand Book”, 6th edition, SAE, 2004.
2. J. Powloski - “Vehicle Body Engineering” - Business books limited, London - 1969.

3. Ronald. K. Jurgen - “Automotive Electronics Handbook” - Second edition- McGraw-Hill Inc., - 1999.
4. ARAI Safety standards

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	3	3	3	3	3	2	2	1	2	1	1	3	3	3
2	3	3	3	3	3	2	2	1	2	1	1	3	3	3
3	3	3	3	3	3	2	2	1	2	1	1	3	3	3
4	3	3	3	3	3	2	2	1	2	1	1	3	3	3
5	3	3	3	3	3	2	2	1	2	1	1	3	3	3
Avg	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**1**	**2**	**1**	**1**	**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

AU23904	TWO–WHEELER TECHNOLOGY	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

1. Identify various Engine layout for Two-wheeler.
2. Evaluate the necessity of Engine subsystems in Two-Wheeler.
3. Selection of Transmission system for Two-wheeler
4. Selection of Brakes, Wheels and Tyres for Two-wheeler.
5. Evaluate the current Two-wheeler technological advancements.

UNIT - I	POWER PLANT	9

Two Stroke and Four Stroke SI and CI Engine Construction and Working, Limitations of CI engines in Two wheelers, Valve and Port Timing, Scavenging in Engines. Exhaust systems. Introduction to E-bike Layout.

UNIT - II	FUEL SYSTEM, IGNITION SYSTEM AND STARTING SYSTEM	9

Fuel System – Carburetor System, Fuel Injection System. Ignition Systems- Magneto coil and Battery Coil Spark Ignition System, Electronic Ignition System. Cooling Systems. Lubrication System. Starting System - Manual Starting System, Self-Starter System. Fuel Injection Testing

UNIT - III	STRUCTURES AND POWERTRAIN	9

Types of Frames and its Layout, Clutches, Gear box -Types, CVT, Need for Freewheeling devices. Final Drives. Steering Geometry. Front and Rear Suspension Systems. Suspension Testing

UNIT - IV	BRAKES, WHEELS AND TYRES	9

Need for Braking System, Types of Brakes -Construction and Working of Drum Brakes, Disc Brakes. Types of Wheels – Construction of Wheel. Types of Tyres – Tubeless Tyres and Tubed Tyres, Radial Tyres and Cross Ply Tyres, Speed and Load Rating. Two-wheeler Testing

UNIT - V	ELECTRICAL SYSTEM AND RECENT TRENDS	9

Instrumentation and Controls on Handle Bar. Types of Head Lamps. Head Lamp Adjustment. Lead Acid Battery. Supercharging of Race Sports Bikes. Brakes: Antilock Braking System. Catalytic Converters, Emission Norms, Case Study of Two-Wheeler.

TOTAL: 45 PERIODS

COURSE OUTCOMES

On successful completion of this course students will be able to:

CO1	Understand the assembly and layout of Two Wheelers Engine.
CO2	Understand the Ignition system and Fuel system involved in two wheelers.
CO3	Understand the different types of frames, Suspension systems and Transmission systems.
CO4	Understand the working of Brakes, Types of Wheels and Tyres in Two wheelers.
CO5	Understand the basic Auto Electrical systems and recent trends in Two-wheelers.

TEXTBOOKS:

1. John Harold Haynes, Motorcycle Basics Tech book 2nd Edition, 2015
2. Irving, P.E., Motor cycle Engineering, Temple Press Book, London, 1992.
3. Dhruv U. Panchal, Two and Three-Wheeler Technology,2015
4. K. K. Ramalingam, Two Wheelers, Scitech publications, Chennai

REFERENCES:

1. Marshal Cavandedish, ‘Encyclopedia of Motor cycling’, New York, 1989
2. 2.Srinivasan.S., ‘Motor cycle, Scooter, Mopeds’, New century book house, 1988.

CO-PO Mapping

COs	POs												PSOs	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
1	2	1	2	2	1	1		1	1	1		3	3	3
2	2	1	2	2	1	1		1	1	1		3	3	3
3	2	1	2	2	1	1		1	1	1		3	3	3
4	2	1	2	2	1	1		1	1	1		3	3	3
5	2	1	2	2	1	1		1	1	1		3	3	3
Avg	**2**	**1**	**2**	**2**	**1**	**1**		**1**	**1**	**1**		**3**	**3**	**3**

1 – Slight, 2 – Moderate, 3 – Substantial

UC23E01 ENGINEERING ENTREPRENEURSHIP DEVELOPMENT L T P C

2 0 2 3

COURSE OBJECTIVES:

1. Learn basic concepts in entrepreneurship, develop mind-set and skills necessary to explore entrepreneurship
2. Apply process of problem - opportunity identification and validation through human centred approach to design thinking in building solutions as part of engineering projects
3. Analyse market types, conduct market estimation, identify customers, create customer persona, develop the skills to create a compelling value proposition and build a Minimum Viable Product
4. Explore business models, create business plan, conduct financial analysis and feasibility analysis to assess the financial viability of a venture ideas & solutions built with domain expertise
5. Prepare and present an investible pitch deck of their practice venture to attract stakeholders

MODULE – I: ENTREPRENEURIAL MINDSET **4L,8P**

Introduction to Entrepreneurship: Definition – Types of Entrepreneurs – Emerging Economies – Developing and Understanding an Entrepreneurial Mindset – Importance of Technology Entrepreneurship – Benefits to the Society.

Case Analysis: Study cases of successful & failed engineering entrepreneurs - Foster Creative Thinking: Engage in a series of Problem-Identification and Problem-Solving tasks

MODULE – II: OPPORTUNITIES **4L,8P**

Problems and Opportunities – Ideas and Opportunities – Identifying problems in society – Creation of opportunities – Exploring Market Types – Estimating the Market Size, - Knowing the Customer and Consumer - Customer Segmentation - Identifying niche markets – Customer discovery and validation; Market research techniques, tools for validation of ideas and opportunities

Activity Session: Identify emerging sectors / potential opportunities in existing markets - Customer Interviews: Conduct preliminary interviews with potential customers for Opportunity Validation - Analyse feedback to refine the opportunity.

MODULE – III: PROTOTYPING & ITERATION **4L,8P**

Prototyping – Importance in entrepreneurial process – Types of Prototypes - Different methods – Tools & Techniques.

Hands-on sessions on prototyping tools (3D printing, electronics, software), Develop a prototype based on identified opportunities; Receive feedback and iterate on the prototypes.

MODULE – IV: BUSINESS MODELS & PITCHING **4L,8P**

Business Model and Types - Lean Approach - 9 block Lean Canvas Model - Riskiest Assumptions in Business Model Design – Using Business Model Canvas as a Tool – Pitching Techniques:

Importance of pitching - Types of pitches - crafting a compelling pitch – pitch presentation skills - using storytelling to gain investor/customer attention.

Activity Session: Develop a business model canvas for the prototype; present and receive feedback from peers and mentors - Prepare and practice pitching the business ideas- Participate in a Pitching Competition and present to a panel of judges - receive & reflect feedback

MODULE – V: ENTREPRENEURIAL ECOSYSTEM **4L,8P**

Understanding the Entrepreneurial Ecosystem – Components: Angels, Venture Capitalists, Maker Spaces, Incubators, Accelerators, Investors. Financing models – equity, debt, crowdfunding, etc, Support from the government and corporates. Navigating Ecosystem Support: Searching & Identifying the Right Ecosystem Partner – Leveraging the Ecosystem - Building the right stakeholder network

Activity Session: Arrangement of Guest Speaker Sessions by successful entrepreneurs and entrepreneurial ecosystem leaders (incubation managers; angels; etc), Visit one or two entrepreneurial ecosystem players (Travel and visit a research park or incubator or makerspace or interact with startup founders).

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

CO1: Develop an Entrepreneurial Mind-set and Understand the Entrepreneurial Ecosystem Components and Funding types

CO2: Comprehend the process of opportunity identification through design thinking, identify market potential and customers

CO3: Generate and develop creative ideas through ideation techniques

CO4: Create prototypes to materialize design concepts and conduct testing to gather feedback and refine prototypes to build a validated MVP

CO5: Analyse and refine business models to ensure sustainability and profitability Prepare and deliver an investible pitch deck of their practice venture to attract stakeholders

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4. Ries, E. (2011). The Lean Startup: How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses. Crown Business
5. Blank, S. G., & Dorf, B. (2012). The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company. K&S Ranch

6. Osterwalder, A., & Pigneur, Y. (2010). Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers. John Wiley & Sons

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